Comment Letter L

VIA ELECTRONIC MAIL

December 22, 2011

Matthew Schneider
County of San Diego DPLU
5201 Ruffin Road, Suite B
San Diego, CA 92123-1666

RE: Comments on DEIR for San Diego County Wind Energy Ordinance

Dear Mr. Schneider:

The Endangered Habitats League (EHL) is a regional conservation organization with members throughout Southern California, including unincorporated San Diego County. EHL submits the following comments on behalf of itself and its members on the proposed DEIR for the San Diego County Wind Energy Ordinance (Ordinance).

I. Introduction

The proposed Ordinance is intended to facilitate the development of wind energy in the County. While EHL generally supports the development of alternative, renewable energy resources, the facilities must be sited and operated to minimize impacts to a broad suite of avian and terrestrial species (from clearing, etc.) Despite a wealth of available information concerning the devastating impact on birds and bats of badly sited and designed wind energy projects, and in spite of an abundance of ways to reconcile wind energy with biodiversity concerns, the County's Ordinance does not even mention biological considerations. Not one word. L-1

And although the County proposes to find that impacts on wildlife from both small and large wind turbines are significant and unavoidable, the DEIR does not reflect a good faith effort to identify and consider a range of feasible less harmful alternativesor develop meaningful mitigation. Indeed, the two biological mitigation measures suggested are completely ineffective in lessening impacts. L-2

Finally, as detailed in the letter submitted concurrently from wind expert and wildlife ecologist Scott Cashen (Cashen Letter), the DEIR fails to properly acknowledge and analyze numerous impacts of the proposed ordinance on biological resources. L-3

For all of these reasons, the DEIR cannot pass muster under CEQA. Moreover, the record developed so far does not permit the County to adopt a project with significant and L-4

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purportedly unavoidable impacts because no substantial evidence supports the finding—required under CEQA—that no feasible alternatives or mitigation-reducing project exists. To the contrary, as described in the Cashen Letter and in the submissions accompanying this letter, numerous feasible methods are available to reduce impacts of wind energy systems—both large and small. L-4 Cont.

EHL therefore urges the County to reconsider and revise its Wind Energy Ordinance in a revised DEIR.

II. The DEIR Contains Significant Disclosure Gaps

In determining an EIR's adequacy, California courts have held that L-5

> Whether an EIR will be found in compliance with CEQA involves an evaluation of whether the discussion of environmental impacts reasonably sets forth sufficient information to foster informed public participation and to enable the decision makers to consider the environmental factors necessary to make a reasoned decision

Berkeley Keep Jets Over the Bay Com. v. Board of Port Commissioners ((2001) 91 Cal. App. 4th 1344, 1355). The DEIR, in its current state, contains inconsistencies and disclosure gaps that preclude informed public participation and inhibits effective decision-making. These inadequacies in the disclosure and analysis of environmental impacts are described in detail in the Cashen Letter, submitted concurrently, and will not be repeated here. L-6

III. The DEIR's Alternatives Analysis Is Inadequate.

CEQA requires that an EIR "shall describe a range of reasonable alternatives to the project, which would feasibly attain most of the objectives of the project but would avoid or substantially lessen any of the significant effects of the project" (See CEQA Guidelines §15126.6, subd (a).) Further, the analysis must consider alternatives "capable of eliminating any significant adverse environmental effects or reducing them to a level of insignificance, even if these alternatives would impede to some degree the attainment of project objectives." (§15126(d)(3).) L-7

As mentioned, the DEIR's failure even to consider an alternative that would take *biologically*-based siting considerations into account in the placement, design and operation of both small and large turbines is patently unreasonable. As the suite of guidance from both state and federal agencies and other documentation submitted concurrently with this letter make abundantly clear, "proper siting of wind energy projects is the most important element in avoiding and minimizing wildlife impacts." (Petition for Rulemaking at p. 79.) As the L-8

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California Energy Commission's Guidance makes clear, "[t]he most important decision regarding impact avoidance and minimization comes early in site screening." (CEC Guidance at p. 62.) L-8 Cont.

Instead of biologically driven site considerations, and with the minor exception of prohibiting turbines along ridges, the proposed ordinance would permit indiscriminate siting of small turbines. For example, 80-foot tall turbines could be sited next to a golden eagle nest fully consistent with the proposed ordinance. (L-9) In addition, MSCP conservation areas could be littered with turbines—all with a ministerial action that takes no account of biological damage or how to avoid, minimize, or mitigate it. (L-10) The environmental analysis must consider an alternative which prohibits placement of any turbines within MSHCP areas, close to other known, biologically sensitive areas, or within known migratory corridors or raptor foraging areas.

Such an alternative would permit the County to achieve most of the project's stated objectives, while greatly reducing collision risk to resident bird and bat species. (L-11) An additional siting step would mandate a pre-area screening and flatly prohibit the placement of turbines in areas frequented by endangered species (such as the Coastal California Gnatcatcher, Least Bell's Vireo) or those subject to specific federal protections (the Golden Eagle). (L-12)

The County may respond that an alternative containing biologically based siting restrictions for small turbines is infeasible given AB 45's strictures on a local jurisdiction's ability to prohibit small wind turbines fitting the criteria in that statute. However, nothing in AB 45 prohibits the County from imposing reasonable conditions to minimize environmental impacts. To the contrary, the law provides that a small turbine wind "ordinance *may impose conditions* on the installation of small wind energy systems that include, *but are not limited to*, notice, tower height, setback, view protection, aesthetics, aviation, and design-safety requirements." (Gov't Code § 65896, subd. (b), emphases added.) (L-13)

Even if AB 45 could be interpreted to limit the County's discretion in this regard, such an interpretation would run afoul of *federal* laws mandating the protection of endangered species,[1] (L-14)

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[1] Section 9 of the Endangered Species Act (ESA) prohibits any "person" from "taking" any member of an endangered species. 16 U.S.C. § 1538(a). The term "take" is defined broadly to include "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect." *Id.* § 1532(19) In addition, "harm" is defined to "include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering." *Id.*

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migratory birds,[2] and bald and golden eagles.[3] As the DEIR acknowledges, and as confirmed by Cashen and the abundant evidence contained in the documents submitted concurrently with this letter, species protected under all these laws would be killed or "taken" by the operation of both small and large wind turbine systems. L-14 Cont. L-15

Even if AB 45 were construed to require Counties indiscriminately to permit small turbines under the conditions defined in Government Code § 65896, subd. (b) without regard to biological impacts, federal laws, including ESA, MBTA, and BGEPA, would effectively preempt the operation of AB 45 in every case where placement of a turbine would likely result in a prohibited "take" of a protected avian species. A bedrock principle of federal constitutional law holds that the Constitution, as well as all laws and treaties made under U.S. authority, is the "supreme law of the land" and thus enjoys legal superiority over any conflicting provision of a state constitution or law (Article VI, Section 2). Specifically, under the doctrine of "obstacle preemption," application of a state law in a particular case is invalid if it "stands as an obstacle to the accomplishment and execution of the full purposes and objectives of Congress." (*Hines v. Davidowitz*, (1941) 312 U.S. 52, 67.) Here, AB 45 would stand as such an obstacle because it would require Counties to permit wind turbines despite their inconsistency with federal law. L-16

Nor does CEQA allow the artificially constrained articulation of project purposes in the DEIR to preclude development of feasible ordinance alternatives that add biological impact minimization criteria, including siting criteria, to the permitting of small turbines. (See *City of Santee v. County of San Diego* (1989) 214 Cal. App. 3rd 1438, 1455 [unnecessarily narrow project purpose invalidates EIR's treatment of alternatives]. Here, the County proposes that a purpose of the project is to allow ministerial review of small turbines "without a discretionary permit." This narrow project purpose artificially and unnecessarily precludes the development of L-17

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2 The Migratory Bird Treaty Act (MBTA) prohibits the killing of numerous migratory birds without the authorization of the Secretary. Enacted to fulfill the United States' treaty obligations, the MBTA provides that "[u]nless and except as permitted by regulations made as hereinafter provided in this subchapter, it shall be unlawful *at any time, by any means or in any manner,* to pursue, hunt, take, capture, kill, attempt to take, capture, or kill . . . any migratory bird." (16 U.S.C. § 703(a), emphasis added.)

3 The Bald and Golden Eagle Protection Act provides that "[w]hoever . . . shall knowingly, or with wanton disregard for the consequences of his act take, possess, sell, purchase, barter, offer to sell, purchase or barter, transport, export or import, at any time or in any manner . . . any golden eagle, alive or dead, or any part, nest, or egg thereof . . . shall be fined not more than $5,000 or imprisoned not more than one year or both." 16 U.S.C. § 668(a). Violators are also subject to civil penalties. *Id.*§ 668(b).

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reasonable alternative permit schemes that facilitate the development of wind energy while reducing biological impacts. L-17 Cont.

IV. Mitigation for Biological Impacts Measures Is Absent or Ineffective in Violation of CEQA. L-18

Mitigation under CEQA cannot be meaningless. Rather, to be legally adequate, it "must be fully enforceable through permit conditions, agreements, or other legally-binding instruments." (Guidelines, § 15126.4, subd. (a) (2).) Moreover, mitigation as defined under CEQA must have the potential to actually reduce impacts. (Guidelines § 15370; § 15126.4, subd. (a) (1) ["EIR *shall* describe feasible measures which could minimize significant adverse impacts"]

The proposed mitigation for significant biological impacts does not meet this minimum standard. A total of two measures are proposed.[4] As an initial matter, *neither of these measures even applies to small wind turbines*, even though the DEIR recognizes their significant adverse environmental effects on biological resources. M-BIO-1 by its terms is limited to Major Use Permits, while M-BIO-2 is implicitly so limited, as it would apply only to *subsequent* environmental review that the proposed ministerial process for small turbines wouldn't require. The DEIR's failure to propose or adopt *any* mitigation in connection with project-level approval of this ministerial process violates CEQA. (See Guidelines § 15126.4.) . L-19 L-20

Insofar as the EIR applies programmatically to large turbines, the measures proposed are impermissibly vague, essentially meaningless deferred mitigation. M-BIO-1 simply states that L-21

[4] **Mitigation Measures**
M-BIO-1: During the environmental review process for future Major Use Permits for wind turbines, the County Guidelines for Determining Significance for Biological Resources shall be applied. When impacts to biological resources are determined to be significant, feasible and appropriate project-specific mitigation measures shall be incorporated. Examples of standard mitigation measures within the County Guidelines include: avoidance of sensitive resources; preservation of habitat; revegetation; resource management; and restrictions on lighting, runoff, access, and/or noise.
M-BIO-2: Update the County Guidelines for Determining Significance for Biological Resources to include, or incorporate by reference, recommendations from the California Department of Fish and Game, the Avian Power Line Interaction Committee, the USFWS Draft Guidance, and the California Energy Commission (e.g., California Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development). Examples of recommended mitigation measures include: site screening; pre-permitting monitoring; acoustic monitoring; buffer zone inclusion; reduction of foraging resources near turbines; specific lighting to reduce bird collisions; post-construction monitoring; and avian protection plans.

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CEQA will apply to the Major Use Permit process; it is not a mitigation measure, but a general statement of law. Similarly, M-BIO-2 simply commits the County to *reference* various guidance documents in the County Guidelines for Determining Significance for Biological Resources. Completely absent is *any commitment to adopt concrete mitigation, or to adhere to any particular standard.* (See *Endangered Habitats League v. County of Orange* (2005) 131 Ca. App. 4th 777, 793-794 [permissible mitigation requires adherence to performance standards or commitment to take specific action in future].) Accordingly, to constitute legally cognizable mitigation under CEQA, mitigation measure M-BIO-2 must be revised to commit the County to *apply* the cited resource agency guidance *throughout* the project approval and implementation process. This commitment can be implemented by amending the ordinance to require adherence to the cited guidance at all stages of project review and implementation. L-21 Cont. L-22

V. The County Is Precluded from Making the Finding of Overriding Considerations Required to Approve the Project Because the County Has Ignored Feasible Alternatives and Mitigation Measures Are Available that Would Lessen Impacts.

As detailed above, CEQA Guideline §15126.4(a) requires lead agencies in an EIR affirmatively to develop potentially feasible mitigation measures to avoid or substantially reduce a project's significant environmental impacts, an obligation the County has followed in the breach. This failure not only constitutes an independent CEQA violation, but also precludes the County from approving a project—such as the one here—with significant and purportedly unavoidable impacts. L-23

Here's why. In approving a project, a lead agency must make two sets of findings. The first must address how the agency responds to significant effects identified in the environmental review process, either by finding that these effects will be mitigated, or that "[s]pecific economic, legal, technological, or other considerations . . . make infeasible the mitigation measures or project alternatives identified in the final EIR." (CEQA Guidelines § 15091, subd. (a)(3).) The second set concerns any statement of overriding considerations, permitting an agency to approve a project despite the existence of significant environmental impacts. (CEQA Guidelines, § 15093.) Because the findings requirements implement CEQA's substantive mandate that public agencies refrain from approving projects with significant environmental impacts when there are feasible alternatives or mitigation measures that can lessen or avoid these impacts, an agency is prohibited from reaching the second set until it has properly addressed the first. (See CEQA Guidelines, § 15091, subd. (f), subd. (c); *Mountain Lion Foundation v. Fish & Game Commission* (1997) 16 Cal. 4th 105, 134.) These findings must be supported by substantial evidence in the record. (Pub. Res. Code § 21081.5; CEQA Guidelines, § 15091, subd. L-24

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(b).) Any finding that an alternative is infeasible must not only reflect a reasoned analysis, but must be based on specific and concrete evidence. Only if this finding of infeasibility can properly be made may a lead agency rely on a statement of overriding considerations. L-24 Cont.

The record developed so far, if the DEIR is any guide, is completely devoid of the evidence required to substantiate the first required finding—that no feasible mitigation or alternatives that would lessen impacts exist. To the contrary, as explained above, feasible alternative ordinances with less impacts on wildlife can be developed. Moreover, numerous feasible mitigation measures exist. Some examples include: L-25

- All turbines and MET towers should be prohibited within a three hundred foot vicinity of: L-26
    - Listed State or Federal threatened/endangered species (or species of special concern)
    - Wildlife nursery sites
    - Essential habitat elements for threatened and endangered species
    - Rare plant species (as specific by the California Native Plant Protection Act)
- Areas disturbed by construction should be restored to native habitat and inspected to ensure complete and appropriate restoration. L-27
- All large and small wind energy facilities should be responsible for implementing the "California Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development" and all other survey and mitigation guidelines issued by State and Federal Agencies. Compliance with these guidelines should be mandatory. L-28
- Unavoidable impacts to birds and bats should be compensated. Feasible compensation measures include protecting habitat that benefits birds and bats, acquiring high-priority conservation sites, and implementing management actions that benefit species affected by wind-energy (among other potential measures). L-29
- The County should implement a scientific study designed to examine the effects of small wind turbines on birds and bats. Data obtained from the study should be used to make informed decisions on turbine siting and adaptive management practices. L-30
- The ordinance should specifically prohibit any project which does not comply with the Bald and Gold Eagle Protection Act L-31

These are just a sampling of feasible mitigation measures recommended by wildlife resource agencies or adopted by other jurisdictions in California and elsewhere. More examples are L-32

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provided in the Cashen Letter, and in the documents EHL submits concurrently with this comment letter, made part of the administrative record and incorporated herein.[5] L-32 Cont.

In light of the precarious state of the species and habitats likely to be negatively affected by this project, every potentially feasible mitigation measure and/or alternative appearing in all the documents submitted must be fully explored. If determined to be infeasible, a specific justification must be provided in any responses to these comments.

L-33

CEQA requires no less. (See Pub. Res. Code § 21002 ["The Legislature finds and declares that it is the policy of the state that public agencies should not approve projects as proposed if there are feasible alternatives or feasible mitigation measures available which would substantially lessen the significant environmental effects of such projects"].) Until the County has thoroughly exhausted the suite of potentially feasible alternatives and mitigation appearing in the record, it is precluded from making the finding of overriding considerations required to approve the proposed ordinance.

VI. Conclusion

L-34

EHL is not opposed to an increase in wind generated energy in San Diego County. To the contrary, we recognize the necessity of wind and other renewable energy sources in combating climate change and ensuring a healthier environment. However, CEQA mandates

[5] These documents include: National Wind Coordinating Collaborative (CWEC) Mitigation Toolbox; email dated December 6, 2011 from Albert Manville, USFWS; USFWS Comments on Summit Ridge Wind Project, September 2010; California Energy Commission (CEC) Guidelines for Reducing Impacts to Birds and Bats From Wind Energy Development, October 2007; Permitting Fees for Small Wind Turbines in California Counties, CWEC March 2009; Golden Eagles in a Perilous Landscape: Predicting the Effects of Mitigation For Wind Turbine Blade Strike Mortality, CEC July 2002; Guidelines For Siting Wind Turbines Recommended For Relocation To Minimize Potential Collision-Related Mortality Of Four Focal Raptor Species In The Altamont Pass Wind Resource Area, Alameda County May 2010; Smallwood and Thelander, "Bird Mortality in the Altamont Pass Wind Resource Area, California," *The Journal of Wildlife Management*, Vol. 72, No. 1 (Jan., 2008); Rulemaking Petition to the U.S. Fish & Wildlife Service for Regulating the Impacts of Wind Energy Projects on Migratory Birds, American Bird Conservancy, December 14, 2011; Permitting Setback Requirements for Wind Turbines in California, CEC, November 2006; Draft Eagle Conservation guidance, USFWS, January 2011; McKinsey, "Regulating Avian Impacts Under the Migratory Bird Treaty Act and Other Laws: The Wind Industry Collides With One Of Its Own - the Environmental Protection Movement," *Energy Law Journal*, Vol. 28:71; Marin County Wind Energy Ordinance, November 2009; USFWS Interim Guidance on Avoiding and Minimizing Wildlife Impacts From Wind Turbines, May 2003; Land-Based Wind Energy Guidelines, USFWS, Draft dated September 13, 2011

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that wind energy be implemented in California in a manner that stewards and preserves the County's rich biodiversity. L-34 Cont.

Thank you for your attention to EHL's concerns.

Respectfully submitted,

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Scott Cashen, M.S.—Independent Biological Resources and Forestry Consultant

December 22, 2011

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Subject: Comments on the Draft Environmental Impact Report Prepared for San Diego County's Proposed Wind Energy Ordinance Amendment

Dear Mr. Silver:

This letter contains my comments on the Draft Environmental Impact Report ("DEIR") prepared for San Diego County's ("County") proposed amendments to the County's Zoning Ordinance ("Ordinance") related to wind turbines and meteorological testing ("MET") facilities. The proposed Ordinance would allow temporary MET facilities without a discretionary permit. It also would allow the installation of up to three "small" wind turbines per lot without a discretionary permit. Large wind turbines would continue to be subject to Major Use Permit procedures and requirements, and they would require separate project-specific environmental review. However, the proposed Ordinance incorporates technological changes that affect design standards for large wind turbines, and it establishes a low frequency C-weighted sound-level limit for them. L-35

I am an environmental biologist with 19 years of professional experience in wildlife ecology, forestry, and natural resource management. To date, I have served as a biological resources expert for over 35 projects, the majority of which have been renewable energy facilities. My experience in this regard includes testifying before the California Energy Commission and assisting various clients with evaluations of biological resource issues. My educational background includes a B.S. in Resource Management from the University of California at Berkeley, and a M.S. in Wildlife and Fisheries Science from the Pennsylvania State University. L-36

I have gained particular knowledge of the biological resource issues associated with the Ordinance through my work on several other wind energy projects, and through my work on several projects in San Diego County. The comments herein are based on my review of the environmental documents prepared for the Project, published scientific literature, consultations with biological resource experts, and the knowledge and experience I have acquired during more than 19 years of working in the field of natural resources management.

The DEIR's Failure to Provide Consistent Information on the Height of Small Turbines Prevents an Accurate Assessment of Impacts to Birds and Bats

The proposed Ordinance would allow the installation of up to three "small" wind turbines per lot without a discretionary permit. The DEIR does not provide consistent information on the height limit of these "small" turbines. Specifically,

a. Page 1-9 of the DEIR states small turbines shall not exceed 80 feet with the *blade* in a vertical position.

b. Page 1-18 of the DEIR states the *tower* of small turbines shall not exceed 80 feet.

This discrepancy has considerable consequences on the impacts of the Ordinance on bird and bat species. The collision risk to many species is believed to be a function of both the height of a wind turbine's rotor blade above ground level, and the total rotor-swept area. Because these variables are highly correlated with the height of the turbine's tower, the DEIR must clearly establish the height limit for small turbine towers and/or blades. L-37

The DEIR Must Provide Information on the Types of Facilities that Might Install Small Wind Turbines

One of the objectives of the Ordinance is to facilitate development of small wind turbines that would generate electricity primarily for use on the lots where the wind turbines are located. However, the DEIR lacks information on the types of facilities that may be powered by small wind turbines. This precludes an assessment of alternative types of renewable energy (e.g., solar and biomass utilization) that potentially could be used to power the facilities. L-38

The DEIR Must Provide Information on Lot Sizes Such That the Public and Decision Makers Can Analyze Impacts Caused by Ground Disturbance

Under the Ordinance, all transmission lines connecting turbine towers and/or generators to a structure must be installed underground. Installing transmission lines underground will result in ground disturbance, which may have an adverse effect on sensitive species and habitats.[1] The DEIR lacks any information on lot sizes, and consequently, the amount of ground disturbance that is likely to occur when transmission lines are installed underground. This information is needed to fully disclose the Ordinance's impacts to sensitive biological resources, and to enable independent analysis of the impacts associated with the installation of transmission lines. L-39

The DEIR Lacks Adequate Information on the Species That Would Be Affected by the Ordinance

The DEIR identifies several "species of concern related to wind turbine projects."[2] The DEIR's discussion of these species, however, is limited primarily to natural history information; it fails to provide: (a) the population status of each species in San Diego County, (b) any specific analysis of the anticipated levels of impacts that will occur to each species, or (c) the relative L-40

[1] DEIR, p. 2.4-28.
[2] DEIR, p. 2.4-12.

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significance of impacts on population viability and conservation. This information must be disclosed in a revised DEIR. I have the following comments in this regard: L-40 Cont.

1. The DEIR fails to disclose fundamental information on the status of golden eagles in San Diego County. Survey data indicate the golden eagle population in San Diego County has experienced a "precipitous" decline.[3] Wildlife Research Institute estimates that the county's eagle population may decline by an additional 50 percent by the year 2030.[4] The proposed Ordinance has the potential to exacerbate this decline. L-41
2. The DEIR acknowledges that there is "critical habitat" for the Peninsular bighorn sheep in San Diego County.[5] The DEIR, however, does not discuss how the proposed Ordinance would affect critical habitat, the U.S. Fish and Wildlife Service's ("USFWS") *Recovery Plan for Bighorn Sheep in the Peninsular Ranges*, or the viability of bighorn sheep populations in San Diego County.[6] L-42
3. Current data suggest burrowing owl populations are declining throughout the State. The foraging and social behavior of burrowing owls makes them highly susceptible to collisions with wind turbines, especially the small (i.e., shorter) turbines that would be promoted by the Ordinance. L-43

The DEIR also does not mention numerous special-status species that may be impacted by the Ordinance. These include special-status species identified in the California Department of Fish and Game's ("CDFG") letter to the County in response to the Notice of Preparation.[7] I agree with the CDFG that the species identified in its letter should be addressed in the DEIR. At a minimum, the DEIR must disclose and analyze impacts of the proposed Ordinance on the following species: L-44

1. The pallid bat, western red bat, western mastiff bat, and potentially other special-status bat species. Bats are known to be susceptible to collisions with wind turbines. Existing scientific information suggests that additive mortality caused by wind turbines may have severe consequences on bat populations.[8] L-45
2. Due to widespread habitat loss, fragmentation, and degradation, the flat-tailed horned lizard has been a candidate for listing under the Endangered Species Act.[9] Scientific research has demonstrated that flat-tailed horned lizard populations are extremely susceptible to "edge effects" and other indirect impacts associated with development.[10] The Ordinance will promote projects that provide perches for flat-tailed horned lizard L-46

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[3] Unitt PA. 2004. San Diego County Bird Atlas. Proceedings of the San Diego Society of Natural History, No. 39.
[4] Id.
[5] DEIR, p. 2.4-13.
[6] *See* U.S. Fish and Wildlife Service. 2000. Recovery plan for bighorn sheep in the Peninsular ranges, California.
[7] California Department of Fish and Game. 2010 Oct 13. Solar Wind Energy Zoning Ordinance Amendment (POD 09-006, LOG NO. 09-00-003), San Diego County (SCH#2010091030). Letter to Matthew Schneider, County of San Diego. DEIR, Appendix C.
[8] Committee on Environmental Impacts of Wind Energy Projects, National Research Council. 2007. Environmental Impacts of Wind-Energy Projects. National Academies Press, Washington (DC). 394 pp.
[9] Id. p. 23.
[10] Young KV and AT Young. 2005. Indirect effects of development on the flat-tailed horned lizard. Final Report submitted to Arizona Game and Fish Department, Yuma. 11 pp.

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predators. Heightened predation pressure is considered a significant threat to the conservation of flat-tailed horned lizard populations.[11] As a result, indirect impacts on the flat-tailed horned lizard must be analyzed in a revised DEIR. L-46 Cont.

The DEIR Does Not Accurately Disclose Levels of Ground Disturbance and Habitat Loss

Under the proposed Ordinance, wind turbines that are not roof-mounted must include at least 10 feet of vegetation clearance "around the base," along with placement of gravel to reduce potential habitat for prey species that would attract birds and bats.[12] It does not appear that the DEIR included these requirements in its analyses of impacts to habitat. L-47

The DEIR estimates small wind turbines and MET towers would cause a maximum of 7,724 acres of total ground disturbance. This estimate is based on the number of foundations that may be installed to support small turbines and MET towers. The estimate does not consider the ground disturbance (i.e., trenching) that will occur to install transmission line underground (as required by the Ordinance). Although the DEIR does not quantify the amount of trenching that will be required to install transmission lines underground, it acknowledges that lots in the eastern portion of the County are "large."[13] This suggests a considerable amount of trenching may occur when small turbines are installed on large lots. The ground disturbance associated with trenching often results in habitat degradation and the colonization and spread of invasive plants. In addition, open trenches act as pitfalls for wildlife, including sensitive species. The DEIR must be revised such that it (a) quantifies the amount of ground disturbance that may be necessary to install transmission lines underground; and (b) discloses and analyzes the potentially significant impacts associated with trenching. L-48

The DEIR Provides Misleading Information on the Impacts of Small Wind Turbines

The DEIR suggests that the height and spacing of "small" wind turbines would result in minimal impacts to birds and bats.[14] This suggestion is indefensible. Research indicates "small" wind turbines are disproportionately lethal to some species. For example, Hunt (2002) concluded turbines on 18.3-meter (60-foot) towers were disproportionately more lethal to golden eagles in the Altamont Pass Wind Resource Area than taller turbines.[15] Research has also demonstrated that even one, poorly located wind turbine can have significant impacts on birds, bats, and other sensitive resources.[16] As a result, the DEIR must be revised such that it provides decision makers with accurate information pertaining to the impacts of small wind turbines. L-49

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[11] Id. *See also* Barrows CW, MF Allen, JT Rotenberry. 2006. Boundary processes between a desert sand dune community and an encroaching suburban landscape. Biological Conservation 131:486–494. *See also* Flat-tailed Horned Lizard Interagency Coordinating Committee. 2003. Flat-tailed horned lizard rangewide management strategy, 2003 revision. 80 pp. plus appendices. p. 49.

[12] DEIR, p. 2.4-28.

[13] DEIR, p. 1-2.

[14] DEIR, p. 2.4-28.

[15] Hunt WG. 2002. Golden eagles in a perilous landscape: Predicting the effects of mitigation for energy-related mortality. California Energy Commission Report P500-02- 043F.

[16] Committee on Environmental Impacts of Wind Energy Projects, National Research Council. 2007. Environmental Impacts of Wind-Energy Projects. National Academies Press, Washington (DC). 394 pp.

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The DEIR Lacks Adequate Analysis of the Impacts of Small Turbines on the Golden Eagle

The golden eagle is a CDFG Watch List species and a USFWS Bird of Conservation Concern. It also is protected by California Fish and Game Code and the federal Bald and Golden Eagle Protection Act. The DEIR acknowledges that because of these factors, the collision risk that wind turbines pose to the golden eagle is of particular concern.[17] Nevertheless, the DEIR L-50
provides almost no analysis of the impacts that small turbines will have on the golden eagle. Indeed, the DEIR's analysis in this regard is limited to the statement that "the height of small wind turbines and MET facilities is not tall enough to be within migratory wildlife flight paths, such as that of the golden eagle."[18] This analysis is both insufficient and inaccurate. L-51

First, the DEIR ignores the fact that migrant birds, including the golden eagle, may collide with wind turbines of any size while taking off or landing. L-52

Second, data demonstrate migrating eagles are highly susceptible to collision with small (and large) wind turbines. During migration, golden eagles (and other raptors) conserve energy by using deflective updrafts or thermals to go long periods without flapping their wings. Because eagles are adapted to use even the smallest and weakest of thermals, they can migrate at elevations low to the ground. They also may fly low to the ground when weather conditions are "poor," or while they are foraging. L-53

Third, golden eagles and other migratory birds may be attracted to turbine sites where they become susceptible to collision. For example, certain birds are prone to perching on wind towers because the towers simulate trees with which the species is familiar.[19] Additionally, soil and vegetation disturbance associated with turbine installation promotes habitat for prey species, which may attract eagles and other predatory birds.[20] Thus, even though a bird may migrate L-54
above the turbine, characteristics of the turbine site may stimulate the bird to descend and enter the rotor-swept area. L-55

Fourth, and perhaps most importantly, the DEIR lacks any analysis of the collision risk to San Diego County's *resident* (i.e., non-migratory) eagle population. The foraging, breeding, and social behavior of resident golden eagles makes them highly susceptible to collision with wind turbines of all heights. This is well substantiated in scientific literature.[21] L-56
The loss of breeding (i.e., resident) birds has relatively severe consequences on the overall population given the mortality to young that is likely to occur if one of the parents dies. L-57

As a result of the issues described above, the DEIR must be revised such that it provides a thorough and accurate assessment of the potentially significant impacts that small turbines are likely to have on the golden eagle. L-58

[17] DEIR, p. 2.4-30.
[18] DEIR, p. 2.4-28.
[19] Thelander CG, KS Smallwood, L Rugge. 2003. Bird Risk Behaviors and Fatalities at the Altamont Pass Wind Resource Area. Prepared by BioResource Consultants for National Renewable Energy Laboratory. Ojai, California: BioResource Consultants. December 2003.
[20] Id.
[21] Id.

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The DEIR Presents Misleading and Erroneous Information on the Collision Risk to Golden Eagles

The DEIR states the following in regard to the collision risk that large turbines pose to the golden eagle:

> Based on studies of the flight behavior of golden eagles, they are at lower risk than species such as red-tailed hawks because only 15% of their flight behaviors put them in a vulnerable position to turbine collisions (flying at the height of the rotor plane), and they do not spend significant time within close proximity (within 50 meters or 164 feet) to turbines (Thelander et al. 2003). The golden eagle has high maneuverability and therefore may be able to use high-powered flight to avoid collisions with turbines.[22]

These statements are very misleading. Research has demonstrated that golden eagles behave as if wind turbines are non-existent.[23] Consequently, golden eagles are highly vulnerable to collisions with wind turbines, and they routinely fly right through the rotor area.[24] The substantial number of golden eagles that are killed annually in the Altamont Pass Wind Resource Area alone demonstrates the vulnerability of golden eagles to mortality from wind turbines.[25] L-59

I have the following additional comments pertaining to the aforementioned statements presented in the DEIR:

1. Scientific data do not support the statement that golden eagles are at lower risk than other species. Contrary to the data presented in the DEIR, Thelander et al. (2003) reported 29.5% of eagle flights were within 50 meters of a turbine, and that eagles spent significantly more time flying close to turbines than would be expected by chance.[26] Similarly, Smallwood et al. (2009) concluded golden eagles often exhibit behaviors that corresponded with higher fatality rates.[27] L-60
2. Golden eagles have long, broad wings that are adapted for soaring—not maneuverability.[28] In addition, golden eagle wingbeats are slow, which prevents eagles from sharply turning and twisting in flight to avoid turbines.[29] L-61
3. The DEIR misapplies the term "risk." A true evaluation of risk requires that estimated L-62

[22] DEIR, p. 2.4-30.
[23] KS Smallwood, personal communication to S. Cashen on 9 Dec 2011.
[24] Id.
[25] Arnett, E. B., D. B. Inkley, D. H. Johnson, R. P. Larkin, S. Manes, A. M. Manville, J. R. Mason, M. L. Morrison, M. D. Strickland, and R. Thresher. 2007. Impacts of wind energy facilities on wildlife and wildlife habitat. Wildlife Society Technical Review 07-2. The Wildlife Society, Bethesda, Maryland, USA. *See also* Smallwood KS and C Thelander. 2008. Bird Mortality in the Altamont Pass Wind Resource Area, California. Journal Wildlife Management. 72(1):215-223.
[26] *See Table 9 and p. 18* In: Thelander CG, KS Smallwood, L Rugge. 2003. Bird Risk Behaviors and Fatalities at the Altamont Pass Wind Resource Area. Prepared by BioResource Consultants for National Renewable Energy Laboratory. Ojai, California: BioResource Consultants. December 2003.
[27] Smallwood KS, L Rugge, ML Morrison. 2009. Influence of Behavior on Bird Mortality in Wind Energy Developments. The Journal of Wildlife Management. 73(7): 1082-1098.
[28] Terres JK. 1980. The Audubon Society Encyclopedia of North American Birds. New York: Knopf.
[29] Id.

mortality be put into context with the total population size.[30] Although estimating population size is difficult, preliminary research results indicate that turbine-related fatalities might be contributing to a long-term decline in regional golden eagle populations.[31] L-62 Cont.

Data indicate the golden eagle population in San Diego County is experiencing a precipitous decline. These data, in conjunction with data from mortality and behavior studies, suggest the Ordinance would promote projects that pose high "risk" to the golden eagle. This risk must be accurately disclosed and analyzed in a revised DEIR. L-63

The DEIR Does Not Provide an Accurate Assessment of the Collision Risk to Bird and Bat Populations

The DEIR recognizes that the Ordinance will generate a collision risk to birds and bats, and that this risk constitutes a potentially significant impact.[32] The DEIR's analysis of this impact, however, suffers two principal flaws: (1) an inappropriate level of analysis, and (2) the provision of indefensible conclusions. L-64

Unique suites of attributes contribute to turbine-caused fatalities of each bird and bat species.[33] *Species-specific* analysis is required to understand these attributes and the associated risk that a project poses. The DEIR does not provide this level of analysis. Instead, it lumps analysis of all potentially affected bird and bat species. This level of analysis is inappropriate for disclosing impacts of the Ordinance. L-65

The characteristics of the populations of affected species will determine the consequences of increased mortality resulting from wind turbines.[34] Bats, for example, are relatively long-lived and have low reproductive rates compared to many other mammals.[35] These traits may seriously limit their ability to recover from persistent or repeated fatality events.[36] The Natural Academy of Sciences (2007) concluded: "[i]f migratory tree bats experience naturally high mortality during migration from such factors as inclement weather, predation, and reduced food supplies, it is possible that with their low reproductive rates they *will not be able to adjust* to the expected cumulative affects resulting from the development of wind-energy facilities proposed in the United States and elsewhere."[37] L-66

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[30] Thelander CG, KS Smallwood, L Rugge. 2003. Bird Risk Behaviors and Fatalities at the Altamont Pass Wind Resource Area. Prepared by BioResource Consultants for National Renewable Energy Laboratory. Ojai, California: BioResource Consultants. December 2003.
[31] Id.
[32] DEIR, p. 2.4-29.
[33] Thelander CG, KS Smallwood, L Rugge. 2003. Bird Risk Behaviors and Fatalities at the Altamont Pass Wind Resource Area. Prepared by BioResource Consultants for National Renewable Energy Laboratory. Ojai, California: BioResource Consultants. December 2003. *See also* DEIR, p. 2.4-29.
[34] Committee on Environmental Impacts of Wind Energy Projects, National Research Council. 2007. Environmental Impacts of Wind-Energy Projects. National Academies Press, Washington (DC). 394 pp.
[35] Id.
[36] Id.
[37] Id. [emphasis added].

Similarly, because local populations of raptors and vultures are relatively small, they are highly susceptible to fatalities from wind-energy generation.[38] Thus, even if one accepts the DEIR's premise that small turbines "would not be expected to result in frequent bird and bat strikes," these deaths may have very significant effects on the viability of the overall population.[39] L-67

The DEIR concludes: "[s]ome birds and bats could be killed through collisions with the wind turbines and power lines; however, populations of individual species would not be eliminated, and the impacts to populations would not be irreversible."[40] <u>The DEIR has no basis for this conclusion</u>. To the contrary, the Natural Academy of Sciences (2007) has concluded that for rare species and local populations, the impacts of wind energy facilities, when combined with other sources of mortality, could affect population viability (i.e., persistence).[41] For example, researchers believe the unprecedentedly high number of bat fatalities at wind turbine sites may contribute to the extirpation of some species.[42] L-68

The conclusion that impacts to populations would not be "irreversible" is entirely indefensible. First, it assumes a thorough understanding of impacts caused by wind turbines. This is simply not the case. Virtually every publication dedicated to the topic articulates this. Second, the conclusion that impacts to populations would not be irreversible defies principles of wildlife science. In short, if all population declines were reversible every recovery effort would have been successful. Past experiences clearly have proven otherwise. L-69

As a result of the issues discussed above, the DEIR must be revised such that it provides the public and decision makers with accurate information on the threat of wind turbinesto birds and bats. L-70

The DEIR Fails to Disclose or Assess Indirect Impacts Caused by Small Turbines

Incredibly, the DEIR fails to disclose or analyze any of the indirect impacts that small wind turbines may have on sensitive biological resources. The installation and maintenance of small wind-energy facilities has the potential to alter ecosystem structure through vegetation clearing and soil disturbance.[43] This issue is particularly problematic in areas that are difficult to reclaim, such as in desert, shrub-steppe, and forested habitats—all of which are present within San Diego County. L-71

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[38] Id.
[39] DEIR, p. 2-4-28.
[40] DEIR, p. 2.10-3
[41] Committee on Environmental Impacts of Wind Energy Projects, National Research Council. 2007. Environmental Impacts of Wind-Energy Projects. National Academies Press, Washington (DC). 394 pp.
[42] Id. *See also* Thelander CG, KS Smallwood, L Rugge. 2003. Bird Risk Behaviors and Fatalities at the Altamont Pass Wind Resource Area. Prepared by BioResource Consultants for National Renewable Energy Laboratory. Ojai, California: BioResource Consultants. December 2003.
[43] Committee on Environmental Impacts of Wind Energy Projects, National Research Council. 2007. Environmental Impacts of Wind-Energy Projects. National Academies Press, Washington (DC). 394 pp.

Ground disturbance associated with the installation of small wind turbines may promote the colonization and spread of invasive plant species.[44] The colonization and spread of invasive plants is a significant threat to many sensitive biological resources and overall ecosystem health. L-72

Both flying and non-flying organisms may be affected by the noise and vibration associated with wind turbine construction and operation.[45] Noise can damage an organism's hearing or increase stress hormones, leading to a reduction in reproductive output and survivorship.[46] Noise and vibration also can interfere with communication essential for reproduction, prey acquisition, and predator avoidance.[47] L-73

The noise, vibration, motion of rotor blades, and/or mere presence of turbines on the landscape may displace organisms.[48] L-74 In addition, wind turbines and associated vegetation clearance activities can influence the microclimate, which may displace organisms due to the dramatic effect that microclimate has on habitat quality.[49] L-75

The indirect impacts outlined above are potentially significant. Consequently, assessments of the effects of wind-energy facilities on organisms and their habitat should not be confined to simple estimates of the amount of ground disturbance that may occur (as was done in the DEIR). The DEIR must be revised such that it fully discloses, analyzes, and mitigates all of the potentially significant indirect impacts that may be caused by the Ordinance. L-76

The DEIR Lacks an Adequate Assessment of Impacts to Local Policies, Ordinances, and Adopted Plans

The DEIR concludes small wind turbines and MET facilities would have a less than significant impact on local policies, ordinances, and plans protecting biological resources.[50] The DEIR supports this conclusion with the following rationale: L-77

a. Impacts would occur near existing development with minimal ground disturbance, if any.[51]

b. Sensitive areas or preserves (as defined by the Multiple Species Conservation Program ["MSCP"] or other habitat conservation plan) would be avoided.[52]

This rationale is not substantial evidence supporting the conclusion that impacts would be less than significant. First, the DEIR lacks a mechanism for ensuring wind turbines would occur L-78

[44] Id.
[45] Id. *See also* Rabin LA, B McCowan, SL Hooper, DH Owings. 2003. Anthropogenic Noise and its effect on Animal Communication: An Interface Between Comparative Psychology and Conservation Biology. International Journal of Comparative Psychology Vol. 16(2/3):172-193.
[46] Manci KM, DN Gladwin, R Villella, MG Cavendish. 1988. Effects of aircraft noise and sonic booms on domestic animals and wildlife: a literature synthesis. National Ecology Research Center Report # NERC-88/29.
[47] Id.
[48] Committee on Environmental Impacts of Wind Energy Projects, National Research Council. 2007. Environmental Impacts of Wind-Energy Projects. National Academies Press, Washington (DC). 394 pp.
[49] Id.
[50] DEIR, p. 2.4-38.
[51] Id.
[52] Id.

"near existing development." As the DEIR acknowledges, the eastern portion of the County is primarily rural, with large lot sizes and limited infrastructure.[53] This reflects the possibility that impacts would not be limited to areas "near existing development." L-78 Cont.

Second, the DEIR's rationale fails to consider the numerous, potentially significant indirect impacts that small wind turbine and MET facilities may have on sensitive areas or preserves, including MSCP areas. These indirect impacts include noise and vibration, fugitive dust, night lighting, the spread of invasive plants, and alterations to hydrology (among potentially other indirect impacts). For example, at the Altamont Pass Wind Resource Area, wind turbines upslope of a preserve have caused severe erosion and sedimentation, which have affected the preserve's red-legged frog and California tiger salamander populations.[54] L-79

Impacts to Critical Habitat, Core Habitat Areas, Landscape Linkages, and Federal Recovery Plans

San Diego County contains designated "critical habitat" for several federally listed plant and animal species.[55] It also contains core habitat areas and linkages that have been identified in the MSCP.[56] The DEIR lacks any analysis of impacts to critical habitat, or core habitat areas and linkages. L-80

Recovery plans have been approved for several federally listed threatened and endangered species occurring in San Diego County. Each recovery plan establishes the conservation and management actions needed to (a) reverse the decline of the species; and (b) reduce the threats to the species' survival to the point where protections under the Endangered Species Act are no longer needed. The DEIR does not provide any information on the Ordinance's consistency with the various recovery plans or the MSCP, nor does it provide any analysis of the Ordinance's impact on the recovery of potentially afflicted threatened or endangered species. L-81

The DEIR Lacks Adequate Analysis of Cumulative Impacts

The DEIR concludes the Ordinance would contribute to cumulatively considerable impacts to (1) special-status species; (2) riparian habitats and other sensitive natural communities; and (3) wildlife movement corridors and nursery sites.[57] The DEIR, however, fails to provide any substantive analyses of cumulative impacts to these resources. This precludes an evaluation of the Ordinance's contribution to cumulative impacts, and thus, the anticipated consequences of cumulative impacts on the conservation of each resource. To enable independent analysis of the Ordinance's contribution to cumulative impacts to sensitive biological resources, the DEIR must: L-82

1. identify the number, size (i.e., footprint and MW), and location of existing and reasonably foreseeable future wind energy projects in San Diego County. L-83

[53] DEIR, p. 1-2.
[54] Contra Costa County. 2011 October. Final Environmental Impact Report for the Tres Vaqueros Windfarm Repowering Project. SCH No. 2009032077. County File No. LP09-2005.
[55] DEIR, p. 2.4-11.
[56] DEIR, p. 2.4-17.
[57] DEIR, p. 2.4-40 through 2.4-43.

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2. identify the number, size, and location of all other types of past, present, and reasonably foreseeable future projects that may contribute to cumulative impacts to sensitive biological resources in San Diego County. L-83 Cont.
3. conduct cumulative impacts analyses at an ecologically appropriate level. It is not appropriate to lump analysis of all potentially afflicted species (as was done in the DEIR). The type and severity of cumulative impacts varies considerably among species due to inherent variability in threats and population status. L-84
4. put cumulative impacts into context. For example, how would the Ordinance, in conjunction with other projects, affect the regional golden eagle population (e.g., contribute to additional population declines)? L-85

The DEIR Fails to Incorporate All Feasible Mitigation Measures for Significant Impacts to the Golden Eagle

The DEIR acknowledges that the Ordinance would have a potentially significant impact on the golden eagle. The DEIR further acknowledges: "for eagle management populations that cannot sustain additional mortality, any remaining take must be offset through compensatory mitigation such that the net effect on the eagle population is, at a minimum, no change."[58] L-86 Nevertheless, the DEIR lacks any mitigation for impacts to the golden eagle. L-87 Data indicate the golden eagle population in San Diego County is rapidly declining, and that the population cannot sustain additional mortality.[59] The lack of any attempted mitigation for impacts to the golden eagle has serious implications on a decision about the Ordinance. L-88 New provisions of the Bald and Golden Eagle Protection Act prohibit the USFWS from authorizing a project that would result in a net take of eagles. Therefore, because wind turbines of all sizes have the potential to cause take of eagles, and because the Ordinance does not provide mitigation for compensating that take (i.e., ensuring no-net-loss), the Ordinance would permit projects that may not comply with federal law. L-89

The USFWS's Draft Eagle Conservation Plan Guidance discusses several mitigation measures for impacts to eagles. The measures recommended by the USFWS are feasible, and they should be incorporated into a revised DEIR to demonstrate a good-faith effort to comply with federal law and achieve a no-net-loss standard for the regional eagle population.[60] L-90

The DEIR Fails to Incorporate All Feasible Mitigation Measures for Potentially Significant Impacts to Special-Status Bird and Bat Species

The DEIR concludes the Ordinance would result in potentially significant impacts to sensitive bird and bat species. I agree with this conclusion. However, the DEIR fails to impose all feasible mitigation measures to avoid, minimize, and mitigate impacts to birds and bats. I outline feasible mitigation in a subsequent section of this letter. L-91

[58] DEIR, p. 2.4-19.
[59] Unitt PA. 2004. San Diego County Bird Atlas. Proceedings of the San Diego Society of Natural History, No. 39.
[60] U.S. Fish and Wildlife Service. 2011 Jan. Draft Eagle Conservation Plan Guidance. Available at: http://www.fws.gov/windenergy/.

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The DEIR Fails to Incorporate All Feasible Mitigation Measures for Potentially Significant Impacts to Wildlife Corridors and Nursery Sites L-92

The DEIR recognizes that the Ordinance would cause potentially significant impacts to wildlife corridors and nursery sites.[61] The DEIR offers no mitigation to avoid and minimize these impacts. There are feasible measures for mitigating impacts to wildlife corridors and nursery sites. I discuss these measures in a subsequent section of this letter.

The DEIR Fails to Incorporate All Feasible Mitigation Measures for Potentially Significant Impacts to Riparian Habitat and Other Sensitive Natural Communities L-93

The Ordinance would allow development of small wind turbines and temporary MET facilities that would have potentially significant impacts to riparian habitat and other sensitive natural communities.[62] According to the DEIR, proposed mitigation measures could reduce these potentially significant impacts, but not below a significant level.[63] However, the DEIR lacks the basis for this conclusion because it does not impose *all* feasible measures to avoid, minimize, and mitigate impacts. In the subsequent section I discuss feasible mitigation measures for impacts to riparian habitat and other sensitive natural communities.

Recommended Mitigation for Potentially Significant Impacts Caused by the Ordinance L-94

The Ordinance would have potentially significant impacts on several sensitive biological resources. Under CEQA, the County is obligated to adopt all feasible mitigation to avoid or lessen significant impacts. The DEIR is deficient in this regard because it fails to demonstrate a substantive attempt to formulate feasible mitigation measures that could reduce impacts to a level considered less than significant. The following mitigation measures are feasible, and they must be incorporated into the Ordinance's mitigation program. In addition, these measures will minimize a permittee's civil and potential criminal liability for violations of the Endangered Species Act, the Migratory Bird Treaty Act, and the Bald and Golden Eagle Protection Act—federal protections that preempt state law, including AB 45. L-95

General standards-

1. Turbines should be sited on disturbed land when practical. L-96
2. Existing roads should be used to the maximum extent feasible. L-97
3. Construction should be scheduled to avoid disruption of wildlife reproductive activities or other important behaviors. L-98
4. As has been adopted by Marin County, a Bird and Bat Study should be conducted for each proposed wind energy facility. A County-approved biologist should conduct the L-99

[61] DEIR, p. 2.4-36 and 2.3-37.
[62] DEIR, p. 2.4-45.
[63] Id.

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Bird and Bat Study according to California Energy Commission and CDFG guidelines.[64] L-99 Cont.

5. If the Bird and Bat Study for a proposed ministerial project finds that there is a potential for impacts to any (a) listed State or Federal threatened or endangered species; or (b) bird or bat "species of special concern" found to nest or roost in the area of the proposed project site, the project should become discretionary. L-100

6. Wind turbines, MET towers, and supporting infrastructure should be prohibited near sensitive biological resources, as determined by a County-approved biologist and/or the CDFG and USFWS. L-101 At a minimum, wind turbines, MET towers, and supporting infrastructure should be prohibited within 5 times the height or 300 feet, whichever is greater, of:

   a. a known nest or roost of a listed State or Federal threatened or endangered species or "species of special concern."

   b. a known or suspected migratory concentration or stopover point.

   c. known or suspected corridors that enable movement of special-status species, especially narrow corridors (e.g., a culvert), or corridors that are essential to landscape-level connectivity.

   d. wildlife nursery sites.

   e. an essential habitat element (e.g., burrow) for any threatened or endangered species.

   f. any plant listed as threatened or endangered, or that is a candidate for future listing as threatened or endangered, under the California Endangered Species Act ("ESA") or federal ESA. L-102

   g. any plant listed as rare under the California Native Plant Protection Act, or as a "List 1" or "List 2" species by the California Native Plant Society.

   h. all water courses, ponds, lakes, and other wetlands.

   i. all riparian habitat.

   j. previous and pending mitigation lands, conservation reserves, and lands encumbered by a conservation easement.

   k. State and Federal parks, refuges, wilderness areas, and other designated wildlife management areas.

   l. in any areas where impacts would threaten the persistence of a special-status species population.

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[64] *See* Marin County Development Code Title 22. *See also* California Energy Commission and California Department of Fish and Game. 2007. California Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development. Commission Final Report. California Energy Commission, Renewables Committee, and Energy Facilities Siting Division, and California Department of Fish and Game, Resources Management and Policy Division. CEC_700_2007_008_CMF.

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Information on the resources listed above should be obtained through a biological field study in conjunction with a review of previously completed field studies; consultation with state and federal resource agencies and local experts; and queries of the California Natural Diversity Database, California Partners in Flight Database, and California Consortium of Herbaria Database. L-103

7. Areas disturbed during construction should be restored to the native habitat and subject to inspection. Habitat restoration should begin as soon as possible after the completion of construction. The County, in conjunction with the resource agencies, should develop success standards for all restoration efforts. If restoration sites do not meet success standards within five years following construction, the wind turbine operator should be responsible for funding remedial actions conducted by a County-approved contractor or purchasing credits at an approved habitat conservation bank. L-104
8. All wind turbines operators should provide compensation for permanent impacts to native habitat. Compensation could be achieved through: (a) the acquisition and permanent protection of replacement habitat; (b) purchasing credits at an approved habitat conservation bank; or (c) contribution to a mitigation fund established by the County.[65] L-105
9. The wind turbine operator should be responsible for erosion and sediment control on slopes disturbed during construction. Disturbed slopes should be subject to inspection, and the wind turbine operator should be responsible for funding remedial actions conducted by a County-approved contractor if the wind turbine site does not meet water quality standards. L-106
10. The County should conduct and document the aforementioned inspections at the frequency necessary to ensure compliance. L-107
11. All large wind energy facilities should be responsible for implementing the "California Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development," and all other survey and mitigation guidelines issued by the State and Federal resource agencies.[66] The Ordinance must specify that compliance with these guidelines is mandatory. L-108

Birds and Bats-

1. Projects should not be located in areas with a high incidence of fog and mist, or other meteorological conditions that cause low visibility. L-109
2. All large wind energy facilities should develop an (a) Avian and Bat Protection Plan; and (b) Adaptive Management Plan. These plans should conform to guidelines issued L-110

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[65] *See* National Wind Coordinating Collaborative. 2007 May. Mitigation Toolbox. Available at: http://www.nationalwind.org/publications/wildlifewind.aspx

[66] California Energy Commission and California Department of Fish and Game. 2007. California Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development. Commission Final Report. California Energy Commission, Renewables Committee, and Energy Facilities Siting Division, and California Department of Fish and Game, Resources Management and Policy Division. CEC_700_2007_008_CMF.

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by the USFWS. The Ordinance must specify that preparation and implementation of the plans is mandatory. L-110 Cont.

3. Wind turbines of any size should be prohibited:
   a. at the edge of a steep slope, on a steep slope, or in a saddle, ravine, or canyon.
   b. along ridgelines, in saddles of ridges, in saddles between ridges, and especially where saddles form the apex of ravines that face a prevailing wind direction. L-111
   c. on benches of hill slopes or ridges, or at the base of shoulders of hills (i.e., in locations of sudden elevation changes).
   d. next to artificial rock piles or natural rock formations. L-112
   e. next to transmission towers, electric distribution poles, or litter control fences around a landfill . L-113
   f. where slope-accelerated winds would likely position a raptor at the height domain of the rotor plain of functional turbines, including where lips in the slope can locally accelerate winds.[67] L-114
4. Facilities shall be designed to discourage their use as perching or nesting substrates for birds. L-115
5. Ground disturbance should be conducted outside of the avian breeding season. If vegetation clearing cannot occur outside the avian breeding season, a County-approved biologist should conduct a preconstruction survey for nesting birds no more than seven days prior to vegetation clearing. L-116
6. Unavoidable impacts to birds and bats should be compensated. Feasible compensation measures include protecting habitat that benefits birds and bats, acquiring high-priority conservation sites, and implementing management actions that benefit species affected by wind-energy (among other potential measures).[68] L-117
7. The County should implement a scientific study designed to examine the effects of small wind turbines on birds and bats. Data obtained from the study should be used to make informed decisions on turbine siting and adaptive management practices. L-118
8. The County should develop a program that encourages wind turbine operators to report bird and bat fatalities. Fatality data should be kept in a County-maintained database. L-119
9. The County, in conjunction with state and federal wildlife professionals, should establish acceptable mortality thresholds for target bird and bat species. L-120

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[67] *See* Scientific Review Committee for the Altamont Pass Wind Resource Area. 2010 May 23. Guidelines for siting wind turbines recommended for relocation to minimize potential collision-related mortality of four focal raptor species in the Altamont Pass Wind Resource Area. Available at: www.altamontsrc.org/alt_doc/p70_src_relocation_guidelines.pdf

[68] Smallwood KS, C Thelander. 2004. Developing Methods to Reduce Bird Mortality in the Altamont Pass Wind Resource Area. Prepared by BioResource Consultants for the California Energy Commission Public Interest Energy Research (PIER) Program, Report #500-04-052.

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10. The County should conduct a scientifically defensible monitoring study to estimate fatality levels associated with wind turbines.
11. The County must establish a contingency plan to implement if operational monitoring shows unacceptable impacts to birds and bats or their habitat. L-121
12. If significant mortality rates cannot be resolved, then turbines should be shut down during periods of peak risk to birds or bats.

Golden Eagle-

1. Wind turbines should be located at least six miles from a golden eagle nest.[69] L-122
2. All large wind energy facilities should develop an Eagle Conservation Plan that conforms to the guidelines issued by the USFWS. The Ordinance must specify that preparation and implementation of the plan is mandatory. L-123
3. The County should not approve any project that does not comply with the Bald and Golden Eagle Protection Act. L-124
4. Individuals that propose turbines that may impact the golden eagle should be required to provide compensatory mitigation such that the net effect on the eagle population is, at a minimum, no change. Feasible compensation measures are described in the USFWS's Draft Eagle Conservation Plan Guidance. These include retrofitting "lethal" power poles and provision of funding for eagle conservation. L-125

Sincerely,

Scott Cashen, M.S.
Senior Biologist

[69] USFWS. 2010 Sep 20. Request for Comments on the Application for Site Certification for the Proposed Summit Wind Ridge project, Wasco County, Oregon.

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Scott Cashen, M.S.
Senior Biologist / Forest Ecologist
3264 Hudson Avenue, Walnut Creek, CA 94597. (925) 256-9185. scottcashen@gmail.com

Scott Cashen has 19 years of professional experience in natural resources management. During that time he has worked as a field biologist, forester, environmental consultant, and instructor of Wildlife Management. Mr. Cashen currently operates an independent consulting business that focuses on CEQA/NEPA compliance issues, endangered species, scientific field studies, and other topics that require a high level of scientific expertise.

Mr. Cashen has knowledge and experience with many taxa, biological resource issues, and environmental regulations. This knowledge and experience has made him a highly sought after biological resources expert. To date, he has been retained as a biological resources expert for over 30 projects. Mr. Cashen's role in this capacity has encompassed all stages of the environmental review process, from initial document review through litigation support and expert witness testimony.

Mr. Cashen is a recognized expert on the environmental impacts of renewable energy development. He has been involved in the environmental review process for 22 renewable energy projects, and he has been a biological resources expert for more of California's solar energy projects than any other private consultant. In 2010, Mr. Cashen testified on 5 of the Department of the Interior' "Top 6 Fast-tracked Solar Projects", and his testimony influenced the outcome of each of these projects.

Mr. Cashen is a versatile scientist capable of addressing numerous aspects of natural resource management simultaneously. Because of Mr. Cashen's expertise in both forestry and biology, Calfire had him prepare the biological resource assessments for all of its fuels treatment projects in Riverside and San Diego Counties following the 2003 Cedar Fire. Mr. Cashen has led field studies on several special-status species, including plants, fish, reptiles, amphibians, birds, and mammals. Mr. Cashen has been the technical editor of several resource management documents, and his strong scientific writing skills have enabled him to secure grant funding for several clients.

AREAS OF EXPERTISE

- CEQA, NEPA, and Endangered Species Act compliance issues
- Comprehensive biological resource assessments
- Endangered species management
- Renewable energy
- Forest fuels reduction and timber harvesting
- Scientific field studies, grant writing and technical editing

EDUCATION

M.S. Wildlife and Fisheries Science - The Pennsylvania State University (1998)
B.S. Resource Management - The University of California, Berkeley (1992)

PROFESSIONAL EXPERIENCE

Litigation Support / Expert Witness

As a biological resources expert, Mr. Cashen reviews CEQA/NEPA documents and provides his client(s) with an assessment of biological resource issues. He then prepares written comments on the scientific and legal adequacy of the project's environmental documents (e.g., EIR). For projects requiring California Energy Commission (CEC) approval, Mr. Cashen has submitted written testimony (opening and rebuttal) in conjunction with oral testimony before the CEC.

Mr. Cashen can lead field studies to generate evidence for legal testimony, and he can incorporate testimony from his deep network of species-specific experts. Mr. Cashen's clients have included the Sierra Club, Mount Diablo Audubon Society, Save Mount Diablo, and the law firm of Adams Broadwell Joseph & Cardozo.

REPRESENTATIVE EXPERIENCE

Solar Energy Facilities

- Ivanpah Solar Electric Generating System
- Calico Solar Project
- Imperial Valley Solar Project
- Genesis Solar Energy Project
- Blythe Solar Power Project
- Victorville 2 Power Project
- Avenal Energy Power Plant
- Carrizo Energy Solar Farm
- Beacon Solar Energy Project
- Abengoa Mojave Solar Project
- San Joaquin Solar I & II
- Fink Road Solar Farm
- Maricopa Sun Solar Complex
- Catalina Renewable Energy Project
- Vestal Almond, Fireman, and Herder Solar Facilities
- Heber Solar Energy Facility

Geothermal Energy Facilities

- Western GeoPower Power Plant and Steamfield
- East Brawley Geothermal Development
- Mammoth Pacific 1 Replacement Facility

Wind Energy Facilities

- Vasco Winds Relicensing Project
- Tres Vaqueros Windfarm Repowering Project
- Catalina Renewable Energy Project

- Ocotillo Express Wind Energy Project

Development Projects

- Live Oak Master Plan: (*390-acre housing development, Hanford, CA*)
- Rollingwood: (*214-unit housing development, Vallejo, CA*)
- Columbus Salame: (*430,000 ft² food processing plant, Fairfield, CA*)
- Concord Naval Weapons Station: (*5,028-acre redevelopment, Concord, CA*)
- Chula Vista Bayfront Master Plan: (*556-acre development, Chula Vista, CA*)
- Alves Ranch: (*320-acre housing development, Pittsburgh, CA*)
- Roddy Ranch: (*640-acre housing and hotel development, Antioch, CA*)
- Aviano: (*320-acre housing development, Antioch, CA*)
- Napa Pipe: (*154-acre development, Napa County, CA*)

Other

- Faria Annexation: (*607-acre parcel annexation, Pittsburgh, CA*)
- Sprint-Nextel Tower: (*communications tower in open space preserve, Walnut Creek, CA*)

Project Management

Mr. Cashen has managed several large-scale wildlife, forestry, and natural resource management projects. Many of these projects have required hiring and training field crews, coordinating with other professionals, and communicating with project stakeholders. Mr. Cashen's experience in study design, data collection, and scientific writing make him an effective project manager, and his background in several different natural resource disciplines enable him to address the many facets of contemporary land management in a cost-effective manner.

REPRESENTATIVE EXPERIENCE

Wildlife Studies

- Peninsular Bighorn Sheep Resource Use and Behavior Study: (*CA State Parks*)
- "KV" Spotted Owl and Northern Goshawk Inventory: (*USFS, Plumas NF*)
- Amphibian Inventory Project: (*USFS, Plumas NF*)
- San Mateo Creek Steelhead Restoration Project: (*Trout Unlimited and CA Coastal Conservancy, Orange County*)
- Delta Meadows State Park Special-status Species Inventory: (*CA State Parks, Locke*)

Natural Resources Management

- Mather Lake Resource Management Study and Plan – (*Sacramento County*)
- Placer County Vernal Pool Study – (*Placer County*)
- Weidemann Ranch Mitigation Project – (*Toll Brothers, Inc., San Ramon*)
- Ion Communities Biological Resource Assessments – (*Ion Communities, Riverside and San Bernardino Counties*)
- Del Rio Hills Biological Resource Assessment – (*The Wyro Company, Rio Vista*)

Forestry

- Forest Health Improvement Projects – (*CalFire, SD and Riverside Counties*)
- San Diego Bark Beetle Tree Removal Project – (*SDG&E, San Diego Co.*)
- San Diego Bark Beetle Tree Removal Project – (*San Diego County/NRCS*)
- Hillslope Monitoring Project – (*CalFire, throughout California*)

Biological Resources

Mr. Cashen has a diverse background with biological resources. He has conducted comprehensive biological resource assessments, habitat evaluations, species inventories, and scientific peer review. Mr. Cashen has led investigations on several special-status species, including ones focusing on the foothill yellow-legged frog, mountain yellow-legged frog, desert tortoise, steelhead, burrowing owl, California spotted owl, northern goshawk, willow flycatcher, Peninsular bighorn sheep, red panda, and forest carnivores.

REPRESENTATIVE EXPERIENCE

Avian

- Study design and Lead Investigator - Delta Meadows State Park Special-Status Species Inventory *(CA State Parks: Locke)*
- Study design and lead bird surveyor - Placer County Vernal Pool Study *(Placer County: throughout Placer County)*
- Surveyor - Willow flycatcher habitat mapping *(USFS: Plumas NF)*
- Independent surveyor - Tolay Creek, Cullinan Ranch, and Guadacanal Village restoration projects *(Ducks Unlimited/USGS: San Pablo Bay)*
- Study design and Lead Investigator - Bird use of restored wetlands research *(Pennsylvania Game Commission: throughout Pennsylvania)*
- Study design and surveyor - Baseline inventory of bird species at a 400-acre site in Napa County *(HCV Associates: Napa)*

- Surveyor - Baseline inventory of bird abundance following diesel spill *(LFR Levine-Fricke: Suisun Bay)*
- Study design and lead bird surveyor - Green Valley Creek Riparian Restoration Site *(City of Fairfield: Fairfield, CA)*
- Surveyor - Burrowing owl relocation and monitoring *(US Navy: Dixon, CA)*
- Surveyor - Pre-construction raptor and burrowing owl surveys *(various clients and locations)*
- Surveyor - Backcountry bird inventory *(National Park Service: Eagle, Alaska)*
- Lead surveyor - Tidal salt marsh bird surveys (*Point Reyes Bird Observatory: throughout Bay Area*)
- Surveyor – Pre-construction surveys for nesting birds (*various clients and locations)*

Amphibian

- Crew Leader - Red-legged frog, foothill yellow-legged frog, and mountain yellow-legged frog surveys *(USFS: Plumas NF)*
- Surveyor - Foothill yellow-legged frog surveys *(PG&E: North Fork Feather River)*
- Surveyor - Mountain yellow-legged frog surveys *(El Dorado Irrigation District: Desolation Wilderness)*
- Crew Leader - Bullfrog eradication *(Trout Unlimited: Cleveland NF)*

Fish and Aquatic Resources

- Surveyor - Hardhead minnow and other fish surveys *(USFS: Plumas NF)*
- Surveyor - Weber Creek aquatic habitat mapping (*El Dorado Irrigation District: Placerville, CA*)
- Surveyor - Green Valley Creek aquatic habitat mapping *(City of Fairfield: Fairfield, CA)*
- GPS Specialist - Salmonid spawning habitat mapping *(CDFG: Sacramento River)*
- Surveyor - Fish composition and abundance study (*PG&E: Upper North Fork Feather River and Lake Almanor*)
- Crew Leader - Surveys of steelhead abundance and habitat use *(CA Coastal Conservancy: Gualala River estuary)*
- Crew Leader - Exotic species identification and eradication *(Trout Unlimited: Cleveland NF)*

Mammals

- Principal Investigator – Peninsular bighorn sheep resource use and behavior study (*California State Parks: Freeman Properties*)

- Scientific Advisor –Study on red panda occupancy and abundance in eastern Nepal *(The Red Panda Network: CA and Nepal)*
- Surveyor - Forest carnivore surveys *(University of CA: Tahoe NF)*
- Surveyor - Relocation and monitoring of salt marsh harvest mice and other small mammals *(US Navy: Skagg's Island, CA)*
- Surveyor – Surveys for Monterey dusky-footed woodrat. Relocation of woodrat houses (*Touré Associates: Prunedale*)

Natural Resource Investigations / Multiple Species Studies

- Scientific Review Team Member – Member of the science review team assessing the effectiveness of the US Forest Service's implementation of the Herger-Feinstein Quincy Library Group Act.
- Lead Consultant - Baseline biological resource assessments and habitat mapping for CDF management units *(CDF: San Diego, San Bernardino, and Riverside Counties)*
- Biological Resources Expert – Peer review of CEQA/NEPA documents (*Adams Broadwell Joseph & Cardoza: California)*
- Lead Consultant - Pre- and post-harvest biological resource assessments of tree removal sites *(SDG&E: San Diego County)*
- Crew Leader - T&E species habitat evaluations for Biological Assessment in support of a steelhead restoration plan *(Trout Unlimited: Cleveland NF)*
- Lead Investigator - Resource Management Study and Plan for Mather Lake Regional Park *(County of Sacramento: Sacramento, CA)*
- Lead Investigator - Biological Resources Assessment for 1,070-acre Alfaro Ranch property *(Yuba County, CA)*
- Lead Investigator - Wildlife Strike Hazard Management Plan *(HCV Associates: Napa)*
- Lead Investigator - Del Rio Hills Biological Resource Assessment *(The Wyro Company: Rio Vista, CA)*
- Lead Investigator – Ion Communities project sites (*Ion Communities: Riverside and San Bernardino Counties*)
- Surveyor – Tahoe Pilot Project: Validation of California's Wildlife Habitat Relationships (CWHR) Model *(University of California: Tahoe NF)*

Forestry

Mr. Cashen has five years of experience working as a consulting forester on projects throughout California. Mr. Cashen has consulted with landowners and timber operators on forest management practices; and he has worked on a variety of forestry tasks including selective tree marking, forest inventory, harvest layout, erosion control, and

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supervision of logging operations. Mr. Cashen's experience with many different natural resources enable him to provide a holistic approach to forest management, rather than just management of timber resources.

REPRESENTATIVE EXPERIENCE

- Lead Consultant - CalFire fuels treatment projects *(SD and Riverside Counties)*
- Lead Consultant and supervisor of harvest activities – San Diego Gas and Electric Bark Beetle Tree Removal Project *(San Diego)*
- Crew Leader - Hillslope Monitoring Program *(CalFire: throughout California)*
- Consulting Forester – Forest inventories and timber harvest projects *(various clients throughout California)*

Grant Writing and Technical Editing

Mr. Cashen has prepared and submitted over 50 proposals and grant applications. Many of the projects listed herein were acquired through proposals he wrote. Mr. Cashen's clients and colleagues have recognized his strong scientific writing skills and ability to generate technically superior proposal packages. Consequently, he routinely prepares funding applications and conducts technical editing for other organizations.

PERMITS

U.S. Fish and Wildlife Service Section 10(a)(1)(A) Recovery Permit for the Peninsular bighorn sheep

CA Department of Fish and Game Scientific Collecting Permit

PROFESSIONAL ORGANIZATIONS / ASSOCIATIONS

The Wildlife Society

Cal Alumni Foresters

Mt. Diablo Audubon Society

OTHER AFFILIATIONS

Scientific Advisor and Grant Writer – *The Red Panda Network*

Scientific Advisor – *Mt. Diablo Audubon Society*

Grant Writer – *American Conservation Experience*

Scientific Advisor and Land Committee Member – *Save Mt. Diablo*

TEACHING EXPERIENCE

Instructor: Wildlife Management - The Pennsylvania State University, 1998

Teaching Assistant: Ornithology - The Pennsylvania State University, 1996-1997

Response to Comment Letter L

Endangered Habitats League
Scott Cashen
December 22, 2012

L-1 These introductory comments regarding biological impacts are more fully developed later in this comment letter and, therefore, more detailed responses are presented below.

L-2 For small wind turbines, mitigating measures were incorporated into the zoning verification process proposed for Section 6951 of the Wind Energy Ordinance. For large wind turbines, project-specific mitigation will be required as part of the Major Use Permit process with additional new provisions included in the proposed ordinance. Less harmful alternatives for both small and large wind turbines are analyzed in DEIR Chapter 4 for consideration by the decision makers.

The County has also added additional design and siting criteria to the draft ordinance pertaining to small wind turbines. Through discussions with the commenter and wildlife agencies, the following criteria are proposed to be added to Section 6951:

1.iv.a: No part of the wind turbine shall be closer than 300 feet or 5 times the turbine height, which every is greater from the following: Power transmission towers and lines

1.iv.a: No part of the wind turbine shall be closer than 300 feet or 5 times the turbine height, which every is greater from the following: Blue line watercourse(s) as identified on the United States Geological Survey Topographic Map

1.iv.c: No part of the wind turbine shall be closer than 300 feet or 5 times the turbine height, which every is greater from the following: Significant roost sites for sensitive bat species as mapped on the California Natural Diversity Database

1.v: No part of a wind turbine shall be closer than 4,000 feet from a known golden eagle site.

2. Area of Disturbance. A small wind turbine shall not result in an area of ground disturbance (including grading, clearing, brushing, or grubbing) that is larger than a 25 foot radius around the base of a tower, and an access path to the tower that is a maximum of four feet wide. The entire area of disturbance shall be clearly defined on the plans submitted for Zoning Verification Permit review.

12. Pre-Approved Mitigation Area. No more than one small turbine is allowed on a legal lot designated as Pre-Approved Mitigation Area within the Multiple Species

Conservation Program Subarea Plan. An Administrative Permit may be approved for more than one turbine if all the requirements of subsection" a" of this section are met and the cumulative rated capacity does not exceed 50 kilowatts.

L-3 The County has prepared responses to the comments in the Scott Cashen letter in responses to comments L35 through L125 below.

L-4 The County agrees that the project cannot yet be adopted based on the Draft EIR. Findings regarding alternatives and significant impacts are not prepared until the hearing process for the project.

County staff has prepared responses regarding specific issues from the commenter and the Cashen Letter below.

L-5 The County agrees with the statements regarding EIR adequacy as cited.

L-6 The County has prepared responses to the comments in the Scott Cashen letter in responses to comments L35 through L25 below.

L-7 The County agrees with the statements regarding alternatives as cited from CEQA Guidelines.

L-8 Siting considerations shall be included in the permitting process for large wind turbines. Such considerations will take into account biological resources as well as other environmental concerns. Site screening and pre-permit monitoring are also included in mitigation measure M-Bio-2.

The County does not agree that site selection and screening is feasible for small turbines under the proposed project. The project proposes to make permitting of small wind turbines ministerial if they meet the standards provided in Section 6951 of the draft ordinance. Site selection and screening would make the process discretionary by definition. See also responses to comments I6, I7, I8, J14, L2, DD15, and DD18. County staff has reviewed California Energy Commission (CEC) guidance and incorporated as many design features into the project as feasible while still maintaining a ministerial review process for small turbines. Additional features have also been added in response to public comment and discussions with the commenter. These include setbacks from fixed locations such as known golden eagle nests, known roost sites for sensitive bats, blue-line streams or water bodies, and transmission lines (see draft ordinance Section 6951.a.9).

L-9 The County appreciates the concerns expressed in this comment with regard to small wind turbine impacts on biological resources. As discussed in the DEIR, the County agrees that there is the potential for significant impacts to special status species which cannot feasibly be mitigated. As stated in the comment, an 80-foot tall small wind turbine could be sited in close proximity to a golden eagle nest. This situation can also occur today under the existing ordinance, which allows for one small wind turbine with a ministerial permit. However, under the proposed ordinance, all small turbines will be required to meet updated standards. For example, the draft ordinance requires certification by the CEC or a national program, which limits the types of small turbines that can be used (see Appendix B to these responses to comments). In addition, the County has added additional siting criteria that can be measured objectively under a ministerial process but that may help reduce biological impacts (see responses to comments I6, I8, and L2).

L-10 The comment raises concerns with regard to MSCP conservation areas. Permits for development, including ministerial permits, are not issued for properties or portions of properties designated as Preserve or otherwise conserved as open space. In order for a development permit to be processed on such lands, other discretionary actions (e.g., open space vacation, rezone, MSCP Amendment) must be processed first or concurrently with environmental review. In addition, the County has added a new design feature to the draft ordinance with regard to Pre-approved Mitigation Areas (PAMA) in the MSCP (see response to comment I11).

L-11 This comment recommends an alternative that prohibits any turbines near known biologically sensitive areas, within known migratory corridors or raptor foraging areas.

After review of public comments and further discussions with the commenter, the County agreed that some additional criteria could feasibly be added to the ministerial process for small wind turbines while still meeting project objectives. The following provisions are proposed within Section 6951:

<u>1.iv.a: No part of the wind turbine shall be closer than 300 feet or 5 times the turbine height, which every is greater from the following: Power transmission towers and lines.</u>

<u>1.iv.a: No part of the wind turbine shall be closer than 300 feet or 5 times the turbine height, which every is greater from the following: Blue line watercourse(s) as identified on the United States Geological Survey Topographic Map.</u>

<u>1.iv.c: No part of the wind turbine shall be closer than 300 feet or 5 times the turbine height, which every is greater from the following: Significant roost sites for sensitive bat species as mapped on the California Natural Diversity Database.</u>

1.v: No part of a wind turbine shall be closer than 4,000 feet from a known golden eagle site.

2. Area of Disturbance. A small wind turbine shall not result in an area of ground disturbance (including grading, clearing, brushing, or grubbing) that is larger than a 25 foot radius around the base of a tower, and an access path to the tower that is a maximum of four feet wide. The entire area of disturbance shall be clearly defined on the plans submitted for Zoning Verification Permit review.

12. Pre-Approved Mitigation Area. No more than one small turbine is allowed on a legal lot designated as Pre-Approved Mitigation Area within the Multiple Species Conservation Program Subarea Plan. An Administrative Permit may be approved for more than one turbine if all the requirements of subsection “a” of this section are met and the cumulative rated capacity does not exceed 50 kilowatts.

In addition, the Limited Small Wind Turbine Alternative analyzed in Chapter 4 would require placement of small wind turbine towers within disturbed or developed areas of the subject property as opposed to naturally vegetated areas of the site.

For large wind turbines, the best approach environmentally is to require site-specific evaluation and follow the latest guidelines from the CEC and the wildlife agencies (see M-BIO-1 and M-BIO-2 in DEIR Section 2.4.6.1).

L-12 The County does not agree with this comment. For small wind turbines, this recommendation would require discretionary review and would conflict with the project objectives (see responses to comments I6 and L8). For large wind turbines, the presence of a listed species should not necessarily preclude development. Through consultation with the wildlife agencies and appropriate permitting, a large wind project may be able to provide mitigation that is of greater benefit to the affected species.

L-13 The County does not contend that AB 45 prohibits the ability for a local jurisdiction to require environmental considerations or other conditions on small wind turbines. The scope of the County's Wind Energy Ordinance project was primarily established through direction from the County Board of Supervisors on February 25, 2009. Based on that direction, County staff developed the eight project objectives stated in Section 1.1 of the DEIR. Based on the project objectives, the County rejects biologically based siting restrictions for small turbines as infeasible (see responses to comments I6, I7, I8, L8, L12, and DD15).

L-14 The County does not contend that AB 45 or any other State regulation or mandate supersedes federal laws that protect endangered species, migratory birds, and bald and golden eagles.

L-15 This comment states with certainty that protected species will be killed or "taken" by the operation of small and large turbines permitted through the proposed Wind Energy Ordinance. While the County does not agree that this is a certainty, the DEIR discloses that there is a potential for significant impacts to special status species from future small and large wind turbines. See also responses to comments J5 and J7.

L-16 The County does not agree or disagree with this comment. As discussed in more detail in response to comment L13, the County does not contend that AB 45 requires Counties to indiscriminately permit small wind turbines.

L-17 The County disagrees with the comment's assertion that the project objectives as stated in the DEIR are artificially constrained so as to preclude alternatives, such as alternatives that would include siting criteria for small turbines. As noted in responses to comments I6, L8, and L12, siting criteria for small turbines would directly conflict with the objective to allow development of small wind turbines without a discretionary permit. This project objective was established in response to the Board of Supervisors hearing on February 25, 2009. This hearing included much public testimony regarding the current obstacles to development of small wind turbines as an accessory use. The Board of Supervisors directed County staff to prepare an two-tiered ordinance that maintains the Major Use Permit requirement for large wind turbines but allows small wind turbines without a discretionary permit. As such, the description and objectives of the Wind Energy Ordinance project have been prepared in a transparent manner with extensive stakeholder input. Without clear and focused project objectives, the County would be at greater risk of not having an adequate EIR. This too is illustrated in City of Santee v. County of San Diego (1989) 214 Cal. App. 3rd 1438, 1455.

L-18 The County agrees with the statements regarding adequacy of CEQA mitigation as cited.

L-19 Since small wind turbines will be permitted ministerially, all feasible measures to minimize environmental impacts were included as design features within the proposed Wind Energy Ordinance (see Ordinance Section 6951). These features are further discussed DEIR Sections 2.4.3.1 and 2.4.3.4 but with the conclusion that impacts would still be potentially significant. The County has also added additional criteria in response to comments (see responses to comments I6, I8, L2, and L11).

L-20 The County agrees that proposed mitigation measures M-BIO-1 and M-BIO-2 would apply to large wind turbines permitted through the Major Use Permit process and would not apply to the ministerial permitting of small wind turbines. The County also agrees that no feasible mitigation measures were identified for biological resource impacts in the DEIR for small wind turbines other than design features within the draft ordinance that are discussed in DEIR Sections 2.4.3.1 and 2.4.3.4. It is not clear from the comment how this situation violates CEQA Guidelines Section 15126.4.

L-21 The County does not agree with this comment. Mitigation measure M-BIO-1 does not state that CEQA will apply to Major Use Permits. Such a statement may not even be true depending on the circumstances. Rather, M-BIO-1 states that the County's Guidelines for Determining Significance for Biological Resources will be applied to Major Use Permit applications for wind turbines. This is something that is generally done now, but not required. Moreover, it will be applied to the permitting process even if the County is not the lead agency under CEQA. Application of these Guidelines will result in substantial avoidance, minimization, and compensatory mitigation requirements for future large wind turbine projects.

L-22 The County does not agree with this comment. However, the County is willing to enhance mitigation measure M-BIO-2 as needed to be more clear and effective. As currently written, this measure commits the County to update its Guidelines for Determining Significance for Biological Resources, which are to be applied to large wind turbine projects pursuant to M-BIO-1, so as to be more applicable to biological concerns and issues related to wind turbines. The update for the Guidelines will incorporate the latest guidance from state and federal agencies.

The County considers this mitigation to be congruous with impacts of the project. The project proposes an amendment to the Zoning Ordinance for the permitting of large wind turbines. The actual permitting process will not change; a Major Use Permit is currently required and will still be required under the proposed project. However, the height limits and setbacks set forth in the Zoning Ordinance amendment will be less restrictive and more achievable for large wind turbine developers. This may result in new significant impacts to biology. To address these new impacts, the County proposes to also provide updated guidelines and always apply them to large wind turbine projects. This will also allow for the latest recommendations and technology to be applied to avoid and minimize impacts. Conversely, setting rigid biological standards as regulations at the present time would likely result in applying the wrong solution to problems identified with site-specific study. And it is County staff's experience that the setting of minimum biological standards often gets interpreted as the maximum requirements during individual permit reviews.

The reason that potentially significant biological impacts associated with large wind turbines are not considered to be mitigated below significant with these measures is that application of all the latest guidelines may still result in some large turbine projects not being able to feasibly mitigate impacts below significant. It is foreseeable that some large wind developments may require statements of overriding considerations for significant unavoidable impacts to biological resources.

L-23 The County agrees with stated CEQA requirements, but does not agree that the DEIR fails to meet such requirements. A major part of the CEQA process is receiving public input and evaluating all suggested changes, alternatives, and mitigation measures after public review of the DEIR. The County is diligently considering all public comments in order to present the best feasible options to the decision makers.

L-24 The County agrees with this comment.

L-25 The County presented two potentially feasible alternatives in the DEIR that would reduce impacts, though not to a level below significant. Determinations of feasibility and how the County can best meet its objectives will be determined by the County Board of Supervisors. The County as lead agency may determine alternatives to be infeasible when they fail to satisfy basic project objectives and/or policy objectives. *California Native Plant Society v. City of Santa Cruz* (2009) 177 Cal.App.4th 957. The County Board of Supervisors may adopt the proposed project, choose a reduced alternative, impose additional mitigation, or may choose the No Project Alternative.

L-26 The County does not agree that the listed features in this comment could be avoided or buffered without using discretionary review of proposed small wind turbines and MET facilities. The County's project objectives for the Wind Energy Ordinance are to allow development of small wind turbines without a discretionary permit (objective 6) and to streamline and clarify the approval process for the development and operation of small wind turbines (objective 4). Determinations regarding whether or not a site contains certain species or habitats would require a biological study with site evaluation from qualified County staff who must use discretion regarding where a species territory occurs or the extent of its habitat. This process would directly conflict with the stated project objectives. In fact, it would be more prohibitive and cumbersome than the existing Zoning Regulations as described under the No Project Alternative in the DEIR.

The measuring of a 300 foot setback from a fixed point can be done ministerially. Therefore, the County included several important setbacks from pre-mapped features.

Section 6951 of the draft ordinance has been revised to include buffers from known golden eagle nests, important bat roosts, water features, and transmission towers (see also responses to comments I6, I8, L2, and L11).

For large wind turbines, the County does not agree that this type of standard is the best mitigation. Large wind turbine projects will be required to avoid, minimize, and mitigate significant impacts whenever feasible. Establishing a 300 foot buffer from specified resources may preclude better mitigation alternatives and be perceived as a maximum buffer during future permitting.

L-27 This is a standard requirement for development permitted through a Major Use Permit. For small wind turbines and MET facilities, no construction or staging areas are expected. Installation of small turbines and MET towers requires minimal ground disturbance (see worst-case ground disturbance discussion in DEIR Section 2.4.3.1).

L-28 The County does not agree with this comment. The California Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development (CEC Guidelines) do not apply to ministerial permits since most of the guidance requires discretionary review. The recommendations from the CEC Guidelines that were applicable were incorporated into the proposed ordinance (e.g., prohibit guy wires. remove prey habitat around base, underground power lines, prohibit trellis style structures, etc.). The majority of the CEC Guidelines would not apply to small wind turbines under the proposed ministerial process.

The County agrees that application of the CEC Guidelines should be included in the environmental review of large wind turbines. The County is proposing to incorporate this guidance into the County's Guidelines for Determining Significance for Biological Resources. However, County staff does not agree that adherence to the CEC Guidelines should be mandatory. The CEC Guidelines were written in a way to make them flexible and to prompt solution-oriented methods for specific projects. If they were suitable to be used as regulations, the State would have codified them. Moreover, these and other guidelines provided for wind energy projects can quickly become outdated with emerging technology. The County seeks to apply all the latest methods for reducing impacts rather than having ordinance provisions that refer to obsolete methods. Any future changes or updates to the Ordinance, particularly with regard to a change in mitigation requirements, could result in another lengthy ordinance amendment project with new environmental review. For these reasons, it is better to include the latest biological guidelines within the County's Significance Guidelines, which will be applied to all future large wind turbines permitted by the County.

L-29 The County agrees with this comment for large wind turbine projects. This standard shall be applied to future large wind turbine projects through the Guidelines for

Determining Significance, and potentially through the Resource Protection Ordinance as well.

The County does not agree that compensatory mitigation for impacts to birds and bats from small wind turbines can feasibly be exacted under the proposed ordinance. Since small wind turbines would be permitted ministerially on private land, there is no way to determine if there will be any potentially significant impacts to special status species necessitating mitigation such as habitat conservation.

L-30 The County does not agree that this recommendation is feasible or meaningful. Small wind turbines permitted by the County are located on private property with no on-going permitting requirements or conditions. The County does not have legal authority to access and monitor such sites. Moreover, it is not very likely that bird and bat impacts would be identifiable if County staff or approved consultants could conduct site visits. Private landowners would not be motivated to report any instances of bird or bat strikes or to preserve any evidence of bird or bat mortality. Consequently, any such study would not have scientific credibility.

L-31 It is not clear what is meant by this comment. The Bald and Golden Eagle Protection Act is a federal regulation enforced by federal agencies.

L-32 The County acknowledges that these recommendations were made by wildlife resource agencies and adopted by other jurisdictions as part of their discretionary review process.

L-33 The County agrees with this comment.

L-34 The County acknowledges and appreciates this comment.

L-35 The County agrees with the project description provided in this comment.

L-36 The County acknowledges the commenter's expertise on biology and wind energy.

L-37 The County agrees with this comment and regrets the confusion regarding the height limit of small turbines as presented both in the DEIR and in the draft Ordinance. The statement provided on Draft EIR Page 1-18 was incorrect. In response to this comment, the sentence on Page 1-18 has been revised as follows:

The wind turbine ~~tower~~ height, from existing grade at the base of the tower to the highest point of the turbine blade when in use, may exceed the height limit of the zone in accordance with Section 4620.j, but it shall not exceed 80 feet.

In addition, County staff has made edits to the draft Wind Energy Ordinance to make absolutely clear that all height limitations regarding small wind turbines refers to the turbine height rather than the tower height.

Of the alternatives presented in this comment, the intended and actual height limitations are the more restrictive. Therefore, the revisions to the DEIR provide clarifying text only and do not result in any new significant environmental impacts, an increase in the severity of previously identified project impacts, or new feasible project alternatives or mitigation measures.

L-38 The County does not agree with this comment. Small turbines can be used to produce energy for any legal uses on a given site. This is true under the existing ordinance and will still be true under the proposed ordinance. Assessments regarding other types of renewable energy that can be used for a given site are not required.

L-39 It is not clear from this comment how lot size information would provide any meaningful analysis within the DEIR. Small wind turbines may be located on lots of any size provided they will be accessory to existing uses. Within the County unincorporated area, lot sizes for privately owned land generally range from approximately 6,000 square feet to 640 acres. Within the DEIR, the County provided a worst-case ground disturbance footprint to convey the amount of impact that may occur for a given property, which includes the undergrounding of power lines.

L-40 The County does not agree that the DEIR lacks adequate information on sensitive species. San Diego supports over 400 sensitive species, 295 of which are identified in the DEIR as potentially occurring in the project area (184 plants and 111 wildlife species). These species are incorporated by reference from Appendix C of the County's General Plan Update EIR (see DEIR Pages 2.4-10 to 2.4-11). This appendix is available at http://www.sdcounty.ca.gov/dplu/gpupdate/docs/BOS_Aug2011/EIR/Appn_C_Bio.pdf . To provide population status, quantitative impact estimates, and viability/conservation analysis for each sensitive species would not only be infeasible, it would make the DEIR too burdensome to allow for meaningful evaluation by the public and decision makers. Instead, the DEIR refers to the most common and reliable references on these species (see DEIR Chapter 5.0 under "Biological Resources)."

L-41 The County believes sufficient information on golden eagles was provided on DEIR Pages 2.4-12, 2.14-19, and 2.4-29. While there is no substantial evidence that small wind turbines will have a significant direct impact on golden eagles, the County acknowledges that development of future small turbines under the proposed ordinance will likely result in significant impacts to special status species. The additional information provided in this comment will be included in the documents presented to decision makers for their consideration. However, this additional information does not identify deficiencies in the adequacy of the DEIR.

L-42 The DEIR does not address how the project may affect critical habitat because critical habitat designations are not used to determine whether or not the project may have a significant adverse effect based on the County's Guidelines for Determining Significance for Biological Resources. In fact, it is not even mentioned within the County's Guidelines. This is generally because critical habitat designations do not affect the ability to use private property; they include areas that are already developed; and they do not regulate development unless a federal agency is involved with the action (i.e., situations where federal funding, authorization, or land is involved).

The presence of critical habitat is often noted within the existing conditions section of County EIRs. Since critical habitat designations incorporate recent scientific data, it is appropriate that some of the information be acknowledged in the DEIR. However, the County uses the habitats identified in the Guidelines for Determining Significance to determine whether or not potentially significant impacts may occur.

L-43 The County does not agree that there is substantial evidence that small wind turbines will have particularly adverse impacts on burrowing owl. Nevertheless, the DEIR acknowledges that potentially significant impacts due to bird strikes and habitat removal are foreseeable due to development of small turbines permitted by the proposed ordinance.

It should also be noted that the County is working closely with the California Department of Fish and Game on the preservation of burrowing owls in the County unincorporated area. The primary populations of concern are located in Ramona (within the Ramona Grasslands) and in East Otay Mesa. The County has made significant progress in preserving and managing the Ramona Grasslands. And development in East Otay Mesa is carefully regulated through the MSCP Amendment process. However, impacts to burrowing owl from future small wind turbines may still occur in other areas of the County.

L-44 The County does not agree with this comment. Based on the California Department of Fish and Game response letter to the Notice of Preparation, nine species of particular concern with regard to wind turbines that are known to occur in the unincorporated area were discussed in detail within the document (see DEIR Pages 2.4-12 to 2.4-16). For the remaining 102 special status species that occur in the project area, Appendix C of the County's General Plan Update EIR was referenced (see DEIR Pages 2.4-10 to 2.4-11 and response to comment L40).

L-45 The DEIR refers to a list of 111 special status wildlife species with potential to occur in the project area. This list is available in Appendix C of the General Plan Update EIR at: http://www.sdcounty.ca.gov/dplu/gpupdate/docs/BOS_Aug2011/EIR/Appn_C_Bio.pdf. It includes the sensitive bat species mentioned in this comment and in the Department of Fish and Game response letter to the Notice of Preparation. The DEIR acknowledges that there may be significant impacts to these special status species and particularly discusses avian and bat collision. The County has also added a provision to the draft ordinance in response to comments to include a buffer for small wind turbines located near a known roosting location for sensitive bat species. For large wind turbines, bird and bat studies will be conducted during the discretionary review process.

L-46 The County agrees that the project will have potentially significant effects on the flat-tailed horned lizard. This too is one of the 111 special-status wildlife species referenced in the DEIR (see response to comment L45 above).

The County does not agree that a specific indirect impact analysis need be conducted for this species. The existing conditions section of the biological resources subchapter describes each vegetation type, its general regional location, and the types of species (common and sensitive) that it supports. Appendix C of the County's General Plan Update EIR is incorporated by reference and lists each sensitive species and its habitat type. DEIR Pages 2.4-12 through 2.4-16 provide detailed information on species of concern with regard to wind turbines. DEIR Section 2.4.3.1 provides impact analyses from small and large wind turbines with regard to habitat and species. Together, this information provides a very thorough overview of potential impacts to special status species. Detailed impact analyses of each sensitive species in the project area (nearly 300 plant and animal species) are neither feasible nor necessary to determine the project's overall impacts and identify appropriate mitigation measures. Therefore, no changes to the document were deemed necessary in response to this comment.

L-47 The ten feet of vegetation clearance required around the base of small turbines is included within the estimated worse-case scenario ground disturbance footprint for small turbines. See discussion on DEIR Page 1-9 regarding the conservative ground disturbance estimate that was used. This estimate was conducted for turbines that would be substantially larger than those allowed by the draft ordinance.

L-48 The anticipated trenching that may occur for small wind turbines would also be covered by the conservative ground disturbance estimate discussed in response to comment L47 above. In addition, the County has added a provision to the draft ordinance stating that a small wind turbine shall not result in ground disturbance (including grading, clearing, brushing, or grubbing) more than is necessary for the base of a tower, ten feet of clearance around the base of the tower, other authorized equipment for turbine installation and operation, and, if necessary, a 4-foot wide access path to the tower. There is also an inherent incentive to landowners to minimize the amount of trenching and infrastructure needed in order to keep costs low.

L-49 The County acknowledges that small wind turbines will result in potentially significant impacts to biological resources, as is disclosed in the DEIR. The County also agrees that the statements made in this comment are reasoned based on the cited references. However, much of the study that has been done, including those cited in the comment, focused solely on utility-scale "wind farms" where individual turbines produced 100kW to 1.5MW and typically operated on ridgelines.

It appears the statement in the DEIR that is being referred to in this comment is as follows: "This type of setting combined with the design of the turbines would not be expected to result in frequent bird and bat strikes." This statement is made with regard to all of the design features included in the draft ordinance for small turbines combined with their use as accessories to existing development. Therefore, it is a valid statement.

L-50 The County agrees with this comment.

L-51 See responses to comments L40 and L41 above.

L-52 Under the discussion of small wind turbine impacts to special-status species (Section 2.4.3.1), the DEIR states "wind turbines of any size can potentially result in collisions with sensitive bat species and avian species." The County agrees that the information provided in this comment can further clarify the potential impacts. Within the same DEIR section, the County has made the following revision:

In addition to ground disturbance resulting in habitat impacts, wind turbines of any size can potentially result in collisions with sensitive bat species and avian species, sometimes called bird and bat "strikes." Moreover, migrant birds, including golden eagle, may collide with wind turbines of any size while taking off or landing.

This information does not result in any new significant environmental impacts, an increase in the severity of previously identified project impacts, or new feasible project alternatives or mitigation measures.

L-53 The County appreciates this information. The following revision has been made to DEIR Section 2.4.3.1:

Furthermore, the height of small wind turbines and MET facilities is not tall enough to be within migratory wildlife flight paths, such as that of the golden eagle. However, migrating and resident eagles (and other raptors) conserve energy by using deflective updrafts or thermals to go long periods without flapping their wings. Because eagles are adapted to use even the smallest and weakest of thermals, they can migrate at elevations low to the ground. They may also fly low to the ground when weather conditions are "poor," or while they are foraging. Therefore, significant impacts to these types of avian species may still occur.

This information does not result in any new significant environmental impacts, an increase in the severity of previously identified project impacts, or new feasible project alternatives or mitigation measures.

L-54 The County does not agree that the information in this comment needs to be included in the impact analysis for small wind turbines. The design features of the small turbines to be permitted by the proposed ordinance were based on recommendations to minimize perching and to minimize presence of prey habitat around the base (see also responses to comments I6, J7, and DD12). The study cited in this comment is a study focused on the wind farms at Altamont Pass, which were extreme cases for large turbines using outdated technology in a critical resource area (see also response to comment L49). The site factors related to golden eagle mortality at Altamont Pass would not be the same for sites supporting small wind turbines pursuant to this project. As an extra precaution, the County has included a 4,000 foot setback requirement from known golden eagle nests for small wind turbines. Nonetheless, as noted within the DEIR and responses to comments L49 through L54 above, impacts to special-status species, such as golden eagle, would be potentially significant.

L-55 See response to comment L53 above.

L-56 The County agrees that impacts to resident special-status species, such as golden eagle, would be significant. However, the County does not agree that impacts from small accessory-use wind turbines would be comparable to those found at the wind farms studied at Altamont Pass, as suggested by this comment. To clarify that migratory and resident eagles are potentially affected by small turbines, the County added additional language to the DEIR analysis as noted in response to comment L53 above. In addition, the County has added a provision to the draft ordinance to prohibit small wind turbines within 4,000 feet of a known golden eagle nest. This regulation would be consistent with the requirements of the San Diego Multiple Species Conservation Program (MSCP) Plan.

L-57 The County agrees that potential impacts to birds from small wind turbines, such as impacts to breeding/resident birds, are potentially significant. However, the County does not agree that impacts will likely result severe consequences to overall populations. This is partly because the small turbines that will be permitted by the County will be limited to those that are certified by the CEC (see Appendix B to these responses to comments). The most cost-effective models have small rotor diameters with towers shorter than 80 feet. To further reduce potential impacts to golden eagle, the County has added a provision to the draft ordinance to prohibit small wind turbines within 4,000 feet of a known golden eagle nest. This regulation would be consistent with the requirements of the San Diego Multiple Species Conservation Program (MSCP) Plan.

L-58 The County agrees that more clarification needed to be added to the DEIR as a result of the issues described in these comments (see responses to comments L52 and L53).

L-59 As noted in the DEIR, there is evidence that golden eagles have greater ability to avoid wind turbines than other predatory birds. Yet, as noted in this comment, there is also evidence that golden eagles routinely fly through the rotor area of large turbines. In light of all of this evidence, the County continues to support the determination that potential impacts from large wind turbines would be significant, as concluded in the DEIR.

The County also agrees that the Altamont Pass Wind Resource Area has been extremely detrimental to golden eagles. As such, future large wind turbine projects must be designed to avoid the mistakes made at Altamont Pass. The latest guidelines from State and federal agencies will be applied to large wind turbine projects in the County as part of this project (see M-BIO-1 and M-BIO-2 in DEIR Section 2.4.6.1).

L-60 See response to comment L59 above.

L-61 See response to comment L59 above.

L-62 The County agrees that the evaluation described in this comment is another type of risk assessment than what was specifically provided in the DEIR. The commenter has a different emphasis than the County's analysis. However, the DEIR method for presenting potential impacts is also valid. The DEIR describes some of the restrictions posed by the ordinance, the discretionary process, and regulatory requirements including the requirements for large turbine projects to minimize impacts.

The DEIR also states, "The actual locations and details of future projects are unknown at this time; therefore, impacts as a result of the development of future large wind turbines cannot be fully analyzed." Instead, the types of impacts are discussed. Quantitative impact analyses with respect to population sizes would be too speculative. These types of analyses, however, will be required for specific large wind turbine projects. During environmental review, biological studies will be required that conform to the County's Biological Report Content and Format Guidelines available at http://www.sdcounty.ca.gov/dplu/docs/Biological_Report_Format.pdf. Population size estimates are required as part of the impact analysis to allow for the risk assessment described in this comment.

L-63 Concerns about the regional status of golden eagle and the potential impacts from large wind turbines are clearly presented in the DEIR (see Pages 2.4-12, 2.14-19, 2.4-29, and 2.4-30).

L-64 The County does not agree with this comment. The level of analysis and the conclusions provided in the DEIR are appropriate for the kind of project being proposed. The County is not proposing specific development at this time but is proposing a revised ordinance to clarify the permitting processes for future wind turbines. The County does not know with certainty where wind turbines will be located or what environmental impacts they will have. To provide a meaningful analysis, some assumptions were made and reasonable foreseeable effects were discussed in the DEIR.

L-65 The County does not agree with this comment. Refer to responses to comments L46 and L64 above.

L-66 The County acknowledges that the project may have significant impacts on sensitive bat species. However, as described in the DEIR, the County does not expect small wind turbines to result in frequent bat strikes. County staff's research indicates that small wind turbines permitted by the ordinance will generally be limited to a few types due to the requirement for CEC certification and height limits (see Appendix B to these responses). Based on the design criteria and the expectation that construction of small turbines will occur intermittently near existing development, elimination of local bat populations would not be foreseeable. The County has also added a provision to the draft ordinance in response to comments to include a buffer for small wind turbines located near known roosting locations for sensitive bat species (see revised ordinance Section 6951). This should further reduce potential impacts to local populations of sensitive bat species.

L-67 The County agrees that there's the potential for impacts to raptor species, and that such impacts are considered to be significant. However, the County does not agree that the potential impacts from small turbines threaten the viability of whole populations. The wildlife agencies have not indicated this is the case or prohibited use of small turbines. And for reasons stated in responses to comments I6 and DD12, the County expects that the ordinance criteria in the zoning verification process will reduce potential impacts to birds and bats, though not to a level below significant.

L-68 The County regrets that Section 2.10 of the DEIR was not very clear in terms of significant irreversible environmental changes. Under 2.10.1, the DEIR states "Irreversible long-term environmental changes associated with the proposed project would include those potential significant impacts described in Chapters 2.1 through 2.9 of this EIR." This includes the significant impacts to biological resources as identified in Chapter 2.4. However, Section 2.10.1 goes on to provide specific examples in bulleted format that did not include biological resources. To make clear that impacts to biological resources, such as special-status species, would be significant and irreversible, the following bullet was added to Section 2.10.1 in response to this comment:

• Where turbines are constructed and operational, there would be a potential for destruction of sensitive biological resources, including special-status species.

However, the County still agrees with the last sentence in Section 2.10.1, which is the statement quoted in this comment. For the reasons stated in L66 and L67 above, County staff does not agree that the project would significantly affect population viability. The references cited in this comment specifically focused on large wind farms. Under the proposed ordinance, large wind turbine projects will have to undergo extensive biological review and monitoring to avoid, minimize and mitigate potential impacts to sensitive bird and bat species. In addition, County staff biologists do not agree that small turbines would contribute to the extirpation of some species.

L-69 See response to comment L68 above.

L-70 The County has made revisions and clarifications to the DEIR pursuant to the comments in this letter, as noted in responses to comments above.

L-71 The DEIR discusses direct impacts from vegetation clearing, with a worst-case scenario of 441 square feet of clearance and 61 cubic yards of excavation for one small turbine. The County has determined that this direct impact would be significant. However, the County does not agree this type of disturbance for an accessory use would potentially alter ecosystem structure indirectly. The comment suggests that some areas would be difficult to reclaim. Yet, reclamation would not be expected for these areas of disturbance. Rather, they are analyzed as a permanent direct impact within areas allowed to be developed with accessory uses.

L-72 The County agrees that installation of a small wind turbine may result in colonization of invasive plant species. Indirect effects such as this are not expected to result in impacts to areas of contiguous habitat since small wind turbines will be permitted as an accessory to existing uses where disturbance and development already exist. As such, potential indirect impacts from disturbance such as the occurrence of invasive species would be covered under the conservative worst-case scenario of 441 square feet of direct impact per small turbine. To further restrict potential disturbance from small turbines, an additional provision has been added to the draft ordinance Section 6951.a.2 as follows:

2. Area of Disturbance. A small wind turbine shall not result in an area of ground disturbance (including grading, clearing, brushing, or grubbing) that is larger than a 25 foot radius around the base of a tower, and an access path to the tower that is a maximum of four feet wide. The entire area of disturbance shall be clearly defined on the plans submitted for Zoning Verification Permit review.

Therefore, direct impacts associated with vegetation clearing for installation of a small turbine would be significant; however, indirect effects from exotic plant species are not expected to result in significant impacts.

L-73 Construction and operational noise output from small turbines would be less than significant as described in Chapter 2.8. Construction activities would be temporary and would not include equipment associated with the generation of excessive noise. On modern residential-scale wind turbines, mechanical and aerodynamic noise from these small turbines is minimal. Project noise typically needs to reach 60 dBA before it is considered to be adverse to sensitive species (see page 13 of the County's Guidelines for Determining Significance for Biological Resources). The specifications of the small turbines certified by the California Energy Commission indicate that the small turbines permitted by this ordinance would not reach that decibel level (see Appendix B to these responses to comments). Therefore, significant effects to sensitive species from noise impacts would not be foreseeable.

L-74 The County agrees that this comment would be true of large turbines, such as those that were studied in the cited literature. However, the small turbines that would be permitted by the proposed ordinance would not result in significant noise or vibration impacts (see response to comment L73).

L-75 The County does not agree with this comment. The evidence used to suggest that vegetation disturbance from turbines results in significant impacts to microclimate is based on studies of industrial-scale wind farms. Estimated vegetation impacts from future small turbines would be potentially significant but would not be large enough to induce indirect effects such as microclimate changes (see response to comment L72).

L-76 The County does not agree with this comment. Adverse effects from invasive species may sometimes occur with the installation of a small wind turbine but would not be expected to exceed the estimated ground disturbance impacts. Significant noise and microclimate effects from modern small turbines, such as those currently certified by the CEC, are not anticipated (see responses to comments L73 through L75 above.

L-77 The County concurs with this comment.

L-78 The County agrees that some small turbines may be sited farther away from existing development on site, such as on a rural lot. However, such an instance would not conflict with any local policies or ordinances that protect biological resources, or adopted HCPs or NCCPs. If future small turbines were typically to be located within sensitive habitat areas away from existing development, then such a pattern would impede efforts to preserve contiguous sensitive habitat areas under County ordinances and adopted conservation plans. However, the small wind turbines proposed for a ministerial process under the draft ordinance would be accessory uses to existing development. They will not typically be located in sensitive and undeveloped areas.

L-79 The County does not agree that future small wind turbines will have significant indirect impacts on the MSCP. Some indirect effects may occur such as the presence of invasive plant species. However, these impacts would not exceed the worst-case scenario impacts analyzed in the DEIR (see response to comment L72). Noise, vibration, dust, lighting, hydrology pattern, and erosion would be minimal based on the zoning verification process in Section 6951 which requires small turbines to meet the following:

-California energy commission certification requirements;

-Noise restrictions set forth in the County Noise Ordinance;

-Area of disturbance restrictions

-Lighting restrictions

Moreover, any extensive land modification would require a discretionary grading or clearing permit. And to further ensure that sensitive areas within the MSCP are not significantly affected, the County is limiting the number of small turbines allowed with a ministerial permit to just one per legal lot in the pre-approved mitigation area of the MSCP (see response to comment I11).

Potential impacts from future small wind turbines permitted by the proposed ordinance are not comparable to impacts that have been observed at the Altamont Pass Wind Resources Area where large industrial-scale wind turbines were sited along ridgelines in large numbers. Severe erosion and sedimentation, for example, would not result from the permitting of small wind turbines given the provisions outlined in draft Ordinance Section 6951.

L-80 The County did not analyze potential impacts to critical habitat, nor is this required (see response to comment L42). Direct impacts to linkages and corridors from small wind turbines are determined to be potentially significant as discussed in DEIR Section 2.4.3.4. Critical biological resource areas in the MSCP are designated as pre-approved mitigation areas (PAMA) or as preserve. Preserve areas are protected from development, including ministerial projects. Ministerial projects in the PAMA are allowed without environmental review, assuming the County continues to achieve conservation goals. Nonetheless, the potential loss of sensitive habitat is considered to be significant as discussed in DEIR Sections 2.4.3.1 and 2.4.3.2. To ensure that potential impacts do not exceed what is currently allowed under the existing ordinance provisions, the County is limiting the number of small turbines allowed with a ministerial permit to just one per legal lot in the pre-approved mitigation area of the MSCP (see response to comment I11). This would be consistent with what is currently allowed under the existing Zoning Ordinance and MSCP Subarea Plan.

L-81 Section 2.4.3.5 of the DEIR describes the project's consistency with adopted HCPs and NCCPs. Specific discussion regarding recovery plans or recovery of listed species is not required in the DEIR. See also responses to comments L77 through L80 above.

L-82 The County does not agree with this comment. For each environmental issue, the DEIR includes specific discussion of potential cumulative impacts. For biological resources, this discussion is provided in Section 2.4.4.

L-83 The County does not agree that a separate discussion of existing wind energy projects is appropriate. Past and present projects considered in the cumulative analysis are provided in Section 1.7 of the DEIR. Reasonably foreseeable wind energy projects in the County unincorporated constitute the proposed project. Reasonably foreseeable projects in other jurisdictions that were considered in the cumulative analysis are provided in Section 1.7 of the DEIR. Other reasonably foreseeable projects in the County unincorporated are discussed in DEIR Section 1.7 and include the projections of the recently approved General Plan Update.

L-84 The County does not agree that this type of detailed analysis, which would include 295 sensitive species, is feasible or required (see also response to comment L40). A qualitative cumulative analysis is provided in the DEIR with regard to special-status species impacts.

L-85 The County does not agree that this type of specific population analysis is required as part of the cumulative analysis. The County is working on MSCP Plans for North and East County that will address this type of conservation analysis. The DEIR evaluates the potential project-level impacts to special status species and also provides a cumulative analysis of potential impacts in DEIR Section 2.4.4. Moreover, regional golden eagle information is not readily available. However, the County is making every effort to minimize potential project impacts to golden eagle from small and large wind turbines. Small wind turbines will be prohibited within 4,000 feet of known golden eagle nests; and large wind turbines will be required to follow the latest bird and bat guidelines provided by the CEC and the wildlife agencies.

L-86 The County does not agree with this comment. The sentence cited in the comment is taken out of context. This sentence is a description of the Draft Eagle Conservation Plan Guidance. It is not a blanket regulatory requirement.

L-87 The County does not agree with this comment. The County has included design features for small ministerial wind turbines to reduce potential impacts to special status species. These were discussed in the DEIR that was circulated for public review. In response to comments, the County has also included a provision to prohibit small wind turbines within 4,000 feet of a known golden eagle nest. For large wind turbines that will have discretionary review, the County has included two mitigation measures (M-BIO-1 and M-BIO-2) to reduce potential impacts to special status species.

L-88 The County appreciates this information regarding the severity of impacts to golden eagle in San Diego. This information will be provided to decision makers for consideration when evaluating the potential impacts of the project. The County will also consider recommendations from the wildlife agencies, particularly with regard to golden eagle impacts. However, to date, the County has the authority to approve a project in spite of significant and unavoidable impacts if certain overriding findings can be made.

L-89 The County does not agree with this comment. The comment does not distinguish between discretionary projects and ministerial projects. While discretionary projects must undergo environmental review and potentially consult with the US Fish and Wildlife Service (USFWS) to ensure no net loss of bald and golden eagles, the County also has the ability to issue ministerial development permits without individual environmental reviews. Under the existing Zoning Ordinance provisions, a single small turbine can be permitted ministerially. The County is proposing to expand that provision to allow for three free-standing turbines or five roof-mounted turbines. Based on the County's review of federal and State regulations and comments from the wildlife agencies, the project does not conflict with federal law.

L-90 The County is including all feasible design features into the draft Wind Energy Ordinance for small wind turbines that will help to reduce impacts to birds based on recommendations from the wildlife agencies and the public. The USFWS Draft Eagle Conservation Plan (ECP) Guidance is geared toward wind farm applications rather than small private landowners seeking to install a residential turbine to offset non-renewable energy usage. The Draft ECP Guidance would not be feasible for any applicants of small wind turbine permits as the costs would be many times more than the benefits. In addition, it would not be feasible for the County to apply the Draft ECP Guidance to the standards for issuing ministerial permits for small wind turbines since the Guidance requires discretionary review.

The measures in the Draft ECP Guidance are appropriate to apply to future large wind turbine projects during the discretionary review process. The County is proposing to include or incorporate by reference all the latest recommendations from the wildlife agencies and the CEC in its Guidelines for Determining Significance for Biological Resources. In addition, the County will be consulting with the wildlife agencies during the permitting of large wind turbine projects.

L-91 The County is including all feasible measures to minimize impacts to special status species from both small and large wind turbines. Specific responses to recommended measures are provided in responses to comments L96 through L125 below.

L-92 The County does not agree with this comment. Measures to avoid and minimize impacts from small wind turbines were included in the draft ordinance, and additional measures were included in response to comments (see responses to comments I6, I8, L2, and L11). Mitigation measures to reduce potential biological resource impacts from large wind turbines are proposed in DEIR Section 2.4.6.

L-93 The County is including all feasible measures to minimize impacts to riparian habitat and other sensitive natural communities from both small and large wind turbines. Specific responses to recommended measures are provided in responses to comments L96 through L125 below.

L-94 The County concurs with this comment.

L-95 This comment introduces recommended mitigation measures. Specific responses to each suggestion are provided in the responses to comments below.

L-96 The Limited Small Wind Turbine Alternative proposes to only allow small wind turbines in disturbed areas. The feasibility of this approach will be evaluated by decision makers.

For future large wind turbine projects, siting considerations will be part of the environmental review and application of the County's Guidelines for Determining Significance for Biological Resources.

L-97 For small wind turbines, no new roads would be allowed under the ministerial permit. Road improvement plans are discretionary projects that require environmental review.

For large wind turbines, road improvements will be evaluated as part of the Major Use Permit (MUP) process. As part that process, the County will apply the General Plan Policies in the Mobility Element. Goal M-9 of the Mobility Element states: "Reduce the need to widen or build roads through effective use of the existing transportation network and maximizing the use of alternative modes of travel throughout the County." Should new roads need to be built as part of a large wind turbine project, the policies in the Mobility Element also require environmentally sensitive road design (e.g., policies M-2.3 and M-2.5).

L-98 Construction activities for small wind turbines would typically last one day and would generally involve the delivery of component parts and equipment (if the turbine is too large for the individual property owner to manage), and the pouring of a concrete foundation. These activities would usually not last more than a single day and would not be expected to have a significant effect on wildlife reproductive activities.

Pursuant to the County of San Diego Guidelines for Determining Significance for Biological Resources, future large wind turbine projects would have to consider scheduling construction activities to avoid the breeding seasons of applicable sensitive wildlife species (see Sections 4.1 and 5.1 of the Guidelines).

L-99 The County has reviewed the Marin County Development Code for Wind Energy Conversion Systems, including Section 22.32.180(B), Development Standards, which requires a bird and bat study for small wind turbine projects. These standards apply to discretionary permits for small Wind Energy Conversion Systems. The County of San Diego's objective is to allow small wind turbines with a ministerial building permit. This objective would not be attainable if the Marin County development standards, a discretionary process, were applied to small turbine projects and MET facilities in the County of San Diego Zoning Ordinance

However, the County does agree that bird and bat studies should be required for discretionary permit applications, such as Major Use Permit applications for large wind turbines. Mitigation measures M-BIO-1 and M-BIO-2 would ensure that future large turbine projects will conduct bird and bat studies in accordance with the latest guidelines from the wildlife agencies and the CEC.

See also responses to comments I6 through I9.

L-100 The County does not agree with this comment. A bird and bat study is not a "yes-or-no" type of study for which it will be quickly evident whether or not there will be potential impacts to a species of concern. Preparation and review of the study would require a certain amount of discretion. As such, the comment is recommending that the determination of whether small wind turbine permits are discretionary or ministerial will be based on a discretionary review. The County's Zoning Ordinance does not currently have this type regulation for any other permits and the County does not agree that it is appropriate.

Moreover, the requirement for a biological study prior to consideration of a small wind turbine application would defeat the County's objective to streamline and clarify the approval process for the development and operation of small wind turbines. In most cases, it would be complicating the process since no such requirement exists under the current ordinance regulations for small, medium or large turbines

Therefore, including a mandate for a biological study with unclear consequences for the applicant would directly conflict with project objectives #4 and #6. Since this recommended mitigation conflicts with the project objectives, it is rejected as infeasible.

L-101 The County does not agree with this comment as it pertains to small wind turbines or MET facilities. County staff or wildlife agency review of the proposed small turbine or MET tower proximity to sensitive biological resources would, by definition, involve a discretionary review. See also responses to comments I6, L8, and L100.

For large wind turbines, the County agrees that proximity to sensitive biological resources should be evaluated, though not necessarily prohibited. The County will be applying Guidelines for Determining Significance for Biological Resources to future large wind turbine projects to determine the best way to avoid, minimize and/or mitigate significant impacts to biological resources. Depending on existing conditions, it is sometimes better to permit development with direct impacts and allow for off-site mitigation that contributes to an open space network. The County's Resource Protection Ordinance allows for mitigation over avoidance when mitigation provides an equal or greater benefit to the affected species.

L-102 For large wind turbines, the County does not agree that this type of standard is the best mitigation. Large wind turbine projects will be required to avoid, minimize, and mitigate significant impacts whenever feasible. Establishing a 300 foot buffer (or five times height setback) from specified resources may preclude better mitigation alternatives and be perceived as a maximum buffer during future permitting. With regard to recommended distance from sensitive resources, the CEC's Guidelines For Reducing Impacts To Birds And Bats From Wind Energy Development state: "Determine the extent of the buffer zone in consultation with CDFG, USFWS, and biologists with specific knowledge of the affected species

For small wind turbines and MET facilities, the County does not agree that setbacks from the resources listed in this comment could be established through a ministerial process. The determination as to where these may occur would require biological studies and discretionary review. However, the County can establish setbacks from pre-mapped locations that can be measured objectively. As such, the following provisions have been added to the draft ordinance:

<u>1.iv.a: No part of the wind turbine shall be closer than 300 feet or 5 times the turbine height, whichever is greater from the following: Power transmission towers and lines.</u>

<u>1.iv.a: No part of the wind turbine shall be closer than 300 feet or 5 times the turbine height, whichever is greater from the following: Blue line watercourse(s) as identified on the United States Geological Survey Topographic Map.</u>

<u>1.iv.c. No part of the wind turbine shall be closer than 300 feet or 5 times the turbine height, whichever is greater from the following: Significant roost sites for sensitive bat species as mapped on the California Natural Diversity Database.</u>

<u>1.v: No part of a wind turbine shall be closer than 4,000 feet from a known golden eagle site.</u>

There is no guarantee that these provisions will result in reduced biological impacts for any given site, but overall they should help to minimize potential adverse effects to sensitive species. See also responses to comments I6, I7, I8, I9, J6, J9, L26.

L-103 This comment recommends collecting data regarding resources listed in comment L102. Reliance on some data can be used to map known locations and establish buffers as described in response to comment L102 above. The County will utilize its Geographic Information Systems (GIS) to implement the proposed setbacks from pre-mapped golden eagle nests, significant bat roosts, water bodies, and transmission towers.

Additional mapping and site-specific review could not be achieved with the ministerial process. Based on countless reviews of biological studies in the County unincorporated area, determinations such as where a wetland begins or ends, how wide a wildlife corridor is, whether habitat on site is used by a sensitive species off site, or whether an isolated rare plant is part of a larger population are all determinations that require discretionary review. The County's project objectives for the Wind Energy Ordinance are to allow development of small wind turbines without a discretionary permit (objective 6) and to streamline and clarify the approval process for the development and operation of small wind turbines (objective 4). The County does not agree that it can achieve those objectives with the type of biological data collection and reviews suggested by the commenter.

For large wind turbines that will undergo discretionary review, site-specific mapping will be required and potential impacts to sensitive resources will be addressed through application of the latest guidelines from State and federal agencies.

L-104 The County does not agree with this comment as it pertains to large or small wind turbines. For large wind turbine projects, construction and staging areas will be identified during the environmental review for the project. Treatment of such areas following construction will be determined on a case by case basis. The County agrees that in most cases native habitat will need to be revegetated and that success criteria should be developed in consultation with the wildlife agencies. This is a typical mitigation measure included the County's Guidelines for Determining Significance for Biological Resources (see Section 5.1 of the Guidelines). Since this will be determined through site evaluation and agency consultation, the County does not agree that it should be established as a requirement in all cases. For some large turbine projects, it may be determined that the staging area should be developed or vegetated with particular plant species that do not attract prey species for raptors

For small wind turbines, construction and staging areas are not expected to be needed. Construction activities for small wind turbines would typically last one day and would generally involve the delivery of component parts and equipment (if the turbine is too large for the individual property owner to manage), and the pouring of a concrete foundation. These activities would usually occur near existing on-site development and would not be expected to result in a substantial area of disturbance. In addition, the County has added the following provision to the small wind turbine provisions in the ordinance:

Area of Disturbance. A small wind turbine shall not result in an area of ground disturbance (including grading, clearing, brushing, or grubbing) that is larger than a

25 foot radius around the base of a tower, and an access path to the tower that is a maximum of four feet wide. The entire area of disturbance shall be clearly defined on the plans submitted for Zoning Verification Permit review.

Therefore, land disturbance from construction of small wind turbines will be kept to the minimum necessary and will not result in the need for restoration plans.

L-105 The County agrees with this recommendation as it pertains to large wind turbines. The County's Guidelines for Determining Significance for Biological Resources establishes mitigation measures for temporary or permanent impacts to native or non-native sensitive habitat (see Guidelines Section 5). In addition, the County's Resource Protection Ordinance requires avoidance or mitigation for Sensitive Habitat Lands.

The County does not agree that impacts to habitat from small wind turbines can be mitigated as part of this project. The County's project objectives for the Wind Energy Ordinance are to allow development of small wind turbines without a discretionary permit (objective 6) and to streamline and clarify the approval process for the development and operation of small wind turbines (objective 4). The County does not agree that it can achieve those objectives with a requirement that each small turbine be reviewed for potential impacts to habitat and include conditions of approval requiring applicants to provide habitat mitigation.

L-106 The County agrees with this recommendation as it pertains to large wind turbines. The County's Resource Protection Ordinance requires Major Use Permits to protect steep slopes. In addition, the County's Grading Ordinance and Watershed Protection Ordinance have strict requirements for erosion and sediment control as well as remedial measures for disturbed slopes.

The County does not agree that significant impacts related to water quality or erosion will occur from the installation of small wind turbines (see DEIR Section 3.1.2.3.3).

L-107 The County will inspect, monitor, and document compliance with permitting requirements for large wind turbine projects as required through the Major Use Permit conditions. For small wind turbines permitted ministerially, the County does not agree with the suggested requirements and inspections listed by the commenter (see responses to comments L96 through L106 above).

L-108 The County does not agree with this comment. See response to comment L28.

L-109 Based on the CEC Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development, this recommendation will be a consideration during the environmental review of large wind turbine projects. Though it should be noted that low visibility conditions may not necessarily require relocation of the project depending on consultations with the California Department of Fish and Game.

The County does not agree that this standard should be applied to the ministerial permitting of small wind turbines. It is not clear from the comment what would be considered "high incidence" or how meteorological conditions for a given property could be determined or measured fairly and objectively. The County's project objectives for the Wind Energy Ordinance are to allow development of small wind turbines without a discretionary permit (objective 6) and to streamline and clarify the approval process for the development and operation of small wind turbines (objective 4). The County does not believe that it can achieve those objectives with a requirement that turbines be prohibited if certain weather conditions potentially affect an applicant's property.

L-110 The County agrees with the intent of this comment; however, it is not a foregone conclusion at this time that all future large wind turbines will have a significant impact on sensitive bat and avian species. The County is proposing to apply the latest guidelines for reducing impacts to birds and bats to its environmental review process for large wind turbines. These guidelines first emphasize siting considerations to minimize impacts, followed by environmentally sensitive project design. In many cases, it is anticipated that the potential for impacts to sensitive birds and bats will still remain. However, this must be apparent before requiring a bird and bat protection plan and adaptive management plan. In other words, there must first be a nexus to require these measures. Therefore, implementation of such plans should not be mandatory.

L-111 The County does not agree with this comment. This recommendation would prohibit placement of turbines in most of the County unincorporated area. The County has existing regulations regarding development on slopes and ridgelines. Future large wind turbines will have to address the latest guidelines regarding siting considerations, in particular to minimize bird and bat impacts. Future small wind turbines will be prohibited on ridgelines and must be sited so as to minimize landform modification or else require a discretionary grading permit. Additional stipulations such as those stated in this comment are not necessary for either large or small wind turbines.

L-112 The presence of rock piles or natural rock formations may indicate roosting or foraging areas. These features are not specifically called out in the CEC or USFWS guidelines; however, all site-specific characteristics will be evaluated and species surveys will be conducted during the review of large turbine projects to minimize potential biological impacts. The County does not agree with establishing a rigid prohibition on having turbines near rock piles or rock formations when better alternatives or mitigating measures may be identified through consultation with the wildlife agencies.

The County would not feasibly be able to regulate the proximity of small wind turbines to rock piles or rock formations. Artificial rock piles or similar features can be established on a private property at any time before or after a ministerial permit is issued. And the determination as to whether or not natural rock formations are of concern near a small wind turbine site would take discretion on the part of County staff, with unclear guidance for applicants. The County's project objectives for the Wind Energy Ordinance are to allow development of small wind turbines without a discretionary permit (objective 6) and to streamline and clarify the approval process for the development and operation of small wind turbines (objective 4). The County does not agree that it can achieve those objectives if it includes unclear regulations related to the presence of undefined features such as rock piles or rock formations.

L-113 The County agrees that a buffer between proposed small wind turbines and existing transmission towers is feasible. Locations of transmission towers are readily available and a setback from then can be measured objectively to maintain a ministerial permitting process. The County has added the following provision to the draft ordinance:

<u>1.iv.a: No part of the wind turbine shall be closer than 300 feet or 5 times the turbine height, whichever is greater, from the following: Power transmission towers and lines.</u>

The County does not agree that litter control fences around landfills are features that require setbacks. In addition, the locations of such fences are not readily available on County maps to allow for fixed standards and objective measurements.

L-114 The conditions stated in this comment can only be identified with a technical study combined with species surveys which are then evaluated by local specialists such as staff from the California Department of Fish and Game. For large wind turbine projects, this type of situation will be considered since it is noted in the CEC Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development. However, this consideration is more important as a guideline than as a regulation because it requires expert opinion rather than just scientific methodology to assess.

The County would not feasibly be able to regulate the proximity of small wind turbines to areas where slope-accelerated winds would position a raptor at the height domain of the rotor plain of functional turbines, including where the lips in the slope can locally accelerate winds. The determination of whether or not this condition occurs near the proposed site of the small turbine would require technical study and discretion on the part of County staff, with unclear guidance for applicants. The County's project objectives for the Wind Energy Ordinance are to allow development of small wind turbines without a discretionary permit (objective 6) and to streamline and clarify the approval process for the development and operation of small wind turbines (objective 4). The County does not agree that it can achieve those objectives if it includes unclear regulations related to the presence of slope-accelerated winds.

L-115 The County agrees with this comment. For large wind turbine projects, the design of the turbines will have to be evaluated in terms of the potential for perching or nesting. This is addressed in the CEC Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development under *Reduce Impacts with Appropriate Turbine Design.* Therefore, the latest recommendations and guidelines for turbine design will be applied to large wind turbine projects during the environmental review process.

For small wind turbines, the proposed Wind Energy Ordinance specifies that use of trellis style towers and guy wires is prohibited (see draft Section 6951.a.10). These design limitations were specifically included in order to reduce the potential for perching and nesting near the turbine.

L-116 See responses to comments L98 and L104.

L-117 See responses to comments L29 and DD23.

L-118 The County does not agree with this comment. See response to comment L30.

L-119 For large wind turbine projects, post-construction surveys and monitoring will be required as necessary to evaluate and mitigate significant impacts to sensitive bird and bat species.

With regard to small wind turbines, the County has considered this comment in great depth and has had multiple meetings with the commenter to discuss it. To date, no feasible method for implementing such a program has been identified. There is no incentive for residential-scale turbine owners to report bird or bat fatalities that may occur on their properties. In fact, there would be a potential for punitive consequences if it were determined that a small wind turbine was affecting protected species.

L-120 It is not clear what is meant by this comment or how the thresholds would be used. The CEC Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development discuss what to do if bird and bat collisions that result from the project exceed the impacts that were anticipated before construction. In such cases, additional mitigation and adaptive management is required. If this is what is meant by the comment, the County agrees with this approach but does not agree that there should be pre-established thresholds. Rather, each large turbine project should have a post-construction monitoring plan and contingency measures for unexpected impacts as necessary

For small wind turbines, on-going monitoring and adaptive management is not feasible since the turbines would be permitted ministerially. See also responses to comments I6, J5, J20, J21, L30, L107, and L119.

L-121 See responses to comments I6, J5, J20, J21, L107, L119, and L120.

L-122 In response to comments, the County has added a provision to the draft ordinance to prohibit small turbines within 4,000 feet of known golden eagle nest locations. The 4,000 foot distance is consistent with the provisions of the San Diego MSCP Plan.

L-123 The County agrees with the intent of this comment; however, it is not a foregone conclusion at this time that all future large wind turbines will have a significant impact on eagles. The County is proposing to apply the latest guidelines (including the USFWS draft Eagle Conservation Plan Guidance) for reducing impacts to birds during the environmental review process for large wind turbines. These guidelines first emphasize siting considerations to minimize impacts, followed by environmentally sensitive project design. In many cases, it is anticipated that the potential for impacts to eagles will still remain. However, this must be apparent before requiring an Eagle Conservation Plan. In other words, there must first be a nexus to require these measures; therefore, implementation of such plans should not be mandatory.

L-124 The County agrees with this comment as compliance with State law is mandatory.

L-125 The County agrees with this comment as it pertains to discretionary permits. Compensatory mitigation for impacts to golden eagle will have to satisfy California Fish and Game requirements and be consistent the USFWS draft Eagle Conservation Plan Guidance. The County will apply the latest guidelines and consult with the wildlife agencies during the review of large wind turbine projects with potential impacts to sensitive species, particularly with regard to golden eagle impacts.

Compensatory mitigation for impacts that result from ministerial small wind turbine permits cannot be mandated or enforced. A ministerial decision involves only the use of fixed standards or objective measurements. And once the ministerial permit is issued, there are no on-going or follow-up actions between the County and the developer.

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ATTACHMENT L3

MITIGATION TOOLBOX

Compiled by:
NWCC Mitigation Subgroup &
Jennie Rectenwald, Consultant

First published as a living document in May 2007.

Table of Contents

Executive Summary

Human disturbances to the landscape have often led to increased fatality rates for wildlife. Mitigation techniques have been applied in an effort to reduce or eliminate the harmful effects of human disturbance. This "mitigation toolbox" was created to provide direction for future wind development projects by presenting an assortment of mitigation measures that can be used to minimize or eliminate the negative impacts to wildlife that result from the design, construction, and operation of wind farms. However, there are relatively few instances where research has been done to validate whether mitigation strategies have reduced impacts as expected, specifically in relation to wind development. The following 'mitigation toolbox' is a compilation of mitigation policies, guidelines, and research that are either directly or indirectly applicable to the wind industry.

The information in this toolbox was obtained through Internet, library, and database searches; literature reviews; and interviews of experts in the field. Although there is considerable research on mitigation, and there are many tools that might be applied in the context of wind power, few scientifically proven mitigation strategies are currently available to the wind industry. Numerous mitigation strategies are proving to be successful in certain situations in the field, however, and a significant amount of promising research is currently underway that could result in new techniques.

Intended to improve current and future mitigation efforts, this toolbox is a living document that will grow and change as new information becomes available to fill in the gaps between existing policies or guidelines and current research, as well as within the research itself.

Introduction

U.S. wind development is expected to increase from about 10,000 MW in 2007 to 50,000 MW by 2020. As a result, government groups at all levels are beginning to publish wind turbine siting and mitigation policies and guidelines to minimize the effects of future wind power development on wildlife. Suggested mitigation techniques range from general strategies (e.g., avoid locations used heavily by migrating bats and birds) to specific ones (e.g., reduce motion smear by painting the blades). The development of mitigation policies and guidelines may be an important step for minimizing the impacts of development on wildlife; however, in order to be truly successful, the suggested strategies must work.

The Mitigation Toolbox

The National Wind Coordinating Committee's (NWCC) Mitigation Subgroup has compiled a number of mitigation strategies in this "mitigation toolbox." The toolbox provides guidance and direction for future wind development by describing various mitigation measures or tools that can be used in the decision-making process. For the purposes of the toolbox, 'tools' are defined as effective approaches to mitigating avian and bat fatalities, as well as habitat impacts, as proven through statistically significant research. Since differences in habitat, topography, and landscape among wind facilities often make it difficult to generalize findings from one geographic region to another, the toolbox is intended to house a wide variety of tools rather than a single, 'all-purpose' one. The toolbox is also intended to be a living document that will be periodically updated as new mitigation research and tools become available.

There are relatively few instances where research has been done to validate whether mitigation strategies have reduced impacts as expected, specifically in relation to wind development. As a result, the toolbox currently contains few verifiable tools. There are, however, numerous guidance documents that have been developed for the wind industry that incorporate a wide variety of mitigation strategies.

Information for Decision Makers

To help guide future decision making, this toolbox provides information about existing mitigation policies and guidelines, as well as on whether strategies are based on sound scientific research. It indicates the effectiveness of various methods of avoiding, minimizing, or compensating for direct and indirect impacts on wildlife caused by wind power facilities (recognizing, however, that avoiding wildlife mortality completely is probably not possible).

The toolbox contains four main sections:

- A comparison of existing mitigation policies and guidelines from the United States, Canada, Europe, and Australia that examines policies at both local and federal levels
- An Annotated Bibliography that includes research on wind development mitigation, as well as general habitat mitigation studies that could be applicable to wind sites
- Case studies that focus on exceptional mitigation strategies and currently available tools
- A matrix illustrating gaps and overlaps between existing policies or guidelines and current research.

The information presented here is intended to improve overall mitigation efforts by illustrating the gaps between current policies and guidelines and the research supporting them. Identifying the gaps makes it possible to tailor future research and policies to better meet goals for both wildlife and development. However, since each type of habitat is different, the results of mitigation research in one area might not apply in another area.

Defining Mitigation

The NWCC Mitigation Subgroup acknowledges the definition of mitigation established by the United States Fish and Wildlife Service, for all resources:

> "The President's Council on Environmental Quality defined the term "mitigation" in the National Environmental Policy Act regulations to include:
> '(a) avoiding the impact altogether by not taking a certain action or parts of an action; (b) minimizing impacts by limiting the degree or magnitude of the action and its implementation; (c) rectifying the impact by repairing, rehabilitating, or restoring the affected environment; (d) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; (e) compensating for the impact by replacing or providing substitute resources or environments.' [40 CFR Part 1508.20(a-e)].
>
> The Service supports and adopts this definition of mitigation and considers the specific elements to represent the desirable sequence of steps in the mitigation planning process."[1]

The toolbox exists in the context of this definition. However the emphasis is on the tools available to mitigate impacts after developers and decision makers determine that a wind power project will be built.

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[1] U.S. Fish and Wildlife Service Mitigation Policy, FR 46 (15) Jan 81, 7656, at www.fws.gov/policy/A1501fw2.html.

Methods

Literature Review

The literature review included a general review of existing wind siting policies, guidelines, and research pertaining to wildlife mitigation both nationally and internationally. Information was acquired by conducting Internet searches, conducting library searches, contacting ornithological societies, interviewing experts in the field (see Appendix A) via phone and e-mail, and searching numerous databases. The National Wind Coordinating Committee (NWCC) provided an initial list of existing policies. Previous literature reviews—including those of Gerson and Klute (2006), Johnson and Arnett (2004), Kerlinger (2000), Manville (2005), Spellerberg (1998), and Herbert et al. (1995)—were also used (see the Annotated Bibliography).

Research methods included searching the National Renewable Energy Laboratory's (NREL) Avian Literature Database, the National Wind Technology Center's EBSCO Database, the Colorado State University (CSU) EBSCO Database, the CSU JSTOR Database, the CSU Web of Science Database, Google, and Google Scholar, as well as compiling citations in relevant review articles. Most published articles were acquired from the CSU library.

Research and Analysis

From a significant amount of existing literature, the studies reviewed were limited to those deemed relevant, i.e., that examined the effects of specific changes to wind farm characteristics on birds or bats as well as those that examined more general habitat mitigation efforts and their effects on wildlife, which may be applicable to wind power development. Relevant studies included research that examined the effectiveness of mitigation strategies on wildlife, certain avian or bat behavior studies conducted at wind sites, studies comparing the effects of wind site alterations on wildlife, studies that examined mitigation strategies suggested in policies or guidelines, and studies mentioned by experts in the field. Research was not included that focused on avian or bat ecology, searcher efficiency rates, scavenging rates, avian or bat mortality estimates, study design, or modeling.

The mitigation studies selected represented those reflecting the views of the scientific community overall but also numerous studies in which scientific opinions differed. Selections focused on recent literature (1995 and later), unless that was not possible. Some earlier literature was included if it was cited often in other studies because of its historical foundations. A number of interesting studies could not be obtained from either the NREL or CSU library, online, or in personal communications, and this was further complicated by cost and time limitations.

Reviews included determining the goals of the research, its location and habitat types, the length of the study, and the general methodology used. Also researched were any conclusions, results, and management suggestions that would mitigate negative effects on wildlife. Earlier literature reviews (e.g., by Orloff in Erickson et al. 1999) were used occasionally because of time constraints and difficulty in attaining original papers. They are footnoted in the Annotated Bibliography.

The studies were then divided into two matrixes. One matrix illustrates the type of review process used (peer, none, or unknown) and the other combines existing research with policies and guidelines on mitigation. Due to difficulties in ascertaining the difference between credible peer reviews and non-credible peer reviews, studies were divided into journals and reports under an umbrella section entitled 'Reviewed'. Further analysis is required to differentiate studies into more specific categories.

For the matrix comparing policy or guideline recommendations with research results, mitigation strategies were divided into nine general categories: lighting, siting, turbine type, turbine configuration, power lines, habitat enhancement, revegetation, disturbance during construction, and operation. Individual studies were then analyzed to determine whether or not they supported the mitigation strategies suggested within any of the categories.

A Review of Existing Policies and Guidelines

The following is a compilation of existing policies and guidelines pertaining to wind power development, impacts on wildlife and habitats, and mitigation efforts. Guidelines are categorized according to their scope, i.e., Local, State, Federal, International, and Other. Within each category, guidelines are alphabetized by author and then organized into design-stage, construction-stage, and operational-stage mitigation efforts, when possible. A more comprehensive summary of policies and guidelines that allows for easier comparisons is in Appendix A. The information presented here is also in the Guidelines Spreadsheet, which allows for easier comparisons of guidelines among policies.

Local Policies and Guidelines

Washington Department of Fish and Wildlife: Wind Power Guidelines

Date Established: August 2003

Location: East of the Cascades

Contact: Dr. Jeff Koenings, Director of WDFW, 360-902-2200

See: http://wdfw.wa.gov/hab/engineer/windpower/wind_power_guidelines.pdf

General Principles for Siting and Mitigation

- Implementation of mitigation measures is presumed to fully mitigate for habitat losses for all species; state or federal *endangered* or federal *threatened* species may require additional mitigation efforts.
- Developers should be encouraged to place linear facilities[1] in or adjacent to existing disturbed corridors in order to minimize habitat fragmentation and degradation.
- Developers should be encouraged to site wind power projects on disturbed lands.
- Developers should be discouraged from using or degrading high-value habitat areas.
- Developers are responsible for acquiring replacement habitat under this proposal and for management of such lands for the life of the project,[2] unless otherwise indicated.

Conventional Mitigation Policies and Guidelines

Permanent Habitat Impacts

A. No mitigation required for cropland, developed or disturbed areas
B. All other areas require the acquisition of replacement habitat that is:
    - Like-kind (e.g., shrub-steppe for shrub-steppe; grassland for grassland) and/or of equal or higher habitat value than the impacted areas (alternative ratio may be negotiated)
    - Given legal protection
    - Protected from degradation for the life of the project
    - In the same geographical region as the impacted habitat
    - Jointly agreed upon by the wind developer and WDFW

Ratios: Replacement Habitat Subject to Imminent Development – 1:1

[1] Examples include collector cable routes, transmission line routes, or access roads.
[2] "Life of project" is defined as beginning at the end of the first year of commercial operation and ending with implementation of the project decommissioning plan.

Grassland, CRP Replacement Habitat – 1:1
Shrub-Steppe, or Other High-Value Replacement Habitat[3] – 2:1

Temporary Habitat Impacts (anticipated to end when construction is complete and land has been restored)

A. No mitigation required for cropland, developed, or disturbed areas
B. Mitigation options for other land types include:
    - Implementing a WDFW-approved restoration plan for the impacted area, including site preparation, reseeding with appropriate vegetation, noxious weed control, and protection from degradation.
    - Acquiring suitable replacement habitat for every acre temporarily impacted by the project (see ratios below).
    - A good faith effort to restore the impacted area. However, long-term performance targets should not be imposed since temporal losses and the possibility of restoration failure are incorporated into the acquisition and improvement of replacement habitat.
    - WDFW and a wind developer may agree on other 'customized' or 'alternative' ratios and terms where doing so is mutually beneficial, and accepted methodologies are used, such as a natural resource damage assessment (NRDA) or an alternative mitigation option.

Ratios: Acquisition of Grassland, CRP Replacement Habitat – 0.1:1
Acquisition of Shrub-Steppe Habitat – 0.5:1

<u>Alternative Mitigation Policies and Guidelines</u>

The goal of the Wind Power Alternative Mitigation Pilot Program is to provide an optional and streamlined approach to mitigation that results in better habitat value and is more attractive to wind developers than conventional on-site mitigation.

Alternative: Applicant will pay an annual fee[4] for the life of the project,[5] which is based on an alternative mitigation fee rate of $55/acre/year for each acre of replacement habitat that would be owed using the ratios and analysis discussed in the section titled Conventional Mitigation Policies and Guidelines.

General Provisions:

- The fee is based on habitat in average condition and can be increased or decreased by 25% to account for differences in habitat quality.
- The applicant is required to implement an approved restoration plan for temporarily impacted areas.
- In cases in which the project impacts a mixture of habitat types, the fee schedule will be applied accordingly (to the nearest acre).
- The annual fee will be used primarily to support stewardship of high-value habitat in the same ecological region as the project.
- If the applicant and the WDFW cannot agree on a mutually advantageous package under the alternative mitigation program, conventional mitigation guidance will be applied to the project.

[3] Habitat considered to be in excellent condition will require developers to engage in additional consultation with WDFW regarding suitable mitigation requirements.
[4] The fee will be reviewed annually and adjusted as necessary by WDFW.

State Policies and Guidelines

California Energy Commission & California Department of Fish and Game: ***DRAFT*** Guidelines for Reducing Wildlife Impacts from Wind Energy Development

Date Established: Draft released December 2006; Final expected June 2007.

Location: State of California

Contact: Rick York, California Energy Commission, 916-654-3945, ryork@energy.state.ca.us

See[6]: www.energy.ca.gov/2006publications/CEC-700-2006-013/CEC-700-2006-013-SD.PDF

Every wind energy project site is unique, and no one recommendation will apply to all prepermitting site selection and layout planning. The following elements, however, should be considered in site selection, in turbine layout, and in developing infrastructure for the facility.

Design-Stage Mitigation

- Good macro-siting decisions are essential for choosing an acceptable site or portion of a site.
- Once a site is selected, micro-siting efforts can avoid or reduce potential impacts to birds, bats and other biological resources.
- Minimize fragmentation and habitat disturbance.
- Establish buffer zones around areas of high bird or bat use in which no disturbance is allowed in order to minimize the risk of collisions.
- Avoid guy wires.
- Reduce impacts with appropriate turbine layout based on micro-siting decisions.
- Place power lines underground, unless burial would result in greater impacts to biological resources.
- Ensure that all above-ground lines, transformers, or conductors comply with Avian Power Line Interaction Committee (APLIC) standards, including the use of deterrents.

Operation-Stage Mitigation

- Decommission nonoperational turbines so they no longer present a collision hazard to birds and bats. Developers should submit a decommissioning and reclamation plan that describes the expected actions when some or all of the turbines at a wind site are nonoperational as part of the permitting application. Decommissioning typically involves removal of turbine foundations to 1 meter below ground level and removing access roads and unnecessary fencing and ancillary structures.
- Avoid lighting that attracts birds. Until more is known, lights with short flash durations that emit no light during the “off phase” should be used—those that have the minimum number of flashes per minute and the briefest flash duration allowable.
- Use lights on auxiliary buildings near turbines and meteorological (met) towers that are motion-sensitive rather than steady burning; they should be downcast.
- Limited and periodic feathering during low-wind nights may help avoid impacts to bats.

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[6] Since the drafting of this document, the California Energy Commission released a second draft staff report on April 2007, it can be viewed at at http://www.energy.ca.gov/renewables/06-OII-1/documents/index.html#041607.

- Note that high fatality levels may require removal of problem turbines or seasonal shutdowns of turbines.
- Apply adaptive management and effectiveness monitoring processes to better achieve management objectives.
- Modify habitat to make the site less attractive to at-risk species.

Off-Site Activities

- Provide for long-term conservation of the target species and its habitat.
- Ensure that the site is large enough to be ecologically self-sustaining and/or part of a larger conservation strategy.
- Before the property is sold or credits are sold at a mitigation bank, have a resource management plan approved by all appropriate agencies or nongovernment organizations involved in property management.
- Protect the site permanently through a fee title and/or a conservation easement.
- Provide for long-term management of the property after the project is completed or after all mitigation credits have been awarded for the mitigation bank.
- Ensure the implementation of the resource management plan in the event of nonperformance by the owner of the property or nonperformance by the mitigation bank owner and/or owner.
- Provide a sufficient level of funding with acceptable guarantees to fully ensure the operation and maintenance of the property, as may be required.
- Provide for monitoring and reporting on the identified species/habitat management objectives, with an adaptive management/effectiveness monitoring loop to modify management objectives as needed.

The Kansas Renewable Energy Working Group: Siting Guidelines for Windpower Projects in Kansas

Date Established: January 22, 2003

Location: State of Kansas

Contact: Jim Plogger, Kansas Corporation Commission, j.ploger@kcc.state.ks.us

See: www.krewg.org/reports/KREWGSitingGuidelines.pdf

The Environmental and Siting Committee of the Kansas Renewable Energy Working Group (KREWG) has drafted these guidelines for wind power project stakeholders to use as they consider potential project sites in the State of Kansas. Wind energy siting and permitting requirements vary from county to county, depending largely on whether or not a county is zoned. Currently, statewide regulations for siting wind projects do not exist.

Design-Stage Mitigation

- Use biological and environmental experts to conduct preliminary reconnaissance of the prospective site area. If a site has a large potential for biological and/or environmental conflicts, it may not be worth the time and cost of conducting detailed wind resource evaluation work.
- Involve local environmental/natural resource groups as soon as practical.
- Use landscape-level examinations of key wildlife habitats, migration corridors, staging/concentration areas, and breeding and brood-rearing areas to develop general siting strategies.
- Situate turbines in a way that does not interfere with important wildlife movement corridors and staging areas.

- Do not allow any perches on the nacelles of turbines. Towers should not utilize lattice-type construction or other designs that provide perches.
- In regions where grassland burning is practiced, make sure that the infrastructure is able to withstand periodic burning of vegetation.
- Consider potential cumulative regional impacts from multiple wind energy projects when making environmental assessments and mitigation decisions.
- Take care to avoid damage to unfragmented landscapes and high-quality remnants in the Sandsage, Mixed Grass, and Shortgrass prairies in central and western Kansas. Allowing for an undeveloped buffer adjacent to intact prairies is desirable.
- When feasible, locate wind energy development on already altered landscapes.

Construction-Stage Mitigation
- Bury power lines, when feasible.
- Minimize roads and fences, and take care to avoid sensitive habitats.
- Ideally, implement construction and maintenance when the ground is frozen or when soils are dry and native vegetation is dormant.

Operational-Stage Mitigation
- Address potential adverse affects of turbine warning lights on migrating birds.
- If significant ecological damage results from siting, consider mitigation for habitat loss, including ecological restoration, long-term management agreements, and conservation easements to enhance or protect sites with an ecological quality that is similar to or higher than that of the developed site.
- Use native vegetation of local ecotypes to reseed disturbed areas.
- Consider wildlife and plant composition in determining the frequency and timing of mowing near turbines.

Wind Energy Technical Advisory Group: ***DRAFT*** Siting Guidelines to Mitigate Avian and Bat Risks from Windpower Projects

Date Established: July 6, 2006

Location: State of Maryland

Contact: Michael Dean, 410-767-8149; mdean@psc.state.md.us

Applicants should consult with the Department of Natural Resources Power Plant Research Program (PPRP) well in advance of filing an application with the Public Service Commission; failure to do so may result in project delays. Applicants are required to consult with Department of Natural Resources Natural Heritage Program (NHP) biologists to ensure that construction is scheduled to avoid or minimize disruptions to bird and bat breeding seasons, as well as to determine the boundaries of allowed physical disturbance during construction. Applicants are then required to submit a request for environmental review from the state's Wildlife and Heritage Service, which includes the project site and boundaries, results from 1 year of monitoring on the proposed site for impacts to bats and birds, an assessment of potential bat habitat on the site, the results of a Phase 1 avian risk assessment, and breeding bird survey results. The PPRP will establish a peer review group composed of relevant experts to assess monitoring plans and data, and the applicant undertakes a post-construction study of mortality rates for at least 3 years. Any mitigation plans should be graded in their implementation so as to reasonably reflect the level of the observed impact and the probability of successful mitigation.

Design-Stage Mitigation
- Use tubular towers, as opposed to lattice towers.

- Construct no permanent towers, including met towers, that are supported by guy wires.
- Avoid locations that have been identified to have potentially high risk to birds or bats, have unique habitat features, or are occupied by species of particular concern (as determined by the applicant or the state).

Construction-Stage Mitigation

- Bury on-site electrical collector cables when possible.
- Avoid or minimize disruptions during bird and bat breeding seasons.
- Reestablish any disturbed nesting/maternity areas, as feasible.

Operational-Stage Mitigation

- Minimize lighting of turbines by lighting the fewest possible number of turbines, synchronizing the flashing cycles of all strobes, installing red strobes (as opposed to white strobes) with the longest possible cycle, and not installing high-intensity lamps for area lighting (e.g., sodium vapor lamps).
- In the event that a larger-than-expected number of fatalities occurs, contact the NHP as soon as possible, at least within 24 hours. If the impacts to bird or bat populations are considered adverse, the state will seek corrective actions from the applicant to avoid, minimize, or mitigate the adverse impact. Mitigation plans may involve either on-site or off-site activities, or both.

Massachusetts Executive Office of Environmental Affairs: ***DRAFT*** Guidance on the Siting of Wind Turbines

Date Established: In progress; expected to be released by end of 2006

Location: State of Massachusetts

Contact: Josh Bagnato, MA Executive Office of Environmental Affairs, 617-626-1041; Josh.Bagnato@state.ma.us

State of Michigan Department of Labor & Economic Growth: Michigan Siting Guidelines for Wind Energy Systems

Date Established: December 14, 2005

Location: Rural areas; not meant for On-Site Use or Utility Grid

Contact: John Sarver, Energy Office, 517-241-6280

See: www.michigan.gov/documents/Wind_and_Solar_Siting_Guidlines_Draft_5_96872_7.pdf

(1) The applicant shall have a third-party, qualified professional conduct an analysis to identify and assess any potential impacts on the natural environment or wildlife and endangered species.

(2) The applicant shall take appropriate measures to minimize, eliminate, or mitigate adverse impacts identified in the analysis.

(3) The applicant shall identify and evaluate the significance of any net effects or concerns that will remain after mitigation efforts.

(4) Sites requiring special scrutiny include wildlife refuges, other areas where birds are highly concentrated, bat hibernacula, wooded ridge tops that attract wildlife, sites that are frequented by federally and/or state-listed endangered species of birds and bats, significant bird migration pathways, and areas that have landscape features known to attract large numbers of raptors.

(5) The analysis shall include a thorough review of existing information regarding species and habitats, as well as the potential effects on species listed under the federal Endangered Species Act and Michigan's Endangered Species Protection Law.

(6) The analysis shall indicate whether a post-construction wildlife mortality study will be conducted and, if not, the reasons why such a study does not need to be conducted.

(7) Power lines should be placed underground, when feasible, to prevent avian collisions and electrocutions. All above-ground lines, transformers, or conductors should comply with APLIC published standards.

(8) The applicant shall be responsible for making repairs to any public roads damaged by the construction of the utility grid wind energy system.

Montana Department of Fish and Wildlife

Date Established: N/A

Location: State of Montana

Contact: T.O. Smith, 406-444-3889; TOSmith@mt.gov

There is no regulatory authority over wind development in Montana; however, Montana Environmental Protection Agency requires developers on public and state lands to obtain input from the Montana Department of Fish and Wildlife (MDFW). MDFW has established an internal draft strategy for working with wind development on private lands to minimize environmental impacts to the extent possible. While the draft strategy has not yet been released to the public, the main points pertain to the following:

1. Coordination with county commissioners
2. Location of transmission lines
3. Staff education
4. Research
5. Coordination with the wind industry
6. Working with environmental assessments and environmental impact statements

In addition, the MDFW advocates locating turbines near transmission lines and in areas that are not visible from critical recreation areas, as close as possible to where the power will be used, and in areas that are not composed of native shortgrass prairie. The MDFW also advocates minimizing road traffic to and from sites, minimizing the loss of topsoil, replanting disturbed areas with native seeds, conducting preassessment surveys for impacts to bats and birds, and avoiding major migratory routes (waterbird, waterfowl, and raptor).

New York State Department of Agriculture and Markets: Guidelines for Agriculture Mitigation for Windpower Projects

Date Established: March 25, 2003

Location: Construction areas in county-adopted, state-certified agricultural districts.

See: http://www.agmkt.state.ny.us/AP/agservices/constructWind.html

Operational-Stage Mitigation
The following actions are to occur following construction until October 1. For areas to be restored after that date, provision should be made to restore any eroded areas in the springtime.

- All disturbed agricultural areas will be decompacted to a depth of 18 inches with a deep ripper or heavy-duty chisel plow.[7]
- All rocks 4 inches and larger will be removed before and after the replacement of topsoil.
- Topsoil will be replaced to original depth and original contours will be reestablished where possible.
- Access roads will be regraded, and original surface drainage patterns will be restored.
- Restored agricultural areas will be seeded with the seed mix specified by the landowner.
- All construction debris will be removed from the site.

Monitoring and Remediation
The Project Sponsor will provide a monitoring and remediation period of no less than two years immediately following the completion of initial restoration. General conditions to be monitored include topsoil thickness, relative content of rock and large stones, trench settling, crop production, and drainage and repair of severed fences.

- Topsoil deficiency and trench settling shall be mitigated with imported topsoil that is consistent with the quality of the topsoil on the affected site.
- Excess rocks and large stones will be removed and disposed of by the project sponsor.
- Appropriate rehabilitation measures will be determined and implemented when subsequent crop productivity within the affected area is less than that of the adjacent unaffected agricultural land.
- Where representative subsoil density of the affected area exceeds the representative subsoil density of the unaffected area, shattering of the soil profile will be performed. Deep shattering will be applied during periods of relatively low soil moisture, and any oversized stone or rock material will be removed that was uplifted to the surface.

Oregon Department of Fish and Wildlife: Fish and Wildlife Habitat Mitigation Policy For Siting Non-Nuclear Energy Facilities (635-415-0000)

Date Established: September 1, 2000

Location: State of Oregon

Contact: 503-947-6000

See: http://www.dfw.state.or.us/OARs/415.pdf

[7] In areas where the topsoil was stripped, soil decompaction shall be conducted prior to topsoil replacement.

The fish and wildlife habitat mitigation policy of the Oregon Department of Fish and Wildlife requires or recommends mitigation for losses of fish and wildlife habitat resulting from development actions. Whether it is a requirement or a recommendation depends on the habitat protection and mitigation opportunities provided by specific statutes. Priority for mitigation actions is given to habitat for native fish and wildlife species. Mitigation actions for nonnative fish and wildlife species may not adversely affect habitat for native fish and wildlife.

- Departmental recommendations or requirements for mitigation are based on the following:
  - The location, physical and operational characteristics, and duration of the proposed development action.
  - The alternatives to the proposed development action.
  - The fish and wildlife species and habitats that will be affected by the proposed development action.
  - The nature, extent, and duration of impacts expected to result from the proposed development action.
- The Department may recommend or require the posting of a bond, or other financial instrument acceptable to the Department, to cover the cost of mitigation actions based on the nature, extent, and duration of the impact and/or the risk of the mitigation plan not achieving mitigation goals.
  - The Department may only use mitigation banks and payment to provide mitigation for habitat categories 2-6 (see below).
  - The amount of payment to provide mitigation will include, at a minimum, the cost of property acquisition, mitigation actions, maintenance, monitoring, and any other actions needed for the long-term protection and management of the mitigation site.
- The Department requires the submission of a mitigation plan, which includes:
  - Protocols and methods, and a reporting schedule for monitoring the effectiveness of mitigation measures. Performance measures include success criteria and long-term protection and management provisions
- The project proponent is responsible for the expenses of developing, evaluating, and implementing the mitigation plan and monitoring the mitigation site.

To issue a site certificate, the Council must find that the design, construction, operation and retirement of the facility, taking into account mitigation, are consistent with the fish and wildlife habitat mitigation goals and standards.

All Habitat Category mitigation strategies must first seek to avoid impacts through alternatives to the proposed development action. If that does not work, then the following mitigation strategies will be pursued:

<u>Habitat Category 1</u>: Irreplaceable, essential habitat for a fish or wildlife species, population, or a unique assemblage of species and is limited on either a physiographic province or site-specific basis, depending on the individual species, population or unique assemblage.
MITIGATION = no loss of either habitat quantity or quality, requiring:

- No authorization of the proposed development action if impacts cannot be avoided.

<u>Habitat Category 2</u>: Essential habitat for a fish or wildlife species, population, or a unique assemblage of species and is limited on either a physiographic province or site-specific basis, depending on the individual species, population, or unique assemblage.
MITIGATION = no net loss of either habitat quantity or quality, and the provision of a net benefit of habitat quantity or quality, requiring:

- In-kind, in-proximity habitat mitigation to achieve no net loss of either predevelopment habitat quantity or quality. In addition, a net benefit of habitat quantity or quality must be provided.

- If neither of the above can be achieved, the Department shall recommend against or shall not authorize the proposed development action.

Habitat Category 3: Essential habitat for fish and wildlife, or important habitat for fish and wildlife that is limited either on a physiographic province or site-specific basis, depending on the individual species or population.

Habitat Category 4: Important habitat for fish and wildlife species.
MITIGATION = no net loss of either habitat quantity or quality.
- In-kind, in-proximity habitat mitigation to achieve no net loss of either predevelopment habitat quantity or quality. Habitat Category 4 also includes out-of-kind and off-proximity habitats.
- If neither of the above can be achieved, the Department shall recommend against or shall not authorize the proposed development action.

Habitat Category 5: Habitat for fish and wildlife having high potential to become either essential or important.
MITIGATION = provide a net benefit in habitat quality or quantity.
- Actions that contribute to essential or important habitat.
- If neither of the above can be achieved, the Department shall recommend against or shall not authorize the proposed development action.

Habitat Category 6: Habitat has low potential to become essential or important for fish and wildlife.
MITIGATION = to minimize impacts.
- The Department shall recommend or require actions that minimize direct habitat loss and avoid impacts to off-site habitat.

South Dakota Bat Working Group & South Dakota Game, Fish and Parks: Siting Guidelines for Wind Power Projects in South Dakota

Date Established:

Location: Entire state

Contact: Alyssa Kiesow, 605-773-2742

See: http://www.sdgfp.info/wildlife/Diversity/windpower.htm

The guidelines outlined in this document are neither mandates nor regulations. They have been compiled and developed to encourage developers to select potential wind sites using a process that is acceptable to all stakeholders, to protect South Dakota's rare and unique areas, to minimize deleterious effects to wildlife, to help provide information to all involved and interested parties, and to promote a responsible, guided, uniform approach to the siting of wind power projects in South Dakota.

Design-Stage Mitigation
- Use biological and environmental experts to conduct a preliminary biological reconnaissance of the likely site area.
- Involve wildlife agency personnel, universities, and local environmental and natural resource groups and agencies; their involvement will provide resource information as well as minimize potential conflicts.
- Situate turbines so they do not interfere with important wildlife movement corridors and staging areas.
- Avoid large, intact areas of native vegetation.

- Avoid lattice-designed towers or other designs providing perches for avian predators.
- Develop a stringent plan for preventing the introduction or establishment of nonnative or invasive flora.
- Consider turbine designs.

Construction-Stage Mitigation

- Bury power lines and/or place turbines near existing transmission lines and substations.
- Minimize the number of roads and fences.
- Consider the timing of construction and maintenance activities (including mowing). Avoid construction and maintenance activities during breeding season (April to July) and, if possible, during migrations (April to June and August to October).

Operational-Stage Mitigation

- Mitigate for habitat loss through ecological restoration, long-term management agreements, conservation easements, or fee title acquisitions.
- Address potential adverse affects of turbine warning lights on migrating birds and bats.

Vermont Fish and Wildlife Department: ***DRAFT*** Guidelines for the Evaluation and Mitigation of Impacts to Wildlife Associated with Wind Energy Development in Vermont

Date Established: April 20, 2006

Location: Entire state

Contact: Julie Moore, 802-241-3687

See: http://www.energy.ca.gov/renewables/06-OII-1/documents/other_guidelines/VERMONT_GUIDELINES_2006-04.PDF

In general, habitat disturbance should be minimized, as well as the risk of collision mortality for both resident and migratory bird and bat species. In addition, permittees should be required to establish an escrow fund to support the necessary post-construction monitoring.

Design-Stage Mitigation

- The applicant should establish the presence or absence of different wildlife species and significant habitats, well in advance of any construction activities, so that appropriate mitigation and avoidance practices can be used.
- Studies need to be completed during breeding and migratory seasons.
- The Department will review all survey results to determine if the project will result in undue adverse impacts,[8] and may seek revisions to the project.

Construction-Stage Mitigation

- Construction activities should be scheduled to avoid important periods of wildlife courtship, breeding, and nesting.
    - o Any clearing of montane spruce-fir must take place outside the breeding period for Bicknell’s Thrush.

[8] Fatality rate exceeds the national average (2.3 birds/turbine/year and 3.4 bats/turbine/year) or some of the species affected are considered threatened or endangered by the state or federal government.

    - Construction activities within ¼ mile of significant black bear hard mast habitat or spring feeding areas should take place outside the feeding periods September 1–November 21 and May 1–July 15.
- Noise-reduction devices should be maintained in good working order on vehicles and construction equipment.

Operation-Stage Mitigation

- Habitat restoration activities should be initiated as soon as possible after construction is complete.
- A minimum of three years of rigorous post-construction bird and bat mortality surveys are necessary for any utility-scale wind project in Vermont.
    - Monitoring is to be conducted from April 15 to October 31.
- If a project is considered to have undue adverse impacts, mitigation measures will be required that may include the following:
    - Modified Operations – additional monitoring or research, technological improvements, adjustment of operations during periods of highest risk, or suspension of operation during periods of highest risk.
    - Modified Lighting – alternative aircraft warning lighting, reduction in number of lit turbines, altering the arrangement of lights, using LED fixtures, or providing baffling around the lights.
    - On-site Habitat Management – modifying the type or extent of vegetation cover, forest openings, perching and nesting sites, or cover for prey species.
    - Habitat Protection – compensatory mitigation measures such as protection or enhancement of wildlife habitat.

Wisconsin Department of Natural Resources: Wind Farm Siting Guidance

Date Established: August 31, 2005

Contact: Steve Ugoretz, 608-266-6673

See: http://www.dnr.state.wi.us/org/es/science/energy/wind/studies.htm

A baseline wildlife evaluation should be conducted for each site under serious consideration for wind farm development. To allow comparison with other studies, this evaluation should follow accepted standard protocols for wind farm evaluations (such as the NWCC study guidelines). If the U.S. Fish and Wildlife Service guidelines are used, they should also incorporate Wisconsin Department of Natural Resources (DNR) considerations.

Design-Stage Mitigation

- Bird and bat use and interactions with wind turbines and supporting facilities should be monitored for an adequate period (at least two years is recommended) after installation, using accepted standard methods. This should be done for the first wind farms in any ecological region of the state.
    - If no problems are determined by the DNR's evaluation of the results, it is likely that later installations with similar characteristics will not require as much detailed study as the initial wind farms.
- Mitigation measures proven to minimize collisions and mortality should be designed into the wind farm.
- An adaptive management approach to planning, design, construction, and operations is highly recommended.

Construction-Stage Mitigation

- Placing electric lines underground is highly recommended.
- The use of perch guards on above-ground poles and other APLIC-endorsed technologies is recommended.

Federal Policies and Guidelines

Bureau of Land Management – Programmatic Environmental Impact Statement on Wind Energy Development on BLM-Administered Lands in the Western United States

Date Established:	June 2005
Location:	All wind energy development projects on BLM-administered lands
See:	https://www.eh.doe.gov/nepa/otheragency/fes0511/index.html

The BLM proposes the following best management practices (BMPs) be applied to all wind energy development projects:

Design-Stage Mitigation

- The area disturbed by installation of met towers shall be kept to a minimum.
- Individual towers shall not be located in sensitive habitats or in areas where ecological resources known to be sensitive to human activities are present.
- Installation of towers shall be scheduled to avoid disruption of wildlife reproductive activities or other important behaviors.
- Existing roads shall be used to the maximum extent feasible.
- Avian and bat use of the project area should be evaluated using rigorous survey methods.
- Turbines shall be configured to avoid landscape features known to attract raptors.
- Disturbance to any population of federally listed plant species is prohibited.
- A habitat restoration plan shall be developed to avoid, minimize, or mitigate negative impacts on vulnerable wildlife while maintaining or enhancing habitat values for other species, including revegetation, soil stabilization, and erosion-reduction measures.
- Procedures shall be developed to mitigate potential impacts to special status species.
- Locations heavily utilized by migratory birds and bats should be avoided, especially migration corridors or known flight paths, raptor nest sites, and areas used by bats as colonial hibernation, breeding, and maternity/nursery colonies, if studies show that they would pose a high risk to species of concern.
- Facilities shall be designed to discourage their use as perching or nesting substrates for birds.
- Operators shall develop a plan to control noxious weeds and invasive species.
- Habitat disturbance should be minimized by locating facilities in previously disturbed areas.
- Projects should not be located in areas with a high incidence of fog and mist.
- The use of sodium vapor lights should be minimized or avoided.

Construction-Stage Mitigation

- The area disturbed by construction and operation will be kept to a minimum.
- Topsoil from all excavations and construction activities shall be salvaged and reapplied during reclamation, along with weed-free native grasses, forbs, and shrubs.
- Guy wires on permanent towers shall be avoided.
- Habitat restoration will begin as soon as possible after the completion of construction.

- Access roads should be located to follow natural contours of the topography and minimize side hill cuts, and they should minimize stream crossings.
- The creation of, or increase in, the amount of edge habitat between natural habitats and disturbed lands should be minimized.
- Stream crossing should be designed to provide in-stream conditions that allow for and maintain the uninterrupted movement and safe passage of fish.
- Construction activities should be scheduled to avoid important periods of wildlife courtship, breeding, nesting, lambing, or calving.
- Buffer zones should be established around raptor nests, bat roosts, and biota and habitats of concern, if facilities are believed to pose a significant risk to avian or bat species of concern.
- Noise-reduction devices should be maintained in good working order on vehicles and construction equipment.
- Explosives should be used only within specified times and at specified distances from sensitive wildlife or surface waters.
- Dust abatement techniques should be used on unpaved, unvegetated surfaces.
- Construction materials and stockpiled soil should be covered if they are a source of fugitive dust.
- Refueling should occur in a designated fueling area that includes a temporary berm to limit the spread of any spill.
- Drip pans should be used.
- Construction equipment should be visually inspected to identify and remove seeds that may be adhering to tires and other surfaces.
- Fill materials that originate from areas with known invasive vegetation problems should not be used.
- Certified weed-free mulch should be used when stabilizing areas of disturbed soil.
- Pesticide use should be limited to nonpersistent, immobile pesticides.

Operation-Stage Mitigation

- Measures to reduce raptors' use of the project site shall be considered, including minimization of road cuts and maintenance of either no vegetation or nonattractive plant species around the turbines.
- All unnecessary lighting should be turned off at night to limit attracting migratory birds.
- Higher-height vegetation should be encouraged along transmission corridors to minimize foraging in these areas by raptors, to the extent that local conditions will support this vegetation.

Federal Aviation Administration Advisory Circular: Obstruction Marking and Lighting, Chapter 13

Date Established: February 1, 2007

Location: Any terrestrial location within the United States

Contact: Scott Larwood, 503-752-7479; smlarwood@ucdavis.edu

Wind turbine farms are defined as a wind turbine development that contains more than three turbines that measure more than 200 feet high above ground level. The recommended marking and lighting of wind turbines is intended to provide day and night conspicuity and to assist pilots in identifying and avoiding these structures. There was no mention of the effects of these guidelines on wildlife, and no sign of plans to research this topic in the future.

Operational-Stage Lighting Requirements

- Maximum separation gap between lights along a row $\leq$0.5 miles.

- Omission of lighting within clusters (unless turbines are taller than peripheral units); lighting of end turbines or end rows necessary.
- Synchronization of lights for entire project.
- No daytime lighting necessary if white or light off-white paint is used. Daytime lighting should be used if darker paint is used.
- Omit steady burning lights; use of Federal Aviation Administration (FAA) L-864 aviation red-colored flashing lights is recommended for nighttime lighting (and found to be most effective); however, white strobe fixtures (FAA L-865) may be used in lieu of L-864 lights if they are used alone without any red lights and positioned in the same manner as red flashing lights would be.
- Light fixtures should be placed as high as possible on the turbine's nacelle, so as to be visible from 360 degrees.
- Turbines that protrude from the general limits of the turbine farm should be lit.
- High concentrations of lights should be avoided.

United States Fish and Wildlife Service: Service Interim Guidance on Avoiding and Minimizing Wildlife Impacts from Wind Turbines

Date Established: July 10, 2003

Location: Any terrestrial location within the United States

Contact: For general use of guidance, and contacts with Ecological Services Field Offices, contact: David Stout, Chief, Division of Habitat and Resource Conservation, 703-358-2555
For avian-wind issues, research protocols, and technical issues contact:
Robert Blohm, Chief, Division of Migratory Bird Management, 703-358-1714

See: http://www.fws.gov/habitatconservation/wind.pdf

The Potential Impact Index (PII) represents a first-cut analysis of the suitability of a site proposed for development by estimating wildlife species' use of the site. The PII is derived from the results of three checklists: physical attributes, species occurrence and status, and ecological attractiveness. The PII ranking is intended to guide developers by estimating the level of impact that may be expected if a site is developed.

Design-Stage Mitigation

- Predevelopment evaluations should be conducted by a team that includes federal and/or state agency wildlife professionals with no vested interest (e.g., monetary or personal business gain) in the sites selected. Teams may also include academic and industry wildlife professionals, as available. Any site evaluations conducted by teams that do not include federal and/or state agency wildlife professionals will not be considered valid evaluations by the Service.
- Avoid placing turbines or towers in documented locations of any species of wildlife, fish, or plant protected under the Federal Endangered Species Act, or where species reside that are sensitive to human disturbance (e.g., prairie grouse).
- Avoid locating turbines or towers in known local bird and bat migration pathways or in areas where birds and bats are highly concentrated, unless the mortality risk is low.
- Avoid known daily movement flyways and areas with a high incidence of fog, mist, low cloud ceilings, and low visibility.
- Configure turbines to avoid potential avian mortality where feasible (e.g., group turbines rather than spreading them out widely, orient rows of turbines parallel to known bird movements).
- Avoid fragmenting large contiguous tracts of wildlife habitat.
- Where practical, place turbines on disturbed habitats.

- Reduce the availability of carrion by practicing responsible animal husbandry.
- Develop a habitat restoration plan for the proposed site that avoids or minimizes negative impacts on vulnerable wildlife while maintaining or enhancing habitat values for other species.
- Collocate the communications equipment on an existing communication tower or other structure. If this is not feasible, construct towers no more than 199 feet above ground level, using construction techniques that do not require guy wires (e.g., monopole), if possible.

Construction-Stage Monitoring

- Road access and fencing should be minimized
- If significant numbers of breeding, feeding, or roosting birds are known to habitually use the proposed tower construction area, relocation to an alternate site should be recommended. If this is not an option, seasonal restrictions on construction may be advisable to avoid disturbance during periods of high activity among birds.
- Minimize roads, fences, and other infrastructure. Infrastructure should be capable of withstanding periodic burning of vegetation.

Operational-Stage Monitoring

- The Service recommends that all sites be monitored for impacts on wildlife after construction is completed; monitoring is not expected to exceed 3 years.
- Where feasible, turbines should be shut down at times when birds are highly concentrated.
- Daytime visual markers should be on any guy wires used to support towers that are located in known raptor or waterbird concentration areas or daily movement routes, or in major diurnal migratory bird movement routes or stopover sites.
- Where feasible, power lines should be underground or if on the surface, should be insulated, shielded wire.
- The minimum amount of pilot warning and obstruction avoidance lighting required by the FAA should be used.
    - The use of solid red or pulsating red warning lights at night should be avoided.
    - White strobe lights should be used at night; the minimum number, minimum intensity, and minimum number of flashes per minute allowable by FAA.
    - Security lighting for on-ground facilities and equipment should be down-shielded to keep light within the boundaries of the site.
- When the height of the rotor-swept area poses a high risk for wildlife, the tower height should be adjusted, where feasible.
- Older turbines that have been shown to cause high rates of mortality should be retrofitted or relocated.

A Federal Advisory Committee Act (FACA) process and call for committee nominations were published in the Federal Register on March 13, 2007, with the receipt of nominations accepted through April 12, 2007. A FACA committee intended to review the Service's interim guidelines is anticipated to begin meeting later in 2007.

United States Forest Service: ***DRAFT*** 36 CFR 251, Special Use Permits

Date Established: Currently being drafted; expected release date is fall 2006

Location: Any development taking place on Forest Service land

Contact: Kristen Nelson, (202) 205-1406, kristennelson@fs.fed.us

- The proposed land use must be consistent with standards and guidelines in the applicable forest land and resource management plan prepared under the National Forest Management Act (NFMA) and 36 CFR part 219: National Forest System Land and Resource Management Planning (219.20, ecological sustainability, is below).
    - The planning process must include the development and analysis of information regarding ecological components at a variety of spatial and temporal scales, as determined by the responsible official.
    - Plan decisions affecting ecosystem or species diversity must provide for maintenance or restoration of the characteristics of ecosystem compositions and structure within the range of variability that would be expected to occur under natural disturbance regimes in accordance with paragraphs (b)(1)(i) through (v) of this section.
- The proposed activity cannot materially impact the characteristics or functions of the environmentally sensitive resources or lands identified in Forest Service Handbook 1909.15, chapter 30.

Note: To date, only two wind power projects have occurred on forest service lands—one in Vermont, the other in Michigan. The Forest Service is in the process of revising current permitting guidelines to include issues specific to wind power. The updated guidelines were not available as of 2/15/07.

International Policies and Guidelines

Australian Wind Energy Association: Best Practice Guidelines for Wind Energy Projects

Date Established: March 2002

Location: Australia

See: www.auswea.com.au

Developers must submit to development approval authorities documentation demonstrating how the design has taken into account the need to mitigate potential impacts, and how mitigation measures will be implemented during construction and operation. The development application must include details of impact mitigation measures incorporated into the design, construction, and operation of the development to address regulatory or legislative requirements and to meet general best practice environmental management targets.

Design-Stage Mitigation

- Avoid development sites and turbine sites with high bird usage.[9]
- Locate turbines and roads well away from wetlands and other bird-rich habitats
- Consider widening the spacing between turbines to permit movement of birds around and between the turbines.
- Design roads and tracks to avoid changes to surface water runoff and to not cause erosion.
- Route power cable to avoid the need to remove native vegetation and habitat
- Ensure that power cables are not placed across regular bird flight paths.
- Locate the switchyard to avoid areas of native vegetation or habitat.

Construction-Stage Mitigation

[9] A radius of up to 30 km from the potential site should be used when gathering information on flora and fauna present within the site.

- Monitor for any downslope deposition of material from construction areas, and ensure that weeds are controlled and areas are revegetated.
- Implement strict speed limits where tracks are within 200 meters of wetlands or other habitats where birds could be disturbed.
- Locate storage areas and vehicle standing areas away from native vegetation and habitat and at least 200 meters from wetlands.
- Avoid building roads and placing turbines on areas of native vegetation and fauna habitat
- Avoid construction during the most sensitive times of the year, and/or stage construction work to ensure adequate distances between work and sensitive habitats.

Operation-Stage Mitigation

- Avoid human disturbances to any wetlands or other habitats that hold bird groups potentially vulnerable to collision.
- Undertake an extensive rabbit control program to minimize the attractiveness of the site to birds of prey.
- Clear away sheep and cattle carcasses rapidly.
- Provide alternative habitat off site to attract at-risk birds from near turbines.
- Monitor and repair any erosion and reduce surface water pooling or concentration of runoff.
- Do not illuminate wind turbines as this can attract insects and confuse night-flying birds.
- Bird and bat utilization studies should be continued for at least 2 years after operation begins.

Environment Canada, Canadian Wildlife Service: Wind Turbines and Birds – A Guidance Document for Environmental Assessment

Date Established: July 2005

Location: Canada

Contact: 819-997-1095; cws-scf@ec.gc.ca,

See[10]: http://www.energy.ca.gov/renewables/06-OII-1/documents/other_guidelines/CANADIAN_GUIDELINES_2005.PDF

These guidelines are intended to be used in consultation with regional Canadian Wildlife Service biologists and Environment Canada (EA) experts. The guide should not be regarded as exhaustive or restrictive, and should serve as the starting point for discussions with EA staff on each project.

These guidelines include a level of concern matrix (low to very high) based on site sensitivity and facility size: very high concern (2+ years of baseline data and 3+ years of follow-up required), high concern (comprehensive surveys to gather baseline and 2+ years of follow-up), medium concern (basic baseline information surveys and 2-year basic follow-up), and low concern (minimum amount of baseline information and 1-year follow-up).

Design-Stage Mitigation

- Preliminary information must be gathered to determine site sensitivity.
- Any turbine taller than 150 meters in height should be subject to closer scrutiny, especially for sites close to arrival and departure sites of nocturnal migrants, on mountain tops or in foggy areas.

[10] Since the drafting of this document, Environment Canada and the Canadian Wildlife Service finalized their guidance document in April 2007. The April 2007 version can be downloaded at http://www.cws-scf.ec.gc.ca/publications/eval/index_e.cfm.

- A smaller number of larger turbines may pose less of a risk to birds than a larger number of smaller turbines.
- Tubular and met towers without guy wires are recommended in commercial wind energy projects.
- Configuration should avoid creating barriers to bird movement. Spacing between the turbines should be greater than 200 meters to avoid inhibiting movement.
- Perching opportunities such as lattice towers, guy wires, hydro poles or other structures should be reduced or removed whenever possible.

Construction-Stage Mitigation

- Focus intense construction outside the core breeding and migration seasons to reduce disturbance to birds.
- Keep the number of access roads constructed to a minimum. When roads need to be constructed, minimize habitat destruction, fragmentation, and disturbance of breeding and wintering grounds as much as possible.
- Bury all lines, when possible. When that is not possible, consider the following mitigation techniques:
    - Line visibility should be increased by using bird flappers or other bird flight diverters and by increasing the size of the wire
    - Lines should not be built over water or other areas with high concentrations of birds.
    - Small lightning shield wires should be eliminated where lines cross wetlands and migration routes.
    - Lines should be made parallel to the direction of prevailing winds.
    - Place lines crossing rivers at oblique rather than right angles.
    - Place lines as close to trees as practical and below the level of tree tops, wherever possible.
- All wastes should be collected and disposed of.

Operation-Stage Mitigation

- Access roads that are not used after construction should be allowed to revegetate (with native and not invasive plant species).
- Lighting should be used only where required by Transport Canada regulations. Use strobe lights only, with the minimum number of flashes per minute and the briefest flash duration allowable. Avoid steady-burning or other bright lights such as sodium vapor or spotlights on turbines and other structures.
- Take measures to minimize motion smear.
- If a moving blade appears to be causing high bird mortality along a particular flight path, the turbine can be shut down, which may reduce the number of direct hits.
- If mortality is due to attraction to lights, other lighting options may need to be considered. It may be possible to reduce the amount of lighting, or even to turn lights off during periods of high risk.
- If there are high densities of raptors in the area, implement a prey control program and/or remove other raptor food sources at the site.
- In agricultural sites, the area under the turbines can be planted in a crop that is less attractive to birds.
- If grassland birds are being killed during aerial displays, it may be possible to offset losses in productivity if hay cutting can be delayed at adjacent sites.

When wind farms are found to cause an unacceptable number of bird kills, and various mitigation strategies prove unsuccessful, other options should be considered, such as encouraging the proponent to purchase and then protect a parcel of land of similar size and habitat type. Other “last-resort” methods include decommissioning or moving problem turbines to a new location.

Department for Environment, Food and Rural Affairs: Nature Conservation Guidance on Offshore Windfarm Development (Version 1.9)

Date Established: March 2005

Location: England

See: http://www.defra.gov.uk/WILDLIFE-COUNTRYSIDE/ewd/windfarms/windfarmguidance.pdf

This document has been produced by the Department for Environment, Food and Rural Affairs to provide developers with a greater understanding of the potential nature conservation impacts of offshore wind farms and the steps they are legally obliged to follow to comply with the requirements of the European Commission's Habitats and Wild Birds Directives, including steps to avoid harming the Natura 2000 network.

Design-Level Mitigation

- The whole wind farm area plus surrounding buffer of 1-2 kilometers should be surveyed; observers should be trained by ornithologists.
- Survey data from at least 2 years are necessary, and more survey data (preferably 3 years) will be required in circumstances where important concentrations of birds occur.
- Avoid areas with concentrations of important conservation species or important migratory paths.
- Ensure that siting and design are appropriate in terms of orientation, spacing, and location:
    - Allow wide corridors between clusters of turbines, with a line formation parallel to the main flight direction.
    - Lines of turbines should be broken up.
- Construction of larger turbines may provide greater visibility.

Construction-Level Mitigation

- Time construction work and methods to avoid critical periods such as molting.
- Use high contrast patterns on turbine blades to reduce motion smear.
- Postpone maintenance of turbine(s) during critical periods.
- Employ methods of chemical use that minimize the release of polluting materials into the water column and use only chemicals selected from the List of Notified Chemicals.
- Do not undertake construction between December 16 and March, to minimize impacts on the over-wintering common scoter.
- Cable laying along the beach from October to April should avoid the sensitive period 2 hours either side of high water for over-wintering wader species. Cable laying should also occur outside of the molting period for the common scoter (July to September).
- Piling work for turbine foundations should only be carried out between high tide minus 3 hours and high water plus 3 hours to minimize disturbance to little terns.
- No work should be carried out near nesting and breeding areas between May 1 and August 1.

Operation-Stage Mitigation

- Use intermittent rather than continuous navigation lighting, particularly strobing lights. Clusters of turbines will reduce the single point source and provide a more diffuse light distribution. Avoid floodlighting of turbines, particularly in periods of bad weather. White lights are preferable to red.
- Surveys should be carried out for at least 3 years following construction, and some monitoring may be required for the lifetime of the development.

Other Policies and Guidelines

American Birding Conservancy: Wind Energy Policy

Date Established: October 12, 2004

See: http://www.abcbirds.org/policy/windpolicy.htm

The American Birding Conservancy (ABC) supports alternative energy sources, including wind power. However, ABC emphasizes that before approval and construction of new wind energy projects proceeds, potential risks to birds and bats should be evaluated through site analyses, including assessments of the abundance of birds and bats, the timing and magnitude of migrations, and habitat use patterns. Wind energy project location, design, operation, and lighting should be carefully evaluated to prevent, or at least minimize, bird and bat mortality and adverse impacts through habitat fragmentation, disturbance, and site avoidance.

Design-Stage Mitigation

- Compile a minimum of 1 year of monitoring data; 2 years of data are suggested. Seasonal observations and detailed evaluation of the site should be conducted by qualified professionals with no vested interest in the project.
- Wind energy project location, design, operation, and lighting should be carefully evaluated to prevent, or at least minimize, bird and bat mortality and adverse impacts through habitat fragmentation, disturbance, and site avoidance.
- Sites requiring special scrutiny include those that are frequented by federally listed endangered species of birds and bats, are in known bird migration pathways, have high concentrations of birds, and have landscape features known to attract large numbers of raptors.
- Wind turbines, associated communication towers, and permanent met towers should be monopoles, not of lattice construction, and use no guy wires.

Construction-Stage Mitigation

- All connecting power transmission lines should be underground; if above-ground lines are required, the lines and poles should comply with APLIC standards.
- When disturbance is temporary, such as from construction impacts, disturbed areas should be fully reclaimed to approximate the same habitat functions for wildlife that existed before the disturbance.

Operational-Stage Mitigation

- The number of turbines that are lit should be minimized.
- Lit turbines should use only simultaneously pulsing white or red strobes, preferably at 20 pulses per minute.
- If significant mortality rates cannot be resolved, then turbines should be shut down during periods of peak risk to birds or bats.
- Two years of monitoring data should be collected after construction is complete. If legitimate mortality concerns arise, then studies should continue until monitoring demonstrates that concerns have been resolved.

Audubon Washington: Wind Power Policy for Washington State

Date Established: September 23, 2002

Location: State of Washington

Contact: Nina Carter, Executive Director Audubon Washington, 360-786-8020 x208

See: http://www.audubon.org/chapter/wa/wa/DOCs/Sept2002_WindPowerPolicy_ExecSummary.doc

The following policy statement applies to the siting, development, operation, and monitoring of wind power generation facilities. Although wind power generation generally has less detrimental impact than other forms have, this focus on wind power results from recent, high-profile developments in Washington. Furthermore, because the construction and operation of wind turbines has immediate, quantifiable impacts on birds, the public looks to Audubon for guidance on reducing or mitigating these impacts. This policy on wind power facilities is part of a more comprehensive energy policy, the remainder of which will be developed at a later date.

Design-Stage Mitigation

- At least 2 years of baseline monitoring of bird use of the project area and a surrounding buffer zone need to be completed. This requirement may be reduced to 1 year if monitoring is conducted using radar systems such as BIRDRAD.
    - Monitoring activities should span all seasons and be carried out during the night as well as during daylight hours, be conducted by professional ornithologists, and follow standard protocols.[11]
- Designs need to include technologies that are known to reduce detrimental impacts on birds (e.g., tubular towers, absence of guy wires, absence of lights that may attract night-migrating birds).
- A contingency plan must be established to be implemented when operational monitoring shows detrimental effects to birds and/or bird habitat.
- Wind power developers should encourage the involvement of local Audubon chapters and the environmental community during the initial project development phase.

Operational-Stage Mitigation

- Maximum speed of turbines is less than 30 rpm.
- Environmental monitoring must be conducted to assess the level of bird mortality caused by collisions, and it must follow standard protocols.
- Monitoring reports and data must be submitted quarterly to the Washington State Energy Facility Site Evaluation Council and the Washington Department of Fish and Wildlife for the first 2 years following commencement of operations and annually thereafter.

Clean Energy States Alliance: Model State Guidance Document Governing Avian and Bat Impacts from Wind Facilities

Date Established: October 2006

Location: State and federal agencies

[11] If the environmental impact study, site ranking process, or adaptive management results reveal areas with low bird density or use, or areas where substantial detrimental impacts to birds would not likely occur, these requirements could be reduced or waived.

Contact: Mark Sinclair, Deputy Director, Clean Energy States Alliance, 802-223-2554; msinclair@cleanegroup.org

The following “model” guidelines are recommendations for consideration by state and federal agencies to use in avoiding or minimizing impacts to avian and bat species from the construction and operation of wind-energy facilities. The purpose of the proposed guidelines is to outline the types and extent of the information needed to adequately identify, assess, mitigate, and monitor the potential adverse effects of wind energy projects on birds and bats. These guidelines are intended to be used in consultation with state wildlife biologists. A technical advisory committee should be established to review monitoring results and make suggestions to the permitting agency regarding the need to adjust mitigation and monitoring requirements.

Design-Stage Mitigation

- At least 1 year of preassessment monitoring should be conducted for micrositing (and more in areas with particularly high uncertainty about level of impacts and/or high site sensitivity). Survey methods used should be based on the objectives of the study, the species of interest, and the landscape. Studies should be conducted as seasonally and spatially appropriate; the intensity and frequency of monitoring is determined in consultation with the state wildlife agency.
- Avoid locations identified to have the potential for high risk to birds or bats or that are occupied by species of particular concern.
- Site projects on disturbed lands where possible.
- Avoid using or degrading high habitat areas.
- Avoid areas with high concentrations of birds through micrositing alternatives.
- Use tubular towers (as opposed to lattice towers) or best available technology to reduce the ability of birds to perch and the risk of collision.
- Turbine configurations should avoid creating barriers to bird movement, to the extent possible.
- Constraint mapping should be undertaken to assess where roads should or should not be located.

Construction-Stage Mitigation

- Minimize road cuts and the number of access roads.
- Power lines in open or high-elevation exposed locations should be buried, where possible. Overhead lines may be acceptable if they follow tree lines or are otherwise screened from potential collisions.
- Habitat destruction and fragmentation and disturbance of breeding, staging, and wintering birds should be minimized, to the extent possible.

Operational-Stage Mitigation

- Use the minimum number of pilot warnings and obstruction avoidance lighting recommended by the FAA. No high-intensity lighting should be permanently installed. Site lighting generally should be turned off unless needed for specific tasks.
- A decommissioning condition should be established for wind projects that require the creation of a plan and fund for the removal of the turbines and infrastructure when they cease operation, and for restoration of the site to approximate preproject conditions.
- Postconstruction operations monitoring is recommended at sites that support high densities of native breeding birds, concentrations of migrating birds, or threatened and endangered species. When the risk of fatalities is of concern, or considered likely for a species of concern, mortality surveys should be recommended for 1-2 years (and more if significant mortality concerns are identified) at a fairly modest level of sampling and intensity to determine possible effects.
- Determinations of carcass losses, scavenging trails, and searcher efficiency trials should be conducted in order to assess fatality rates as accurately as possible.

Annotated Bibliography

The literature included in this section was selected for its relevance to this mitigation study. Selections were limited to studies that examine the effects of specific changes to wind farm characteristics on birds and bats, as well as those on general habitat mitigation that appeared applicable to wind development. Studies were deemed relevant that examined one of several areas:

- The effectiveness of mitigation strategies on wildlife
- Avian/bat behavior studies conducted at wind sites along with management suggestions
- Studies comparing the effects of wind site alterations on birds or bats
- Studies that examined mitigation strategies suggested in policies and guidelines
- Studies mentioned by experts in the field.

Research was not included that focused on avian or bat ecology, searcher efficiency rates, scavenging rates, avian or bat mortality estimates, study design, classes of wildlife other than birds or bats, and modeling.

Referenced mitigation studies were representative of the current body of literature, and when scientific opinions differed, numerous studies were included. In general, selections were made from recent literature (published since 1995), but in some cases this was not possible. Some earlier literature was included if it was cited repeatedly within other studies because of its historical foundations. Previously conducted literature reviews (e.g., Appendix G by Orloff in Erickson et al. 1999) were used occasionally because of time constraints and difficulties in obtaining original papers; these are marked by a footnote within the annotated bibliography.

The literature is categorized according to the primary topic of the mitigation effort and research (e.g., location of the turbine on the site vs. habitat alterations). The bold type at the end of each citation indicates the type of publication (e.g., report, journal) as well as whether or not a peer review process was used (based on information gathered from the Acknowledgements section). Remaining categories include literature reviews and current research that has not yet been published. See also Appendixes B and C.

Turbine Location/Turbine Type

1. Anderson, R., N. Neuman, et al. (2004). *Avian Monitoring and Risk Assessment at the Tehachapi Pass Wind Resource Area.* Prepared for National Renewable Energy Laboratory: 1-102.

This study was conducted to examine bird utilization, fatality rates, and collision risk indices between bird species, turbine types and turbine locations within the Tehachapi Pass WRA. Research was conducted between October 1996 and May 1998. Results indicated very few differences in the effects of turbine characteristics. There was a pattern of higher fatality rates at larger turbines, but when the fatality rates and collision risks were adjusted by rotor swept area (RSA) or turbine density, those differences were reduced, and in some cases the fatality rates for smaller turbines were higher than those for the larger turbines, on an RSA equivalence basis. Tubular towers were found to have lower estimated fatality rates than lattice towers in general, but the true cause of the difference cannot be determined because the two types of turbines were in different geographic locations. Results from this study and others conducted at the Altamont suggest that tower type is not likely to be related to collision risk where perch sites are abundant; however, the data indicate a higher rate of perching behavior on small and large lattice turbines, and on small tubular turbines compared with tall tubular turbines. Most perching occurs on turbines that are not operating. Structures such as lattice turbines and overhead lines that provide perches could lead to higher mortality because of an increase in the use of sites. Recommendations include higher search

frequencies (e.g., monthly or twice monthly, at a minimum), a larger sample size (N=127, with 75 found on search plots), and searching entire turbine strings as opposed to individual ones when turbines within strings are closer together than two times the fatality plot search radius. **Report; review process used.**

2. Barrios, L., and A. Rodriguez (2004). "Behavioral and environmental correlates of soaring-bird mortality at on-shore wind turbines." *Journal of Applied Ecology* **41**: 72-81.

This study measured bird mortality, analyzed the factors that led birds to fly close to turbines, and proposed mitigation measures at two wind farms installed in the Straits of Gibraltar. Research was conducted between December 1993 and December 1994 at the wind farms, E3 and PESUR, which are located on hills and ridges composed of scrubland, rangeland, and forest habitat. Bird vulnerability and mortality were found to reflect a combination of site-specific, species-specific, and seasonal factors. Mortality was found to be much lower at E3 than at PESUR, as were risk indices (0.059 vs. 0.198, respectively). The frequency of risk situations at PESUR varied significantly with wind speed; the risk index was 0.343 between 4.6-8.5 m/s winds and decreased with increasing wind speed (0.037 in strong winds). Risk was observed to increase in autumn and winter. Mortality caused by turbines was higher than that caused by power lines, but it was not significantly associated with either structural attributes of wind farms (lattice vs. tubular) or visibility. The absence of thermals is believed to cause birds (specifically vultures) to use slopes for lift, and this could be a prominent factor in the high mortality rates observed. All species affected by the turbines were listed as threatened or vulnerable in Spain; thus, mitigation measures are necessary. Results indicate the most sensible approach is to suspend the operation of the small number of turbines that cause most deaths only under the wind speeds that lead to risk situations. A more general recommendation is that all new wind power facility projects should include a detailed study of bird behavior at the proposed construction site. **Journal; no mention of review process.**

3. Brown, W. M., R. C. Drewien, et al. (1985). *Mortality of Cranes and Waterfowl from Power Line Collisions in the San Luis Valley, Colorado*. 4th Crane Workshop, Grand Island, Nebraska, Platte River Whooping Crane Habitat Maintenance Trust.

The authors recommend that no new transmission lines be placed within two kilometers of traditional roost or feeding sites. The static wire (the nonconducting topmost wire on a power line used to minimize power outages from lightning strikes) is normally smaller than the conductors and appears to be the wire most often struck by birds in flight. Static wire removal is recommended whenever possible, but modification or better marking are preferred methods. **Unable to relocate study for review information.**

4. Erickson, W. P., G. D. Johnson, et al. (1999)*. Baseline Avian Use and Behavior at the CARES Wind Plant Site, Klickitat County, Washington.* Prepared for the National Renewable Energy Laboratory**:** 1-75.

This report summarizes the avian research conducted at the Columbia Wind Farm #1 in Klickitat County, Washington. This report documents only the preconstruction data collected because development of the site was indefinitely postponed and the field surveys were suspended at the end of one year. After one year of data collection, spatial use data indicated that avian use of the CARES study area tends to be concentrated near the rim edge, indicating that risk may be reduced by placing turbines away from the rim edge. High use of rim edges by raptors has also been documented at other sites. **Report; review process used.**

5. Hoover, S. (2002). *The Response of Red-tailed Hawks and Golden Eagles to Topographical Features, Weather, and Abundance of a Dominant Prey Species at the Altamont Pass Wind Resource Area, California*. Prepared for the National Renewable Energy Laboratory: 1-64.

The goals of this study were to determine which characteristics of the landscape influence hawk and eagle habitat selection within the Altamont Pass Wind Resource Area (WRA). The study period was June 9, 1999, to June 20, 2000; observations were conducted weekly. The variables showing the strongest relationship for red-tailed hawks (RTHA) were wind speed, wind direction, and slope aspect. There was a significant relationship between kiting or gliding activity and elevation; 90% of RTHA kiting occurred on only 3 of the 24 slopes in the steepest incline category and 14% of all mortalities found on 4% of the slopes. Kiting behavior was found to be used in high winds and was seen significantly more often at 11-50 m from the ground, the height of the rotating turbine blades. RTHA flight activity did not increase in areas with progressively higher squirrel density, suggesting that favorable wind currents have a stronger appeal because they make foraging more energy efficient. Golden eagles were noted as using narrow corridors that transect large hills, specifically ones that are oriented east to west with steep (>23% average grade) and tall (peak elevations of 170-205 m) hills located on the north and south sides. All 7 eagle fatalities occurred where these 'canyons' opened up onto the valley floor (Rugge 2001). Closing down the turbines that are constructed on valley plateaus or along the rim where the plateau meets the sloping hillsides is recommended. It is also recommended that turbines be powered down atop hazardous slopes (RTHA) and where high winds are perpendicular to the slope. This well-done study illustrates numerous significant relationships to support recommendations. **Report; review process used.**

6. Hoover, S. L., and M. L. Morrison (2005). "Behavior of red-tailed hawks in a wind turbine development." *Journal of Wildlife Management* **69**(1): 150-159.

Between June 1999 and June 2000, the flight behaviors of RTHA were recorded in relation to characteristics of the topography (e.g., slope aspect, elevation, and inclination) and to various weather variables (e.g., wind speed and direction). RTHA behavior and their use of slope aspect was found to differ according to wind speed; hawks perched or soared more often in low winds and showed kiting behavior in strong winds. Results indicate that red-tailed hawk behavior is strongly influenced by a combination of wind conditions and topography. Strong winds from the south-southwest resulted in kiting behavior on south-southwestern facing slopes with inclines greater than 20% and peak elevations greater than adjacent slopes. Because topographical features and weather variables have been shown to predict the strength and location of deflection updrafts necessary for kiting behavior, it is essential that a detailed site assessment and behavioral study be conducted to identify locations where the topographical/weather interaction may produce dangerous conditions for foraging RTHA and other raptors. Mitigation measures to decrease fatalities should be directed specifically to these areas and others fitting the general model. It is suggested that turbines be powered down at the top of these hazardous slopes when they pose the greatest danger, i.e., strong winds facing perpendicularly to the slope. No significant relationships were specifically mentioned within results to support management considerations. **Journal; review process used.**

7. Hunt, W.G. (2002). *Golden Eagles in a Perilous Landscape: Predicting the Effects of Mitigation for Wind Turbine Blade-Strike Mortality*. Prepared for the California Energy Commission**:** 1-72.

This study was initiated in June 1998 to provide information to the California Energy Commission's Public Interest Energy Research (PIER) Program before an extensive repowering project was carried out to replace approximately 1300 Type-12 turbines with larger turbines on tubular towers at a ratio of 7:1. The objectives of this study were to increase the number of radio-tagged eagles and to continue monitoring them to further understand demographics, track the net result of repowering, and explore other mitigation measures to reduce golden eagle mortality rates. Density comparisons of eagle relocations and fatalities in the two northern polygons, both of which contained relatively high numbers of relocations, suggested that the one containing Type-13 turbines was more lethal (19 mortalities) than that containing Type-28 turbines (2 mortalities). Reducing the number of Type-13s as part of the repowering would very likely benefit eagles, especially in areas where they concentrate. The turbines that caused lower mortality rates had blades higher off the ground, towers that were spread apart more widely, and tubular towers that offered little opportunity for perching. Other suggestions include reducing ground squirrel density around the turbines through live-trapping and relocation, a recommendation based on surveys indicating golden eagles use of high-density squirrel areas over low ones at a ratio of 7:1. **Report; reviewed by four referees (incl. Erickson, Strickland, and Manly).**

8. Johnson, G. D., M. K. Perlik, et al. (2004). "Bat activity, composition, and collision mortality at a large wind plant in Minnesota." *Wildlife Society Bulletin* **32**(4): 1278-1288.

Bat activity levels, species composition, and collision mortality were examined at a large wind plant in southwest Minnesota from June 15-September 15, 2001, and again in that period in 2002. Peak bat activity at turbines followed the same trend as bat mortality, occurring from mid-July through the end of August. It is believed that most bat mortality (151 individuals) involved migrating bats, because of the species involved in collision fatalities (hoary, eastern red, and silver-haired bats). There was no significant relationship between bat activity at turbines and the presence of lights or number of fatalities at turbines. Bat activity decreased with increasing distance from woodlands; however, this relationship may reflect only the high bat activity (>10 bat passes/night) recorded at a small number of turbines within 100 m of woodlands rather than a true relationship between bat activity as a function of distance from woodlands. **Journal; two reviewers (incl. R. Osborn).**

9. Osborn, R. G., C. D. Dieter, et al. (1998). "Bird flight characteristics near wind turbines in Minnesota." *American Midland Naturalist* **139**(1): 29-38.

This study was conducted at Buffalo Ridge Wind Resource Area (BRWRA), where the habitat consists of agricultural and CRP fields. Data suggests that birds avoid flying in areas with wind turbines. Most birds observed (75% in 1994; 70.2% in 1995) flew below blade height, with only 16% (1994) and 17.5% (1995) seen flying between 21-51 m. Birds seen flying through tower string often adjusted their flight patterns when turbine blades were rotating and often made no adjustments when turbine blades were not rotating, suggesting that birds could detect blade movement either by sight or sound (80% in 1994 & 74.8% in 1995 seen flying 31 m or further from turbine at time of sighting). The absence of raptor mortality at the site is believed to be the result of the small number of raptors frequenting the area and the tubular tower design which discourages perching and nesting on turbines. The availability of alternative perching sites is also believed to have reduced the attractiveness of wind turbines as perching sites for raptors at this location. 75% of passerine mortality occurred during migration periods. Baseline data noted as being essential for establishing initial abundance, migration patterns, identifying species of concern, and evaluating post-construction effects of turbines on bird populations. It is unclear how tower design conclusions were reached based on study design. **Journal; no mention of review process.**

10. Osborn, R. G., K. F. Higgins, et al. (2000). "Bird mortality associated with wind turbines at the Buffalo Ridge Wind Resource Area, Minnesota." *The American Midland Naturalist* **143**(1): 41-52.

The purpose of this research was to determine the degree of avian mortality resulting from collisions with wind turbines and to assess the influence of biases affecting our ability to detect avian mortality at Buffalo Ridge in Minnesota. Research occurred in 1994 and 1995 (1994 considered a pilot year & methodologies modified in 1995), and turbines were located in agricultural and Conservation Reserve Program (CRP) fields. Because of the small number of dead birds found (12l), it was not possible to determine if any particular species or group of birds is more susceptible to collisions with turbines. Observer efficiency was found not to differ by year or cover type, but to be influenced by the size of the bird. Consideration of potential impacts on avian communities before designing and siting of a facility may be a best first step to reduce mortality at wind power resource projects involving wind turbines (citing Nelson and Curry 1995). The recommendation is to avoid building wind plants near areas with large concentrations of birds (e.g., high-density breeding or wintering areas), known migration corridors, or refuges until further research is done. Recommendations also include conducting mortality searches on a 2- to 3-day-rotation to minimize the impacts of scavenging and decomposition on recovery numbers; however, biases affecting bird recovery are expected to be unique for each wind plant, so bias assessments must be made on a site-by-site basis. Unable to find definitive information within paper pertaining to significance of results or if recommendations are supported by research. Also, very small sample size. **Journal; reviewed by six referees (incl. S. Ugoretz, J. Schladweiler, S. Cooper).**

11. Orloff, S., and A. Flannery. (1992). *Wind Turbine Effects on Avian Activity, Habitat Use, and Mortality in Altamont Pass and Solano County Wind Resource Areas Tiburon, California.* Prepared for the Planning Departments of Alameda, Contra Costa, and Solano Counties and the California Energy Commission.

This study was conducted at the Altamont Pass WRA over six seasons between 1989 and 1991 to determine the relationships among bird use, fatalities, turbine characteristics, and physical variables associated with the site. Of 182 bird carcasses found, 119 (65%) were raptors (55% killed by turbines, 8% electrocuted, 11% collided with wires, and 26% unknown). Lattice turbine types were associated with a higher mortality rate than all other turbine types combined; however, mortality rates at tubular towers were found to increase 12.5% when located in end rows and close to a canyon. A discriminate analysis indicated three turbine characteristics were significantly associated with raptor mortality: end-row turbines, turbines close to canyons, and the number of steep-sided slopes (0-4). Using the same analysis, these characteristics were not found to have a significant association with raptor mortality: first turbine row, degree of slope, slope aspect, length of turbine row, position on slope, and ground squirrel density. Elevation was also deemed significant, although the authors question the biological significance because (1) mean elevation difference was only 157 ft, (2) distribution of elevations between killing and nonkilling turbines was similar, and (3) elevation was associated with canyon proximity and number of steep slopes, which were related to mortality. None of the characteristics were found to be significant for nonraptors, but the authors note this may have been caused by the low sample size. Mortality did not appear related to abundance. **Report; review process used.**

12. Smallwood, K.S., and C.G. Thelander. (2004). *Developing Methods to Reduce Bird Mortality in the Altamont Pass Wind Resource Area.* Prepared for the California Energy Commission: 1-363.

This study involved a five-year research effort to better understand bird mortality at the Altamont WRA. Bird behaviors, raptor prey availability, wind turbine and tower design, interturbine distribution, landscape attributes, and range management practices were studied to explain variations in bird mortality. Researchers recommended the following mitigation measures: relocate selected, highly dangerous wind turbines; move rock piles away from wind turbines (prey cover for kit fox); retrofit tower pads to prevent burrowing by small mammals; remove broken and nonoperating wind turbines; implement means to effectively monitor the output of each turbine; and retrofit noncompliant power poles to minimum Avian Power Line Interaction Committee (APLIC) guidelines. Researchers recommend the following measures be abandoned because of their ineffectiveness in reducing avian mortality rates: rodent control program, installation of perch guards, provision of alternative perches, and barricading of rotor blades. The following mitigation measures are unproven but believed to be highly effective: exclude cattle from around wind turbines through fencing (decreasing cattle pats and associated grasshopper populations may decrease Burrowing Owl population because of perching preference); install flight diverters (poles placed 5-10 m apart and just beyond the rotor plane of the wind turbine at end of string); paint blades using scheme of Hodos et al.; reduce vertical and lateral edge in slope cuts and nearby roads (to decrease pocket gopher population); and use devices to identify when to operate problem wind turbines with the least effect on birds (accelerometers). Turbine strings were found to be most dangerous when some turbines are on and others off; wind turbines at the ends of strings and at the edges of clusters were found to kill disproportionately more birds. Access roads should be minimized, along with buried pipelines near wind turbines. Also, the APWRA could be repowered with fewer wind turbines mounted on taller towers with larger individual output capacities (turbines should have blades no closer to the ground than 29 m). Researchers found that at least 3 years of carcass searches are needed before the sample of wind turbines sufficiently stabilizes. **Report; review process used (five referees).**

13. Smallwood, K.S. (2006). *Biological Effects of Repowering a Portion of the Altamont Pass Wind Resource Area, California: The Diablo Winds Energy Project*.

This paper provides a review of the WEST, Inc. (2006) report on the Diablo Wind Energy Project, in which 169 vertical-axis wind turbines were replaced with 31 larger horizontal-axis wind turbines in the Altamont Pass WRA. The author found WEST, Inc., to have inappropriately analyzed bird mortality rates because the study area was increased (800-m radius) compared with the initial smaller area (300-m radius). Adjusted mortality estimates from 1 year of monitoring data indicated a 70% reduction in overall bird mortality, a 62% reduction in raptor mortality, and an 85% reduction in burrowing owl mortality. RTHA mortality, however, was shown to have increased nearly 300%, and some mortalities were not recorded during prereplacement studies (e.g., golden eagles and bats). Analysis of utilization and mortality indicated a decline in utilization over the past 8 years and a decrease in mortality since repowering. Mortality adjustments include uncertainties and potential statistical bias. Several years of monitoring will be needed more accurately compare mortality before and after the project. **No review process.**

14. Thelander, C. G., and L. Rugge. (2000). *Avian Risk Behavior and Fatalities at the Altamont Wind Resource Area*. Prepared for the National Renewable Energy Laboratory: 1-22.

In this progress report, mortality data were collected during an 11-month period to meet these objectives: (1) to relate bird flight and perching behaviors to mortality risk, and (2) to identify any relationships between these behaviors and turbine or tower type, weather, topography, habitat features, and other factors that may predict high degrees of risk to birds, especially raptors. Findings indicated that there may be no significant difference between the frequency of fatalities associated with turbines at the ends of turbine strings when compared with those within turbine strings (contrary to Orloff and Flannery 1996). Findings also indicated that, to date, 57% of all bird fatalities had been associated with tubular towers (50% of all turbines included in fatality searches were on tubular towers). This is significant because it implies that tubular towers may represent as significant a risk to birds as do horizontal-lattice turbine towers (contrary to Orloff and Flannery 1992). This paper also pointed out the difficulty of finding a universal management solution when underlying risk factors vary greatly from species to species. **Report; review process used.**

Lighting

15. Erickson, W. P., J. Jeffrey, et al. (2004). *Stateline Wind Project Wildlife Monitoring Final Report, July 2001-December 2003.* Prepared for FPL Energy, the Oregon Energy Facility Siting Council, and the Stateline Technical Advisory Committee**:** 1**-**105.

Nocturnal migrant and bat fatality rates for lit turbines, turbines adjacent to lit turbines, and other unlit turbines were collected and compared from July 2001-December 2003. Observed fatality rates at lit turbines were slightly higher than at unlit turbines, although none of the differences were statistically significant ($p > 0.10$). This suggests that lights on Stateline turbines did not attract large numbers of bats or birds during the study (supported by Erickson et al. 2003b and Johnson et al. 2002). One factor that may cause this lack of association is the height of turbines and rotors (74 m [242 ft]), which is significantly lower than tall communication towers associated with large fatality events. Light type (solid, flashing, strobe), color (red, white), and intensity (low, medium, high) may be important factors in attracting birds, but these factors are not well understood. Nearly all bat fatalities were found in late summer and fall, at times when silver-haired and hoary bats are migrating; these two species comprised 96.1% of fatalities. A common resident of the area, the horned lark, had the largest fatality rate (40%), but the next most abundant fatality rate was for the golden-crowned kinglet, not a local breeder but believed to have been affected while migrating through the area at night. Fatality estimates per turbine may be lower for smaller turbines than for larger ones, but could be misleading since it takes more small turbines to generate the same amount of electricity. The true cause of death is unknown for most of the 2002-2003 fatalities; several are believed to be caused by vehicles (e.g., maintenance personnel) and not wind turbines, given the location of the finds. Preliminary results suggest a relatively small-scale impact on nesting birds; the majority is due to direct loss of habitat from pads and roads. Grassland bird displacement studies, fatality monitoring, raptor nest monitoring, and the Wildlife Reporting and Response System (WRRS) components of this study will be continued. **Report; five reviewers (J. White, T. Meehan, M. Kirsch, K. Blakley, G. McEwen)**

16. Howell, J. A., J. Noone, et al. (1991). *Visual Experiment to Reduce Avian Mortality Related to Wind Turbine Operations.* Prepared for Altamont U.S. Windpower, Inc.: 1-25.

Three hypotheses about bird collisions and wind turbines in the Altamont Pass were tested from August 1988 to August 1989: birds cannot see the blades under specific conditions, collisions tend to occur at ends of turbine strings, and collisions tend to occur at swales or hill shoulders. During the study, 10 dead birds were found beneath turbines. Increasing turbine blade visibility (alternating patterns of red and white) appeared to reduce the number of collisions, since only one bird was recovered under a painted tower. It was not clearly determined that specific locations in the turbine string are foci for mortality, although site-specific variation did exist. No significant differences were found as a result of the three studies; however, the authors say that lower p-values for the paint experiment may suggest a significant effect would be detected if the sample size were larger. **Report; unsure of review process.**

17. Johnson, G. D., W. P. Erickson, et al. (2003). "Mortality of bats at a large-scale wind power development at Buffalo Ridge, Minnesota." *American Midland Naturalist* **150**: 332-342.

This study was conducted from 1996-1999 to assess the effects of wind power development on wildlife. A total of 184 bat collision fatalities were documented (97% of carcasses found $\leq$ 20 m from a turbine); hoary and eastern red bats constituted most of the fatalities. There was a near absence of mortality in June and early July when resident bats are breeding, indicating that resident populations are not being impacted by the wind plant. The timing of mortalities, among other factors, suggests that most mortality involves migrant rather than resident breeding bats. Lighting on turbines did not increase the number of bat collision fatalities at the Buffalo Ridge wind plant. The potential for wind plants to impact bat populations should be addressed when siting new facilities, especially in areas where threatened or endangered bat species may be found. **Journal; no mention of peer review.**

18. Kerlinger, P., and J. Kerns (2004). *A Study of Bird and Bat Collision Fatalities at the Mountaineer Wind Energy Center, Tucker County, West Virginia: Annual Report for 2003*. Prepared for FPL Energy and Mountaineer Wind Energy Center Technical Review Committee**:** 1-39.

A postconstruction bird and bat fatality study was conducted between April 4 and November 11, 2003, at the Mountaineer Wind Energy Center (MWEC) in Tucker County, West Virginia. A total of 69 avian carcasses representing 24 known species were found; the majority were nocturnal migrant songbirds or songbird-like species (70.8%). Of the 69 fatalities, 33 (47.8%) were found on May 23, 2003, and determined to have been caused by the combination of heavy fog and several sodium vapor lights at a substation located near turbine 23. No avian fatality events occurred at the site after the sodium vapor lights were extinguished. A total of 475 bat carcasses representing 7 species were detected, mostly between August 18 and September 30, 2003 (92.5%). Correlation between weather during fall migration and new bat fatalities reveal no strong relation between fatalities and wind speed, wind direction, temperature, or fog/precipitation at the site. Bats killed at the MWEC might have collided with the turbine itself rather than the blades. No difference in numbers of birds or bat fatalities was found at lit versus unlit turbines. This suggests that FAA lighting (L-864 red strobes) did not attract nocturnal migrants, unlike the lighting on communication towers (which include steady-burning red, L-810 lights). Recommendations include conducting weekly searches of turbines in the eastern United States, particularly during avian/bat migration periods. Ideally, daily searches of all turbines or a random subset during fall migration should be conducted to examine correlations between weather conditions and bat fatalities. **No review process; statistical reviews by Erickson and Shoenfeld.**

19. Larwood, S. (2005). *FAA Obstruction Lighting Standards for Wind Energy Plants*. Prepared for the California Wind Energy Collaborative, sponsored by the California Energy Commission Public Interest Energy Research (PIER) program.

This project report established lighting standards for wind turbine sites as an issue of pilot safety. Proposed guidelines include establishing a maximum separation gap of 0.5 mile between lights along a row; omitting lights within clusters; no daytime lighting; synchronizing lights for entire project; using red or white flashing lights if possible; omitting steady-burning lights; lighting end row turbines; and using a single light mounted above the hub radius. No research was conducted on the effects of this lighting scheme on wildlife. These guidelines are based on the outcomes of airplane flight evaluations conducted by J. Patterson (2004). **Report; no review process**.

20. U.S. Fish and Wildlife Service. (2007). *"Effects of Communication Towers on Migratory Birds."* Comments of the U.S. Fish and Wildlife Service submitted electronically to the FCC on 47 CFR Parts 1 and 17, WT Docket No. 03-187, FCC 06-164, Notice of Proposed Rulemaking: 32, 12-18.

These comments and recommendations assess a compilation of past and very recent (through 2006) peer-reviewed studies conducted most recently in Michigan and New York on the impacts of various lighting regimes (i.e., steady-burning red [L-810] and white lights, white strobe lights [L-865], red strobe lights [L-864 red strobes], and red blinking incandescent lights [L-864 flashing beacons]) on night-migrating avifauna. Where steady-burning L-810 lights were completely extinguished in the Michigan study (Gehring et al. 2007), avian collision injury and mortality with the communication towers were reduced by 71%. USFWS also provisionally recommended use of red strobe and/or red blinking lighting regimes as a secondary option if white strobes cannot be used. This recommendation is predicated on the use of no steady-burning lights. The results from these communication tower studies are also applicable to lighting regimes on wind turbine facilities. Recommendations to the Federal Communications Commission based on peer-review of the Michigan research protocol (2 independent reviewers), and independent peer review of the preliminary research results; peer review of the New York study to be published in North American Birds independently peer-reviewed by anonymous professionals.

Visual Blades

21. Hodos, W. (2003). *Minimization of Motion Smear: Reducing Avian Collisions with Wind Turbines*. Prepared for the National Renewable Energy Laboratory**:** 1-43.

This study evaluated the pattern electroretinogram (PERG) visibility of 7 blade velocities from 36-144 rpm. To reduce motion smear, eight blade patterns, a serious of blade tip devices, and various chromatic and achromatic single blade types were devised and tested. Thin, staggered black stripes were found to have a visibility approximately 4x greater than blank blades at 130 degrees of visual angle per second (dva/sec). At 170 dva/s, all the patterns had about the same visibility. By 240 dva/s, all the patterns essentially had no visibility as individual blades appeared blurry or transparent. No data suggest the optimum ratio of black to white stripe thickness. Tests using a 20-m diameter turbine rotating at 45 rpm against a neutral background found that blank blades, thin-stripe blades, and thick-stripe blades would all be visible at a distance of 21 m; thin-striped blades were the most visible. By 19 m, the anti-motion-smear patterns lost advantage over blank blades; by 17 m, visibility for all three blade types was close to zero. A combination of blade diameter, rotation rate, and viewing distance resulting in velocities of the retinal-image of the blade tip exceeding 130 dva/s will result in motion smear. No data illustrate how these stimuli retain their improved visibility under suboptimal viewing conditions (e.g., mist, rain). A single, solid-black blade or a thin-striped blade paired with two blank blades would probably be the most visible visual deterrent. Colored blades are not recommended because of cost and possible problems with background contrast. Data showed that two-tip devices were superior to blades with no devices, but single and three-tip devices were found to be ineffective. However, two-tip devices became less visible against naturalistic backgrounds, thereby making the results rather ambiguous. The size of tip devices was arbitrary. This study has not been field-tested; results are based on lab data to date. **Report; review process used**.

22. Young, D. P., W. P. Erickson, et al. (2003). *Comparison of Avian Responses to UV-Light-Reflective Paint on Wind Turbines*. Prepared for the National Renewable Energy Laboratory: 1-67.

This study examined the effects on bird use and mortality of painting wind turbine blades with UV-reflective gel at Foote Creek Rim Wind Plant in Carbon County, Wyoming. Data were collected from six permanent stations within the study area (33 conventionally painted turbines and 72 turbines painted with UV-reflective paint) using avian point count surveys and carcass searches. A total of 3,501 bird observations were made between July 1, 1999, and December 31, 2000. Passerine use was similar between the two areas; raptor use was significantly higher in the UV area. Of 84 fatalities found within the search plots, 57 (68%) were found at the UV turbines, 13 (15%) at the non-UV turbines, and 14 (17%) at the 7 meteorological (met) towers. Although other studies (Hurlbert 1984, Morrison et al. 2001) found significant differences between UV and non-UV turbines, this study found no significant difference between bird mortality, use, or risk between turbine blades painted with a UV-light-reflective paint and those with conventional paint. Although two times more passerine fatalities were found at the UV-painted turbines, statistical inferences are limited because of the low level of avian mortality observed and the lack of a controlled experimental design. Better spatial representation, accomplished by providing a larger sample size of turbines and more observations, would have improved this study. **Report; review process used.**

Microwaves

23. Kreithen, M.L. (1996). "Development of a pulsed microwave warning system to reduce avian collisions with obstacles." *Second International Conference on Raptors*. Urbino, Italy.

In this study, 20 homing pigeons were tested for their ability to detect pulsed microwaves. For 707 trials, 84.3% of the birds responded to pulsed microwaves, and 17.1% responded to control trials. Study results should not be used to make statistical inferences for species of birds other than homing pigeons.[1]

Sound

24. Dooling, R. (2002). *Avian Hearing and the Avoidance of Wind Turbines*. Prepared for the National Renewable Energy Laboratory: 1-17.

This report describes hearing measurement in birds, the effects of noise on hearing, and the relationship between avian hearing and the general noise levels around wind turbines. A review of the literature on the ability of birds to hear in noisy (windy) conditions suggests that birds cannot hear the noise from wind turbine blades as well as humans can (humans can hear blades 2x further away). Because some blades whistle as a result of blade defects, minor modifications to the acoustic signature of a blade might make them more audible to birds (between 1 and 5 kHz) while making no measurable contribution to overall noise. The hypothesis that louder blade noises (to birds) results in fewer fatalities remains untested. **Report; review process used.**

Marking Power Lines

25. Alonso, J.C., J.A. Alonso, and R. Munoz-Pulido. (1994). "Mitigation of bird collisions with transmission lines through groundwire marking." *Biological Conservation* **67**: 129-134.

This study was conducted in southwestern Spain during two winters (1990 and 1991) to evaluate the effectiveness of groundwire marking in reducing bird collisions with transmission lines. The habitat studied included agricultural lands alternating with oak forests, and markers were placed at sites frequently crossed by birds of several species during daily flights between roosting and feeding areas. A significant decrease in collision frequency ($p = 0.029$) was found between spans marked with red PVC spirals (18 birds found) compared with the same spans before marking (45 birds found). Bird mortality at unmarked spans increased (19 to 25 birds), but this change was found to be insignificant ($p = 0.461$). The percentage of birds flying between the cables decreased, and those flying above the cables increased, suggesting that the birds saw the groundwire markers. **Journal; reviewed by three referees (incl. E. Duffey).**

26. Brown, W. M., and R. C. Drewien (1995). "Evaluation of two power line markers to reduce crane and waterfowl collision mortality." *Wildlife Society Bulletin* **23**(2): 217-217.

This study evaluated two power line markers for reducing crane and waterfowl mortality in the San Luis Valley, Colorado, and examined factors contributing to collisions and marker effectiveness. Collision mortality rates at 8 segments (about 0.8 km each) of power lines marked with either yellow spiral vibration dampers or yellow fiberglass swinging plates were compared with 8 adjoining unmarked segments. During 3 spring and 3 fall migration periods (1988-1991), estimated mortality on study segments was 706, affecting 35 species or more. Waterfowl and cranes constituted >80% of mortality. Both marker types reduced mortality ($P < 0.005$). Birds reacted to marked lines at greater distances and increased their altitude compared with unmarked lines ($P < 0.0001$). Factors affecting collisions or marker effectiveness included wind, nocturnal flights and disturbance, and age of sandhill cranes. Neither marker performed better in all study seasons; each may have had unique benefits.

[1] Cited by Sue Orloff in Erickson et al. (2002). *Baseline Avian Use and Behavior at the CARES Wind Plant Site, Klickitat County, Washington*. Prepared for the National Renewable Energy Laboratory: 1-75.

Plates damaged distribution lines, precluding their continued use; however, a new marker from Europe that incorporates the benefits of both plates and dampers should be evaluated, because it may protect best against collision losses.[2] **Journal; no mention of review.**

27. Janss, G. F. E., and M. Ferrer (1997). "Rate of bird collision with power lines: effects of conductor-marking and static wire-marking." *Journal of Field Ornithology* **69**(1): 8-17.

This study tested the ability of different markers to reduce bird collisions by comparing marked spans with unmarked spans along three different power line types in west-central Spain. The study consisted of two periods over 4 years. The first period (1991-1993) had no markers; the second (1993-1995) had markers in some of the study spans. No statistical differences were detected among the three power lines in collision frequency per survey ($P = 0.86$). The spiral marker was found to significantly reduce collisions for all birds by 81% ($P = 0.0198$). Black crossed bands were also found to be effective, resulting in a decrease in collisions of 76% for all birds. However, when the vulnerable great bustard is included in the analysis, markers were found to have no effect ($P = 0.080$). The third marker, consisting of thin black strips, showed no significant reduction in mortality ($P = 0.052$). Overall reduction in mortality for both the spiral and the crossed bands was more than 75% (excluding the great bustard), deemed an encouraging result compared with other studies where reductions in mortality are about 50%. **Journal; no mention of review.**

28. Morkill, A. E., and S. H. Anderson (1991). "Effectiveness of marking power lines to reduce sandhill crane collisions." *Wildlife Society Bulletin* **19**(4): 1-8.

This study was conducted near the Platte River in portions of Dawson, Buffalo, and Kearney Counties in south-central Nebraska to evaluate the effectiveness of marking power lines to reduce collisions with sandhill cranes. Nine segments of static wires were divided into spans that were either marked or unmarked with yellow aviation balls containing vertical black stripes. Of the 36 carcasses, 25 had died from collisions with unmarked spans. No significant difference between the number of birds flying over marked and unmarked transmission lines was found, but significantly more cranes were killed in collisions with unmarked spans because cranes reacted sooner to marked spans. Although this study was deemed appropriate and strong (see Orloff in Erickson et al. 1999), it is unclear how the segments or spans were selected. **Journal; reviewed by six referees (W. Hubert, E. Williams, F. Lindzey, M. Czaplewski, J. Lewis, C. Faanes)**.

29. Organ, C. A., M. Timewell, et al. (2003). *Bird Surveys along the Proposed Musselroe Wind Farm Transmission Line - Ringarooma Ramsar Area, North-east Tasmania*. Prepared for Hydro-Electric Corporation: 1-62.

This study is a preassessment for a proposed transmission line easement. Surveys were conducted in areas up to 300 m from the proposed easement and occurred over two seasons, one day during winter and several days in spring 2002. Overall, potential impacts on birds are expected to be low, as the route selected largely avoids areas of high bird activity. Bird flight diverters where transmission lines cross the Ringarooma River and the Marsh Creek Dam are recommended. The study also recommended that the power line be kept high where it crosses the Marsh Creek Dam to minimize the potential for collisions with birds taking off or landing. **No mention of review.**

[2] Cited by Sue Orloff in Erickson et al. (2002). *Baseline Avian Use and Behavior at the CARES Wind Plant Site, Klickitat County, Washington*, Prepared for the National Renewable Energy Laboratory: 1-75.

Perch Guards

30. Nelson, H. K., and R. C. Curry (1995). "Assessing avian interactions with wind plant development and operations." *61st North American Wildlife and Natural Resources Conference*. Washington, D.C.

This study was conducted to assess whether perch guards reduced the number of birds perching on turbines at Altamont Pass, California. Wires or wire screens were installed to prevent perching and nesting on 50 turbines. A 54% reduction in perching was estimated; however, no power analyses were conducted to evaluate sample size and no confidence intervals were calculated.[3] **Unsure of review process.**

Curtail Turbines

31. Huppop, O., J. Dierschke, et al. (2006). "Bird migration studies and potential collision risk with offshore wind turbines." *Ibis* **148**: 90-109.

This study was begun in 2003 to investigate year-round bird migration over the North Sea in Germany to determine avian behavior in regard to wind farms (flight distances, evasive movements, influence of lights, collision risk). Data were collected from a platform holding a 100-m mast located at the proposed construction site. Results show weather severely impacting variations in intensity, time, altitude, and species of migration. Most offshore bird migration was confined to a few nights, when tailwinds were above a certain strength. More than half of the cadavers were collected in two nights; most birds clearly collided with the tower rather than died from starvation. Terrestrial birds, especially passerines, were attracted by illuminated offshore obstacles, especially in poor visibility conditions. Disoriented birds flew around the platform repeatedly, increasing the risk of collision and energy consumption. Inland findings are not believed applicable to offshore ones because birds tend to migrate at lower altitudes over sea than land, particularly night migrants on dark nights, in headwinds, or when there is precipitation. The study suggests that turbines be turned off and rotor blades adjusted during the few nights in which numerous bird strikes are expected (e.g., in adverse weather conditions with high migration intensities). It also recommends that turbines not be placed in dense migratory zones or between resting and foraging grounds, that they be aligned in rows parallel to the main migratory direction, and that do not feature large-scale continuous illumination. This research was conducted before the establishment of an actual wind farm, so it cannot be directly applied to offshore wind farms. Recommendations need to be field-tested. **Journal; three reviewers (R. Langston, K. Huppop, S.A. Gauthreaux, Jr.)**

Habitat

Habitat Alterations

32. Grindal, S.D., and R.M. Brigham. (1998). "Short-term effects of small-scale habitat disturbance on activity by insectivorous bats." *Journal of Wildlife Management* **62**(3): 996-1003.

This study examined the effect of small-scale disturbances (creation of small cutblocks) and an access road in a forest setting on bats' habitat use. This before-after control impact (BACI) study occurred in a low-elevation forest in the southern interior of British Columbia, Canada, in 1993 and 1994. Forest harvesting was found to have a significant effect on bat activity but not on insect availability. Bat activity increased in cutblocks after harvesting

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[3] Cited by Sue Orloff in Erickson et al. (2002). *Baseline Avian Use and Behavior at the CARES Wind Plant Site, Klickitat County, Washington*. Prepared for the National Renewable Energy Laboratory: 1-75.

(activity tended to decrease with increasing cutblock size, although not significantly). Bat activity was increased after road construction. However, data were pooled for different cutblock sizes because of the small sample size (no N located in this study). Small-scale habitat disturbance may provide commuting and foraging areas for bats, but larger scale disturbances on bat ecology are still unclear. **Journal; reviewed by three referees (C.I. Stephan, P. Bradshaw, M.A. Setterington).**

33. Herzog, F., S. Dreier, et al. (2005). "Effect of ecological compensations areas on floristic and breeding bird diversity in Swiss agricultural landscapes." *Agriculture, Ecosystems and Environment* **108**: 189-204.

Vegetative and avian surveys were conducted in 56 study regions between 1998 and 2001 to assess whether ecological compensation areas (ECAs) in Switzerland enhance biodiversity, as stated in policy goals. ECAs make up approximately 13% of the utilized Swiss agricultural area (UAA). ECA grasslands occurred more frequently up to 50 m from the forest edge; they were much more often located in steeper areas. There were very few Red List plant species found within ECAs, suggesting that the ECA program is hardly contributing to the preservation of endangered species, as the policy states. The quality of vegetation of 51%-87% of the ECA meadows did not correspond to traditional hay meadows, and they generally did not enhance populations of meadow birds. Most ECA litter meadows achieved target vegetation compositions; breeding birds used them more frequently than they did other ECA types. Approximately 50% of the hedgerows in the ECA program had good ecological quality and were advantageous for birds, and traditional orchards reflected prior intensive utilization with little contribution to floral diversity. The study recommended that meadow programs be eliminated, litter meadow and hedgerow programs be expanded, and extension activities be concentrated on traditional orchards. Results are limited to the Swiss plateau and cannot be extrapolated to the whole of Switzerland. **Journal; reviewed by seven referees (S. Aviron, S. Birrer, P. Jeanneret, L. Kohli, D. Bailey, M. Kuusaari, G. Le Lay).**

34. Larsen, J.K., and J. Madsen. (2000). "Effects of wind turbines and other physical elements on field utilization by pink-footed geese (*Anser brachyrhynchus*): A landscape perspective." *Landscape Ecology* **15**: 755-764.

This study was carried out in spring 1998 to examine the effects of wind turbines and other physical landscape elements on field utilization by wintering pink-footed geese in farmlands in Denmark. Habitat loss per turbine was found to be higher in wind farms with turbines arranged in a large cluster than for those with turbines in small clusters or lines, with avoidance distances at 200 m and 100 m, respectively. This is believed to result from placing wind farms in small clusters or linear layouts generally close to roads or other 'avoidance zones,' whereas large clusters were placed in open farmland areas. The study notes, however, that the configuration with the fewest impacts in a given situation may be the result of factors other than habitat loss. A significant difference was determined between field utilization and the location of avoidance zones; geese were unlikely to use fields in which avoidance zones covered the centers (2 of 11 used) and more likely to use fields in which zones did not cover the centers (13 of 15 used). The synergistic avoidance effects of reducing field use was not taken into account and needs to be researched in the future. Overall, this study indicated that wind farm disturbance is relatively minor (<200 m) in relation to foraging pink-footed geese. **Journal; reviewed by numerous referees (incl. T. Fox).**

35. Leddy, K. L., K. F. Higgins, et al. (1999). "Effects of wind turbines on upland nesting birds in Conservation Reserve Program grasslands." *Wilson Bulletin* **111**(1): 100-104.

Conservation Reserve Program grasslands without turbines and areas located 180 m from turbines supported grassland birds at mean densities that were 4x higher than those found in grasslands closer to turbines. Although wind turbines may not cause mortality directly, the presence of turbines may affect local grassland bird populations indirectly by decreasing the area of grassland habitat available to area-sensitive breeding birds. In addition to human disturbance and noise, the physical movements of the turbines when they are operating may have disturbed nesting birds. Maintenance trails between turbines that are driven daily may have further decreased the availability of grassland habitat adjacent to turbines. The study recommended that wind turbines be placed within cropland habitats that support lower densities of grassland passerines than those found in CRP grasslands. The study was conducted for one only breeding season (May-July 1995), and data indicate a larger number of birds identified in the turbine area than in the nonturbine area (379 vs. 150, respectively). Species composition, however, varied between the two sites. **Journal; reviewed by numerous referees (incl. L.D. Flake, D.H. Johnson).**

Artificial Nests

36. Belthoff, J.R., and R.A. King. (2002). "Nest-site characteristics of burrowing owls (*Athene cunicularia*) in the Snake River Birds of Prey National Conservation Area, Idaho, and applications to artificial burrow installation." *Western North American Naturalist* **62**(1): 112-119.

This study observed 32 burrowing owl nests and 31 unused burrows to (1) measure physical, vegetative, and topographic characteristics of burrowing owl nest sites; (2) determine potentially important features for nest-site selection by burrowing owls; and (3) use this information to help guide future construction and placements of artificial burrows. A significant difference was found between nest and comparison burrows in relation to tunnel angle—a 17% reduction in odds of use with each 1-degree increase in the slope of the tunnel angle. This feature and productivity, however, were not found to be significantly related. A weak significant relationship was found between productivity and distance to the perch, and a stronger negative relationship was found between productivity and distance to irrigated agriculture. The most common vegetation surrounding burrowing owl nests included cheatgrass, tumble mustard, and annual wheatgrass; there was no significant difference in cover classes between nest and comparison burrows. Results suggest placing nest burrows near agriculture and open areas, in low shrub cover and short vegetation; however, there are concerns about the effects of pesticides and intensive agriculture on birds. The study also suggested that tunnel entrance angles be limited to gradual slopes (average of 27 degrees), although this suggestion has not been field-tested. **Journal; reviewed by five referees (L. Bond, A. Dufty, J. Munger, B. Smith, N. Woffinden).**

37. Smith, G.C., and G. Agnew. (2002). "The value of 'bat boxes' for attracting hollow-dependent fauna to farm forestry plantations in southeast Queensland." *Ecological Management & Restoration* **3**(1): 37-46.

This study was conducted to assess vertebrates' use of artificial nest or roost boxes, and their contribution toward enhancing biodiversity in plantation forests through the provision of habitat. Two sites were located in a relatively 'intact' forest landscape and two in a more 'fragmented' landscape, and each site was checked 5-9 times from April 1996 to November 2000. Fewer animals were recorded in boxes at the intact sites; the highest numbers of animals were recorded in boxes in forest plantations with variegated landscapes (five native mammal species). No vertebrates were found in boxes at the State Forest (the most intact) site. The maximum occupancy rate recorded was 40%. Data suggested no preference toward box aspect. No significant relationships were determined; the sample size was 50. Additionally, there are approximately 21 species of potentially hollow-roosting microbats in the area, but only 1 species was found to occupy the boxes (max. 25% at one site). **Journal; no mention of review process.**

38. Smith, M.D., C.J. Conway, et al. (2005). "Burrowing owl nesting productivity: a comparison between artificial and natural burrows on and off golf courses." *Wildlife Society Bulletin* **33**(2): 454-462.

This study was conducted on 8 golf courses in south-central Washington to examine whether burrowing owls would locate and occupy artificial burrows placed on golf courses, and if so, which course features influenced the probability that owls used an artificial burrow. The study also examined whether occupied artificial burrows were as successful as other types (natural on golf course, natural off-course, artificial off-course). About 175 natural burrows off golf courses, 14 natural burrows on courses, 86 artificial burrows off golf courses, and 130 artificial burrows on courses were monitored from February 1-August 21 during 2001 to 2004. Burrowing owls used a smaller proportion of artificial nests on golf courses (7% average) than off golf courses (18% average); golf course usage occurred primarily in nonmaintained areas (12.5% of burrows established were used) and only 1 burrow was used in maintained areas. Owls were additionally found to occupy 35% of the 23 burrows installed within 200 m of natural nest burrows. Analysis suggests that proximity to rough, fairway, sprinkler, and maintained areas (areas receiving turf maintenance) influenced the use of artificial burrows, as does proximity to natural burrows. Management suggestions include that burrowing owls preexist for artificial burrows to be successful, as well as the importance of maintaining burrows outside the owl's breeding season. No significant relationships were detected in the analysis; however, the information may prove useful in mitigation at wind turbine sites with burrowing owls in terms of maintenance requirements for burrows and sites. **Journal; reviewed by three referees (incl. D. Cristol, A. Rodewald).**

39. Trulio, L.A. (1995). "Passive relocation: A method to preserve burrowing owls on disturbed sites." *Journal of Field Ornithology* **66**(1): 99-106.

This study examined the belief that passive relocation is more likely to occur if artificial nest boxes are placed within 100 m of destroyed burrows, based on the observation that burrowing owls spend most daylight hours 50-100 m from their nests. Passive relocations using artificial burrows were conducted on six sites in northern California between 1988 and 1993. Burrowing owls moved into the artificial burrows in less than 1 month in all sites where boxes were placed within 75 m of the destroyed burrow; however, birds were not banded at 4 of the 5 sites, so it is unclear as to whether birds living in the boxes were the same ones that were evicted. The only site where birds did not occupy the artificial nest was the one in which the box was placed 165 m from the destroyed burrows. Passive relocation is believed to be a better alternative than active relocation of the owls, because birds generally disappear from a new, unfamiliar site within a season (Schulz 1993), and predation may increase for owls moved long distances in contrast to those living in familiar surroundings (Dyer 1987). While passive relocation is deemed a successful way to relocate birds, the study notes that it is not an adequate mitigation strategy if sufficient adjoining foraging habitat is not preserved. The sample size is unclear; Table 1 provides the number of birds evicted, but this doesn't match the number of artificial burrows or the occupation of burrows. Also, distances to new burrows tested was not consistent (75 m compared with 165 m; a question remains as to distances between those two). **Journal; reviewed by five referees (J. Barclay, P. Delevoryas, T. Schulz, L. Feeney, K. Bildstein).**

Relocation

40. Matthews, K.R. (2003). "Response of mountain yellow-legged frogs, *Rana muscosa*, to short distance translocation." *Journal of Herpetology* **37**(3): 621-626.

The purpose of this study was to determine the response of *R. muscosa* (a species being considered for federal listing) to short-distance (144-630 m) translocations in the upper Dusy Basin, Kings Canyon National Park, California. Twenty frogs were captured and outfitted with radio transmitters and passive integrated transponder (PIT) tags, and body masses were collected. The frogs were then moved distances ranging from 144-630 m from one water body to another. Patterns of movement for the translocated frogs were monitored from August 5-September 4, 1999 (the period is short because the transmitters work for only 30 days). Eighteen of the frogs were relocated at the end of the study, the radio transmitters were removed and body mass collected (the other 2 were found in summer 2000). Of the 20 translocated frogs, 7 returned to their original capture site, 4 moved in the direction of their capture site but had not returned by the end of the study, and 9 did not return and were found at the translocation site. All frog relocations were found closer to the capture site than to the release site. Translocated frogs exhibited a loss in body mass when weighed at the beginning and end of the study (n = 18, mean loss = –1.2 g). A control study that outfitted 14 frogs with radio transmitters but did not translocate them found the frogs exhibited a mean gain in body mass of 2.5 g (n=18). This study illustrates that translocation may not be an effective tool for some species because of increased stress levels and site fidelity. Further research is suggested to determine the effectiveness of relocating eggs or tadpoles. **Journal; no mention of review process**.

41. Roby, D., K. Collins, et al. (2002). "Effects of colony relocation on diet and productivity of Caspian terns." *Journal of Wildlife Management* **66**(3): 662-673.

This study investigated the efficacy of management agencies to reduce the impact of Caspian tern predation on the survival of juvenile salmonids in the Columbia River estuary by relocating approximately 9,000 pairs of terns from Rice Island to East Sand Island, 26k m away. Efforts to attract terns to nest on East Sand Island included the creation of nesting habitat, use of social attraction techniques (decoys and audio playback systems), and predator control (gulls), with concurrent efforts to discourage nesting on Rice Island (fencing, streamers, undesirable vegetation). All nesting Caspian terns shifted from Rice Island to East Sand Island during the 3-year period 1999-2001. Nesting success overall was found to be higher at East Sand Island than at Rice Island; 1.4 young were raised per breeding pair at East Sand Island after gull control attempts had terminated in 2001 (the highest Rice Island productivity was from 1998-2000—0.55 young per pair). Considerable information is provided concerning dietary alterations, but this does not appear to be relevant to current research. **Journal; reviewed by two referees (D. Duffy, C. Thompson).**

Cave Gating

42. Martin, K.W., D.M. Leslie, Jr., et al. (2003). "Internal cave gating for protection of colonies of the endangered gray bat (*Myotis grisescens*)." *Acta Chiropterologica* **5**(1): 1-8.

This study examined the effects of constructing gates inside cave passages on resident populations of the endangered gray bat in eastern Oklahoma, specifically (1) population trends before and after cave passages were gated and (2) initiation of emergence from protected and nonprotected caves. Six gated caves were examined to determine population trends before and after gating, and three gated and three nongated caves were examined to determine cave emergence. The total numbers of gray bats in all six caves was 60,130 in 1981 and 71,640 in 2001 (after gating); two caves harbored more bats after gating and three caves exhibited no change in population (cave 1 is not included because there was no pregate data to compare results with). Internal cave gate effects on bat flight were examined from mid-June to mid-July in 1999 and 2000. Cave gating was not found to impede or delay exit flights of colonies ($\leq$ 25,000) of gray bats. Additional research is suggested to determine the applicability of these findings to other species of bats, as well as to determine the effect of internal gates on larger colonies of gray bats. While these findings are positive, there was no mention of statistical significance. **Journal; reviewed by three referees (D.M. Engle, E.C. Hellgren, J.H. Shaw)**

Livestock Fencing/Grazing

43. Dobkin, D.S., A.C. Rich, et al. (1998). “Habitat and avifaunal recovery from livestock grazing in a riparian meadow system of the northwestern Great Basin.” *Conservation Biology* **12**(1): 209-221.

This research was conducted to examine vegetation dynamics in riparian meadow systems in the absence of livestock and to relate these dynamics to avian species composition and relative abundance. The study was conducted from 1991-1994 in the Hart Mountain National Antelope Refuge in southeastern Oregon, commencing one year after livestock grazing was entirely eliminated from the refuge. Data were compared between areas that had been fenced off from livestock for many years and areas that had been subjected to regionally typical cattle grazing until the study began. Results indicated that the recovery of vegetation in riparian meadow systems does not follow a simple successional direction. Sedges and forbs were found to constitute significantly greater percentages of cover on exclosure plots than on open plots, while bare ground and litter were found to be significantly more extensive on open plots than on exclosure plots. Grass cover increased and litter and bare ground decreased on all plots during years of increased moisture. Forbs, rush, and cryptogamic cover increased on open plots, but not on enclosed ones. Avian species composition was markedly different on the two plots; wetland and riparian birds dominated exclosure plots, and upland grassland species dominated open plots. While avian species richness and relative abundance were greater on exclosure plots, it is not known how closely the restoration of the avian community composition will track vegetation recovery. Although this study indicates that habitat structure and avian populations change in response to livestock grazing (or lack thereof), it was conducted for only four years and many of its findings were not deemed significant. **Journal; reviewed by one referee (D. Pyke).**

44. Earnst, S.L., J.A. Ballard, et al. (2004). *Riparian Songbird Abundance a Decade after Cattle Removal on Hart Mountain and Sheldon National Wildlife Refuges*. U.S. Department of Agriculture Forest Service Gen. Tech. Rep. PSW-GTR-191: 9 pp.

This study compared songbird abundance in 2000-2001 to that in 1991-1993 on 69 permanent plots to determine the effects of cattle removal. It took place in the high desert riparian habitats of Hart Mountain and Sheldon National Wildlife Refuges located in south-central Oregon and northwestern Nevada, respectively. The plots featured 6 different cover types (meadow, riparian aspen, snow pocket aspen, willow, nonriparian shrub, and mixed deciduous), and each was surveyed three times from May 8-June 24, 2000, and from May 17-June 25, 2001. Survey data from 1991-1993 had been collected 3 times annually from May 7-July 11. Comparisons within this study were limited to passerines, doves, woodpeckers, and shorebirds that either primarily nest or forage in riparian habitat within the Hart-Sheldon landscape. Of 51 species for which detections were sufficient to calculate changes in abundance, 71% (36/51) exhibited a positive trend and 76% (16/21) that exhibited a significant change (either positive or negative) increased. Species associated with aspen and willow habitats exhibited a significant increase in detections/km^2, but species associated with meadows did not exhibit this change. Ground/low cup nesting species were found to increase more than either high cup or cavity nesting species; ground/understory foraging species increased significantly more than overstory or bark foraging species. Only meadow associates, cavity nesters, and bark gleaners did not increase significantly. Of the 26 riparian species of concern within the area, 7 exhibited significant increases on original plots after the removal of cattle (yellow warbler, white-crowned sparrow, dusky flycatcher, warbling vireo, MacGillivray's warbler, orange-crowned warbler, and mourning dove) and 3 exhibited significant declines (Bullock's oriole, ruby-crowned kinglet, and Wilson's warbler). For the 16 significantly increasing species identified in this study, patterns of change on breeding bird survey routes from 1980-1999 suggested that the changes were not merely a reflection of regional patterns. Another year of data collection was mentioned, but there is no evidence that this project continued past 2001. **Report; unknown review process**.

45. Manier, D.J., and N.T. Hobbs. (2006). “Large herbivores influence the composition and diversity of shrub-steppe communities in the Rocky Mountains, USA.” *Oecologia* **146**: 641-651.

This study examined changes in plant cover and diversity at 17 sites in western Colorado where livestock and wild ungulate grazing had been excluded for 41-51 years from semi-arid shrub-steppe communities. Differences in species richness and evenness between protected treatments and surrounding grazed communities were small and not significant. Although mean species richness and diversity were similar between treatments, protected areas featured much higher dominance by fewer species, primarily sagebrush. Shrub cover was 2x times greater inside exclosures relative to adjacent areas outside exclosures (significant in protected Great Basin communities and sagebrush steppe sites), with no significant effects of grazing exclusion on cover or frequency of grasses, biotic crusts, or bare ground. Species evenness was positively correlated with richness in protected plots, while evenness and richness were inversely related in grazed plots. The exclusion of grazing appears to cause minor changes in cover and diversity of herbaceous plants, an increase in shrub cover, and an alteration in the relationship between evenness and richness. **Journal; no mention of review process.**

46. Maron, M., and A. Lill. (2005). “The influence of livestock grazing and weed invasion on habitat use by birds in grassy woodland remnants.” *Biological Conservation* **124**: 439-450.

This study compared the intraspecific variation in bird foraging behavior and microhabitat selection of seven ground-foraging bird species among three site types of remnant woodland in southeastern Australia: heavily grazed with little to no ground vegetation (9 sites); weedy, ungrazed sites with a ground layer dominated by tall introduced grasses (9 sites); and a relatively intact ground layer dominated by native plant species (5 sites). Data were collected eight times from January 3 to November 6, 2003 (2 per season). Most bird species were present in similar proportions in each site type, but there was evidence of a negative impact of habitat degradation on all but two of the bird species studied. Observations suggest that weed invasion contributes to a reduction in habitat suitability by reducing the availability of foraging substrates, thereby forcing birds to forage in a subset of available microhabitats when foraging on the ground or inducing them to use more energy-costly foraging maneuvers. Cattle grazing decreases weed invasion, but can injure the development of the cryptogamic crust and result in low tree densities. The ideal management regime, therefore, is believed to be a combination of careful grazing to control weeds alternating with periods of no livestock grazing, during which regeneration can occur. Areas within remnants where the ground layer is in good condition (limited weeds and intact cryptogamic crust) could be fenced permanently, while other areas with heavy weed invasions could be managed through grazing or chemicals. **Journal; reviewed by three referees (incl. S. Attwood, R. Major).**

Wetland Creation

47. Balcombe, C.K., J.T. Anderson, et al. (2005). “Wildlife use of mitigation and reference wetlands in West Virginia.” *Ecological Engineering* **25**: 85-99.

This study was conducted to evaluate the success of mitigation wetlands in West Virginia in supporting healthy wildlife communities by comparing 11 constructed and partially restored mitigation wetlands (4-21 years old) with four reference wetlands. All reference wetlands were classified as palustrine emergent or palustrine scrub-shrub and mitigation wetlands as palustrine emergent or palustrine unconsolidated bottom wetlands. All reference wetlands were located near mitigation sites within each area, usually within the same watershed. Avian communities were evaluated between May 5 and June 27 in 2001 and 2002. Mitigation wetlands were significantly different from reference sites in vegetation community structure, containing more open water (40.6% vs. 11.6%) and less emergent aquatic vegetation.

Despite differences in vegetation and invertebrate abundance, mean species richness, diversity, and abundance were similar between mitigation and reference wetlands. High avian numbers in mitigation wetlands appear to be the result of wetland size, landscape position, vegetative structure, and diversity and invertebrate community structure. The study notes that a diverse wetland community within mitigation wetlands does not mean that birds are successfully reproducing, and that future studies should correlate changes in vegetation and invertebrate communities to avian community structure and evaluate breeding success. Effects on anuran communities were also evaluated. Authors caution that it is premature to assess the outcome of mitigation efforts in West Virginia because this was only a 2-year study, that created wetlands often take more than a decade before functioning in a manner comparable to reference wetlands (5 sites were over 10), and that the data should not be extrapolated to other states. **Journal; reviewed by four referees (incl. W.J. Mitsch, J.S. Rentch, W.N. Grafton).**

48. Darnell, T.M., and E.H. Smith. (2004). "Avian use of natural and created salt marsh in Texas, USA." *Waterbirds* **27**(3): 355-361.

This study examined the "accuracy" of habitat creation as a means of mitigation by comparing avian use of three man-made sites of various ages with three natural marsh reference sites on the central Texas coast. Geomorphology of created sites differed substantially from the natural sites, affecting habitat development and avian use. In both natural and created sites, unvegetated, irregularly flooded habitat was used more consistently by a larger number of birds than any other habitat type (shorebirds, wading birds, and gulls or terns were associated significantly with unvegetated shallow water and exposed substrate). This zone of habitat, however, was compressed into a narrow band along the elevation gradient in created wetlands; more frequent inundation and decreased salinity occurred as a result of their smaller sizes. Results indicated that each of the created wetlands, especially the oldest one (4 years old vs. 2 years), became overgrown with vegetation in intertidal elevations over time, indicating that a habitat component was being lost. The oldest created wetland, which was the most overgrown, had significantly more perching birds than other sites and was rarely used by shorebirds. Management recommendations include a need for created marshes to provide unvegetated habitats, which may be accomplished through management (e.g., removal) of vegetation or through geomorphic design that attempts to mimic natural conditions producing unvegetated habitats. The length of this study was unclear. **Journal; reviewed by numerous referees**.

49. Federal Highway Administration. (1992). *Evaluation of Wetland Mitigation Measures*, Volume 1: Final Report: 1-353.

This study determined the level of success of 23 highway-related wetland mitigation projects (divided into enhancement, creation, restoration) in terms of goal attainment and replacement of wetland functions. Success or failure determinations were based on both informal goals, expectations of biologists, and model assessments of wetland functions and values. This study was conducted during summer 1989, and projects were located around the country. Of the 23 mitigation projects, only 3 (1 enhancement site and 2 creation sites) appeared fully successful in replacing all functions lost to construction. Mitigation type was not apparently a factor in determining mitigation effectiveness; level of planning effort, inclusion of certain design elements in detailed mitigation plans, and precision with which plans were implemented appeared to be the most important aspects of effectiveness. As to planning, firm mitigation objectives and detailed plans were found to be necessary to ensure that good ideas were communicated clearly to construction crews and that the sequencing of construction was correct. Design elements of primary importance to successful enhancement, creation, or restoration of wetlands included location in relation to surface water systems and other wetlands, slope and elevation, topdressing of some type of topsoil, and configuration of vegetation and open water. In determining whether spreading topsoil was more effective than planting marsh plants to protect soils, this study found that although spreading topsoil is significantly more expensive ($14,600/acre vs. $1,100/acre); it was significantly more successful than plantings due to herbivory, harvesting, and moisture/substrate problems. As to set mitigation ratios, the study found that most were not based on scientific study or monitoring of success rates for functional replacement, but rather were set subjectively on the basis of a few previous examples of mitigation successes or failures. The study notes that, if appropriately located and implemented, certain wetland functions can be replaced through out-of-kind mitigation efforts. It also suggests that postconstruction monitoring occur for at least 3-5 years to determine if specific goals have been met. **Report; unkown review process**.

Wildlife Corridors

50. Aresco, M.J. (2005). "Mitigation measures to reduce highway mortality of turtles and other herpetofauna at a north Florida lake." *Journal of Wildlife Management* **69(2)**: 549-560.

The purpose of this study was to test the effectiveness of a drift fence and culvert system in reducing road mortality and facilitating the migration of turtles and other herpetofauna at Lake Jackson near Tallahassee, Florida. This study was conducted from 2000 to 2003 both during and following a severe 3-year drought (a 97.4 cm rainfall deficit in 1998-2000), and entailed a sampling period of 1,367 days and 5,664 total hours. Migration and death rates were attained before and after fence construction by monitoring a 700-m section of U.S. Highway 27N for live and dead animals and by observing the type and number of tracks along the roadside and culvert. A total of 10,229 reptiles and amphibians of 44 species were found either behind fences or on the highway. Road mortality rates for turtles were found to significantly decrease after the installation of fences (to 0.09 dead on road (DOR)/km/day from 11.9 DOR/km/day); less than 1% of turtles accessed the highway by climbing or penetrating the fences. Because all aquatic, semiaquatic, and terrestrial species are able to scale the temporary fences, only 74% of upland and semiaquatic species and 25% of aquatic species (excluding turtles) were prevented from reaching the highway. This study found vinyl erosion control fencing in combination with existing culverts to be an effective method of reducing road mortality. However, it states that attaining these results required frequent fence maintenance and daily monitoring to remove turtles from behind fences. A more effective long-term solution might be a permanent barrier with a smooth, vertical surface and an over-hanging, inward facing lip. Another potential issue of fencing is predation; 92/95 turtles were found dead behind fences as a result of mammalian predation after nightfall. **Journal; reviewed by six referees (incl. K. Dodd, F. James, M. Gunzburge, J. Travis, E. Walters).**

51. Cain, A.T., V.R. Tuovila, et al. (2003). "Effects of highway and mitigation projects on bobcats in southern Texas." *Biological Conservation* **114**: 189-197.

This study identified habitats selected by bobcats, assessed landscape characteristics correlated with vehicle-caused mortalities, evaluated bobcats' use of three types of highway crossing structures (bridges, modified culverts, and unmodified culverts), determined characteristics correlated with bobcats' use of these structures, and tested the utility of 100-m wing fences to increase bobcats' use of crossing structures. The study was conducted from July 9, 1997, to May 31, 1999, using radio collars to track 16 bobcats. Monthly crossing usage varied among structure types; bridges and modified culverts were used more often than unmodified culverts. Openness and cover were positively correlated with felid crossing use. Bobcats were photographed using the crossings at all times during diel periods; however, 41 of 54 complete crossings occurred in darkness. High-use crossing structure types were near dense thornscrub or drainages; regression analysis indicated cover was an important variable explaining bobcat crossing usage. Regression analysis also indicated that openness was significant in crossing usage, but the exact size of optimal culvert openings is not known. Erecting a fence to funnel wildlife toward culvert openings was found to have no significant effect on felid use of crossing structures; however, when culverts were little used were removed from the analysis, there was an indication that fences may increase bobcat use. During this study, 25 bobcats were hit while crossing the highway; mortality was more frequent on sections of the highway with large amounts of thornscrub (the preferred habitat type). Observations also indicate that catwalks may be important where standing water is likely to persist, and culverts that open into the median may reduce the tunnel effect and encourage usage. **Journal; reviewed by four referees (S.E. Henke, F. Hernandez, M.J. Chamberlain, T.J. Mallow).**

52. Dixon, J.D., M.K. Oli, et al. (2006). "Effectiveness of a regional corridor in connecting two Florida black bear populations." *Conservation Biology* **20**(1): 155-162.

This study evaluated the effectiveness of the Osceola-Ocala corridor for the Florida black bear using genetic material (hair and tissue samples) and geographic information system (GIS) maps to characterize the dispersal of bears from the source populations. Data were collected from 1998-2003 within the Osceola-Ocala corridor, a patchwork of public and private lands within a matrix of roads and development. Bears were present in multiple locations in the corridor, indicating that some individuals may be corridor residents. Most bears sampled in the corridor were assigned to Ocala (28 of 31), indicating a predominantly unidirectional pattern of movement from Ocala into the corridor. The ratio of bears sampled in the corridor was 3 females to 31 males, suggesting that the corridor is used primarily for gender-based dispersal. All bears sampled in Ocala (N = 40) were of the same origin, while 5 of 41 bears in Osceola were genetically related to the Ocala population. The results indicate that the corridor is functional and provides genetic and demographic connectivity; however, increasing pressure for development may affect the functional connectivity of these populations if the corridor habitat is not protected. There is some question as to whether the genetic restructuring within the Osceola population is due to corridor migration or the relocation of nuisance bears from Ocala into Osceola (6 of 7 fates are known; 1 is unclear). **Journal; reviewed by one referee (M. Sunquist).**

53. Ng, S.J., J.W. Dole, et al. (2004). "Use of highway undercrossings by wildlife in southern California." *Biological Conservation* **115**: 499-507.

This study sought quantitative data on the extent to which passages beneath highways (underpasses, livestock tunnels, and drainage culverts) in a fragmented landscape are used by wildlife and assessed characteristics of the passages most often frequented by species of concern. Fifteen potential wildlife passages were monitored, and each was observed for four consecutive days each month from July 1, 1999, to June 30, 2000. During the year of study, 2,723 detections were recorded as tracks and photos, of which 531 were native medium to large mammals, 1,640 were humans, 155 were domestic animals, and 397 were small mammals. Length was found to have a significant negative correlation with cross-sectional area. Coyote use showed a significant positive correlation with human activity and a significant negative correlation with development. Bobcat use showed a significant positive correlation between passage use and percentage of natural habitat; all three carnivores—bobcat, mountain lion, and coyote—showed a positive but not significant relationship between passage use and extent of natural habitat. Raccoon use correlated negatively with the extent of natural habitat and positively with the extent of developed habitat and passage length. No statistically significant relationships were found between passage attributes and activity of opossums or either of two skunk species, but passage length and use were positively correlated. Passage dimensions were found to significantly influence deer passage; mule deers' use of passages correlated negatively with passage length and positively with cross-sectional area. No significant relationships were found between the use of passages by mule deer and habitat type; however, all sites used by deer were characterized by significant amounts of nearby natural habitat. Domestic animals' use correlated negatively with passage length and positively with both cross-sectional area and the amount of human activity. This study offers some useful information pertaining to mammalian use of passageways under highways, but significant correlations were confusing and wind turbines are not likely to be close to highways. **Journal; reviewed by three referees (incl. M. Schwartz).**

Baseline Data

54. Erickson, W. P., G. D. Johnson, et al. (2002). *Synthesis and Comparison of Baseline Avian and Bat Use, Raptor Nesting and Mortality Information from Proposed and Existing Wind Developments*. Prepared for Bonneville Power Administration**:** 1-129.

To assist stakeholders in evaluating new projects, this report evaluates the ability to predict direct impacts on avian resources (primarily raptors and waterfowl and waterbirds) using less than a year of baseline avian use data. Data were collected for more than 30 study areas from 15 WRAs, including Foote Creek Rim (Wyo.), Stateline (Ore./Wash. State), Klondike (Ore.), and Buffalo Mountain (Tenn.). The amount and extent of baseline data should be determined on a case-by-case basis using information from this report; recent projects; existing project site data from agencies, groups, and individuals; public scoping; and results of vegetation and habitat mapping. Other factors that should be considered include the likelihood of sensitive species and expected impacts to those species, project size, and project layout. Baseline data on raptors collected during one season (spring, summer, or fall) appear to be adequate for making overall wind plant direct impact predictions (e.g., low, moderate, or high relative mortality), especially in agricultural settings. In areas where baseline data indicates a site has high levels of raptor use, the study recommends that data be collected for more than one season to refine predictions and micrositing decisions. Correlations are very low between fatalities and overall raptor nest density, but data on nests very close to turbines (within one-half mile) are currently inadequate to determine the level of impact. Wind plants with year-round waterfowl use have shown the highest waterfowl mortality; native landscape sites show very little waterfowl use except where significant water sources are available. Resident and migrant passerines constituted a large proportion of the fatalities at wind plants, but nocturnal migrant mortality appears very low compared with utilization rates. Bat collision mortality is virtually nonexistent during the breeding season; most mortalities involve migrant or dispersing bats in late summer and fall. Conclusions are based solely on a literature review; recommendations need to be field-tested. **Report; reviewed by nine referees (D. Malin, K. Kronner, A. Linehan, T. Meehan, G. McEwen, D. Mudd, J. Bernowitz, L. Sharp, Two Ravens Inc).**

55. Percival, S.M. (2003). *Birds and Wind Farms in Ireland: A Review of Potential Issues and Impact Assessment:* 1-25.

This document reviews current knowledge on the effects of wind farms on birds and provides a methodology for assessing those effects. In assessing wind turbine placement, it is not possible to have a fixed baseline survey requirement, so a phased approach (the level of detail required depends on the avian sensitivity of the site) is more useful. Phase 1 should include a collation of all existing information on the proposed site, as well as a bird survey of an area 500 m around the proposed site (or 300 m for breeding birds in less sensitive habitats such as farmland). These areas are based on the results of studies looking at the disturbance effects of wind farms on bird distribution (see Table 2). Phase 2 is completed if important bird species and populations may be affected (defined as those listed in Annex 1 of the European Union's Birds Directive, BirdWatch Ireland's red list, rare or vulnerable migratory species, or species occurring in regionally or nationally important numbers); this phase requires a more detailed assessment of the importance of the site to these species within an area of at least 1 km. An evaluation of potential collision risk and direct or indirect disturbance should also be conducted during this phase. Phase 3 is required where a significant potentially adverse effect (e.g., direct habitat loss, collision risk, or behavioral disturbance) is predicted, and includes a population analysis and options for reducing the risk. To determine the significance of a potential impact, a matrix combining impact magnitude and species sensitivity was established. To account for the inevitable degree of uncertainty in the predictions of wind farm impacts on birds, enhancement measures should be enacted that provide a benefit over and above the predicted adverse effect. This study also provides some useful tables listing bird mortality and habitat disturbance studies throughout Europe. **Report; no review process noted**.

56. Young, D.P., Jr., W. P. Erickson, et al. (2003). *Avian and Bat Mortality Associated with the Initial Phase of the Foote Creek Rim Windpower Project, Carbon County, Wyoming.* Prepared for Pacificorp, Inc., Bureau of Land Management and SeaWest Windpower, Inc.: 1-50.

This report presents results of more than 3 years of carcass search studies for Foote Creek Rim I, consisting of 69 towers and associated met towers. The large majority of wind-plant-related casualties (92%, N = 122) were passerines; slightly more than half of these, based on species and date found, were probably nocturnal migrants. The number of raptor casualties was very low during the study period despite high raptor use estimates for the site and a rotor swept area 5x larger than the average rotor swept area of turbines at Altamont. Although some studies have suggested that birds may be more at risk of collisions with wind turbines during inclement weather, this study found no strong correlations between avian or bat casualties and weather. Correlating fatalities to weather was difficult because the time of death was not known. More frequent casualty searches would be required to better determine time of death; however, in environments with low scavenging and high searcher efficiency, daily or weekly searches would not be necessary to estimate mortality accurately. **Report; no mention of review.**

Postconstruction Data

57. Arnett, E. B., W. P. Erickson, et al. (2005). *Relationships between Bats and Wind Turbines in Pennsylvania and West Virginia: An Assessment of Fatality Search Protocols, Patterns of Fatality, and Behavioral Interactions with Wind Turbines*. Prepared for the Bats and Wind Energy Cooperative: 1-187.

This study investigated the relationships between bats and wind turbines at the Mountaineer Wind Energy Center in Tucker County, West Virginia, and the Meyerdale Wind Energy Center in Somerset County, Pennsylvania. Primary objectives were to compare results of daily versus weekly carcass searches, quantify bias corrections needed to more accurately estimate fatality, and recommend improved search protocols for bats. Bat fatalities were also correlated to previous nights' weather and turbine conditions, and their behavior was quantified when encountering moving and nonmoving blades at turbines with and without Federal Aviation Administration (FAA) approved lights. Estimates at the two locations were among the highest ever reported, supporting the contention that forested ridges pose especially high fatality risks to bats at wind facilities. Weekly searches at Mountaineer produced mortality estimates 3x lower than daily estimates because of high scavenging rates and the periodicity of fatalities. Weekly searches at Meyerdale, however, yielded similar but slightly higher (1.2x) results compared with daily searches because of low scavenging rates. A better design might be to search a portion of turbines each day for 4 days, rather than all turbines on 1 day. Considerably more adult male bat carcasses were found than those of adult females or juveniles of either sex. This may result from differential distribution among males and females within landscapes, especially during summer. Fatalities were distributed across all turbines at both sites, although higher than average numbers of bats were found at turbines near the end or center of a string (but no significant correlation supported a relationship). The only turbine with no fatalities was in a feathered (blades parallel to wind), "free-wheeling" (blades allowed to move freely) mode in which the blade essentially did not move unless winds were quite high (>15 m/s); this suggests that bats are not running into stationary blades or turbine masts. Lighting or ultrasounds do not appear to be significant attractions; however, other sources of ultrasonic emissions from turbines should be investigated further. The timing of all bat fatalities was highly correlated, suggesting broader landscape patterns dictated by weather and availability of prey. Thermal images indicated that bats are attracted to and investigate both moving and nonmoving blades; most bat activity occurs in the first 2 hours after sunset. The majority were killed on low-wind nights when power production appeared insubstantial but turbine blades were still moving, often at or close to full operational speed (17 rpm). Fatalities increased just before and after the passage of storm fronts. Turbines within forest openings and near edges may be misconstrued by bats as favorable roosting sites, as shown in observations of bats landing on turbine masts and stationary turbine blades. Modifications to wind farm landscapes (e.g., open spaces around turbines and access roads) may create favorable foraging habitats for both local and migratory bats. **Report; reviewed by numerous referees (incl. E. Gates, M. Huso, P. Jodice).**

No Effect

58. Lucas, M. D., G. F. E. Janss, et al. (2005). "Bird and small mammal BACI and IG design studies in a wind farm in Malpica (Spain)." *Biodiversity and Conservation* **14**: 3289-3303.

This study was carried out in northwestern Spain for 3 years during various periods of wind farm construction: preconstruction (June 1995), construction (June 1996), and postconstruction (June 1997). The turbines are in a mixed coastal shrub steppe and maritime woods habitat. The study analyzed (1) the possible impacts of the wind farm on nesting and nonnesting bird communities, (2) flight behaviors of both nesting and nonnesting birds affected by the presence of the wind farm, (3) possible impacts of wind farms on rodents. Wind farms were not found to clearly affect bird and small mammal populations, as there was no significant difference in avian abundance or density between study years or areas (wind farm vs. reference). Significant differences were detected in flight heights between study areas; soaring birds were observed to detect the turbines and change flight directions. Small mammals did not appear to be affected by the wind farm at all. Mortality studies were not conducted because the postconstruction period of study was only a few months. **International journal; not sure of review process.**

Offshore

59. Pettersson, J. (2005). *The Impact of Offshore Wind Farms on Bird Life in Southern Kalmar Sound, Sweden.* Prepared at the request of the Swedish Energy Agency**:** 1**-**128.

This study was conducted over four spring and four autumn seasons from 1999 to 2003 in the Kulmar Sound in Sweden. Migration patterns of waterfowl and flock reactions to wind turbines (7 in all) were studied and documented. Researchers found that spring migratory paths have shifted up to 2 km eastward, and that during both spring and fall migration, flocks avoid flying closer than 1 km to turbines. The proportion of flocks that made a change in flight path was about 30% in good visibility in spring and 15% in fall. Radar monitoring showed waterfowl migration in fog and mist to be limited, and indicated that nocturnal migrants reacted similarly to the turbines as daytime migrants did. Visits to turbines by wind farm service boat were found to disturb the long-tailed duck and common scooter, so that they abandoned their feeding areas in the vicinity of the turbines in the daytime. This study site included only 7 turbines, and only 1 death was recorded (Eider). **Report; reference group indicated.**

Literature Reviews

60. Drewitt, A.L., and R.H.W. Langston. (2006). "Assessing the impacts of wind farms on birds." *Ibis* 148: 29-42.

61. Erickson, W. P., G. D. Johnson, et al. (2001). *Avian Collisions with Wind Turbines: A Summary of Existing Studies and Comparisons to Other Sources of Avian Collision Mortality in the United States*. National Wind Coordinating Committee**:** 1-67.

This paper provides a detailed summary of mortality data collected at wind plants and puts avian collision mortality associated with wind power development into perspective in regard to other significant sources of avian collision mortality across the United States. A summary is provided of data collected at many U.S. wind plants and annual bird fatality estimates and projections for all U.S. wind turbines.

62. Gerson, J., and D. Klute. (2006, January). *Wind Power and Wildlife in Colorado: An Informational Resource Guide*. Prepared for the Colorado Division of Wildlife.

63. Herbert, E., E. Reese, and R. Anderson. (1995, October). *Avian Collision and Electrocution: An Annotated Bibliography.* Prepared by the California Energy Commission: 1-114.

64. Johnson, G.D. & E. Arnett. (2004, July 16). *A Bibliography of Bat Interactions with Wind Turbines.*

65. Kerlinger, P. (2000). *Avian Mortality at Communication Towers: A Review of Recent Literature, Research, and Methodology*. Prepared for the U.S. Fish and Wildlife Service Office of Migratory Bird Management.

66. Mabey, S. (2006, November). *Impact of Wind Energy and Related Human Activities on Grassland and Shrub Steppe Birds*. Prepared for the National Wind Coordinating Committee by the Ornithological Council: 1-128.

67. Manville, A. M. (2005). *Bird Strikes and Electrocutions at Power Lines, Communication Towers, and Wind Turbines: State of the Art and State of the Science—Next Steps Toward Mitigation*. U.S. Department of Agriculture Forest Service**:** 1051-1064.

68. Rowland, M.M., M.J. Wisdom, et al. (2005). "Effects of roads on elk: Implications for management in forested ecosystems." In M.J. Wisdom (technical editor), *The Starkey Project: A Synthesis of Long-term Studies of Elk and Mule Deer*. Reprinted from the 2004 *Transactions of the North American Wildlife and Natural Resources Conference*, Alliance Communications Group, Lawrence, Kansas: p.45-52.

This paper (1) describes current knowledge about the effects of roads on elk, emphasizing results of research conducted at Starkey; (2) describes an example in which a distance-band approach, rather than the traditional road density method, was used to evaluate habitat effectiveness (HE) for elk in relation to roads; and (3) discusses the broader implications of road-related policies and land management with regard to elk. Illustrated direct impacts of increased road density on elk include avoidance of areas near open roads (response varies with traffic rates, extent of forest canopy, topography, type of road, gender, and temporal and spatial scales); increased vulnerability to mortality from hunting; and increased stress and movement rates. The study suggests that road closures may have the following benefits: decreased energy expenditures and improved diet quality for elk, increased total amount of effective habitat, increased hunting opportunities on public lands, decreased damage to crop and haystacks by elk on private lands, and decreased vulnerability of elk during hunting

seasons. However, road closures alone may not be effective in eliminating the effects of roads and traffic on elk because of inadequate enforcement. Careful assessment of how roads are being used, rather than their official status, is suggested as necessary to credibly evaluate effects of roads on elk and other wildlife. Additional research is suggested to enhance our understanding of the effectiveness of road closures, as well as on the precise levels of disturbance from motorized traffic that elicits a response and the duration of that response. Much of what has been learned about elk and roads is from field studies that lacked experimental components; thus, there was no sound basis from which to infer cause-effect relationships. **Report in book; reviewed by three referees (J.G. Kie, G.J. Roloff, B.C. Wales)**.

69. Spellerberg, I.F. (1998). “Ecological effects of roads and traffic: A literature review.” *Global Ecology and Biogeographical Letters* **7**(5): 317-333.

70. Trombulak, S.C., and C.A. Frissell. (2000). “Review of ecological effects of roads on terrestrial and aquatic communities.” *Conservation Biology* **14**(1): 18-30.

This study involves a literature review of the ecological effects of roads. Road construction has been shown to cause soil compaction, sedimentation, and direct mortality of individual species. Wildlife collisions with vehicles have increased with traffic volume (Rosen and Lowe 1994, Fahrig et al. 1995); however, high-speed and medium-speed roads have both attracted various species of wildlife. Environmental characteristics that are altered by roads include soil density, temperature, soil water content, light, dust, surface-water flow, pattern of runoff, and sedimentation. In addition, the maintenance and use of roads contribute at least 5 different types of chemicals to the environment: heavy metals, salt, organic molecules, ozone, and nutrients. Heavy metal contamination has been shown to increase with vehicular traffic (Leharne et al. 1992, Dale and Freedman 1982). Accumulations of salts from chemicals used to control dust or deice roads can disrupt natural stratification patterns and thus potentially upset the ecological dynamics of meromictic lakes (Hoffman et al. 1981, Kjensmo 1997). Roads tend to disperse exotic species by stressing or removing native species and allowing easier movement by wild or human vectors. Overall, the specific mechanisms by which flora and fauna are affected by roads are often complicated and uncertain; thus, mitigation or treatment of specific effects can be costly and uncertain. In addition, the multiplicity of effects resulting from the construction of roads suggests it is unlikely that consequences will ever be completely mitigated or remediated. It is thus critical to retain remaining roadless or near-roadless areas in their natural state. **Journal; reviewed by two referees (incl. R. Noss).**

Current Studies

71. Lehn, K., and F. Bairlein. (2006). “Is mulching a suitable method for improving the nesting habitat of the northern lapwing?” *Journal of Ornithology* **147**(5).

This study was conducted from 2002 to 2004 in the Diepholzer Moorniederung in northwest Germany to determine if winter mulching could be used to improve pastures for northern lapwing nesting. Mulching is defined as cutting and leaving the shredded vegetation in situ. Five nature reserves comprising 100.6 ha were mulched during the winter; then, the distribution and breeding of northern lapwings were mapped during the breeding seasons. Vegetation in mulched areas was significantly shorter and less dense during the breeding season (April/May) than in control areas, but no significant difference was found in the density of lapwings between the two areas. Lapwings showed a preference for mulched areas over control areas, however, and more nests were found in mulched areas than within control areas. Mulched areas appear to provide suitable nest sites, presumably because litter is present and vegetative regeneration is delayed. Therefore, they offer a suitable management tool for improving lapwing nesting habitat.

72. Gregory, A., S.M. Wisely, and B.K. Sandercock. (In progress) The Genetic Consequences of Wind-power Development on Greater Prairie Chicken (Tympnuchus cupido) Leks in Eastern Kansas.

This study is using a BACI design to assess the possible genetic consequences of habitat loss and fragmentation due to wind-power development on greater prairie chickens in the Flint Hills region of eastern Kansas.

73. McNew, L.B., B.K. Sandercock, and S.M. Wisely. (In progress) Effects of Wind Power Development on the Demography of the Greater Prairie Chicken.

This study is examining the impacts of wind development on lek attendance, mating behavior, habitat use, dispersal, and demographic performance of greater prairie chickens. A BACI design with three replicates of paired study sites will be used to assess potential impacts of wind development on prairie-chicken demography. Focal population studies will occur at the Elk River II site in Butler County, Kansas, in Year 1, and expand to three sites in Years 2-4. Birds will be captured and radio-marked at leks during the 2006-2009 breeding seasons for this study. Treatment and reference sites will be monitored simultaneously during three phases of wind power development: predevelopment, construction, and operation.

74. PIER Energy-Related Environmental Research. (In progress) Range Management Practices to Reduce Wind Turbine Impacts on Burrowing Owls and Other Raptors in the East Bay Regional Parks. For information, see www.energy.ca.gov/pier/environmental/project_summaries/PS_500-01-032_DIDONATO.PDF.

This study is investigating land management practices in relation to raptor behavior and prey distributions, as well as raptor flight behavior and spatial distribution over land with and without wind turbines at the Altamont Pass WRA. The study seeks to understand how vegetation management practices (e.g., sheep grazing) in the APWRA can modify raptor foraging patterns by changing the distribution of prey. Three-dimensional GIS models will be used to characterize the influence of range management practices on raptor flight patterns, small mammal burrow distributions, burrowing owl nesting patterns, and turbine-induced avian mortality. A progress report detailing preliminary results is expected in January 2007.

75. Schroeder, M.A., C.E. Braun, and J.W. Connelly. (In progress) Effects of Wind Power Development on Sage Grouse.

This study is looking at the effect of sagebrush-steppe site developments on local sage grouse populations. The hypothesis is that the footprint of wind power generation in the sagebrush steppe is far larger than that presented by proponents because of the spread of noxious weeds, habitat loss and fragmentation, and mortality risk due to predation and collisions with turbines, power lines, fences, and vehicles. Researchers believe that site developments within this habitat-type will present major impediments to the retention of local sage-grouse populations.

76. Sherwell, J. (In progress) Developing a Mitigation Strategy for Bat Impacts from Windpower Development in Maryland.

This study presents a model that has been established to aid in the development of mitigation strategies for wind turbine developments in Maryland along the Appalachian Mountains. Two mitigation scenarios were investigated: one in which suboptimum tip speed ratios are explored, the other in which the rotation rate is managed from a low value up to a threshold value, above which the optimum tip speed ratio is established. Results indicate that both mitigation strategies significantly reduce cumulative risk of collisions relative to operation at maximum tip speed ratios.

77. Szewczak, J., and E.B. Arnett. (In progress) Evaluation of Acoustic Deterrents to Reduce Bat Fatality at Wind Facilities.

> This study seeks to determine if high-intensity ultrasounds will deter bats from wind developments. The hypothesis is that above some threshold, bats will exhibit avoidance because they cannot hear anything but the sound being emitted from the deterrence device.

78. Young, D.P. (In progress) Impacts of Wind Power Development on Mountain Plovers at Foote Creek Rim.

> This study showed mountain plover nesting success to be lowest during construction years, increasing in subsequent years. The sample size was small (n = 41), and it is difficult to separate potential disturbance or displacement effects from a broader decline in the mountain plover population. The results of this study indicate that mountain plovers appear to be compatible with wind projects over the long term.

Case Study 1

Arnett, E.B., technical editor. (2005*). Relationships between Bats and Wind Turbines in Pennsylvania and West Virginia: An Assessment of Bat Fatality Search Protocols, Patterns of Fatality, and Behavioral Interactions with Wind Turbines*. Final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA.

Introduction

This study was conducted in 2004 to investigate the relationship between bats and wind turbines at the Mountaineer Wind Energy Center in West Virginia and the Meyersdale Wind Energy Center in Pennsylvania, because an abnormally high number of bat fatalities were discovered at Mountaineer in 2003. Numerous hypotheses were proposed about the mechanisms of bats' attraction to wind turbines or failure to detect them. However, there was little research on the relationships between bats and wind turbines.

In response to concerns about potential bat fatality issues and potentially inaccurate postconstruction monitoring protocols (an avian fatality protocol was used to study bats in Mountaineer), representatives from the American Wind Energy Association (AWEA), Bat Conservation International (BCI), the U.S. Department of Energy's National Renewable Energy Laboratory (NREL), and the U.S. Fish and Wildlife Service (USFWS) joined together to form the Bats and Wind Energy Cooperative (BWEC). The purpose of this collaborative was to conduct research needed to address issues and develop solutions surrounding wind energy development and bat fatalities.

This study describes the first field research undertaken by the BWEC. The primary objectives were to compare results of daily versus weekly carcass searches, quantify bias corrections needed to more accurately estimate fatalities, and recommend improved search protocols for bats. In addition, bat fatalities were correlated to previous nights' weather and turbine conditions, and their behavior was analyzed when bats encountered both moving and unmoving blades on turbines both with and without Federal Aviation Administration (FAA)-approved lights.

This case study summarizes the techniques used, data collection, and results described in each of three chapters in the report: "Bat and Bird Fatality at Wind Energy Facilities," "Timing of Nightly Bat Activity and Interaction with Turbine Blades," and "Use of Dogs to Recover Bat/Bird Fatalities**."**

Techniques Used

Bat and Bird Fatality at Wind Energy Facilities. Statistical techniques were used to develop estimators of fatality and compare these estimates from weekly and daily searches. The researchers also investigated the use of the program DISTANCE for developing estimates of bat fatalities. Associations between turbine and weather characteristics and recent bat fatalities were investigated using graphical methods, univariate association analyses, multiple regression, and logistic regression. For more, see the detailed description of statistical methods used in this study.

Timing of Nightly Bat Activity and Interaction with Turbine Blades. Thermal infrared imaging was used to observe the basic types of flight behavior around the rotor-swept zone of the turbines. This allowed researchers to observe bat and turbine blade interactions and establish the timing of nightly flight activity around operating turbines.

Use of Dogs to Recover Bat/Bird Fatalities. Using hand signals and whistle commands, researchers trained two Labrador retrievers to quarter within a 10-m wide area and to locate bat carcasses of different species and in different stages of decay. Dogs were trained using the fundamental principles employed to teach basic obedience, upland game bird hunting techniques, and blind-retrieve handling skills.

Data Collection

Bat and Bird Fatality at Wind Energy Facilities. Carcass searches were conducted for 6 weeks, from the beginning of August to mid-September. Half the turbines at each site were sampled daily for three weeks; the other half were sampled once a week (on the same day) for three weeks. The sampling protocols switched in the final three weeks to ensure that all turbines were sampled at both daily and weekly intervals.

Fatality studies were conducted by centering a rectangular plot measuring 130 m x 120 m on each turbine sampled. This distance was based on previous studies that indicated most bat fatalities are found within half the maximum distance from the tip height to the ground (the tip height for Mountaineer is 104.5 m and for Meyersdale, 115 m). Search plots at Mountaineer, however, were often irregularly shaped because of the proximity of the forest edge, and the distance from each turbine to its search plot boundary varied in all directions. Transect lines were established 10 m apart within each plot, and searchers walked each transect line and searched the area 5 m away on each side of the line.

Searcher efficiency and carcass removal trials were conducted using fresh and frozen or thawed bat carcasses found at each study site, by discreetly marking each specimen for later identification purposes. Fresh bat carcasses found each day were uniquely marked and either left in the field where found or redistributed to a predetermined randomly selected location. Carcasses were checked daily until removed or until the end of the 21-day trial period.

Information was also collected on whether bat fatalities occurred at lit or unlit turbines, and whether or not ultrasonic sounds were being emitted by digital anemometers at the turbine (anemometers were disabled at half the even-numbered turbines at each site). Finally, weather data were collected every 10 minutes from each meteorological tower and turbine by using a digital anemometer.

Timing of Nightly Bat Activity and Interaction with Turbine Blades. Data were collected between 2030 and 0530 hours from August 2 to 27, 2004, at the Mountaineer Wind Energy Center. Images were collected by using three FLIR Systems S60 uncooled microbolometer video cameras mounted on tripods and grouped together at a single observation station beneath a turbine. Data were captured at 30 frames per second, and the cameras were placed at randomly chosen lit and unlit turbines for five nonconsecutive nights. Terrain permitting, camera stations were located 30 m from the base of the turbine, directly upwind and perpendicular to the plane of rotation; each camera focused on a different part of the rotor-swept area. Each object observed was classified according to a set of qualitative criteria, a time stamp was recorded, and flight elevation and direction were estimated.

Use of Dogs to Recover Bat/Bird Fatalities. Dogs and their handlers and human searchers alone were tested regularly during searcher efficiency trials at both sites. Dog/handler searches were conducted both before and after humans conducted searches alone. The two Labradors alternated between each plot in order to reduce observer bias, evaluate differences in search efficiency between dogs, and allow rest to reduce fatigue and increase performance. Humans alone were restricted to the transect lines; dogs were allowed to quarter the entire 10-m-wide search area for each transect.

Results

Bat and Bird Fatality at Wind Energy Facilities. Searchers found 398 bat carcasses from six bat species at Mountaineer and 262 bat carcasses from seven species at Meyersdale; the most common species killed was the hoary bat. Bat fatalities were highly variable and periodic throughout the study. Fatalities were distributed across all turbines, although generally higher than average numbers of bats were found at turbines near an end or the center of the string at both sites. Of the 64 turbines studied, one (turbine 11 at Mountaineer) was not operational throughout the study period, and no fatalities were found near it.

The timing of all bat fatalities at Mountaineer and Meyersdale was highly correlated. Although more male than female bat fatalities were found, the timing by sex was similar at both sites. Additionally, timing of fatalities of hoary and eastern red bats was positively correlated at both sites. These temporal patterns suggest broader landscape, perhaps regional, patterns dictated by weather and prey abundance or availability or other factors. Ninety-three percent (Mountaineer) and 84% (Meyersdale) of fatalities were found $\leq$40 m from the turbine; there were more adults than juveniles and more male than female carcasses at both sites.

Fatalities per turbine averaged 10.6 at Mountaineer and 13.1 at Meyersdale. The only turbine with no fatalities operated in a ‘feathered’ mode (blades parallel to the wind) and ‘free-wheeling’ (blades allowed to move freely). At Mountaineer, 6.1 times more fatalities were found during daily searches than during weekly ones; at Meyersdale, daily searches yielded only 2.1 times more fatalities than weekly searches. Searcher detection probability was found to be 43.6% overall for all trials at Mountaineer and 25% at Meyersdale; detection probability decreased with distance from the transect line (5x lower >2.5-3 m from the transect, unless it was open habitat), with distance from the turbine (decreasing beyond 10 m), and in lower visibility habitat areas.

Carcass removal rates were found to differ substantially between the two study sites; 24% of the fresh bat carcasses left in place were removed within the first day at Mountaineer, and only 3% were removed within the first 24 hours at Meyersdale. Carcasses placed in high visibility habitats at Mountaineer were removed at approximately twice the rate of those placed in low to extremely low visibility habitats (47.7% vs. 12.5% and 29% respectively) within the first 24 hours, and fresh carcasses were removed more rapidly than those that had been previously frozen. Based on estimates derived from habitat visibility strata, daily searches yielded an estimated 38 bats killed per turbine, and a total of 1,364–1,980 bats were killed for the 6-week study at Mountaineer. An estimated 25 bats were killed per turbine, and a total of 400–660 bats were killed at Meyersdale during the 6-week study.

Bat fatalities were similar between turbines equipped with FAA lights and those that were unlit, and fatalities at turbines with anemometers turned off were slightly lower than at turbines with operating anemometers, but the differences were not statistically significant. Factors relating to wind speed were found to be significantly related; higher wind speeds were associated with lower fatality rates.

Timing of Nightly Bat Activity and Interaction with Turbine Blades. Although 4,572 objects (birds, bats, insects, etc.) were observed within the datasets collected, time constraints required that datasets be selected that were collected by one camera (Camera A) from 10 sample nights for the final analysis. A total of 2,398 observations were made at turbines during this 10-day period from Camera A: 998 bats (41%), 503 insects (20%), 37 birds (1%), and 860 unknown (35%). Flight elevation was highly variable, but 3x more bats were observed to fly within the medium-altitude band (within the upper and lower bounds of the blade swept area), than at ‘low’ or ‘high’ altitudes. The number of bats observed nightly was highly variable, and a significant correlation was found between insect passes or insect abundance and bat passes. Bat activity was highest 2 hours after sunset and in the early morning hours; a lull in activity occurred close to midnight. Aviation lighting did not appear to affect foraging around turbines, although it was observed to result in higher insect activity.

Thermal images indicated that bats are attracted to and investigate both moving and unmoving blades. Thermal images of bats attempting to land or actually landing on stationary blades and turbine masts suggest possible curiosity about potential roosts or use for gleaning insects. Images of bats chasing turbine blades rotating at slow speeds suggest possible attraction to movement out of curiosity. However, most of the observed collisions (7 of 8) were between bats and fast-moving (17 rpm) turbine blades.

Use of Dogs to Recover Bat/Bird Fatalities. Results varied between the male and female dogs at Mountaineer (80% and 60% efficiency, respectively), but were similar between dogs at Meyersdale (80% and 82% for the male and female, respectively). Dog/handler and human searchers' efficiency varied considerably between the two sites; the dog team found 71% of the carcasses at Mountaineer and 81% at Meyersdale, compared with 42% and 14% for the human searchers, respectively. Dog and human searchers' efficiency also varied considerably with distance from the turbine and visibility. Both teams found a high proportion of bats within 10 m of the turbine and in high-visibility habitats, but humans' efficiency declined beyond 10 m with declining visibility while the dog/handler team remained relatively consistent.

Implications For Wind Development

Although this study has improved our understanding of why and how bat collisions and fatalities occur, it marks the first attempt to observe and interpret bat behavior in the rotor-swept zone of operating turbines; as such, it presents numerous questions requiring further investigation. While statistical inferences are limited to the forested ridges in the Appalachian Mountains where the study areas were located, similar findings could be expected at wind facilities with comparable forest composition and topography. The following areas appear to be most promising for improving research and mitigating the effects of wind development in the future:

- Daily searches must be conducted at a portion of turbines in a wind farm to establish relationships between fatalities, weather patterns, and turbine characteristics. These relationships are critical in furthering our understanding of the predictability of fatalities.

- A pilot study on carcass removal rates would be useful in determining intervals for fatality searches. Fresh carcasses should be used to more accurately reflect realistic rates of scavenging.

- In areas where carcass removal rates are relatively low, infrequent searches can yield relatively accurate fatality estimates. However, removal rates should be expected to change over time, thus changing fatality estimates, as scavengers learn about a new food source. In areas where carcass removal rates are high, however, more frequent fatality searches should be conducted to avoid underestimating the fatality rate. Daily searches are advised in areas with high scavenger rates; however, weekly searches interspersed among days of the week rather than on one day should result in similar estimates. It is important to note that searchers' efficiency and scavenger removal differ by habitat type because different vegetative cover conditions influence observer detectability and scavenging rates. Thus, these statistics should not be extrapolated from one habitat type to another.

- Dog/handler teams have strong potential for increasing the precision of fatality estimates for at least some questions of interest. However, the results of this study are preliminary, and further research is necessary to better understand the efficacy of the use of dogs and determine any bias associated with that.

- FAA lighting and ultrasonic sounds were found to have little to no effect on bat fatality rates.

Potential mitigation strategies include the following:

- High wind speeds appeared to result in low levels of bat fatalities associated with wind turbines; low wind speeds were associated with high levels of fatalities. “Feathering” turbines on nights of low winds and relatively low levels of power production may reduce fatalities, but further study is required to evaluate the reductions relative to economic costs.

- Bats’ attraction to turbines appears to be influenced by several interacting factors. Extreme variations in nightly insect and bat activity suggests that dynamic variables (e.g., weather conditions) are at play rather than some fixed property of the turbines themselves. However, bats also were observed attempting to land on stationary blades and masts, supporting the roost-attraction hypothesis. These factors, combined with the fact that bats are most active during the first two hours after sunset, suggest that windows of high risk for collisions may be clearly identifiable with additional long-term studies. Curtailing turbines during these periods may significantly reduce bat fatality rates.

Case Study 2a

Young, D. P., W. P. Erickson, et al. (2003). *Comparison of Avian Responses to UV-Light-Reflective Paint on Wind Turbines.* Prepared for the National Renewable Energy Laboratory: 1-67

Introduction

The study was conducted to test the hypothesis that painting turbine blades to increase their visibility will reduce avian fatalities. Birds can visually detect wavelengths outside the range of human vision, including the ultraviolet (UV) spectrum; some research suggests that birds may be more sensitive to UV light than to visible light (Kreithen and Eisner 1978, Burkhard and Maier 199, Chen et al. 1984). UV light is defined within this study as light between 0 and 400 nm in wavelength.

The objectives of this study were to (1) review and critique published and unpublished information relevant to the study, (2) estimate the spatial and temporal behavior of birds near turbines with blades coated with UV-reflective paint vs. the behavior of birds near turbines coated with non-UV-reflective paint, and (3) compare the number of carcasses found near turbines with blades coated with UV-reflective gel vs. those found at turbines without the coating. The overall study format is quasi-experimental because the study design was based on U.S. Fish and Wildlife Service (USFSW) recommendations without control over the spatial distribution of turbines with UV-reflective blades.

Techniques Used

UV gel was applied by the blade manufacturers at the factory, and conformed to Mitsubishi Heavy Industries standards for spectral reflectance of light wavelengths. UV reflectance was approximately 60% in comparison to that of standard paint, which reflects approximately 10% of UV light and absorbs the rest. UV-reflective blades were installed during Phases I and II of the Foote Creek Rim Wind project in response to USFWS recommendations, but Phase III was constructed using conventionally painted turbine blades. Mean use estimates were calculated (using detections within 400 m of each point) by species and grouped by bird size.

Data Collection

Six permanent stations were established within the Foote Creek Rim (FCR) wind site. Two stations were placed in the section of the plant with conventional paint (FCR III, 33 turbines) and 4 stations were placed in the section in which UV-reflective gel had been applied to turbine blades (FCR I, II, 72 turbines). Avian use was estimated by conducting point count surveys once per week for 76 weeks from July 1, 1999, to December 31, 2000. Each survey consisted of visiting six plots 2x each survey day, once in the morning (0600-1200 hours) and once in the afternoon (1200-1800 hours). A survey consisted of 40-minute point counts at each station.

Data from fatality studies conducted in 1998 were used to estimate the number of fatalities associated with the FCR I turbines, and the protocol was expanded to cover FCR II (UV) and FCR III (non-UV). Fatality searches were conducted within plots that extended 60 m in all directions from the turbine, centered on a turbine by walking parallel transects. Transects were set approximately 8-10 m apart, and searches of all turbine strings were conducted every 28 days. Carcasses found at other times and places were recorded as incidental carcass discoveries. Carcass removal and searcher efficiency trials were conducted for statistical purposes.

Results

Golden eagles (GOEA) were the most abundant raptor species observed (0.238/survey). Overall raptor use was significantly higher on the UV area (0.778) than on the non-UV area (0.215); mainly because of the high estimates for GOEAs and red-tailed hawks (RTHA). The lowest raptor use occurred during winter (November-March). Raptor use by distance from turbine was not significantly different between the UV and non-UV areas. Overall passerine use was not different between the two areas, primarily because of the offset of use in the non-UV area caused by a greater abundance of horned lark (HOLA) in that area.

Eighty-four fatalities were found within the boundaries of the search plots, 57 of which occurred at the 72 UV turbines (68%), 13 at the 33 non-UV turbines (15%), and 14 at the 7 meteorological (met) towers (17%). The majority of casualties were passerines (78/84), most of which were HOLAs (26). No significant differences were noted between fatality rates for the UV and non-UV turbines, although overall passerine fatality rates at the UV turbines were 2x higher than at the non-UV turbines (primarily because of the higher number of HOLA casualties per turbine).

Overall mortality was estimated to be 1.49/turbine; raptor mortality was estimated to be 0.042. The risk index was found to be 3 times higher at the non-UV area compared with that of the UV area for raptors, but this was not statistically significant. Because there were only 6 raptor fatalities, the magnitude of the differences was probably not correctly estimated.

Implications for Wind Development

This study found no evidence to support the claim that turbine blades coated with a UV-light-reflective paint result in lower bird usage, mortality, or risk compared with those associated with blades coated with conventional paint. The low level of avian mortality observed and the uncontrolled experimental design, however, limit researchers' ability to make statistical inferences. The high level of use and fatalities observed for HOLAs suggest a correlation between avian use and mortality; however, relationships between raptor species use and mortality were not apparent. The high rate of passerine deaths at guyed met towers (4-5 times higher than those for either turbine type), support arguments that unguyed permanent met towers should be constructed to minimize avian mortality.

Case Study 2b

Hodos, W. (2003). *Minimization of Motion Smear: Reducing Avian Collisions with Wind Turbines.* Prepared for the National Renewable Energy Laboratory**:** 1-43.

Introduction

This study analyzed the causes of bird collisions with wind turbine blades and evaluated visual deterrents based on the results of the analysis. Although birds have excellent visual acuity (especially raptors), they still collide with turbines. The researcher's hypothesis was that a phenomenon known as "motion smear," "motion blur," or "motion transparency," in which an object becomes progressively blurred as it moves across the retina with increasing speed, may be part of the problem. The purpose of this study was to determine the ability of birds to see turbine blades at varying velocities, with varying patterns and colors and with and without lateral blade tip devices. The data collected were used to model the distances at which patterns maintain their visibility for different turbine diameters and rotation rates.

Techniques Used

A variable-speed motor was fitted with 32-cm-long rotor blades made from 5-mm white foamboard and placed against a background of white posterboard. Three tungsten halogen lamps were used for illumination, and positioned in a manner that minimized shadows. A pattern electroretinogram (PERG) was used to measure the visibility of the blades to birds using a variety of anti-motion-smear patterns and other patterns at various retinal-image velocities and against several types of stimulus backgrounds. The ENFANT visual electrophysiology system apparatus was used to present visual stimuli on a video display monitor and record, amplify, display and analyze electrical potentials. The rotation rate of the blades in rpm was measured by allowing the blades to interrupt a photocell light beam.

Data Collection

Fifteen American kestrels (AMKE) were used throughout this study, and a different number of individual subjects were used for each aspect of it. Individual birds were lightly anesthetized for testing purposes, and their heads were placed in a rigid metal head holder to eliminate movement. Vecuronium bromide was administered to the cornea over 20 to 30 minutes to paralyze accommodation. Platinum electrodes were inserted in each upper eyelid, and a third electrode was inserted in the skin of the scalp to serve as a ground. One eye was covered with a black patch (this electrode served as the reference).

Eight blade velocities, ranging from 36-144 rpm, were tested to determine the threshold visibility of a simulated turbine blade display. Blade visibility was measured by collecting data from seven recording sessions (three measurements were made per session at each velocity) from three AMKE using the following stimuli: (1) blank blades, (2) blades with thin stripes in a staggered, anti-motion-smear pattern, (3) blades with thick stripes in an anti-motion-smear staggered pattern, and (4) no stimulus (both eyes covered).

To evaluate a variety of blade patterns with anti-motion-smear properties, 6 pattern types were tested, as well as blank blades and a physiological noise condition (both eyes covered) on 6 AMKE. Presentation and recording methods were the same as in the velocity experiment, except that the blades were presented at 130 degrees of visual angle per second (dva/s) of retinal-image velocity, which is the retinal velocity at which the patterns are maximally visible. Three measurements were made of each pattern type during each recording session.

To determine the effectiveness of color on blade visibility, chromatic stimuli specified by the R-G-B color system were tested on seven AMKE. Stimuli were printed (solid and striped) using a Hewlett-Packard 2000, photo-quality, professional ink-jet printer. The rotation rate for the blades was 130 dva/s, at which achromatic patterns are maximally visible. Visibility of colored blades was tested against blank and colored backgrounds depicting wind-resource areas (three to five AMKE were used). A single-blade pattern composed of thin, silver, reflective stripes was also tested against the variegated naturalistic background.

The visibility of lateral blade stimuli against a neutral white background was also tested on four AMKE by attaching blade tip devices at right angles to the long axis of the blade. The devices attached were black squares that subtended 6.5 x 6.5 dva.

Results

The visibility of the thin stripes, as measured by the amplitude of the PERG in microvolts (μV), at 130 dva/s (4.2 μV) was significantly more visible than the noise, blank blades, and thick stripes; however, by 170 dva/s the visibility of the thin stripes dropped to 0.9 μV, and by about 240 dva/s it was close to zero. Although neither the thick stripes nor the blank blades were significantly different from the noise at 130 dva/s, at 170 dva/s the visibility of thick stripes was 1.0 μV and for blank blades it was 1.6 μV. By 200 dva/s and at all subsequent velocities, no differences between blades were significant, nor were any of the visibilities significantly different from noise (they were virtually invisible to the AMKE).

Of the 8 scenarios tested, the only blade patterns found to significantly differ from the blank blades at 130 dva/s were noise (both eyes covered), 1 blade painted with solid black and 2 left blank, and thin, staggered black stripes on all blades. Red, black, and green blade patterns were found to be significantly more visible than blank blades; however, when the blank background was changed to a colored scene, no statistically significant differences were found among the stimuli. Color and spatial patterning of the background played a major role in the visibility of a particular stimulus; the visibility of the blank blades increased considerably against this type of background.

The approach angle of a raptor toward the blades will vary the background considerably and could potentially have a major effect on blade visibility; the only color with a relatively consistent level of visibility was black. Results indicated that thin, black stripes on a single blade are the most visible against a variegated naturalistic background, but the small number of subjects tested (2) and recording sessions (4) were not significantly different than for blank blades.

No difference was found between laterally oriented blades with a single, black rectangle and those with no stimulus affixed to the tip with a neutral white background; however, 2-rectangle tip attachments significantly increased visibility when compared with results for blank blades. Three lateral tip devices offered no greater visibility benefit than did the single lateral tip device. When a variegated, naturalistic background was used, the difference between the two-tip device and the no-tip device diminished slightly, indicating that the devices may be less effective.

Implications for Wind Development

Data from this study suggest that a single, solid-black blade paired with two blank blades—or possibly a single, thin-striped blade paired with two blank blades—would be the most visible visual deterrent to birds in the field. Colored blades are not recommended because of their cost and possible problems with background contrast. The results from this study apply only to laboratory conditions that mimic some aspects of optimum viewing in the field, such as bright illumination and good viewing conditions; therefore, field tests need to be conducted. Suggestions for field testing design and implementation are included.

Case Study 3

Barrios, L., and A. Rodriguez (2004). "Behavioral and environmental correlates of soaring-bird mortality at on-shore wind turbines." *Journal of Applied Ecology* **41**: 72-81.

Introduction

This study analyzed the effect on birds of two wind energy farms, PESUR and E3, in the Campo de Gibraltar region, Cadiz province, Spain. The E3 farm consists of one row of 34 turbines and one of 32 turbines along a ridge of the Sierra de Enmedio (420-550 m above sea level). The PESUR farm has seven rows containing 190 turbines in all in the Dehesa de los Zorrillos hills (80-300 m above sea level). The Straits of Gibraltar are the main point of migratory passage for hundreds of thousands of soaring birds on their journeys between Europe and Africa, and this is also one of the four areas in Spain with the greatest potential for producing energy from the wind. Relief and wind are the two principal factors affecting both the behavior of soaring birds and the selection of wind sites. The specific aims of this study were to determine (1) the bird mortality rate associated with wind energy facilities; (2) the effect of these facilities on bird behavior and habitat use; (3) the factors that lead birds to approach turbines; and (4) mitigation measures that may reduce avian mortality.

Techniques Used

Bird corpses were surveyed along turbine lines and an associated power line to estimate mortality rates. The effects of location, weather, and flight behavior on risk situations (passes within 5 m of turbines) were analyzed using generalized linear modeling.

Data Collection

Mortality surveys were conducted between December 1993 and December 1994 at 15 randomly selected sampling sites, defined as groups of eight lattice towers or four tubular towers. Data were collected at a total of 87 wind turbines and seven lattice meteorological towers and lightning conductors. Searches were conducted twice a week within the turbine sampling areas and once a week at the power lines. A 100-m wide band along the entire length of both wind farms was also surveyed weekly for griffon vultures. Carcass removal and searcher efficiency trials were conducted for statistical purposes and to determine search frequency.

Behavioral observations were made from the edge of the ridges where the turbines were placed or from sampling areas of any soaring bird within 250 m of a turbine. Distance was estimated by using binoculars within 200 m of the turbines and using known distances between structures as a reference.

Data were also collected on type of flight, flight height, and wind speed for birds considered to be in a risk situation (passing within 5 m of the blades of an operating wind turbine). The frequency of risk situations was then used to create a risk index, the ratio between the number of birds observed within 5 m of the blades and the total number of passes or observations within 250 m of the turbine lines.

Results

Sixty-eight birds were found to collide with structures associated with the wind farms during this study, the majority of which (51) were from medium to large species. Large differences were found between the two wind farms in the frequency of casualties. The estimated number of bird losses and mortality rates per turbine were much lower at E3 than at PESUR (2 deaths and a 0.030 mortality rate vs. 68 deaths and a 0.360 mortality rate, respectively). Griffon vultures and common kestrels made up the most frequent fatalities (30 and 12, respectively); the highest concentration of fatalities occurred when species density was greatest (kestrels in summer, vultures in autumn/winter).

Vulture deaths were all found to occur between October and April (66.7% occurring between December and February), and more than half of the deaths occurred in two segments of PESUR (15% of turbines were responsible for 57% of collisions). Collisions rarely occurred in strong winds, and all deaths except one occurred on clear days. The absence of thermals in winter is believed to have forced vultures to use slopes for lift, the most likely mechanism influencing both their exposure to turbines and the risk of fatalities. Tower structure could be excluded as a factor, because the number of losses for each type of tower (85% lattice, 15% tubular) was not significantly different from their availability.

Common kestrel deaths were concentrated in the summer after the fledging period; 67% of fatalities occurred between July 15 and August 17, 1994. All common kestrel fatalities occurred at the PESUR wind farm. Fatalities were evenly distributed across the wind farm, and the distribution of collisions for lattice (75%) and tubular towers (25%) was not significant. The concentration of carcasses in open habitats around a single wind farm may indicate that risk is associated with hunting habitat preferences.

Of 14,524 bird passes near the wind farms, 4,809 (33%) were griffon vultures. Average annual sighting frequencies at PESUR (10 vultures/h) were higher than at E3 (6.5 vultures/h), as were the risk indices at the two locations (0.198 vs. 0.059, respectively). At wind speeds lower than 4.5 m/s, the turbine blades did not turn and there was no risk. When the turbine blades were rotating, the risk index was highest (0.343) at wind speeds from 4.6-8.5 m/s, and the risk decreased with increasing wind speed. The risk index was also higher when vultures circled (0.279) rather than when they were in straight or slope flights (0.131 and 0.032, respectively), as well as when the birds approached the turbines from below (0.259) rather than above (0.062).

Implications for Wind Development

This study indicates that avian vulnerability and fatalities at wind power facilities are the result of a combination of site-specific (wind-relief interactions), species-specific, and seasonal factors. Therefore, it is very important to conduct a detailed study of bird behavior at the precise location where construction is proposed in order to identify species that are particularly vulnerable, the sites that are used intensively, and thus the optimum turbine location. The results of this study lead the authors to believe that the most sensible approach to reducing avian mortality at PESUR and E3 would be to suspend operation of the small number of turbines that caused the most deaths during conditions that increase risk.

Case Study 4a

Alonso, J.C., J.A. Alonso, and R. Munoz-Pulido. (1994). "Mitigation of bird collisions with transmission lines through groundwire marking." *Biological Conservation* **67**: 129-134.

Introduction

Collisions with electric power transmission lines are known to cause fatalities among birds, and groundwires are especially problematic because they are thinner and more difficult for birds to see. While methods such as route planning, rerouting, and burying cables have proven effective in minimizing bird fatalities, these approaches are generally carried out before construction or are very expensive (e.g., burying cables). Removing or marking the groundwire can be done after lines have already been installed. The purpose of this study was to evaluate the effectiveness of groundwire marking as a method of reducing bird fatalities caused by collisions at a transmission line in southwestern Spain.

Techniques Used

Before the field study, the four most critical sectors of the power line were determined according to published or known information about local bird populations and collision data. The four sectors measured 4236 m, 7370 m, 8784 m, and 7811 m. Red-colored spirals made of polyvinyl chloride and measuring 1 m long and 30 cm diameter (maximum), were rolled around both groundwires at 10-m intervals in four sectors totaling 12,500 m.

Data Collection

Data were collected on line sectors from December 1989 to April 1990 and again during the same period in 1990 to 1991, before and after bird flight diverters were installed. Each power line sector was searched once weekly; observers walked in a zigzag pattern within the 50-m-wide search area. Full-day observations of bird flight intensity across two spans of the line (approximately 800 m) were conducted once monthly at each of the four line sections, for a total of 366 hours of observations. Flight intensity observations could not be made at unmarked spans during the second year, because the company decided to mark all spans previously selected for flight observation.

Fatality estimations did not take into account errors such as the disappearance of dead birds as a result of scavenging, birds undetected because of vegetation density, or birds seriously injured but not immediately killed by the collision. This is not believed to have affected the estimate of groundwire marking efficiency, however, as the possible bias in fatality estimates affected both study years, before and after the line was marked.

Results

A total of 7,456 individuals belonging to 59 species were observed during flight intensity observations; common cranes were the most numerous of the birds observed (33.6%). The mean daily numbers of birds observed flying across the power line decreased by 61% after the groundwire marking, and three of the four sectors exhibited significant decreases.

The mean number of individual birds of the same species seen flying across the power line decreased from 74.4 birds before groundwire marking to 29.3 birds after marking, but the difference was not significant. There were, however, significantly more species for which flight intensity decreased after groundwire marking than those for which flight intensity increased.

Fatality searches resulted in 107 dead birds belonging to 30 species; the most numerous species was wood pigeons (16.8%). The number and diversity of dead birds found in the marked sectors of the line significantly decreased, from 45 birds (19 species) to 18 birds (13 species) after groundwire marking. This increased from 19 birds (15 species) to 25 birds (15 species) in sectors left unmarked (not significant). The decrease in the number of dead birds found per span was significant in comparison to those found in the same span before marking. However, there was no significant change in the number of dead birds found in the sample of spans left unmarked (26/29 spans resulted in fewer or no change in dead birds).

Implications for Wind Development

This study illustrates the effectiveness of marking groundwires in order to reduce avian collisions with transmission lines. This technique may offer an appropriate solution for reducing avian impacts at wind farms where groundwires, transmission lines, and distribution lines are characterized by increased bird mortality rates.

Case Study 4b

Janss, G. F. E., and M. Ferrer (1997). "Rate of bird collision with power lines: Effects of conductor-marking and static wire-marking." *Journal of Field Ornithology* **69**(1): 8-17.

Introduction

Various marking schemes have been published over the years to address the issue of birds colliding with power lines. Although some studies have examined the effects of wire markers on distribution lines (Brown and Drewien 1995), there has been no comparison of fatalities at transmission lines to those at distribution lines. As a result, this study evaluated three different types of power lines in west-central Spain: one transmission line with static wires and two distribution lines without static wires. The purpose was to quantify the fatalities recorded for three different types of power lines and to evaluate the effect of three different types of markers.

Techniques Used

Line A was a 380-kV double-circuit transmission line with six duplex conductors forming three cable levels with two static wires overhead. Line A crossed a cultivated area in which 40-m-high towers were 500 m apart. Eight consecutive spans were studied (4.5 km) before and after white polypropylene spirals were rolled around the two static wires every 10 m and staggered between the static wires. The spirals were 1-m long with a maximum diameter of 30 cm.

Line B was a 132-kV simple-circuit distribution line without static wires, with three conductors on the same level. Line B crossed an extended cultivated area in which 20-m-high towers were 250 m apart. Fifteen consecutive spans were studied (3.9 km) before and after markers were installed every 20 m; the markers consisted of two neoprene black crossed bands (35 cm x 5 cm) and a phosphorescent stripe (5 cm x 4 cm) fixed on a plastic peg.

Line C was a 13-kV simple-circuit distribution line without static wires, with three conductors almost at the same level. Line C was located in a protected river delta, and consisted of 9-m towers placed 100 m apart. Ten consecutive spans (1.2 km) were examined before and after markers consisting of three thin plastic black stripes (70 cm x 0.8 cm) were hung every 12 m from the central conductor.

Markers were placed on alternating study spans, so that each marked span had an adjacent unmarked span.

Data Collection

Fatality searches were conducted over 4 years and consisted of two study periods. The first study period (1991-1993) took place before the installation of the markers. Surveys were conducted as follows: Line A – seven surveys from February 1992-February 1993, every 2 months; Line B – four surveys from August 1992-March 1993, every 2 months, and four surveys conducted monthly from July-October 1993; Line C – seven surveys conducted from August 1991-August 1992, every 2 months.

The second study period (1993-1995) took place after the line markers were installed in some of the study spans. Fatality searches were conducted monthly for at least 13 months at each line: Line A – February 1994-February 1995, 3 marked, 4 unmarked; Line B – December 1993-

December 1994, 7 marked, 8 unmarked; Line C – August 1993-November 1995, 4 marked, 4 unmarked.

Results

One hundred and fifty casualties of 26 species were found during this study, 64 during the first study period and 86 during the second period. Avian mortality was not found to differ between the three power lines studied. Gruiformes were the most common victims, with great bustards and little bustards representing 15.3% and 17.3%, respectively, of all bird remains.

The greatest frequency of collisions (2.95 birds/km) occurred at Line C, followed by Line A (0.96) and B (0.84). No statistical differences were detected between the three power lines in collision frequency per survey. The reductions in mortality for all birds when the white spirals were used (Line A) was 81%. The total number of birds under spans marks with crossed bands (Line B) was significantly smaller than those under unmarked spans (a 71% reduction); however, when the great bustard was included in the analysis, the markers were found to have no effect. There was no significant reduction in mortality as a result of using the black striped marker (Line C).

Implications for Wind Development

Although overall mortality rates were reduced by more than 75% using both the spiral and crossed-band markers, it is important to note that this excludes the great bustard, for which no effective marker could be found. This suggests that markers for transmission or distribution lines near wind farms, while effective overall, may not be effective for all species and should not be assumed to be an adequate mitigation strategy for some birds. This study also illustrates (through research and reference) that various markers can be effective in reducing avian mortality so that other factors, such as price and durability, should be considered. The effectiveness of these markers on wind turbines and meteorological towers supported by guyed wires has not yet been tested.

Case Study 5

Earnst, S.L., J.A. Ballard, and D.S. Dobkin. (2004). *Riparian Songbird Abundance a Decade after Cattle Removal on Hart Mountain and Sheldon National Wildlife Refuges*. U.S. Department of Agriculture Forest Service Gen. Rep. PSW-GTR-191.

Introduction

Concern has been growing about the health of riparian habitats in the arid West, because they support a higher diversity of breeding songbirds than any other habitat type but comprise only 1% of the landscape. In addition, they are being severely affected by agriculture, recreation, timber harvesting, water diversion, and, in particular, livestock grazing. Previous studies have indicated that ground or near-ground nesting species and shrub nesting species are more affected by cattle grazing than habitat generalists, canopy nesters, and cavity nesters because cattle have a greater effect on lower vegetation strata.

Within the Sheldon-Hart Mountain National Wildlife Refuge Complex in Oregon and Nevada, there are currently 26 riparian species of concern. They are defined in this study as riparian associates that had either (1) a significant declining trend on North American Breeding Bird Survey (BBS) routes within USFWS Region 1 (comprising Calif., Ore., Wash. State, Nev., Idaho); (2) a significant declining trend on BBS routes in the Columbia Plateau physiographic area; (3) a Partners in Flight score for the Columbia Basin of >20; or (4) an Oregon Management Index score of >10. The objectives of this study were to compare the abundance of riparian birds 1-3 years and 11-12 years after livestock removal occurred at the Sheldon and Hart Mountain National Wildlife Refuges.

Techniques Used

Survey data collected during this study was compared with survey data collected during May 7-July 11 from 1991 to 1993 (three times annually). Mean detections per visit were averaged among visits within a year and among years within a phase (i.e., 1991-1993 and 2000-2001). The mean difference across all plots was calculated for each species and a paired t-test was used to determine whether the difference for each species was significantly different from 0. Comparisons were limited to passerines, doves, woodpeckers, and shorebirds that either nested or foraged primarily in riparian habitat within the Hart-Sheldon landscape and that had an average of $\geq$ 0.02 detections per plot visit (n = 51 species). Species were assigned to primary habitats (aspen, willow, meadow), nesting guilds (ground/low cup, high cup, cavity) and foraging guilds (ground/understory, overstory, aerial, bark). Binomial tests, t-tests, and one-way analyses of variance within groups were used to test for differences among guilds over time (based on detections/km^2).

Data Collection

Data were collected from 69 permanent study plots within six different cover types (meadow, riparian aspen, snow pocket aspen, willow, nonriparian shrub, and mixed deciduous): five cover types in five drainages in Hart Mountain (n = 47) and four cover types in six drainages in Sheldon (n = 2). Each plot was 150 m long by 100 m wide, and most plots were at least 250 m apart. Each study plot was surveyed three times from May 8-June 24, 2000, and May 17-June 25, 2001, by an observer walking slowly along the center-line of the plot and recording the first occurrence of each individual seen or heard within the plot.

Results

Preliminary results one decade after cattle removal indicated that 71% (36/51) of riparian species exhibited positive trends and 76% (16/21) of species increased that had exhibited a significant change (either positive or negative). Species associated with aspen and willow habitats exhibited a significant increase in detections/km^2, but species associated with meadows did not exhibit this change. Ground/low cup nesting species were found to increase more than either high cup or cavity nesting species, and ground/understory foraging species increased significantly more than overstory or bark foraging species and marginally more than aerial foragers. Only meadow associates, cavity nesters, and bark gleaners did not increase significantly.

Of the 26 riparian species of concern for which there were sufficient detections, seven exhibited significant increases on original plots since the removal of cattle (yellow warbler, white-crowned sparrow, dusky flycatcher, warbling vireo, MacGillivray's warbler, orange-crowned warbler, and mourning dove) and three exhibited significant declines (Bullock's oriole, ruby-crowned kinglet, and Wilson's warbler). For the 16 significantly increasing species found within this study, patterns of change on BBS routes from 1980-1999 suggested that the changes found in this study were not merely a reflection of regional patterns.

Implications for Wind Development

Removing cattle from riparian habitats has been shown to significantly increase the abundance of certain species, specifically those that are open nesting, insectivorous, or neotropical migrants. Purchasing riparian habitat and enhancing it, or protecting riparian habitat near a wind farm, may prove to be a viable mitigation option. Wind development that occurs near riparian areas where livestock are located should consider installing fences to prevent cattle from decimating the habitat.

Case Study 6

Roby, D., K. Collins, et al. (2002). "Effects of colony relocation on diet and productivity of Caspian terns." *Journal of Wildlife Management* **66**(3): 662-673.

Introduction

This study addresses salmon fishery managers' concerns that colonial waterbirds were inhibiting the recovery of certain endangered and threatened salmon species in the Columbia River Basin. Initial research indicated that Caspian terns relied heavily on juvenile salmonids as a food source, especially the Rice Island colony, which is the largest of its kind in North America. Previous attempts to reduce avian predation of fish stocks along the Columbia River included lethal control, oiling eggs, harassing fish-eating birds, protecting fish, and changing rearing practices in hatcheries. While a number of these techniques had proven effective, the public often considered them unacceptable.

The objectives of this study, therefore, were to monitor and evaluate efforts to relocate the Caspian tern colony from Rice Island to East Sand Island (based on colony size and nest productivity). The study also aimed to test the efficacy of this approach for reducing the reliance of terns on juvenile salmonids as a food source (based on diet composition analyses). This approach was based on studies indicating the successful restoration of historical breeding colonies of terns along the northeastern shore of the United States and Canada, although these studies did not attempt to relocate an entire colony.

Techniques Used

To encourage the relocation of the tern colony, East Sand Island was altered to create a bare sand habitat similar to the one found on Rice Island. Caspian tern decoys and audio playback systems (recorded at the Rice Island colony) were installed throughout the bare sand area on East Sand Island and a limited number of glaucous-winged gulls were removed to encourage prospecting terns to settle and nest on the new island. Site treatments were undertaken again in 2000 and 2001 to reduce encroaching vegetation, and two 20- to 30-m-wide buffer strips were added on either end of the core colony area in 2001 to provide additional protection to the terns by discouraging nesting by glaucous-winged gulls. On Rice Island, suitable nesting habitat was reduced through plantings, silt fencing, and the placement of streamers and wire across the previous colony site. An area of 0.65 ha was left unaltered in the core of the colony in 1999 and was subsequently reduced each year after that to encourage the relocation of terns.

Data Collection

Colony size and productivity data were collected from aerial photographs and ground counts from observation blinds on both islands. Further details on the aerial photo census methods utilized are described in Collis et al. 2002. Diet composition data were collected through direct observation of adults as they returned to the colony with fish (bill-load observations). Prey items were identified as salmonid/nonsalmonid, and researchers were able to further distinguish nonsalmonid taxa, but not salmonid. In order to assess the relative proportion of various salmonid species in tern diets, an additional 10 bill-load fish/week were collected through shooting at each site when that activity was determined to not have a negative impact on the colony. Data on colony numbers, diet composition, and causes of nesting failure were collected daily.

Results

All nesting Caspian terns elected to move from the Rice Island colony to the East Sand Island colony during the 1999-2001 study period. In May 1999, about 550 of the 8,300 pairs of terns were nesting on East Sand Island, and by July 1999 this had more than doubled to 1,400 pairs. By 2000, 94% of the Caspian terns that nested in the Columbia River estuary were located on East Sand Island.

Nest productivity was found to be consistently higher for Caspian terns nesting on East Sand Island than for those nesting on Rice Island, reaching 1.4 young per pair in 2001. This was the highest productivity observed at either tern colony after 1996. Terns nesting on East Sand Island were also found to have significantly fewer salmonids in their diets than those nesting on Rice Island (42% to 83%, respectively); anchovies, herrings, and sardines were becoming the most prevalent prey types found in the East Sand Island terns' diets.

Implications for Wind Development

Although this study does not apply to wind development sites, it does show definitively that it is possible to relocate an entire colony of birds. The study focused on terns, but it may be a useful approach for other colonial nesting bird species, such as double-crested cormorants or great blue herons, which nest near freshwater lakes and wetlands. As wind development grows, there may be some interest in developing near inland water bodies. Thus, this approach may prove useful in minimizing or eliminating the risk to colonial nesting birds. In addition, this study was based on other efforts that successfully restored historical tern colonies along the eastern shore; this suggests that it may prove useful in the future as wind development expands to coastal areas.

Future Case Studies

McNew, L.B., et al. (In progress) Effects of Wind Power Development on the Demography of the Greater Prairie Chicken.

> This study is examining the impacts of wind development on lek attendance, mating behavior, habitat use, dispersal, and demographic performance of Greater Prairie Chickens. A before-after control-impact, or BACI, design with three replicates of paired study sites will be used to assess potential impacts of wind development on prairie-chicken demography. Focal population studies will occur at the Elk River II site in Butler County, Kansas, in Year 1 and expand to three sites in Years 2-4. Birds will be captured and radio-marked at leks during the 2006-2009 breeding seasons for this study. Treatment and reference sites will be monitored simultaneously during three phases of wind power development: predevelopment, construction, and operation.

PIER Energy-Related Environmental Research. (In progress) Range Management Practices to Reduce Wind Turbine Impacts on Burrowing Owls and Other Raptors in the East Bay Regional Parks. For information, see http://www.energy.ca.gov/pier/environmental/project_summaries/PS_500-01-032_DIDONATO.PDF.

> This study is investigating land management practices in relation to raptor behavior and prey distributions, as well as raptor flight behavior and spatial distribution over land with and without wind turbines at the Altamont Pass Wind Resource Area (APWRA). The study seeks to understand how vegetation management practices (e.g., sheep grazing) in the APWRA can modify raptor foraging patterns by changing the distribution of prey. Three-dimensional global information system models will be used to characterize the influence of range management practices on raptor flight patterns, small mammal burrow distributions, burrowing owl nesting patterns, and turbine-induced avian mortality. A progress report detailing preliminary results is expected in late 2007.

Schroeder, M.A., et al. (In progress) Effects of Wind Power Development on Sage Grouse.

> This study is examining the effect of wind power generation on sagebrush steppe habitat, specifically that of the sage grouse. The hypothesis is that the 'footprint' of wind power generation in the sagebrush steppe is far larger than previously believed because of the spread of noxious weeds and exotic plants, habitat loss and fragmentation, and fatality risk due to predation and collision with turbines, powerlines, fences and vehicles. Additional disturbance and noise caused by wind farms is also of concern in relation to sage grouse populations.

Sherwell, J. (In progress) Developing a Mitigation Strategy for Bat Impacts from Windpower Development in Maryland.

> This study presents a model that has been established to aid in the development of mitigation strategies for bats at wind farms in Maryland along the Appalachian Mountains. Two mitigation scenarios were investigated: one in which suboptimum tip speed ratios is explored, the other in which rotation rate is managed from a low value up to a threshold value, above which the optimum tip speed ratio is established. Results suggest that low wind speed curtailment can significantly reduce the risk of bat collisions. This study has been conducted, but results have not yet been published and economic consequences have not yet been explored.

Szewczak, J., and E.B. Arnett. (In progress) Evaluation of Acoustic Deterrents to Reduce Bat Fatality at Wind Facilities.

This study was based on earlier observations that bats avoided areas featuring high-intensity ultrasounds; it sought to determine whether high-intensity ultrasounds deterred bats from wind turbines. The hypothesis is that, above some threshold, bats will show avoidance because they can't hear anything but the sound emitting from the deterrence device. Only preliminary results from laboratory and field tests are currently available.

United States Fish and Wildlife Service (In progress; contact: Ron Reynolds [9/2006])

This study is being conducted to examine the effectiveness of a mitigation strategy to remedy problems for ruddy ducks on their wintering grounds resulting from an oil spill in the Patauxent River in Maryland. A Board of Trustees decided that mitigation for the spill required the organization to introduce new ruddy ducks into the population to make up for the ones that were lost. In order to do this, the USFSW Habitat and Population Evaluation Team is helping to restore or create new habitat on the breeding grounds in North Dakota. Evaluations of mitigation will begin as soon as the mitigation treatments are completed, and they will last for 10 years. Mitigation includes restoring the function of degraded wetlands or replacing drained wetlands, largely through conservation easements on agricultural lands. They are currently targeting areas with high ruddy duck breeding populations because they are already supportive landscapes.

Villegas-Patraca, Rafael et al. (In progress) Impact and Potential Conflicts of Wind Power Generation on Raptor Migration in Tehuantepec Isthmus, Mexico.

Several companies will be developing the largest wind-farm facilities in Latin-American over the next five years in the Isthmus of Tehuantepec in Oaxaca, Mexico. During three field work seasons, more than four million migratory raptors were found around the potential sites for the wind-farm. The majority of these birds were Turkey Vultures, Swainson Hawks and Broadwing Hawks flying at heights less than 120m. There is a potential high risk that birds will collide with the wind turbines within a range of 72-130m high in operation because this area is one of the most important bird migration routes in the world. This study will monitor the effects of a mitigation strategy to shut down the turbines for 3 weeks during Broad-winged Hawk, Mississippi Kite, and Swainson's Hawk migration on avian mortality and economic performance. This study hasn't begun yet.

WEST, Inc. (In progress; contact: Dale Strickland [11/2006])

WEST is conducting research at Altamont Pass in California to evaluate the effectiveness of seasonal wind turbine shut-downs, relocating or removing high-risk turbines, and replacing old turbines with newer, larger ones.

Summary of Existing Policies and Guidelines and Related Research Studies

This matrix combines existing policies and guidelines with existing mitigation research in order to identify gaps and overlaps between the two. The mitigation strategies listed in Column A are sorted by type of strategy (e.g., construction-stage, operational-stage) and are taken directly from existing policies or guidelines; the author is listed in Column B. Column C presents existing research related to the policy or guideline topic; where no research was found to support the policy or guideline, the field was left blank. Column D indicates whether research supports the mitigation strategy advocated in the policy or guidelines. The numbers next to Related Study authors correspond to the Annotated Bibliography, where detailed description of each study can be found. Finally, the Status of Supporting Studies column, Column E, offers anecdotal information pertaining to the research conducted.

GAPS/OVERLAPS MATRIX

A	B	C	D	E
Mitigation Stated in Policies and Guidelines	**Whose Policy/Guideline?**	**Related Studies**	**Support Policy?**	**Status of Supporting Studies & Notes**
Design Stage				
Avoid lattice-type construction - use monopoles/tubular towers	ABC, WA Audubon, KS, MD, WA, CESA	Anderson et al. 2004 (1) Hunt 2002 (7) Orloff & Flannery 1992 (11) Thelander & Rugge 2000 (14)	Y Y Y N	research inconclusive . but, mortality rates at tubular towers increased when located on an end-row and close to canyon 57% bird fatalities at Altamont associated with tubular towers
Perching opportunities should be reduced or removed	Canada, KS, BLM	Osborn et al. 1998 (9) Smallwood & Thelander 2004 (12)	N Y	indent
Construct towers no more than 199 feet above ground level	USFWS			USFWS proposed to address 2 issues: (1) met towers should be unguyed, unlit, < 200 ft AGL, based on documented impacts from guy wires. (2) If wind turbine rotor swept area exceeds 199 ft AGL requiring turbine lighting, use minimum intensity, maximum off-phased white strobe, followed by red strobe, followed by red-blinking incandescent lighting, in decreasing order of priority. No L-810 lights should be used.
Larger turbines reduce mortality	England, Canada	Hunt 2002 (7) Smallwood 2006 (13)	N Y	Based on Diablo Wind Energy repowering project
Situate turbines in a way that does not interfere with wildlife movement corridors (turbine design)	ND, KS, CESA			
Group turbines rather than spreading them widely	England, USFWS	Larsen & Madsen 2000 (34)	N	Habitat loss for PFGO per turbine higher in farms with turbines arranged in a large cluster. USFWS policy supports minimizing overall footprint, reducing habitat fragmentation, disturbance and site avoidance esp. by grassland-sage-steppe-obligate songbirds and "prairie grouse."
Orient rows of turbines parallel to known bird movements	England, USFWS			USFWS policy suggests; where known bird passageways (i.e., staging or migration) have been documented in historically compass-like directions, turbine orientation should minimize potential contacts. Been witnessed with seabird passage.
Spacing between turbines (should be greater than 200m)	Australia, England, (Canada)	Larsen & Madsen 2000 (34)	Y	Habitat loss for PFGO per turbine less in farms with turbines in small clusters or lines (no optimal distance suggested)
Lines of turbines should be broken up	England			
Avoid sensitive & large tracts of native habitat (don't fragment) /locate turbines on altered landscapes	England, USFWS, ND, Australia, WA, KS, CESA, CA	Larsen & Madsen 2000 (34) Leddy et al. 1999 (35)	Y Y	Wind farms placed close to roads or other 'avoidance zones' resulted in less impact to PFGO CRP grasslands 180+m from turbines found to support 4x more nesting birds USFWS policy recommends avoiding placing wind turbines within 5 miles of known leks. We now recognize that since recommending our 5-mile volunteer metric, separations will vary between species – least for Lesser and Greater Prairie-chickens (~3.75 mi), and greatest for migratory populations of Sage-grouse (~12.5 mi).
Avoid landscape features that attract raptors	BLM	Erickson et al. 1999 (4) Orloff & Flannery 1992 (11) Hoover 2002 (5) Hoover & Morrison 2005 (6)	Y Y Y	Rim edges should be avoided Rim edges should be avoided Avoid steep slopes(RTHA) & narrow E-W corridors that open up onto valley floor (GOEA)
Avoid areas heavily used by birds/bats	England, USFWS, Australia, MD, WA, CESA, CA	Osborn et al. 2000 (10) Huppop et al. 2006 (31)	Y Y	no supporting research for management suggestion turbines should not be placed in dense migratory zones between resting and foraging grounds While avoiding areas heavily used by birds and/or bats is intuitive, the premise of the USFWS's voluntary wind guidance is based on avoiding locations that are bird and/or bat unfriendly (i.e., heavily used for whatever purposes).

Do not locate projects in areas with high incidence of fog and mist	USFWS, BLM	Kerlinger & Kerns 2004 (18) Young et al. 2003 (22) Pettersson 2005 (59)	N N N	No correlation between wind speed, direction, temperature, or fog/precipitation and bat fatalities. No strong correlations found between avian/bat acualties and weather events Radar monitoring indicated waterfowl migration in fog and mist limited While weather has been well correlated with mass nighttime bird deaths at communication towers, power lines, building windows, and monuments, no mass mortality events have yet been documented at wind facilities. In an effort to avoid or at least minimize that problem, the USFWS suggested this guideline.
Locate turbines and roads away from wetlands	Australia			
Avoid known daily movement flyways	USFWS			While avoiding areas heavily used by birds and/or bats is intuitive, the premise of the USFWS's voluntary wind guidance is based on avoiding locations that are bird and/or bat unfriendly (i.e., heavily used for whatever purposes).
Create road siting plan (using constraint mapping)	CESA, WA			
Use existing transmission corridors	WA, MT, CA			
Route power cable to avoid need to remove native veg and habitat, and	Australia			
Establish buffer zones around turbines	CA			
Construction-Stage				
Perch guards and other APLIC endorsed technologies recommended	WI, WA	Smallwood & Thelander 2004 (12) Nelson & Curry 1995 (30)	N Y	54% reduction in perching estimated with perch guards, but no statistical support
Bury power lines underground	ABC, USFWS, SD, MI, KS, WI, Canada, MD, WA, CESA, CA			Mentioned by numerous studies as recommended management, but couldn't locate research testing this suggestion. USFWS policy suggests: Where risk of power-line strikes and electrocutions exists, bury lines to minimize injury and death, and reduce habitat fragmentation, esp. to "prairie grouse."
Guy wires should be avoided	ABC, WA Audubon, Canada, BLM, MD, WA, CA			
Follow APLIC standards	Wisconsin, ABC, CA			
Establish buffer zones around raptor nests, bat roosts, and biota if facilities pose significant concern	BLM			
Construction should be done when ground is frozen or soils are dry and native veg dormant	KS			
Minimize area disturbed by construction and operation	BLM, CESA			
Installation of towers should avoid disruption of important wildlife behaviors - seasonal restrictions on construction	England, USFWS, Canada, SD, VT, BLM, Australia, MD			USFWS policy suggests: Construction of access roads, drainage ditches, tower platforms, and the installation of towers and turbines can severely disrupt breeding, feeding, roosting, nesting, fledging, staging and resting birds; as well as breeding (maternity colony), feeding, and overwintering (hibernaculum) bats. By not constructing during these time periods, behavioral disruptions to birds and bats can be avoided.
Minimize roads & fences; those built should follow natural land contours and minimize stream crossings and side hill cuts	USFWS, SD, BLM, KS, Canada, WA, CESA	Smallwood & Thelander 2004 (12) Trombulak & Frissell 2000 (70)	Y Y	Access roads should be minimized - unsure of supporting research Unlikely the consequences of roads will be completely mitigated so critical to retain roadless areas in natural state USFWS policy suggests: Grassland-sage-steppe-obligate songbirds and "prairie grouse" have been shown to be especially susceptible to human disruption, including from road development and use, fences, and other "tall" structures. Efforts should be taken to minimize their presence, and where they are constructed to reduce their effects.
Noise-reduction devices should be maintaind in good working condition on vehicles and equipment	VT, BLM			
Dust abatement techniques should be used	BLM			
Develop plan to prevent intro of weeds/invasive flora	SD, Australia, WA			
Minimize creation of edge habitat	BLM	Arnett et al. 2005 (57)	Y	Turbine locations within forest openings and near edges may be miconstrued by bats as favorable roosting sites
Implement strict speed limits	Australia, WA			

Vehicle storage and standing areas should be away from native veg and habitat, and at least 200m from wetlands	Australia			
Monitor and repair erosion	Australia			
Minimize chemical use	England	Trombulak & Frissell 2004 (70)	Y	Accumulations of salts & heavy metals been shown to disrupt natural stratification patterns (other studies cited)
Operational-Stage				
Adjust tower height where rotor height area poses high risk for wildlife	USFWS			While it is infeasible to generally consider elevating rotor swept areas due to generation inefficiencies, where low flying avifauna such as "prairie grouse" occur USFWS suggests this policy to mitigate interactions.
Older turbines that cause high mortality should be moved or retrofitted	USFWS, CA			USFWS made this recommendation initially with Altamont Pass in mind, but it has applicability elsewhere such as at some of the older CA sites. The retrofit refers to a replacement of 1 new, larger turbine for every 7 older turbines.
Decompact disturbed agricultural areas to 18"	NY			
Reseeding with native vegetation	WA, KS, Canada, BLM			
Certified weed-free mulch should be used when stabilizing disturbed soils	BLM			
Higher height veg encouraged along transmission corridors to minimize foraging in these areas	BLM			
Re-vegetate access roads not used after construction	Canada			
Plant area under turbine with less attractive crop	Canada, BLM			
Disturbed lands fully reclaimed to habitat functions prior to construction	ABC			
Markers on guy wires	USFWS, Canada, WA, CA	Alonso et al. 1994 (25) Brown & Drewien 1995 (3) Janss & Ferrer 1997 (27) Morkill & Anderson 1991 (28)	Y Y Y Y	Significant decrease in collisions between spans marked with red PVC spirals and those without Both yellow spirals and yellow swinging plates reduced mortality 75% reduction in mortality seen with black spiral and black crossed band markers While USFWS recommended marking guy wires (both met tower and guyed turbines) where guys were shown to be necessary but could impact avifauna – e.g., Whooping Crane migratory corridor, Spectacled and Steller's Eider pathways, because of the paucity of published literature in refereed journals, USFWS recommend only limited use of markers until more research can be shown to reduce collisions, especially for night-migrating songbirds in inclement weather.
Use of sodium vapor lights should be minimized or avoided	WA Audubon, BLM, MD, CESA	Kerlinger & Kerns 2004 (18)	Y	
Avoid using solid red or pulsating red warning lights at night	England, USFWS	Kerlinger & Kerns 2004 (18)	N	FAA lighting (L-864 red strobes) did not appear to attract nocturnal migrants, but steady burning red, L-810 lights did USFWS policy suggests that solid/steady-burning L-810 lights should not be used on turbines or met towers. The Service provisionally recommended using minimum intensity red blinking/pulsating lights when minimum intensity, maximum off-phased white strobe lights could not be used.
Security lighting on ground should be down-shielded	USFWS, CA			USFWS policy suggests: Steady-burning sodium, halogen, quartz, or related ground-based security lighting have been implicated in moderate to high levels of bird mortality, especially during inclement weather at night. Security lighting was implicated in the largest yet recorded wind turbine kill in WV; when the lights were extinguished yet the fog continued, bird kills appeared to end.
Site lighting should be 'off' unless needed for specific tasks	CESA, CA			
Strobe lights only, min number of flashes and briefest flashes permintable	England, USFWS, Canada, CA			USFWS recommends as a first option, minimum intensity, maximum off-phased white strobe lights. When infeasible, minimum intensity, maximum off-phased red strobe lights are suggested – provided no steady-burning lights are used.
Minimize number of lit turbines	ABC, MD, WA, Australia, BLM, CESA	Johnson et al. 2003 (17) Erickson et al. 2004 (15) Huppop et al 2006 (31) Arnett et al. 2005 (57)	N N Y N	Presence of lighting did not affect number of bat collisions No statistically significant difference found between lit and unlit turbines and bat/bird mortality Large-scale continuous illumination should be avoided (research pre-construction - off-shore) Lighting does not appear to be a significant source of attraction to bats
Lit turbines should use simultaneously pulsing red or white strobes, 20 pulses per minute if possible	ABC			
Synchronization of lights	FAA, MD	Patterson 2004	Y	Study was conducted by FAA (Patterson) for purposes of pilot safety, not wildlife

Wildlife and plant composition needs to be considered when setting mowing schedule	KS			
Reduce availability of carrion	USFWS, Australia			While this was one of many USFWS recommendations focused on the somewhat unique situation at Altamont Pass, to avoid similar future scenarios, it was also recommended elsewhere.
Shut down turbines during certain periods of time	ABC, USFWS, Canada, CA	Barrios & Rodriquez 2004 (2) Hoover 2002 (5) Hoover & Morrison 2005 (6) Huppop et al. 2006 (31)	Y Y Y Y	Suspend turbines causing most deaths under wind speeds that are problematic Close down turbines where valley plateaus meet sloping hillsides and power down turbines located on steep slopes when there are high winds perpendicular Turn turbines off during few nights there is a combo of adverse weather and high migration USFWS suggests: While we still have only an N=1 of turbine samples feathered during bat migration (i.e., Backbone Mt., WV), other study results are pending and will be assessed with great interest. If bats are present and feeding during periods of minimal electrical generation, "feathering" may soon be scientifically validated as a "conservation measure" recommended to the industry as an option for use.
Limited and periodic feathering durin low wind nights	CA	Arnett et al. 2005 (57)		
Prey control program (extensive rabbit control, squirrel control)	Canada, Australia	Hunt 2002 (7) Smallwood & Thelander 2004 (12)	Y N	No supporting research for management suggestion
Use of rodenticides is discouraged around base of turbines	WA			
Reduce motion smear by painting blades	England, Canada	Smallwood & Thelander 2004 (12) Howell & Noone 1991 (16) Hodos 2003 (21) Young et al. 2003 (22)	Y Y Y N	Unproven, but believed to be highly effective (Hodos et al. scheme) Painting of blades (red/white) reduced collisions but not statistically significant Painting of blades (bk/wh) useful up to 19m, then patterns lose advantage - thin-bk stripes best UV painted blades not significantly different than non-painted
Maximum speed of turbines less than 30rpm	WA Audubon	Hodos 2003 (21) Arnett et al. 2005 (57)	N N	20-m diameter turbine rotating at 45rpm with painted blades was visible up to 21m Low wind nights (17rpm) found to result in highest amount of bat fatalities.
Any nesting/maternity areas disturbed shall be reestablished as feasible	MD			
Habitat modifications to make site less attractive	CA			
Other				
Posting of a bond, or other financial instrument, to cover the cost of mitigation actions	OR, WA			
Education and collaboration with county commissoiners, industry, and government	MT, CA			
Apply adaptive management and effectiveness monitoring processes to better achieve management objectives	CA			
Off-site Habitat Enhancement				
Acquisition of replacement habitat (conservation easement, wetland, etc)	SD, OR, VT, WA, KS, MD, CA, Canada	Smith et al. 2005 (38) Trulio 1995 (39) . Roby et al. 2002 (41) Balcombe et al. 2005 (47) Darnell & Smith 2004 (48)	Y/N Y/N . Y Y N	BUOW boxes positive mitigaiton, but must have preexisting BUOWs for artificial nests to succeed Passive relocaiton of BUOW effective mitigation, but cannot move long distances and must protect enough foraging habitat Example of successful CATE colony relocation project Despite differences in veg and invertebrates, mitigation and reference wetlands very similar Mitigation wetland had high salinity, inundation too frequent, and necessary habitat too narrow
Provide alternative habitat off-site to attract at-risk birds from near turbines	Australia			

Conclusions and Recommendations

The impacts of windpower on wildlife has generated a great deal of debate among windpower's advocates and its opponents, often generating a great deal of heat but little light. This Mitigation Toolbox is not directed at determining what the impacts are, nor does it comment on what level of significance those impacts might have. It does, however, take the general position that there are cost-effective opportunities to lessen wind's impacts where they may be determined to have significance. The purpose of the toolbox is to catalog existing mitigation measures and to further explore others, and bring them to light for discussion, research and innovation.

While numerous studies currently exist pertaining to wildlife management in general, there are few studies that specifically look at the effectiveness of mitigation techniques, and even fewer that focus on mitigation techniques in the context of wind turbines. As a result, there are few verified tools available for use in mitigating wildlife impacts from wind development at this time. However, it is clear from the research conducted for this report that the opportunities for mitigation in windpower have just begun to be explored. In addition to those tools or techniques discussed in this report, there are surely useful tools from other industries that could be applied in the windpower context, including those involving adaptive management or offsite mitigation. Industry, advocates and the scientific community should seek out these opportunities and bring them forward for discussion and evaluation. This report is intended to be the first installment of an ongoing process to highlight, in one document, mitigation strategies.

The process of researching for this report has raised a number of themes that need more attention, such as the straightforward preference for siting wind farms in already disturbed areas rather than in more pristine landscapes. However, this document is not intended to be a prescriptive set of best practices such are typically found in siting guidelines. Instead it is intended to be a discussion of the many mitigation opportunities that have either been tried or represent potential means of lowering wind projects' impacts on wildlife.

Siting guidelines building on the U.S. Fish & Wildlife Service's mitigation definition have tended to focus on avoiding impacts to begin with, which often means not building at all in the highest impact areas. This document picks up from that point, asking the follow-up question to "where shouldn't we build", which is the practical question of what we do to mitigate impacts when a decision has been made to build a wind project. It is accepted by many that avoiding all impacts is not a likely or perhaps even achievable goal. We also recognize that some mitigation techniques will prove to be too expensive to be practical, and others may offer the promise of achieving a given goal at a far lower cost. This toolbox may encourage a discussion of those techniques that can achieve goals at the lowest reasonable cost so that they can be broadly utilized and accepted by industry, advocates, regulators, and other interested parties.

With the expected growth of the wind industry over the next few decades, there is a need to address the existing gaps between what is on the research agenda for wind and the practice of planning, constructing and operating wind farms. This need includes research into the question of "where shouldn't we build", focusing on pre-construction studies to avoid the most problematic areas and examining whether pre construction studies can consistently predict post construction impacts to wildlife. Additionally, post-construction studies are needed to determine what impacts are occurring and methods to reduce those impacts in a cost-effective manner. Expanding the amount of research focused on mitigation strategies will not only improve our knowledge of wildlife management, but it will also help to guide policymakers, regulators, industry and the public in developing guidelines or policies that are beneficial for wildlife and cost-effective for development. Expanding the range and scope of mitigation techniques being utilized, including those that may not appear in this report, is also crucial to a vibrant investigation of the most effective ways of achieving the goal of lowering wind energy's impacts at a reasonable cost that encourages adoption by industry. This toolbox is intended to be a living document, adding new techniques as they are developed and applied.

The existing mitigation techniques described in this toolbox emphasize local mitigation methods to reduce impacts. There is a challenge in the need to create mitigation practices that focus on a landscape scale rather than generalized practices that are constrained by political boundaries. Landscape scale planning and offsite habitat evaluations may provide opportunities to enhance wildlife management. It is clear that many jurisdictions are reinventing the wheel again and again, because of a lack of comprehensive and accessible resources documenting current knowledge. This toolbox is a source of compiled information, which will be available to regulatory agencies and other stakeholders making real-time decisions. By integrating this valuable existing information database at the local and landscape scales, we can help to ensure that wind development occurs in a way that will not diminish sensitive migration corridors, breeding grounds, and wintering areas.

APPENDIX A: Comparison of existing policies and guidelines pertaining to wind development and mitigation efforts

	MONITORING		MITIGATION STRATEGIES				
	Pre-Construction	**Post-Construction**	**Design-Stage**	**Construction-Stage**	**Operational-Stage**	**Off-site**	**Other**
LOCAL							
Washington - east of Cascades Department of Fish and Wildlife *Wind Power Guidelines* August 2003 http://wdfw.wa.gov/hab/engineer/windpower/wind_power_guidelines.pdf . Dr.Jeff Koenings (360) 902-2200	Site-specific components and duration of assessment should depend on the size of project, availability and extent of exisgint data, habitats potentially affected, likelihood and timing of occurrence of sensitive species at site, and other factors such as issues and concerns identified during public scoping. At a minimum, 1 raptor nest survey during breeding season within 1-mile of site should be conducted At a minimum, 1 full season of avian use surveys (spring/summer) is recommended - additional seasonal data recommended if avian site use is high, there is little existing data on site, or project is especially large	Monitoring studies are required, but the duration and scope of the monitoring should depend on the size of the project and the availability of existing monitoring data at projects in comparable habitat types A Techincal Advisory Committee (TAC) is recommended to be responsible for reviewing results of monitoring data and making suggestions to the permitting agency regarding the need to adjust mitigation and monitoring requirements	Developers should be encouraged to site wind power projects on disturbed lands.		No mitigation is required for cropland, developed or disturbed areas Temporary habitat impact may implement a WDFW approved restoration plan for the impacted area, including: site preparation, reseeding with appropriate vegetation, noxious weed control, and protection from degradation	All permanent habitat impacts require the acquisition of replacement habitat that is: like kind, equal/higher habitat value, given legal protection, protected from degradation for the life of the project, in the same geographical region, and jointly agreed upon by developer and WDFW (imminent development, grassland, CRP 1:1; Shrub0Steppe or Other High Value 2:1) All temporary habitat impacts have option to acquire suitable replacement habitat for every acre temporarily impacted (grassland, CRP 0.1:1; Shrub-Steppe 0.5:1)	Annual Fee for life of project based on Alternative Mitigation Fee Rate of $55/acre/year for each acres of replacement habitat that would be owed (using ratios found in Off-Site section) The fee is based on habitat in 'average' condition and can be increased or decreased by 25% to account for differences in habitat quality
STATE							
California CA Energy Commission & CA Department of Fish and Game *DRAFT Guidelines for Reducing Wildlife Impacts from Wind Energy Development* December 2006 http://www.energy.ca.gov/2006publications/CEC-700-2006-013/CEC-700-2006-013-SD.PDF http://www.energy.ca.gov/renewables/06-OII-1/documents/index.html#041607 Rick York (916) 654-3945, ryork@energy.state.ca.us	Data and information gathering should be conducted early in process, be collaborative and include experts A scientific advisory committee of relevant experts should be established for life of project, ideally composed of a member from: the lead agency, CDFG, USFWS, developer and conservation organization Minimum of 1 year data collection for birds/bats - nightly acoustic monitoring for bats, weekly bird use counts (BUCs) for birds Small Bird Counts (SBC) may be required in special cases One year bird/bat carcass study to determine natural predation rates Raptor nest searches and bat roost searches conducted within 5 km of proposed site	2 years of carcass searches and bird/bat use surveys recommended, with carcass searches every 2 weeks More frequent searches necessary if pre-permitting studies indicated potential for impacts to bats or small birds Monitoring for repowering projects should use same methodology as for new projects Searcher efficiency trials and carcass removal trials to be conducted seasonally over 2 years More or less monitoring may be appropriate depending on project Science advisory committee and/or USFWS and CDFG should be consulted in determining study protocols and duration	Macro-siting, then micro-siting to maximize impact avoidance Minimize fragmentation and habitat disturbance. Reduce impacts with appropriate turbine layout. Establish buffer zones to minimize collision hazards. Avoid guy wires Power lines should be placed underground, unless burial would result in greater impacts to biological resources All aboveground lines, transformers, or conductors should comply with APLIC standards, including use of deterrents		Decommision non-operational turbines, which includes turbine foundations 3 ft below ground level, access roads, unnecessary fencing and auxillary structures Avoid lighting that attracts birds - use lights with short flash durations that emit no light during "off phase", with minimum number of flashes per minute and briefest flash duratino allowable Lights on auxilary buildings should use motion-sensitive lights and be downcast Limited and periodic feathering during low wind nights Removal of problem turbines Seasonal shutdowns of turbines Habitat modifications to make site less attractive	Mitigation site must provide for long-term conservation of target species and its habitat Site must be large enough to be ecologically self-sustaining Site must be permanently protected through fee title and/or conservation easement Resource managment plan should be approved and provisions made for implementation prior to sale of property/ easement or credits at mitigation bank Provisions for long-term management of property should be made Provisions should be made for monitoring/reporting on identified species and managment objectives	Post-construction monitoring may not be needed if findings from pre-contruction monitoring indicate low bird use and no special-status species or issues of concern, or if the site is near or adjacent to a recently well studies and comparable site with low fatality numbers.

Kansas Renewable Energy Working Group *Siting Guidelines for Windpower Projects in Kansas* January 22, 2003 http://www.krewg.org/reports/KREWGSitingGuidelines.pdf Jim Plogger (785) 271-3349, j.ploger@kcc.state.ks.us http://www.energy.ca.gov/renewables/06-OII-1/documents/index.html#041607	Biological and environmental experts should be used No time frame mentioned Landscape-level examinations should be used Detailed evaluation may not be worthwhile on sites with high potential for biological and environmental conflict		When feasible locate on altered landscapes Infrastructure should be able to withstand periodic burning of vegetation No perches allowed on nacelles Avoid lattice-type construction or other designs that provide perches Turbines should be situated in a way that does not interfere with important wildlife movement corridors and staging areas Avoid damage to unfragmented landscapes and high quality prairie remnants	Power lines underground when feasible Roads and fences should be minimized Avoid sensitive habitats Ideally, construction and maintenance should be done when the ground is frozen or when soils are dry and native vegetation is dormant	Native vegetation of local ecotype should be used to reseed disturbed areas Wildlife and plant composition should be considered in setting mowing schedule Potential adverse affects of warning lights should be addressed If there is significant ecological damage, mitigation for habitat loss should be considered, including: ecological restoration, long-term mangement agreements, conservation easements		
Maryland Wind Energy Technical Advisory Group DRAFT *Siting Guidelines to Mitigate Avian and Bat Risks from Windpower Projects* July 6, 2006 . Michael Dean (410) 767-8149, mdean@psc.state.md.us	Consult with DNR and NHP biologists Request Environmental Review be conducted - minimization or mitigation plans identified at this point will become part of conditions filed in CPCN proceeding Determine limits of physical construction disturbance with NHP biologist and clearly mark boundaries 1 year monitoring data for birds/bats (must be spatially and seasonally appropriate), assessment of potential bat habitat, results of Phase 1 avian risk assessment, and survey results of breeding birds required with CPCN application Additional monitoring may be required for rare, threatened and endangered species	Monitoring shall be conducted for minimum of 3 years Maryland PPRP will establish a peer review group external to State Agencies and comprising of relevant experts to assess monitoring plans and data Data shall be reported to NHP, PPRP, and external peer review group after each migration period (twice/year); and shall include species impacted and weather conditions Additional studies identified by State will not be responsibility of applicant	Avoid lattice-type construction or other designs that provide perches Construct no permanent towers supported by guy wires Avoid locations identified as high risk to birds/bats, have unique habitat features, or are occupied by species of concern	Bury onsite electrical collector cables when possible Avoid or minimize disruptions during bird/bat breeding seasons Any nesting/maternity areas distrubed shall be reestablished as feasible	Minimize lighting by lighting fewest number of turbines possible, synchronizing flashing cycles, installing red rather than white strobes, and avoiding high intensity lights (i.e. sodium vapor) Corrective actions will be sought by State if unforeseen adverse impacts occur	Mitigation plan may involve onsite and/or offsite activities, but offsite may be inappropriate for species of concern	Projects are exempt from CPCN process and guidelines only if the generated power is to remain onsite Mitigation actions should be graded in their implementation so as to reflect the level of the observed impact and the probability of successful mitigation, while defining and bounding the operational limitations or costs associated with the mitigation action
Massachusetts Executive Office of Environmental Affairs DRAFT *Guidance on the Siting of Wind Turbines* . Josh Bagnato (617) 626-1041, Josh.Bagnato@state.ma.us	Guidelines are in the final draft stage - they have been reviewed, but have not yet been released for public comment. Release expected by the end of 2006.						
Michigan Department of Labor & Economic Growth *Michigan Siting Guidelines for Wind Energy Systems* December 14, 2005 http://www.michigan.gov/documents/Wind_and_Solar_Siting_Guidlines_Draft_5_96872_7.pdf . John Sarver (517) 241-6280	3rd party analysis no time frame mentioned special scrutiny required for wildlife refuges, other areas where birds are highly concentrated, bat hibernacula, wooded ridge tops that attract wildlife, sites that are frequented by endangered species, signifant bird migration pathways, and areas that have landscape features known to attract large numbers of raptors	Analysis shall indicate whether a post construction wildlife mortality study will need to be conducted	The applicant will take appropriate measures to minimize, eliminate, or mitigate adverse impacts identified in analysis	Power lines underground when feasible	Applicant shall identify and evalutate the significance of any net effects or concerns that remain after mitigation efforts		
Minnesota Public Utilities Commission *Wind Turbine Siting Requirements* February 7, 2002 http://energyfacilities.puc.state.mn.us/wind.html . Alan Mitchell (651) 296-3714	An applicant for a site permit shall include with the application an analysis of the potential impacts of the project, proposed mitigative measures, and any adverse environmental effects that cannot be avoided, in the following areas: wildlife, rare and unique natural resources, wetlands, vegetation...						

New York Department of Agriculture and Markets *Guidelines for Agriculture Mitigation for Windpower Projects* March 25, 2003 http://www.agmkt.state.ny.us/AP/agservices/constructWind.html . Contact Unknown (800) 554-4501		2+ years of data needs to be collected			All disturbed agricultural areas will be decompacted to a depth of 18 inches with a deep ripper or heavy-duty chisel plow . All rocks 4 inches and larger will be removed prior to and after the replacement of topsoil. Topsoil will be replaced to original depth and the original contours will be reestablished where possible. Access roads will be regraded and original surface drainage patterns will be restored. Restored agricultural areas will be seeded with the seed mix specified by landowner. Topsoil deficiency and trench settling shall be mitigated with imported topsoil that is consistent with the quality of the topsoil on the affected site. Appropriate rehabilitation measures will be determined and implemented when subsequent crop productivity within the affected area is less than that of the adjacent unaffected agricultural land. Where representative subsoil density of the affected area exceeds the representative subsoil density of the unaffected area, shattering of the soil profile will be performed.		
New York Department of Environmental Conservation . Jack Nasca (518) 402-9172, janasca@gw.dec.state.ny.us	Guidelines are in the final draft stage - they have been reviewed, but have not yet been released for public comment. Release expected by the beginning of December 2006.						
Oregon Department of Fish and Wildlife *Fish and Wildlife Habitat Mitigation Policy for Siting Non-Nuclear Energy Facilities* September 1, 2000 http://www.dfw.state.or.us/OARs/415.pdf . Contact Unknown (503) 947-6000	Departmental recommendations or requirements for mitigation will be based on: location, physical characteristics, duration of action and its impacts, alternatives available, fish and wildlife species and habitats affected	Department requires submission of a mitigation plan, which includes protocols, methods, and a reporting schedule for monitoring the effectiveness of mitigation measures				Any habitat not considered irreplaceable (Habitat Category 1) that is damaged must be mitigated through the acquisition of in/out-of-kind, in/off-proximity habitat depending on the habitat category level.	The Department may require or recommend the posting of a bond, or other financial instrument, to cover the cost of mitigation actions based on the nature, extent, and duration of the impact and/or the risk of the mitigation plan not achieving mitigation goals.
Pennsylvania Pennsylvania Wind Farms and Wildlife Collaborative http://www.dcnr.state.pa.us/wind/index.aspx . Kerry Campbell (717) 772-5985, kcampbell@state.pa.us	Pennsylvania recently intitiated a collaborative approch to develop a set of Pennsylvania-specific principles, policies, best management practices, guidelines, and tools that can be used to assess risk to habitat and wildlife from wind power development, and to mitigate* for the impact of that development. This process is expected to be lengthy. PA does already have a process in place that developers must go through to ensure wildlife is protected entitled the Pennsylvania National Heritage Program. An index (PNDI) is used to evaluate any project that requires a permit from the PA Dept. of Environmenta Protection (DEP). Developers enter information about their project into an online review system (www.naturalheritage.state.pa.us) and are notified if there are any potential conflicts with the species or habitats of concern within the database. If they receive a "hit", they're directed to contact the appropriate jurisdictional agency, which will evaluate the project further. PGC evaluates projects that will impact birds and mammals; PFBC evaluates projects that impact fish, aquatic organisms, reptiles, and amphibians; DCNR evaluates plant impacts; and the US Fish and Wildlife Service evaluates impacts on federally listed species.						

South Dakota Bat Working Group & Game, Fish and Parks *Siting Guidelines for Wind Power Projects in South Dakota* http://www.sdgfp.info/Wildlife/Diversity/windpower.htm . Alyssa Kiesow (503) 947-6000	Prepare a monitoring and mitigation plan for protection of sensitive resources during construction and operation of the project Use biological and environmental experts to conduct a preliminary biological reconnaissance of the likley site area Communicate with personnel from wildlife agencies and universities		Situate turbines so they do not interfere with important wildlife movement corridors and staging areas Avoid large, intact areas of native vegetation Avoid lattice-designed towers or other designs providing perches Develop a stringent plan for preventing the introduction or establishment of non-native/invasive flora Consider turbine designs	Minimize the number of roads or fences Power lines underground and/or place turbine near existing transmission lines and substations Consider timing of construction and maintenance activities (including mowing). Avoid construction and maintenance activities during breeding season (April to July) and, if possible, during migration (April-June and August October)	Mitigate for habitat loss through: ecological restoration, long-term management agreements, conservation easements, or fee title acquisitions Address potential adverse affects of turbine warning lights on migrating birds and bats.		
Vermont Fish and Wildlife Department _DRAFT_ *Guidelines for the Evaluation and Mitigation of Impacts to Wildlife Associated with Wind Energy Development in Vermont* April 20, 2006 http://www.energy.ca.gov/renewables/06-OII-1/documents/other_guidelines/VERMONT_GUIDELINES_2006-04.PDF . Julie Moore (802) 241-3687	The applicant should establish the presence or absence of different wildlife species and significant habitats so that appropriate mitigation and avoidance practices can be used. Studies need to be completed during breeding and migratory seasons The Department will review all survey results to determine if the project will result in undue adverse impacts, and may seek revisions to the project.	A minimum of 3 years of rigorous post-construction bird and bat mortality surveys are necessary for any utility-scale wind project in Vermont. Monitoring is to be conducted from April 15 to October 31	ANR reviews initial resource assessment with project layout and works with applicant to identify potential indirect and direct impacts and means of addressing them	Construction activities should be scheduled to avoid important periods of wildlife courtship, breeding and nesting Any clearing of montane spruce-fir must take place outside the breeding period for Bicknell's Thrush Construction activities within ¼ mile of significant black bear hard mast habitat or spring feeding areas should take place outside the feeding periods September 1 – November 21 and May 1 – July 15. Noise-reduction devices should be maintained in good working order on vehicles and construction equipment ANR may recommend the retention of an independent engineer to oversee construction	Habitat restoration activities should be initiated as soon as possible after construction is complete If a project is considered to have undue adverse impacts, mitigation measures will be required, which may include the following: modified operations, modified lighting, on-site habitat management, habitat protection		
Wisconsin Department of Natural Resources *Wind Farm Siting Guidance* August 31, 2005 http://www.dnr.state.wi.us/org/es/science/energy/wind/studies.htm . Steve Ugoretz (608) 266-6673, Steven.Ugoretz@dnr.state.wi.us	A baseline wildlife evaluation should be conducted for each site under serious consideration for windfarm development. To allow comparison with other studies, this evaluation should follow accepted standard protocols for windfarm evaluations (such as the NWCC study guidelines).	At least 2 years of monitoring recommended for the first wind farms in any ecological region in the state	Mitigation measures proved to minimize collisions and mortality should be designed into the windfarm An adaptive mangement approach is highly recommended	Power lines underground is highly recommended Perch guards and other APLIC endorsed technologies recommended			
FEDERAL							
BLM *Programmatic Environmental Impact Statement on Wind Energy Development on BLM-Administered Lands in the Western U.S.* June 2005 https://www.eh.doe.gov/nepa/otheragency/fes0511/index.html . Lee Otteni (505) 599-8911	Avian and bat use of the project area should be evaluated using rigorous survey methods Operators shall evaluate avian and bat use of the project area and design the project to minimize or mitigate the potential for bird and bat strikes Scientifically rigorous avian and bat use surveys shall be conducted - the amount and extent of ecological baseline data required shall be determined on a project basis.		Minimize area distubed by installation of tower Individual towers shall not be located in sensitive habitats or in areas with sensitive ecological resources Installation of towers shall be scheduled to avoid disruption of wildlife reproductive activities or other important behaviors Operators shall develop a plan for control of noxious weeds and invasive species Maximize use of existing roads Configure turbines to avoid landscape features known to attract raptors and desgin facilities to discourage perching and nesting Avoid locations heavily used by migratory birds and bats Minimize habitat disturbance by locating facilities in previously disturbed areas Projects should not be located in areas with high incidence of fog and mist	Noise-reduction devices should be maintained in good working order on vehicles and construction equipment Explosives should be used only within specified times and at specified distances from sensitive wildlife or surface waters Dust abatement techniques should be used Refueling should occur in a designated fueling area that includes a temporary berm to limit the spread of any spill Certified weed free mulch should be used when stabilizing areas of disturbed soil Fill materials that originate from areas with known invasive vegetation problems should not be used Minimize area disturbed by construction and operation	Measures to reduce raptor use at project site shall be considered, including: minimization of road cuts, and the maintenance of either no vegetation or non-attractive plant species around the turbines All unnecessary lighting should be turned off at night to limit attracting migratory birds Higher-height vegetation should be encouraged along transmission corridors to minimize foraging in these areas by raptors to the extent local conditions will support this vegetation The use of sodium vapor lights should be minimized or avoided		

				Topsoil from all excavations and construction activities shall be salvaged and reapplied during reclamation along with weed-free native grasses, forbs, and shrubs Guy wires on permanent towers shall be avoided Access roads should follow natural contours of topography and minimize side hill cuts and stream crossings Minimize the creation of, or increase in, the amount of edge habitat between natural and disturbed lands Construction activities should avoid important periods of wildlife behavior Stream crossings should be designed to provide in-stream conditions that allow for and maintain uninterrupted movment and safe passage of fish Establish buffer zones around raptor nests, bat roosts, and biota and habitats of concern, if facilities are beleived to pose a significant concern			
USFWS *Service Interim Guidance on Avoiding and Minimizing Wildlife Impacts from Wind Turbines* July 2003 http://www.fws.gov/habitatconservation/wind.pdf . For general use of guidance contact: David Stout, Chief, Division of Habitat and Resource Conservation, 703-358-2555 For technical issues contact: Robert Blohm, Chief, Division of Migratory Bird Management, 703-358-1714	Pre-development evaluations should be conducted by a team that includes Federal and/or State agency wildlife professionals with no vested interest (e.g., monetary or personal business gain) in the sites selected. Any site evaluations conducted by teams that do not include Federal and/or State agency wildlife professionals will not be considered valid evaluations by the Service Site evaluations are to be conducted using a series of checklists, which are them compiled to determine a ranking for the site	The Service recommends that all sites be monitored for impacts on wildlife after construction is completed – monitoring is not expected to exceed 3 years.	Avoid placing turbines or towers in documented locations of any species protected under the ESA, or where species reside that are sensitive to human disturbance Avoid locating turbines or towers in known local bird/bat migration pathways or in areas where birds/bats are highly concentrated, unless mortality risk is low. Avoid known daily movement flyways and areas with a high incidence of fog, mist, low cloud ceiling, and low visibility. Configure turbines to avoid potential avian mortality where feasible (i.e. group turbines rather than spreading them widely, orient rows of turbines parallel to known bird movements). Avoid fragmenting large contiguous tracts of wildlife habitat. Where practical, place turbines on disturbed habitats. Reduce availability of carrion Develop a habitat restoration plan for the proposed site that avoids or minimizes negative impacts on vulnerable wildlife while maintaining or enhancing habitat values for other species. Construct towers no more than 199 feet above ground level, using construction techniques that do no	Road access and fencing should be minimized If significant numbers of breeding, feedings or roosting birds are known to habitually use the proposed tower construction area, relocation to an alternate site should be recommended. If this is not an option, seasonal restrictions on construction may be advisable tin order to avoid disturbance during periods of high bird activity. Minimize roads, fences and other infrastructure. Infrastructure should be capable of withstanding periodic burning of vegetation.	Where feasible, turbines should be shut down during periods when birds are highly concentrated. Towers using guy wires for support which are proposed to be located in known raptor or waterbird concentration areas or daily movement routes, or in major diurnal migratory bird movement routes or stopover sites, should have daytime visual markers on the wires. Where feasible, power lines should be underground or on the surface as insulated, shielded wire. Where the height of the rotor-swept area produces a high risk for wildlife, adjust tower height where feasible. It is recommended that older turbines that have been shown to cause high mortality be retrofitted or relocated The use of solid red or pulsating red warning lights at night should be avoided. White strobe lights should be used at night – the minimum number, minimum intensity, and minimum number of flashes per minute allowable by FAA. Security lighting for on-ground facilities and equipment should be down-shielded		
USFS _DRAFT_ *36 CFR 251: Special Use Permits* . Kristin Nelson (202) 205-1406	The planning process must include the development and analysis of information regarding ecological components at a variety of spatial and temporal scales, as determined by the responsible official.		Plan decisions affecting ecosystem or species diversity must provide for maintenance or restoration of the characteristics of ecosystem compositions and structure within the range of variability that would be expected to occur under natural disturbance regimes in accordance with paragraphs (b)(1)(i) through (v) of 36 CFR 219.20				

FAA *FAA Advisory Circular: Obstruction Marking and Lighting, Ch.13* February 1, 2007 http://www.energy.ca.gov/2005publications/CEC-500-2005-180/CEC-500-2005-180.PDF . Scott Larwood (530) 752-7479, smlarwood@ucdavis.edu					Maximum separation gap between lights along a row to be 0.5 mi Omission of lighting within clusters (unless turbines are taller than perhiphery) Lighting of end turbines or end rows. Synchronization of lights for entire project. No daytime lighting necessary if white or off-white paint is used. Omit steady burning lights - Use of red (L-864) flashing lights recommended at night, or white(L-865) flashing lights possible if used alone without red lights and positioned in same manner as red flashing lights. Light fixtures should be placed as high as possible on the nacelle. Stray turbines should be lit High concentrations of lights should be avoided		
INTERNATIONAL							
Australia Wind Energy Association *Best Practice Guidelines for Wind Energy Projects* March 2002 www.auswea.com.au	A radius of up to 30km from the potential site should be used when gathering information on flora and fauna present within the site	Bird/bat utilization studies should be continued for at least 2 years after operation begins.	Avoid development sites and turbine sites with high bird usage Locate turbines and roads well away from wetlands and other bird-rich habitats Consider widening turbine spacing to permit movement of birds around and between turbines Design roads and tracks so that changes to surface water runoff are avoided and erosion is not initiated Route power cable to avoid the need to remove native vegetation and habitat Ensure power cables are not placed across regular bird flight paths Locate switchyard to avoid areas of native vegetation or habitat	Monitor for any downslope deposition of material from construction areas and ensure weeds are controlled and areas are revegetated. Implement strict speed limits where tracks are within 200m of wetlands or other habitats where birds could be disturbed. Locate storage areas and vehicle standing areas away from native vegetation and habitat and at least 200m from wetlands. Avoid building roads and placing turbines on areas of native vegetation and fauna habitat Avoid construction during the most sensitive times of year, and/or stage construction work to ensure adequate distance between works and sensitive habitats	Avoid human disturbance to any wetlands or other habitats that hold bird groups potentially vulnerable to collision Undertake an extensive rabbit control program to minimize the attractiveness of the site to birds of prey Clear away sheep and cattle carcasses rapidly Monitor and repair any erosion and reduce surface water pooling or concentration of runoff Do not illuminate wind turbines as this can attract insects, and confuse night-flying birds	Provide alternative habitat off-site to attract at-risk birds from near turbines	
Canada Environment Canada & Canadian Wildlife Service *A Guidance Document for Environmental Assessment* July 2005 http://www.energy.ca.gov/renewables/06-OII-1/documents/other_guidelines/CANADIAN_GUIDELINES_2005.PDF Final April 2007 Version: http://www.cws-scf.ec.gc.ca/publications/eval/index_e.cfm . Contact Unknown (819) 997-1095	Depends upon Level of Concern Matrix (Site Sensitivity + Facility Size): VERY HIGH CONCERN = 2+ years HIGH CONCERN = comprehensive survey MEDIUM = basic baseline surveys LOW = minimum amount of baseline information • Any turbine taller than 150m in height should be subject to closer scrutiny, especially for sites close to arrival and departure sites of nocturnal migrants, on mountain tops or in foggy areas.	Depends upon Level of Concern Matrix (Site Sensitivity + Facility Size): VERY HIGH CONCERN = 3+ years HIGH CONCERN = 2+ years MEDIUM = 2 years LOW = 1 year	A smaller number of larger turbines may pose less of a risk to birds than a larger number of smaller turbines. Tubular and meteorological towers without guy wires are recommended in commercial wind energy projects Configuration should avoid creating barriers to bird movement - spacing between the turbines should be greater than 200m in order to avoid inhibiting movement. Perching opportunities such as lattice towers, guy wires, hydro poles or other structures should be reduced or removed whenever possible.	Intense construction should be focused outside the core breeding and migration seasons to reduce disturbance to birds. Keep the number of access roads constructed to a minimum. When roads need to be constructed, habitat destruction, fragmentation and disturbance of breeding and wintering grounds should be minimized as much as possible. Power lines underground when possible. When above-ground lines, the following mitigation techniques should be considered: bird flappers or other flight diverters, increased size of wire, parallel to prevailing wind directions, removal of small lighting shield wires, placement close to trees and below tree tops, oblique rather than right angles when crossing rivers, avoidance of water crossings.	• Access roads that are not used after construction should be allowed to re-vegetate (with native not invasive plant species). • If grassland birds are being killed during aerial displays, consider delaying hay cutting If there are high densities of raptors in the area, implement a prey control program In agricultural sites, the areas under the turbines can be planted in a crop that is less attractive to birds Minimize or eliminate lighting. Use strobe lights only, with the minimum number of flashes per minute and the briefest flash duration allowable. Avoid steady-burning or other bright lights such as sodium vapor or spotlights on turbines and other structures. • Measures should be t	Encourage proponent to purchase and protect a parcel fo land of similar size and habitat Decommission or move problem turbines to a new location	

England Department for Environment, Food and Rural Affairs *Nature Conservation Guidance on Offshore Windfarm Development* March 2005 http://www.defra.gov.uk/WILDLIFE-COUNTRYSIDE/ewd/windfarms/windfarmguidance.pdf	Survey data from at least 2 years are necessary, with more survey data (preferably 3 years) will be required in circumstances where important concentrations of birds occur. Whole windfarm area plus surrounding buffer of 1-2 km should be surveyed – observers should be trained by ornithologists.	Surveys should be carried out for at least 3 years following construction and some monitoring may be required for the full lifetime of the development.	Avoid areas with concentrations of species of conservation importance or important migratory paths. Construction of larger turbines may provide greater visibility. Appropriate siting and design in terms of orientation, spacing and location should be used: allow wide corridors between clusters of turbines, with a line formation parallel to the main flight direction, and with the lines of turbines broken up.	Time construction works and construction methods should avoid critical times such as molting. Employ methods of chemical use that minimize release of polluting materials into the water column and only using chemicals selected from the List of Notified Chemicals. Construction works must not be undertaken between December 16 and March to minimize impacts on over-wintering Common Scoter. Cable laying along the beach from October to April should avoid the sensitive period 2 hours either side of high water for overwintering wader species. Cable laying should also occur outside of the molting period for the Common Scoter (July to September). Piling work for turbine foundations should only be carried out between high tide – 3 hours and high water +3 hours to minimize disturbance to Little Terns. No work should be carried out between May 1 and August 1 near to nesting/breeding areas.	Use intermittent rather than continuous navigation lighting, particularly strobing lights. Clusters of turbines will reduce the single point source and provide a more diffuse light distribution. Floodlighting of turbines should be avoided, particularly in times of bad weathers. White lights are preferable to red. High contrast patterns should be used on turbine blades to reduce motion smear		

OTHER							
American Birding Conservancy *Wind Energy Policy* October 12, 2004 http://www.abcbirds.org/policy/windpolicy.htm . Unknown Contact (540) 253-5782	1 year minimum, 2 years suggested Seasonal observations and detailed evaluation of site recommended, including surveys for noctrunal migrants Conducted by qualified professionals without a vested interest in the outcome	2 year minimum, statistically robust If legitimate mortality concerns, then studies should continue until monitoring demonstrates resolution of concerns	Location, design, operation, and lighting should be cafefully evaluated to prevent, or at least minimize, adverse impacts Towers and turbines should be monopoles, not of lattice construction, and have no guy wires	Power lines should be underground Above ground lines and poles should comply with Avian Power Line Interaction Committee (APLIC) standards Disturbed areas should be fully reclaimed to approximate the same habitat functions for wildlife that existed before the disturbance	The number of turbines tha are lit should be minimized Lit turbines should use simultaneously pulsing red or white strobes, suggested at 20 pulses per minute if possible If significant mortality rates cannot be resolved, then turbines should be shut down during periods of peak risk to birds or bats		
Audubon Washington *Wind Power Policy for Washington State* September 23, 2002 http://www.audubon.org/chapter/wa/wa/DOCs/Sept2002_WindPowerPolicy_ExecSummary.doc . Nina Carter (360) 786-8020	2+ years of baseline data of project area and surrounding buffer zone - potentially reduced to 1 year if use radar system such as BIRDRAD	Environmental monitoring must be conducted to assess the level of bird mortality caused by collisions, and must follow standard protocols. Monitoring reports and data must be submitted quarterly to EFSEC and WDFW for the first 2 years following commencement of operations, and annually thereafter.	Designs need to include technologies that are through to, or have been shown to reduce detrimental impacts on birds (i.e. tubular towers, absence of guy wires, absence of lights that may attract night-migrating birds) There must be a contingency plan established to be implemented when operational monitoring shows detrimental effects to birds and/or bird habitat		• Maximum speed of turbines less than 30rpm.		
CleanEnergy States Alliance *Model State Guidance Document Governing Avian and Bat Impacts from Wind Facilities* October 2006 . Mark Sinclar (802) 223-2554, msinclair@cleanegroup.org							

APPENDIX B: Wind Development and Wildlife Mitigation Studies Outline

The following collection is a compilation of literature on wind turbine mitigation efforts that has been separated according to the review process utilized (peer, none, or unknown). Within the 'Reviewed' section, documents are sorted into two primary categories (Journal or Report) and by the primary topic of the mitigation efforts and research (i.e., lighting alterations vs. location of turbines within site). The numbers located next to the citation correspond to the Annotated Bibliography, where detailed descriptions of each study can be found.

REVIEW PROCESS UTILIZED

Journals

Turbine Location/Turbine Type

2. Barrios, L. and A. Rodriguez (2004). "Behavioral and environmental correlates of soaring-bird mortality at on-shore wind turbines." Journal of Applied Ecology **41**: 72-81.
6. Hoover, S. L. & M. L. Morrison (2005). "Behavior of Red-Tailed Hawks in a Wind Turbine Development." Journal of Wildlife Management **69**(1):150-159.
8. Johnson, G. D., M. K. Perlik, et al. (2004). "Bat activity, composition, and collision mortality at a large wind plant in Minnesota." Wildlife Society Bulletin **32**(4): 1278-1288.
9. Osborn, R. G., C. D. Dieter, et al. (1998). "Bird Flight Characteristics Near Wind Turbines in Minnesota." American Midland Naturalist **139**(1): 29-38.
10. Osborn, R. G., K. F. Higgins, et al. (2000). "Bird Mortality Associated with Wind Turbines at the Buffalo Ridge Wind Resource Area, Minnesota." The American Midland Naturalist **143**(1): 41-52.

Lighting

17. Johnson, G. D., W. P. Erickson, et al. (2003). "Mortality of Bats at a Large-scale Wind Power Development at Buffalo Ridge, Minnesota." American Midland Naturalist **150**: 332-342.

Marking Power lines

24. Alonso, J.C., J.A. Alonso & R. Munoz-Pulido. (1994). Mitigation of Bird Collisions With Transmission Lines Through Groundwire Marking. Biological Conservation **67**: 129-134.
25. Brown, W. M. and R. C. Drewien (1995). "Evaluation of Two Power Line Markers to Reduce Crane and Waterfowl Collision Mortality." Wildlife Society Bulletin **23**(2): 217.
26. Janss, G. F. E. and M. Ferrer (1997). "Rate of Bird Collision with Power Lines: Effects of Conductor-Marking and Static Wire-Marking." Journal of Field Ornithology **69**(1): 8-17.
27. Morkill, A. E. and S. H. Anderson (1991). "Effectiveness of Marking Power Lines to Reduce Sandhill Crane Collisions." Wildlife Society Bulletin **19**(4): 442-449.

Curtail Turbines

30. Huppop, O., J. Dierschke, et al. (2006). "Bird migration studies and potential collision risk with offshore wind turbines." Ibis **148**: 90-109.

Reports

Turbine Location/Turbine Type

1. Anderson, R., N. Neuman, et al. (2004). Avian Monitoring and Risk Assessment at the Tehachapi Pass Wind Resource Area, Prepared for National Renewable Energy Lab: 1-102.
4. Erickson, W. P., G. D. Johnson, et al. (1999). Baseline Avian Use and Behavior at the CARES Wind Plant Site, Klickitat County, Washington, Prepared for the National Renewable Energy Lab**:** 1-75.

5. Hoover, S. (2002). The Response of Red-tailed Hawks and Golden Eagles to Topographical Features, Weather, and Abundance of a Dominant Prey Species at the Altamont Pass Wind Resource Area, California, Prepared for the National Renewable Energy Lab: 1-64.
7. Hunt, W. G. (2002). Golden eagles in a perilous landscape: Predicting the effects of mitigation for wind turbine blade-strike mortality, Prepared for the California Energy Commission**:** 1-72.
11. Orloff, S. & A. Flannery. (1992). Wind Turbine Effects on Avian Activity, Habitat Use, and Mortality in Altamont Pass and Solano County Wind Resource Areas Tiburon, California, Prepared for the Planning Departments of Alameda, Contra Costa and Solano Counties and the California Energy Commission.
12. Smallwood, K.S. & C.G. Thelander. (2004). Developing Methods to Reduce Bird Mortality in the Altamont Pass Wind Resource Area, Prepared for the California Energy Commission: 1-363.
14. Thelander, C. G. & L. Rugge. (2000). Avian Risk Behavior and Fatalities at the Altamont Wind Resource Area, Prepared for the National Renewable Energy Laboratory: 1-22.

Lighting

52. Arnett, E. B., W. P. Erickson, et al. (2005). Relationships between Bats and Wind Turbines in Pennsylvania and West Virginia: An Assessment of Fatality Search Protocols, Patterns of Fatality, and Behavioral Interactions with Wind Turbines, Prepared for the Bats and Wind Energy Cooperative**:** 1**-**187.
15. Erickson, W. P., J. Jeffrey, et al. (2004). Stateline Wind Project Wildlife Monitoring Final Report, July 2001 - December 2003, Prepared for FPL Energy, the Oregon Energy Facility Siting Council, and the Stateline Technical Advisory Committee**:** 1**-**105.
12. Smallwood, K.S. & C.G. Thelander. (2004). Developing Methods to Reduce Bird Mortality in the Altamont Pass Wind Resource Area, Prepared for the California Energy Commission: 1-363.

Visual Blades

20. Hodos, W. (2003). Minimization of Motion Smear: Reducing Avian Collisions with Wind Turbines, Prepared for the National Renewable Energy Laboratory**:** 1-43.
21. Young, D. P., W. P. Erickson, et al. (2003). Comparison of Avian Responses to UV-Light-Reflective Paint on Wind Turbines, Prepared for the National Renewable Energy Lab: 1-67.

Sound Devices

52. Arnett, E. B., W. P. Erickson, et al. (2005). Relationships between Bats and Wind Turbines in Pennsylvania and West Virginia: An Assessment of Fatality Search Protocols, Patterns of Fatality, and Behavioral Interactions with Wind Turbines, Prepared for the Bats and Wind Energy Cooperative**:** 1**-**187.
23. Dooling, R. (2002). Avian Hearing and the Avoidance of Wind Turbines, Prepared for the National Renewable Energy Lab: 1-17.

Perch Guards

12. Smallwood, K.S. & C.G. Thelander. (2004). Developing Methods to Reduce Bird Mortality in the Altamont Pass Wind Resource Area, Prepared for the California Energy Commission: 1-363.

Baseline Data

53. Erickson, W. P., G. D. Johnson, et al. (2002). Synthesis and Comparison of Baseline Avian and Bat Use, Raptor Nesting and Mortality Information from Proposed and Existing Wind Developments, Prepared for Bonneville Power Administration**:** 1-129.

Post Construction Data

56. Arnett, E. B., W. P. Erickson, et al. (2005). Relationships between Bats and Wind Turbines in Pennsylvania and West Virginia: An Assessment of Fatality Search Protocols, Patterns of Fatality, and Behavioral Interactions with Wind Turbines, Prepared for the Bats and Wind Energy Cooperative**:** 1**-**187.

Offshore

58. Pettersson, J. (2005). The Impact of Offshore Wind Farms on Bird Life in Southern Kalmar Sound, Sweden, at the request of the Swedish Energy Agency**:** 1**-**128.

Curtail Turbines

56. Arnett, E. B., W. P. Erickson, et al. (2005). Relationships between Bats and Wind Turbines in Pennsylvania and West Virginia: An Assessment of Fatality Search Protocols, Patterns of Fatality, and Behavioral Interactions with Wind Turbines, Prepared for the Bats and Wind Energy Cooperative**:** 1**-**187.

NOT PEER REVIEWED

Turbine Location/Turbine Type

13. Smallwood, K.S. (2006). Biological Effects of Repowering A Portion of the Altamont Pass Wind Resource Area, California: The Diablo Winds Energy Project.

Lighting

19. Larwood, S. (2005). FAA Obstruction Lighting Standards for Wind Energy Plants, Prepared for California Wind Energy Collaborative, sponsored by the California Energy Commission Public Interest Energy Research (PIER) program.

Marking Power lines

28. Organ, C. A., M. Timewell, et al. (2003). Bird Surveys along the proposed Musselroe Wind Farm Transmission Line - Ringarooma Ramsar area, north-east Tasmania, Prepared for Hydro-Electric Corporation**:** 1**-**62.

UNKNOWN REVIEW PROCESS

Turbine Location/Turbine Type

25. Brown, W. M., R. C. Drewien, et al. (1985). Mortality of cranes and waterfowl from power line collisions in the San Luis Valley, Colorado. 4th Crane Workshop, Grand Island, Nebraska, Platte River Whooping Crane Habitat Maintenance Trust.

Lighting

16. Howell, J. A., J. Noone, et al. (1991). Visual experiment to reduce avian mortality related to wind turbine operations, Prepared for Altamont U.S. Windpower, Inc.: 1-25.
18. Kerlinger, P. and J. Kerns (2004). A Study of Bird and Bat Collision Fatalities at the Mountaineer Wind Energy Center, Tucker County, West Virginia: Annual Report for 2003, Prepared for FPL Energy and Mountaineer Wind Energy Center Technical Review Committee**:** 1-39.

Visual Blades

1. Howell, J. A., J. Noone, et al. (1991). Visual experiment to reduce avian mortality related to wind turbine operations, Prepared for Altamont U.S. Windpower, Inc.: 1-25.

Microwaves

22. Kreithen, M. L. (1996). Development of a Pulsed Microwave Warning System to Reduce Avian Collisions with Obstacles. 2nd International Conference on Raptors. Urbino, Italy.

Sound Devices

76. Szewczak, J. & E.B. Arnett. (N/A). Evaluation of Acoustic Deterrents to Reduce Bat Fatality at Wind Facilities.

Perch Guards

29. Nelson, H. K. and R. C. Curry (1995). Assessing Avian Interactions with Wind Plant Development and Operations. 61st North American Wildlife and Natural Resources Conference. Washington, D.C.

Baseline Data

54. Percival, S.M. (2003). Birds and Wind Farms in Ireland: A Review of Potential Issues and Impact Assessment: 1-25.
55. Young, Jr., D.P, W. P. Erickson, et al. (2003). Avian and Bat Mortality Associated with the Initial Phase of the Foote Creek Rim Windpower Project, Carbon County, Wyoming, Prepared for Pacificorp, Inc., Bureau of Land Management and SeaWest Windpower, Inc.: 1-50.

Curtail Turbines

75. Sherwell, J. (N/A). Developing a mitigation strategy for bat impacts from windpower development in Maryland.

No Effect

57. Lucas, M. D., G. F. E. Janss, et al. (2005). "A bird and small mammal BACI and IG design studies in a wind farm in Malpica (Spain)." Biodiversity and Conservation **14**: 3289-3303.

APPENDIX C: Habitat Mitigation Studies Outline

The following is a compilation of literature on habitat mitigation efforts that has been separated according to the review process used (peer, none, or unknown). Within each section, documents are sorted by the primary topic of the mitigation effort and research (e.g., livestock fencing). The numbers located next to the citation correspond to the Annotated Bibliography, in which descriptions of each study can be found.

REVIEW PROCESS USED

Wetland Creation

46. Balcombe, C.K., J.T. Anderson, et al. (2005). "Wildlife Use of Mitigaiton and Reference Wetlands in West Virginia." Ecological Engineering **25**: 85-99.
47. Darnell, T.M. & E.H. Smith. (2004). "Avian Use of Natural and Created Salt Marsh in Texas, USA." Waterbirds **27**(3): 355-361.

Livestock Fencing

42. Dobkin, D.S., A.C. Rich, et al. (1998). "Habitat and Avifaunal Recovery from Livestock Grazing in a Riparian Meadow System of the Northwestern Great Basin." Conservation Biology **12**(1): 209-221.
45. Maron, M. and A. Lill. (2005). "The influence of livestock grazing and weed invasion on habitat use by birds in grassy woodland remnants." Biological Conservation **124**: 439-450.
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APPENDIX D: Personal Interview Contacts and Responses

The following list includes individuals that were contacted via phone or e-mail in order to gather information about existing research pertaining to mitigation. A list of interview questions is in Appendix E.

TELEPHONE

1) **Wayne Walker, Director of Project Development, Horizon Wind Energy, 713-265-0247, wayne.walker@horizonwind.com;** He is "not aware of a plethora of mitigation studies." Horizon looking into conservation banks, but hasn't implemented any yet. Mentioned Wild Horse study as only example of conservation/development that Horizon is currently involved in – it was not set up for mitigation specifically. He also mentioned www.bambergerranch.org as an example of someone taking a heavily degraded habitat and returning it to pre-European levels. Includes a manmade cryptorium for free-tailed bats. I looked it up, but seems a little 'fluffy'. (Follow up with the WA Nature Conservancy pertaining to Wild Horse study still necessary) – L/M with Horizon WA office on 11/1/06 for more info, 509-962-1122; also spoke with Jeff Compton of TNC-WA, 206-343-4345.

2) **Ed Arnett, Conservation Scientist – Wind Energy, Bat Conservation International, 512-327-9721, earnett@batcon.org;** no studies/research to his knowledge concerning habitat enhancement and bats. Says most species killed by turbines live in trees, so mitigation of caves/mines does little for repairing damage. Said research on insects/bats at turbines and stopping blades needs to be further researched.

3) **Jill Shaffer, Ecologist, USGS Northern Prairie Wildlife Research Center, 701-253-5547, jshaffer@usgs.gov;** she spoke with a few people about the existence of research that directly examines the effectiveness of any mitigation techniques and "we have come up mostly blank." Mitigation can include creating new habitats as well as protecting what exists – "both are important avenues to consider because placing wind developments in already disturbed land might preclude needing mitigation for habitat impacts or displacement of animals at all." Suggested I contact Habitat and Population Evaluation Team, DOT, FHWA, and SD State University.

She also mentioned the 'Effects of Management Practices on Grassland Birds' research http://www.npwrc.usgs.gov/resource/literatr/grasbird/index.htm. I looked into management suggestions for the Ferruginous Hawk and Burrowing Owl to determine how well supported they were. The research cited is from before the mid-90s, so appears to be a bit dated. When I looked into some of the papers cited, the management suggestions didn't appear to be overwhelmingly supported statistically. Jill did mention that they were updating the publication and that I should contact her to send me the updated versions – I am currently awaiting response from her.

4) **Jim Lowe, Birds in Forested Landscapes, Cornell Ornithology Lab, 607-254-2413;** said they have not studied applied mitigation – just surveys. Suggested contacting Stefan Hames who is their 'wind guru'. Left him a message on 8/22, but have not received a response. Stefan contact is 607-254-2496, rsh5@cornell.edu.

5) **Gail Garber, NM Avian Protection Working Group, HawksAloft (?), 505-828-9455, gail@hawksaloft.org;** the organization has never looked at mitigation as a research project. They have set up nesting platforms, but no research was conducted on its effectiveness. They have done

some pre-site assessments for wind turbines to identify raptors in area and if potential site is in way of migratory pathway. She suggested I contact Wally Erickson and David Young.

6) **Sandy Vana-Miller, USFWS in Colorado (Energy aspect), 303-236-4748;** suggested I call Al Manville. No idea about research pertaining to mitigation or habitat enhancement.

7) **Nick Myatt**, **Access and Habitat Coordinator, Oregon Department of Fish and Wildlife, 503-947-6087;** he doesn't do anything pertaining to habitat enhancement studies himself, but sent word out to co-workers for help with the question. Received response from one woman, who was going to look into studies that have been conducted within her area and send contacts for more information. Nick also suggested looking at the Conservation Plan for OR at www.dfw.state.or.us which outlines how to manage wildlife. Like npwrc research, however, it focuses more on individual species of concern. I emailed him and the woman again this week to see if they had come up with anything or anyone for me to speak with, but I haven't heard back from them yet.

8) **Rob Manes, Director of Conservation, The Nature Conservancy, 620-672-5677, rmanes@tnc.org;** he said that "definitive studies are not out there" pertaining to mitigation and its effects on birds/bats. He did send me some information on a mitigation proposal that TNC has been working on in the Smokey Hills, as well as some studies pertaining to Prairie Chickens and mitigation in Kansas.

9) **John Sherwell, Power Plant Research Program, Maryland Department of Natural Resources, 410-260-8667, jsherwell@dnr.state.md.us;** I called him specifically about a study that he intends to present at the conference in November pertaining to wind turbine rotation speed and bat interactions. He stated that the study modeled risk at low wind speeds, finding that lower rpms significantly decreased the risk to bats. He is looking for comments on whether or not the risk model is reasonable presently.

10) **Paul Garrett & Lamar Smith, Federal Highway Administration;** left messages with both of them, not sure if they are the correct contacts at this department though. Spoke with John Fagan 8/23, who said he would look into the best contact but has yet to get back with me. Left message for Jeff Peterson with the CDOT on 11/1/06 – Jeff.Peterson@dot.state.co.us, 303-512-4959

11) **Al Manville, Wildlife Biologist, Division of Migratory Bird Management, USFWS, albert.manville@fws.gov;** "No one has any idea what is going on in relation to bird/bat mortality and mitigation." He said that it was very important to assess populations, and that post-construction monitoring was a big part of this. Mitigation strategies mentioned included blade-painting strategies (Strickland), Bat-Be-Gone (Arnett) which is currently being testing in the field in TX – acoustic deterrents that do not appear to be cost effective, and Lesser Prairie Chicken studies (Robell, USFWS recommends >5m buffer from leks, BLM recommends ¼ mile) – surrogate structures used to date, need to test at wind facilities. Europe is ahead of US in this department – British, German (Franz Bairlein).

An interesting study that he mentioned was one in Oaxaca, Mexico. They are currently in the process of constructing a very large wind power plant, but World Bank will not fund unless they agree to shut down the turbines for 3 weeks during Broad-winged Hawk, Mississippi Kite, and Swainson's Hawk migration. Monitoring program has been set up to see the effects of this mitigation strategy on avian mortality, as well as on economic performance of plant. Study hasn't begun yet.

12) **Mike Estey, Habitat Population and Evaluation Team, USFWS, 701-355-8540;** he suggested I speak with Ron Reynolds. Did mention that HAPET is currently identifying potential

problems with the siting of a wind power plant in ND (pertaining to wildlife migration); "the biggest problems are identifying any real problems."

13) **Ron Reynolds, Habitat Population and Evaluation Team, USFWS, 701-355-8535;** study currently being conducted to examine the effectiveness of a mitigation strategy to remedy problems caused to Ruddy Ducks on their wintering grounds as a result of an oil spill in the Patauxent River, MD. Board of Trustees decided that mitigation for spill required the organization to return new Ruddy Ducks into the population to make up for the ones that were lost. In order to do this, HAPET is helping organization to restore/create new habitat on the breeding grounds which are in ND. Evaluations of mitigation will begin as soon as the mitigation treatments are completed, and they will last for 10 years. Mitigation includes restoring the function of degraded wetlands or replacing drained wetlands, largely through conservation easements on agricultural lands. They are currently targeting areas with high RUDU breeding populations because they are already supportive landscapes.

14) **Karen Kronner, President, Northwest Wildlife Consultants Inc., 541-278-2987, kronner@oregontrail.net;** stated that there wind is relatively new compared to other types of mitigation, so mitigation approaches have largely been based on mitigation efforts from gas projects, transmission lines, oil pipes, highways, etc. Mitigation depends on the scale of the project, and NWC works directs with state to minimize impacts. She doesn't "believe something needs to be formerly researched if other studies have shown how a habitat/species responds to change." A lot of mitigation efforts are based on intuition which is developed by being in the field and "gaining a sense of things in the area." People don't know what to do – you can learn from other regions, but you will need to tailor strategies to local conditions. They keep asking for more certainty, but you "can study a site for three years and still not know everything." Mentioned BLM in Nevada is currently developing regional specific wind power guidelines that will include pre-construction, environmental, and fatality monitoring. Also mentioned Cotterall Mountain (sp??) project in Idaho, where she though Sage Grouse mitigation tools were developed (Lynn Sharp was mentioned as contact).

Stateline project is the largest in Oregon, and has the largest post-construction study done thus far, which includes grassland bird displacement studies, raptor studies, and recovery of temporary disturbed areas (grass seeding). Pre-construction monitoring was conducted, and gaps were left in saddles when placing turbines as a result. Report on post-construction monitoring is expected January 2007. Stateline was found to exceed the raptor kill threshold established by the state, however, and a three part mitigation plan was developed, including: 1) construction of artificial nest structures, 2) protection of riparian habitat (raptor habitat) through exclosures of riparian area and upland livestock, and 3) provision of financial support to wildlife rehabilitator to purchase food to rehabilitate raptors and chicks. Mitigation efforts are only ¾ completed at this point, and effectiveness monitoring with be conducted on platform usage but not on effects of fencing due to long time period required for effects to be evident.

15) **Sara McMahon, Wildlife Biologist, PPM Energy, 503-796-7000, Sara.McMahon@PPMEnergy.com;** a lot of mitigation not based on research, but based on recommendations and observations. Efforts follow more of a precautionary principle approach, such that "it wouldn't hurt to set the turbines back from the canyon edges." Studies like the Altamont are not useful for the NW because there are different biological characteristics there.

Andy Linnenhahn (??) has been involved with Arnett's study on acoustic deterrents, where high frequency noise generators are used to block the ability of bats to relocate. Initial field trials have been completed and the deterrents appear to be positive at this point. He is not sure how far effects will extend, and mentioned that the devices are still in prototype development.

16) **David Klute, All-bird Conservation Coordinator, Colorado Division of Wildlife, 303-291-7320;** left message, no response

17) **Gregory Johnson, Ecologist/Project Manager, WEST Inc, 307-634-1756;** left message, no response

18) **Jim Lindsey, Principal Biologist Florida Power and Light, 561-691-7032;** left message, no response

E-MAIL

1) **Bruce Johnson, Starkey Experimental Forest (Biologist), johnsobd@eou.edu;** brief initial correspondence, but no response to questions

2) **Franz Bairlein, Editor-In-Chief, Institute for Avian Research, franz.bairlein@ifv.terramare.de;** responded that he was at the International Ornithological Congress and would get back to me when he returned to Germany. Received an email from co-worker Ommo Hueppop, who stated that he didn't "know of any such studies where artificial modifications of habitats around windfarms" were used as a measure to mitigate wildlife interactions. He suggested I pose this question to the Yahoo-group on Wind-turbines and birds/bats, http://tech.groups.yahoo.com/group/wind turbines birds/ . He additionally sent me a paper on offshore-windfarms entitled "Bird migration studies and potential collision risk with offshore wind turbines".

3) **Ellen Paul, Executive Director, The Ornithological Council, ellen.paul@verizon.net;** stated that she isn't aware of what mitigation measures have been taken, and that people tend to make educated guesses about things that will work but that they don't do any studies to determine the outcome. "No one has ever determined if the site selection has reduced mortality." There has been work done with regard to the surrounding vegetation (contact Carl Thelander), and Ed Arnett was suggested as a good contact on bats. "It would be possible that you are looking for information that doesn't exist."

4) **Dave Cowan, VP Environmental Affairs, UPC Wind Management, 207-829-6055, dcowan@upc.wind;** HCP for Hawaii project includes a "very comprehensive mitigation component", but there is not any hard data or research as of yet that can be cited. The project came on-line in June, and mitigation provisions are just getting started. Study has made some headway on documenting behavioral avoidance of turbines by birds that regularly pass through the site, but again, the data is not ready to present as a research paper. Rigorous impact avoidance protocol was implemented during construction phase to "ensure that no birds were accidentally disturbed or killed by clearing, earthwork, or vehicles and heavy equipment moving around the site." HCP plan itself is largely based on uncertainties, so it contains a lot of contingencies. "Track 1 if A happens, but Track 2 if B happens – it's as much a protocol as a prescription." He sent me a copy of the HCP for review.

5) **Dr. Michael L. Rosenzweig, Professor of Ecology and Evolutionary Biology, University of Arizona, scarab@email.arizona.edu;** he had heard of dozens of mitigation cases, but does not keep a formal file of them and is too "freighted with commitments to accomplish this in any reasonable time-frame." He does state, however, that many of them appear in his book "Win-Win Ecology", and although they are not labeled 'mitigation' per se, the will have the fingerprint of mitigation all over them. Additional resources included:

- Rosenzweig, M.L. (2006). Beyond set-asides. In Goble, D., D. Scott, J. Michael, and F.W. Frank (eds), *The Endangered Species Act at Thirty: Renewing the Conservation Promise.* Island Press, Washington, D.C.: p.259-273.
- Rosenzweig, M.L. (2005). Avoiding mass extinction: basic and applied challenges. *American Midland Naturalist* 153: 195-208.

6) **Ryan Burnett, Terrestrial Ecologist, Point Reyes Bird Observatory**, 530-258-2414, **rdburnett@prbo.org;** he stated that "PRBO hasn't done too much work but I know we have at least looked into doing some work and done some research". He suggested I contact Katie Fehring, who does most of the raptor work for the organization. Katie stated that PRBO is currently conducting surveys at a proposed wind site in Marin, but that is all the organization has done with wind development thus far. Her contact info is 415-868-0655 x380, kfehring@prbo.org.

APPENDIX E: Personal Interview Questions

The National Wind Coordinating Committee's Wildlife Workgroup Mitigation Subgroup is collecting information about research that has been conducted to determine the effectiveness of wildlife mitigation strategies, especially as they might apply to wind turbine sites. This research will be presented as case studies that will be included in a mitigation toolbox being developed by the Subgroup.

Questions:

1. Are you familiar with any such studies that have been conducted/are being conducted within your company/organization?
2. If so:
    a. Can you describe the study to me?
    b. What have you learned from this research?
    c. Has it definitively shown certain mitigation strategies to be effective or ineffective?
    d. Can you send me any documentation of this research, especially approach, methodologies, and analyses/results?
3. If not:
    a. Are you familiar with any such research that might be useful to this study?
    b. Has your organization/company implemented any mitigation strategies? Did you find them to be effective/ineffective?
    c. Does your company/organization plan to do any such research in the future?

APPENDIX F: Economic Analysis

This matrix compares the economic costs of certain mitigation strategies with the estimated effect on mortality of that strategy. The mitigation strategies presented in Column A came from both mitigation research and existing policies and guidelines. Column B briefly describes what the mitigation strategy encompasses. Associated Research is presented in Column C and shows existing or current research that has tested the mitigation strategy; the results of that research (in terms of effectiveness) are presented in Column D. Finally, Column E presents the estimated costs of the mitigation strategy.

ECONOMIC ANALYSIS

Mitigation Strategy	Description	Associated Research	Estimated effect on mortality	Estimated Cost
Install beneficial turbine designs	Place turbines in locations that minimize the chances of negatively affecting wildlife - includes placing turbines away from rim edges, away from flyways, creating wind walls, etc.	Orloff & Flannery 1992, Thelander & Smallwood 2004	Estimate 4% decrease in bird/raptor mortality by creating wind wall; untested	Pre-assessment surveys
Avoid areas heavily used by birds/bats	This would include migration pathways and breeding grounds.		untested, but presumably significant	Pre-assessment surveys
Locate turbines on altered landscapes	This would include areas such as agricultural lands - avoid constructing turbines in sensitive or large tracts of native habitat			N/A
Reduce and minimize lateral edge	Cuts into hillsides for wind turbine lay-down areas and access roads should be minimized	Smallwood & Thelander 2004	Ground squirrels avoided zone, but pocket gophers were attracted to it; untested	
Establish buffer zones	Establish areas where there will be no construction or development occuring around areas of high bird/bat use			
Alter tower type	Tower type altered, but existing turbine blade not changed			
Paint blades	One blade painted black (or thinly striped black/white) and two painted white	Hodos et al. 2003	untested	
	Red and white stripes	Howell et al. 1992, Thelander & Smallwood 2004	90% reduction (n=10) according to Howell; 2-3% increase according to Thelander	
	Paint blades with UV gel	Young et al. 2003	52% more fatalities at UV turbines - not significant and nocturnal species; degeneration of gel	

Rodent control	Live-trapping and relocation of rodents.	Hunt 2002	Potential increase in mortality for species that depend upon burrows &/or prey; no compelling evidence that rodent control reduces bird mortality; potential bioaccumulation and biomagnification issues	
	Poisoning of rodents using bait of some form.	Thelander & Smallwood 2004		
Fence around turbines to exclude livestock	Livestock congregate around wind turbines (wind-breaks, shade?), which increases cow pats and subsequent insect numbers. 50-m exclusion area may suffice, but may be necessary to fence off groups of turbines in order to minimize length of fencing and perching opportunities.	Thelander & Smallwood 2004	Estimated 18-22% reduction in avian fatalities; untested	
Rock piles	Establish rock piles to create denning habitat for Kit Fox prey population			
	Move artificial rock piles as far away from wind turbines as possible	Thelander & Smallwood 2004	not believed to reduce mortality substantially by itself; untested	Low
Perch guards	Treatments designed to discourage perching by raptors on lattice-style turbines	Thelander & Smallwood 2004, Nelson & Curry 1995, Curry & Kerlinger 2001	Reduction in perching observed to be 0-54%; Increase in hawk mortality of 2% (Thelander & Smallwood)	
Repower turbines	Older turbines replaced within newer ones (e.g., lattice-style towers replaced with tubular towers).	Thelander & Smallwood 2004, Anderson et al. 2004, Hunt 2002, Orloff & Flannery 1992, Thelander & Rugge 2000, WEST (unpublished)	90% decrease (Hunt), Tubular towers associated with 6-35% increased mortality (Thelander); WEST currenlty testing in CA (Altamont)	
Mark power lines	Placement of various markers on groundwires or power lines to increase visibility.	Alonso et al. 1994, Brown & Drewien 1995, Janss & Ferrer 1997, Morkill & Anderson 1991	60% decrease (Alonso), 76-81% decrease (Janss); 56% decrease (Morkill)	
Install bird flight diverters	Benign pole structures placed beyond the ends of strings and edges of turbine clusters.	Thelander & Smallwood 2004	untested	

Provide alternative perches	Establishment of alternative perches in order to attract birds away from turbines.	Thelander & Smallwood 2004	untested	
Barricade the rotor plane	Erection of barriers to keep birds from flying into moving blades.	Thelander & Smallwood 2004	untested	believed to be overwhelmingly costly & impractical
Accoustic deterrents	Modifying the acoustic signatures of turbine blades in order to make them more audible to birds/bats.	Dooling 2002, Arnett et al. 2005, Szewczak & Arnett (unpublished)	acoustic signatures for birds untested; sonar "jamming" testing in progress	associated costs for decreasing bat fatalities believed high
Retrofit turbine-tower pads				
Reduce availability of carrion	Remove carcasses to discourage scavengers from approaching turbines		untested	
Minimize number of lit turbines		Johnson et al. 2003, Erickson et al. 2004, Huppop et al. 2006, Arnett et al. 2005	lighting did not appear to affect bats/birds (Johnson, Erickson, Arnett); lights observed to cause disorientation and be attractant - needs to be field tested (Huppop)	save $
Avoid sodium vapor lights		Kerlinger & Kerns 2004	47.8% decrease after lights were turned off	
Synchronize lighting	Lights on turbines should flash at same time.	Larwood 2005	untested (only looked at effects on pilots)	N/A
Relocate selected turbines	Dependent upon species/location. Relocation of turbines that cause disproportionately large numbers of fatalities (i.e. isolated turbines, turbines in canyons).	Hoover 2002, Hoover et al. 2005, Thelander & Smallwood 2004, WEST (unpublished)	2-5% decrease in bird/raptor mortality by removing isolated turbine (Thelander); 100% decrease in GOEA mortality from turbines by removing from canyon (Hoover); WEST currenlty testing in CA (Altamont)	
Coordinate timing of operational turbines				
Remove derelict and non-operating turbines	Evidence suggests raptors are killed disproportionately more often by turbines adjacent to broken ones.	Thelander & Smallwood 2004	5-9% increase in mortality at or next to derelict turbines	

Suspend operation during high risk periods	Dependent upon species/location. Includes combinations of adverse weather, high migration, high/low winds, and topography.	Arnett et al. 2005, Hoover 2002, Hoover et al. 2005, Barrios & Rodriquez 2004, Huppop et al. 2006, Sherwell (unpublished), Villegas-Patraca et al. (unpublished), WEST (unpublished)	Currently being tested by Sherwell in MD, WEST in CA (Altamont), and Villegas-Patraca in Mexico.	
Repower using turbines with high rotor planes	Rotor planes should be no lower than 29m above the ground.	Thelander & Smallwood 2004	untested	
Acquire off-site conservation easements	Improving habitat/wildlife population by purchasing/improving habitat in another location.	USFWS (Ron Reynolds contact) unpublished		
Reestablish nesting/maternity areas	Any bird/bat nesting/maternity areas that are disturbed by the construction/operation of the turbines should be reestablished.			

From: Albert_Manville@fws.gov
Subject: Re: "Small" wind turbines
Date: December 6, 2011 6:39:58 AM PST
To: Dan Silver <dsilverla@me.com>
Cc: Albert_Manville@fws.gov, Eric_Kershner@fws.gov, Kelly Fuller <kfuller@abcbirds.org>

Dan,

Received your voicemail. My quick response and terse review of the San Diego County regulations: there is absolutely no mention about impacts to migratory birds protected by the Migratory Bird Treaty Act (totalling 1,007 species) nor impacts to eagles, especially Golden Eagles, protected by the Bald and Golden Eagle Protection Act. "Small" is an incredibly subjective term. Even 1 "small," 80 ft AGL 3-bladed turbine can be a high risk to eagles and other birds if placed in the wrong locations and/or subjected to inclement weather events when birds are present. That has been made quite clear in studies at Altamont Pass (Smallwood and Thelander, Hunt, and others) where some of the small turbines were deemed "killers."

"Small" also does not define the parameters of what kind of turbine is being permitted -- at least what I could find in the regs. Would these be the standard 2- or 3-bladed vertical turbines or would they be vertical helix turbines? While vertical helix turbines are being touted as "bird safe," I'm unaware of any studies yet published in the peer-reviewed, scientific literature that validate this hypothesis. There is a new turbine design that uses a vortex cone and pressure differentials to create electricity. It may, however, still just be a prototype.

Again, whether "small" or "large," if a turbine is placed in a bird- and/or bat-unfriendly location, even one turbine can be damaging, resulting in take. FWS does not issue incidental or accidental take permits under MBTA.

We are developing a take provision under BGEPA (50 CFR 22.26), but the acquisition of a take permit for Golden Eagles (take primarily including disturbance with a very limited allowance for take resulting in mortality) would almost certainly be a programmatic permit. To receive a programmatic take permit, the developer would have to pursue all steps necessary to show that "take is unavoidable." This could require some considerable pre-construction monitoring. Currently, we are recommending at least 2 years pre-construction studies in our evolving Eagle Conservation Plan Guidance -- an earlier draft on our FWS website -- with the latest draft still under development.

If eagle take occurs without a permit, this is a criminal violation of

BGEPA with some significant legal consequences. Officials who were to permit such a facility where unpermitted take occurs could also be legally culpable. A single, small turbine could take a CA Condor -- which would also be problematic.

I'm going to be involved in a conference call later today and most of tomorrow. If you still need to chat, I'll be available for part of the day on Thursday. Otherwise, hopefully I've answered your questions and addressed your concerns about take at "small" turbines. Bottom line: we just don't know until a site is selected and risk assessment calculated for the site. Risk can be significant even for a "small" turbine. The County needs to build a pre-construction monitoring requirement into their permitting process focused primarily on impacts to birds, bats and other wildlife. I failed to see such a provision. Given ongoing risks to Golden Eagles and CA Condors in the County, that would be a prudent path to follow even for a "small" turbine.

I'm also copying my colleague, Dr. Eric Kershner, who just came to us from Southern California. Gotta run. -Al-

United States Department of the Interior

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Reply To: 6320.0010(10)
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September 20, 2010

Sue Oliver
Energy Facility Siting Officer
Oregon Department of Energy
245 Main Street, Suite C
Hermiston, OR. 97838

Subject: Request for Comments on the Application for Site Certificate for the proposed Summit Ridge Wind project, Wasco County, Oregon

Dear Ms. Oliver:

The Fish and Wildlife Service (Service) has reviewed the August 24, 2010, Application for a Site Certificate (ASC) for the proposed Summit Ridge Wind Project (Project) to be located in Wasco County, Oregon. The proposed Project will include up to 87 wind turbines (2.0 to 3.0 MW each) with a total nominal generating capacity of approximately 200 MW of electricity. The Project will include about 19 miles of new access roads, turbine foundations, underground and overhead electrical collection systems, meteorological towers, and an operations and maintenance building. The Project will also include a communications system, a substation, and interconnection facilities to tie into the transmission line, located to the west of the project. The transmission feeder line will be an overhead 230 kV (kilovolt) line and will be approximately eight miles long.

Much of the project site is agricultural land used for dry land winter wheat production. The proposed facility would be built on land one to four miles west of the Deschutes River Canyon extending from approximately river mile 7 on the north end of the project boundary to river mile 31 on the south end. The Service supports the use of disturbed habitats for the placement of wind energy generation. However, we remain concerned regarding short and long-term Project impacts to migratory birds including bald and golden eagles, and bats.

The Service supports renewable energy and the economic benefits that wind energy generation brings to local communities. We also recognize wind power development has the potential to impact wildlife and habitat resources. The Service provided comments on the Notice of Intent to Apply for an Energy Facility Site Certificate (NOI) for the Project in a letter dated July 13, 2009, and Preliminary ASC in a letter dated November 18, 2009. We appreciate the opportunity to provide additional comments, and we look forward to working with you and LotusWorks on this important project.

Our previous comment letters focused on: (1) the potential for project specific mortality to birds and bats, including cumulative impacts of wind energy projects within the Columbia River corridor; and (2) measures to avoid or minimize Project impacts and adequate mitigation to offset unavoidable project impacts to biological resources. The Service subsequently received information in an email on June 24, 2010, from LotusWorks documenting the presence of golden eagles, large stick nests, and bald eagles in the project vicinity. Our comments below will focus on project impacts to bald and golden eagles and other migratory birds. We refer you to our previous two letters referenced above regarding other issues of concern.

Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act

The Migratory Bird Treaty Act (MBTA) prohibits the taking, killing, possession, and transportation, (among other actions) of migratory birds, their eggs, and nests except when specifically permitted by regulations. While the MBTA has no provision for allowing unauthorized take, the Service realizes that some birds may be killed during specific wind project operations even if all known reasonable, effective measures to protect birds are implemented. The Service's Office of Law Enforcement (OLE) carries out its mission to protect migratory birds through investigations and enforcement as well as by fostering relationships with individuals, companies, and industries that have taken effective steps to avoid take of migratory birds. It is not possible to absolve individuals, companies, or agencies from liability even if they implement bird mortality avoidance or other similar protective measures. However, the OLE focuses its resources on investigating and prosecuting individuals and companies that take migratory birds without identifying and implementing all reasonable, prudent and effective measures to avoid that take.

Additionally, the Bald and Golden Eagle Protection Act (BGEPA) prohibits the taking of golden and bald eagles except when specifically authorized by the Department of the Interior (16 U.S.C. 668-668d). The Service has new regulations (Federal Register 74:46836-46879; 11 September 2009) (USFWS 2009) that may eventually allow a wind project to receive a permit to take golden or bald eagles under the BGEPA (50 CFR 22.26), for programmatic actions that are consistent with the goal of stable or increasing eagle breeding populations. Therefore, we encourage LotusWorks to work closely with the Service to identify available protective measures and develop an Avian and Bat Protection Plan (ABPP) and implement those measures prior to and during Project construction and operation.

The Service's goal for golden and bald eagles is stable or increasing breeding populations. Data from long-term studies of golden eagle migration, population models, and surveys sponsored by the Service indicate cause to be concerned about population trends for golden eagle (Millsap and Allen 2006, Good et al. 2007, Farmer et al. 2008, Smith et al. 2008, USFWS 2009). The Service was sufficiently concerned regarding the status of golden eagles that we determined, until further data shows golden eagle populations can withstand additional take, we will only consider BGEPA permit issuance of new golden eagle take for safety emergencies and for projects that result in net benefits to golden eagles. Bald eagle permit issuance criteria would limit permits to only 5% of the Maximum Sustainable Yield.

Project Impacts and Service Recommendation

Golden eagles and other bird species are known to collide with wind turbines and transmission lines. Studies for the Project document the presence of golden eagles (12 detections) and three inactive large stick nests that were likely golden eagle nests, with a fourth nest that may have been built by golden eagles. These nests were located within 1,000 to 10,000 feet from Project wind turbines (Northwest Wildlife Consultants, Inc. 2010). Additionally, adult bald eagles were observed (4 detections) on or in proximity to the Project. The Service is concerned regarding the potential for injury or mortality from a turbine strike, transmission line collision, or other Project-related disturbance to bald and golden eagles. The Project studies and reports provide only a limited eagle impact analysis.

With the expected growth of the wind industry in the western United States, the Service anticipates that the number of golden eagles killed annually will multiply. The Service is concerned that the population trend of golden eagle will drop even more rapidly as a result of collisions with wind turbines, resulting in greater conflicts between renewable energy industry and agencies. Ultimately, fewer golden eagles will exist unless we find solutions to either greatly reduce golden eagle mortalities at wind projects, reduce other sources of mortality to off-set losses of golden eagles from wind farms, or enhance golden eagle populations with habitat or other reforms.

In the absence of clear solutions to address golden eagle mortalities at wind energy projects, to enhance populations through conservation measures, or to off-set losses in other ways, our best efforts should be directed at avoidance of mortalities by siting wind turbines well away from areas where resident and migrating eagles are known to concentrate their activities. The Service believes the Project, including all turbines, transmission and roads, and associated facilities has the potential to result in injury and mortality of individual golden eagles and potential loss of nest sites over the life of the Project.

The Service recommends that LotusWorks prepare an Avian and Bat Protection Plan consistent with the Service "white paper" titled *Consideration for Avian and Bat Protection Plans* (FWS 2010) that addresses bald and golden eagles, other migratory bird species of concern, and bats. We recommend that the Oregon Department of Energy defer the approval of the Project site certificate until an Avian and Bat Protection Plan is completed, and available for review. We further recommend the following measures be incorporated into any site certificate approval:

To reduce the likelihood of golden eagle take and to minimize Project impacts, we recommend the following measures be included in the development of the Project:

1. Minimize the potential for resident golden eagle collisions by locating individual Project wind turbines a sufficient distance from golden eagle nest sites. Based on the best information available to us, a radius of a minimum of six miles from a golden eagle nest to the nearest turbine will likely avoid take of adult golden eagles associated with that nest. Any wind turbines proposed closer than six miles to golden eagle nests should not

be constructed until specific golden eagle studies have been implemented that define areas where no golden eagle use occurs (see studies in #2, below). These golden eagle-specific data should then be integrated into a protective turbine location "micrositing" design where turbines within six miles of a golden eagle nest are only sited in areas determined to be golden eagle non-use locations;

2. Conduct site specific studies to help define areas of use and non-use by golden eagles including:

    - Complete nest surveys within six miles of the Project location;
    - Conduct observation-post studies to observe the behavior of the adults (if present) without disturbing nesting behavior. These studies collect information on territory occupancy, productivity, fledging success, foraging and winter habitat and other information per the Interim Golden Eagle Inventory and Monitoring Protocols (Pagel et al. 2010); and
    - Satellite telemetry of nesting golden eagles within six miles of Project location.

3. Develop a Project construction plan that fully integrates avoidance of golden eagle disturbance during construction activities by implementing concurrent protective timing windows and distance buffers during sensitive nesting and fledging activities.

    - Distance and timing: Construction and maintenance activities between January 1 and July 15 should not be conducted within 1 mile of an active golden eagle nest (or ½ mile if not line-of-sight), unless site specific surveys indicate otherwise.

The Service has regulations in place that allow us to issue 'Programmatic Permits' to project applicants whose developments have the potential to incidentally 'take' golden eagles over extended periods of time. The Service is not currently issuing those permits, but is developing conditions that will likely be components of them. Permit conditions will likely include,, appropriate Advanced Conservation Practices - measures that represent the best available techniques to reduce take to a level where additional take is unavoidable: and permit conditions will also likely include mitigation measures to offset whatever birds are taken so that the effect of the Project on eagles will be consistent with the Service's goal of stable or increasing breeding populations. It is possible that a programmatic permit issued by the Service when it becomes available, would include as permit conditions many of the recommendations for monitoring, adaptive management and conservation actions described below:

1. Develop and implement a golden eagle monitoring plan (including monitoring of Project-related golden eagle mortality, golden eagle territory occupancy, nest success, and productivity) over the life of the Project to ensure all golden eagles injured or killed by wind turbines or other impacts to golden eagles are immediately identified and reported.

2. Develop and implement an adaptive management plan to address new information that is obtained during operation of the Project, including all turbines, transmission, and roads, and connected wind projects that effectively address any identified problems.

- Utilize turbine feathering and cut-in speeds of 5 m/sec to 6 m/sec at times of low wind speed to reduce bird (and bat) fatalities;
- Lock rotors during daytime and at night during peak migration periods and peak presence of migrating birds and bats;
- Specific commitment to integrate turbine operation curtailment (seasonally or permanently) into Project management to minimize impacts to bald and golden eagles;
- Specific commitment to remove turbines if they are found to cause repeated mortalities of golden or bald eagles;
- Experimental procedures (e.g. blade painting for higher visibility);
- Minimize lighting associated with the Project including:
  - a) FAA visibility lighting of wind turbines should employ only strobed, strobe-like, or blinking incandescent lights, preferably with all lights illuminating simultaneously; and
  - b) Keep lighting at both operation and maintenance facilities and substations located within ½ mile of the turbines to a minimum level by using motion or infrared light sensors and switches to keep lights off when not required, shield operation lights downward, and do not use high intensity, steady burning, bright lights; and
- Commitment to implement future technology when available.

Additionally, specific conservation actions should be collaboratively developed with the Service to meet the conservation goal of stable or increasing breeding populations of golden and bald eagles. The Service cannot permit take of golden eagles; however were we able to, we would look for the types of measures identified below to potentially offset such take in a manner that is consistent with the goal of stable or increasing breeding populations of golden eagles. The local-area eagle population of concern in this case is the area encompassed by a circle 140 miles from the Project boundary, by definition (USFWS 2009). This is the area within which we would expect evaluations of the effects of this Project on eagles would take place. The following should guide any collaborative development of proposed conservation measures:

- Ensure no net loss or an increase in golden eagles in the local-area population via:
  - Land acquisitions or easement purchases;
  - Nest site protection;
  - Habitat enhancement via:
    - Restoration projects (e.g. juniper removal in shrub-steppe systems that will enhance prey base);
    - Grassland restoration efforts with native grasslands;
    - Cheatgrass control programs;
    - Nest platforms;
    - Nest enhancements;
  - Reduce electrocution mortality via partnering with utilities to implement Avian Power Line Interaction Committee standard (APLIC 2006) retrofits of problem distribution lines;
  - Reduce losses to lead poisoning via:
    - Education program on lead poisoning;

    - Raptor rehabilitation centers;
- Contribute to regional or population-wide monitoring and research on golden eagles and wind turbines to better inform management across the West.

Conclusion
The Service appreciates the opportunity to comment on the ASC for the Summit Ridge Wind Project. We support well-designed wind projects that are carefully sited on habitats that will result in less impacts to Service trust resources. We recommend that the Oregon Department of Energy defer the approval of the Project site certificate until an Avian and Bat Protection Plan is completed, and available for review. We further recommend the measures outlined in this letter be incorporated into any site certificate approval. The Service is available to continue to work with LotusWorks in the review, development, mitigation, and monitoring of the Project.

If you have any questions regarding the Service's comments or desire to meet with us to discuss these issues further, please contact Jerry Cordova or me at (541) 383-7146.

Sincerely,

Nancy Gilbert

Nancy Gilbert
Field Supervisor

cc:
Steve Cherry, Oregon Department of Fish and Wildlife, Heppner, Oregon
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CALIFORNIA ENERGY COMMISSION

Golden Eagles In A Perilous Landscape: Predicting The Effects Of Mitigation For Wind Turbine Blade-Strike Mortality

CONSULTANT REPORT

JULY 2002
P500-02-043F

Gray Davis, *Governor*

CALIFORNIA ENERGY COMMISSION

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Legal Notice

Acknowledgements

Tom Cade of the Peregrine Fund conceived of this project and provided advice and encouragement throughout. Dick Anderson and Linda Spiegel of the California Energy Commission provided valuable support and assistance throughout the project. We thank Peter Law and Alan Franklin for mathematical and statistical assistance. Chris Gill performed GIS mapping and data organization. Hans Peeters supplied information on nests, productivity and behavior of golden eagles in the study region. Wally Erickson, Bryan Manly, Dale Strickland, and an anonymous reviewer provided valuable comments and insight.

Teresa Hunt and Craig Himmelwright conducted the nest surveys. Daniel Driscoll, Ron Jackman, and Brian Latta captured eagles for transmitter attachment and climbed nests to tag young. Greg Doney, Victor Garcia-Matarranz, Dan Hansen, Christopher Kuntzsch, Stan Moore, and Lynn Polacca provided assistance during trapping efforts and nest climbs. Lois Culp and Karen Lougheed performed ground squirrel surveys and located eagle fatalities. Patti Leiberg-Clark and Randolf Skrovan assisted with data collection on telemetry flights. Brian Walton, Janet Linthicum, Tery Drager, and James Gilardi provided technical assistance and support.

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Don and Kathy Krump cared for eagles that suffered debilitating injuries from turbine blade-strikes. Jim Smith of the Alameda County Agricultural Department provided knowledge of ground squirrels and control methods. Tony Owens of the Alameda County Animal Shelter provided deer killed along roadways for eagle trapping efforts. We thank the personnel from Parks Reserve Forces Training Area for access to radio-tag eagles, especially Sgt. Steven Jenny, Richard Fielder, Col. Thomas Black, and Marshall Marick.

Figure 1. Juvenile Golden Eagle in the WRA (photo by Daniel Driscoll)

Special thanks to the many landowners who helped us with information about eagles and/or let us visit their property. They include: Joe Aljoe and Art Cherry of the N3 Cattle Co., Paul Banke of the Patterson Ranch, Joe Betchart, the Bonavitos, Rene and Mary Meyers, Jim Cox, Mick Dover, Mr. and Mrs. Wayne Calhoun, Pat, Mark, and Matt Connolly, Loree Cornwell, Reese and Ilene Cowden, Don and Mimi Devani, Russ, Steve, and Tony Fields, John Ginochio, John Gomez, Joe Jesse, John and Ann Lindl, Cathy West of Diablo Grande, Peggy Thompson, Hugh Walker and Lois Walker, Cindy and Richard White, and Ernie, Bart, and Jeff Wool, Danny and Nancy Sachau, Sheldon Berz, the Pruitts, and the land owners associated with the Altamont Pass Wind Resource Area.

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Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Commission), annually awards up to $62 million to conduct the most promising public interest energy research by partnering with Research, Development, and Demonstration (RD&D) organizations, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following six RD&D program areas:

- Buildings End-Use Energy Efficiency
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy
- Environmentally-Preferred Advanced Generation
- Energy-Related Environmental Research
- Strategic Energy Research.

What follows is the final report for the "Golden Eagles in a Perilous Landscape: Predicting the Effect of Mitigation for Wind Turbine" project, Contract Number: 500-97-4033, conducted by Predatory Bird Research Group, University of California, Santa Cruz. The report is entitled "Golden Eagles in a Perilous Landscape: Predicting the Effect of Mitigation for Wind Turbine." This project contributes to the Energy-Related Environmental Research program.

For more information on the PIER Program, please visit the Commission's Web site at: http://www.energy.ca.gov/research/index.html or contact the Commission's Publications Unit at 916-654-5200.

Executive Summary

The Predatory Bird Research Group, University of California, Santa Cruz, has been conducting a long-term study of golden eagles (*Aquila chrysaetos*) in the Diablo Mountains of west-central California. The initial work (1994-1997), funded by the wind industry and by the National Renewable Energy Laboratory (NREL), used aerial tracking of radio-tagged eagles to address the question of whether eagle deaths resulting from wind turbine blade strikes at the Altamont Pass Wind Resource Area (WRA) were seriously affecting the population. Estimates are that wind turbines kill 40-60 subadult and adult golden eagles each year, on average. Golden eagles, being naturally slow to reproduce, are particularly sensitive to changes in adult and subadult survival rates. For this reason, and because of its popularity, the species is afforded special protection by both federal and state governments. There is no legal provision for the killing of golden eagles.

Wind turbine blades also kill other protected species in the WRA, including several hundred red-tailed hawks (*Buteo jamaicensis*) and American kestrels (*Falco sparvarius*) each year. The fatalities have caused adverse public perception of wind power plants, and the threat of fines and lawsuits has delayed, modified, or even stopped wind energy development in some states, including California. Alameda County, for example, has imposed a moratorium on increase over current electrical production (~580 MW) until progress is made toward resolving the bird-strike issue. To address the problem, research must determine whether the fatalities threaten the birds on a population basis, what kinds of turbine / tower configurations are most destructive, and what management actions could reduce the number of fatalities.

We began the current investigation in June of 1998 under the support of the California Energy Commission's Public Interest Energy Research (PIER) Program. At that time, extensive repowering appeared imminent in the WRA. Of particular interest was the intended replacement of some 1300 turbines with a larger and possibly more benign type, at an approximate ratio of seven removed for every one replaced. Our objectives were to increase the samples of radio-tagged eagles and to continue monitoring them for the purpose of (1) further understanding the demographics, (2) tracking the net result of repowering, and (3) exploring other measures that might effectively reduce the incidence of golden eagle mortality. As time passed, it became apparent that difficulties within the wind industry would delay the repowering process beyond the scope of the study. We therefore focused upon eagle deaths relative to existing turbine configurations in an attempt to identify the factors contributing most to blade-strike mortality. This approach, with its emphasis on radio-telemetry, a technique with virtually no distributional bias, offered a measure of prediction regarding the efficacy of expected changes in the WRA.

Our earlier (1994-1997) study, which focused primarily on the demographic question, was based on the aerial monitoring of survival within a sample of 179 radio-tagged golden eagles and an annual survey of 60-70 pairs nesting within about 30-km of the WRA. Two population dynamics models yielded widely different estimates of population trend. One of them, developed by an NREL-appointed panel of scientists, concluded that the population was declining rapidly during the period of study. In fall 1998, when we began capturing additional eagles for radio-tagging, we encountered significantly fewer subadults and nonbreeding adults ("floaters") in the study area than previously, an observation that supported the demographic

predictions of the NREL model. However, our telemetry data on the movements of both juveniles and older eagles suggested a greater tendency than before to leave the study area. Possible reasons were that (1) prolonged periods of rainfall in winter 1997-1998 had reduced overall prey density, and (2) land-use changes had reduced habitat and prey abundance.

We recorded the deaths of 100 radio-tagged eagles during the seven-year study. Wind turbine blades killed at least 42, the actual number being higher because the blades occasionally destroyed the transmitter. Adding 12 electrocutions, all outside the WRA, at least 54 percent of all fatalities were attributed to electrical generation or transmission. Wire strikes, vehicle strikes, and poisoning brought human-related fatalities to at least 68 percent of the total.

Blade-strike mortality did not affect all golden eagle life-stages equally. Only one juvenile eagle was struck among a radio-tagged sample of 117 free-ranging individuals (juveniles are 3-15 months of age). In contrast, there were 31 blade-strike deaths among 155 subadults (ages 1-3 years) and floaters (4+ years). We attribute the apparent immunity of juveniles to their lesser tendency to hunt live prey, a fact suggesting that eagles tend to be struck while hunting. Radio-tagged breeders were rarely killed by turbines (2 among 47) because their relatively small home ranges kept most of them out of the WRA.

Five of the 42 blade-strike casualties wandered away from the turbines that had rendered them flightless, leaving 37 for an analysis of their distribution relative to the 25+ types of turbines in the WRA. At least 27 (73%) of these eagles were killed by Type-13 (Kenetech 56-100 on an 18.3-meter lattice tower), not surprising because 56 percent of all turbines were Type-13. However, a comparison of the distribution of radio-tagged eagles and that of fatalities revealed that disproportionate numbers of eagles died in areas containing Type-13 turbines. We then focused on two areas where relocations of radio-tagged eagles were of high density, one containing Type-13 turbines and the other containing other types. Eagle distribution during the 10-month period prior to each of 21 fatalities in the Type-13 area showed comparable numbers of relocations in the two areas but highly disproportionate numbers of Type-13 kills. We concluded from this circumstantial evidence that conditions in the Type-13 area were more hazardous to eagles than conditions in the area occupied by other types of turbines.

Our data did not reveal whether the perceived lethality stemmed from the Type-13 configuration itself or from other factors such as spacing between the turbines or extraneous environmental differences between the areas we compared. Type-13s were on relatively short towers, so their blades passed closer to the ground than 95 percent of the other turbine types. However, Type-13s in the WRA were set closer together than all other turbine types we measured. The distance between blade and wing-tip of a golden eagle passing exactly between two adjacent, wind-aligned Type-13 rotors of normal placement was less than three meters. Turbulence associated with high winds and steep terrain in the WRA, and the fact that golden eagles there typically hunt by actively coursing over long distances within a few meters of the ground, give reason to suspect that flight control difficulties for eagles trying to pass between or under Type-13 turbines may sometimes have lethal consequences.

These circumstantial data suggest that the planned removal of 644 Type-13s as part of the repowering project in the WRA may benefit eagles, especially if the removals were to occur in areas where eagles concentrate. Observations of foraging eagles suggest that the new, larger (Type-28) turbines might be safer than the Type-13 turbines they are intended to replace.

However, even if Type-28 were to prove more lethal on a per-turbine basis, its far greater generating capacity may render it preferable because few are necessary to match the generating capacity of many Type-13s, that is, assuming that overall energy production does not increase in the WRA.

The California ground squirrel (*Spermophilus beecheyii*) was the principal prey of golden eagles in the WRA throughout our study, and we found significantly higher numbers of radio-tagged eagles in areas of high squirrel concentration. A primary reason for squirrel density differences was that some ranchers controlled them while others did not. No control program was in effect within a large area of Type-13 turbines in the northwest portion of the WRA and, not surprisingly, this area contained high eagle relocation densities and the highest concentration of blade-strike fatalities. We conclude from this that ground squirrel control throughout the WRA could profoundly reduce the incidence of blade strike mortality among golden eagles.

However, even though ground squirrel control is a well known and frequent practice, it is not without secondary environmental costs. Animals, including many sensitive species, prey upon ground squirrels in the WRA, and some depend upon their burrows. Another downside of ground squirrel control is the collateral destruction of non-target species which eat the poison grain. We therefore recommend less destructive control methods, for example, trapping ground squirrels in areas near turbines where the squirrels exceed a threshold density. If ground squirrel control becomes more widespread in the WRA, it would be appropriate to mitigate the loss for all affected wildlife, including eagles, by encouraging ground squirrels outside the WRA. This might take the form of conservation easements purchased from ranchers in areas of open grassland.

We resolved the paradox of the two population models that earlier gave such widely divergent estimates of population trend. The first (NREL-supplied model), which incorporated a parameter (alpha) for the rate at which floaters acquired breeding territories, and computed a precipitous decline, proved defective. The computation by matrix algebra of the annual rate of change in population size, requires that all parameters remain constant in time, a feature that produces a stable stage distribution, regardless of trend. However, alpha is a parameter whose value responds to changes in floater numbers such that, during a decline, alpha increases in value, thereby compromising both the computation of the population change rate and its variance. Both the model and its alarming result must therefore be discarded.

A better and more parsimonious model is the traditional one describing the maximum potential rate of population change under the hypothetical assumption that all eagles acquire breeding territories upon maturity. A growth prediction by this model would yield a population at equilibrium in which a stable contingent of floaters buffers the breeding population against decline, whereas a decline estimate predicts the loss of floaters altogether. The parameters of this model, refined by our recent data on eagle survival and reproduction, yielded a point estimate approximating the condition of no annual rate of change in population size, but no production of a floater buffer. The variance of this estimate falls more or less equally into the alternatives of increase and decrease. If the point estimate of the model is correct, any further decrease in survival or reproduction, e.g., as might accompany increasing human development, would be mitigated only by immigrant floaters from outside the study area.

Several current (Spring 2000) indicators of population health are apparent. First, the number of breeding pairs in the broad region surrounding the WRA has remained unchanged, i.e., virtually all territories occupied by pairs in one year have remained occupied in the next, a clear sign that floaters quickly filled vacancies. Second, we observed very few subadults as members of breeding pairs. A high proportion of subadults in the breeding population would suggest a paucity of floaters. Whether the floaters currently buffering the breeding population are generated within the study area or arrive as immigrants is unknown. We recommend a continuation of the nesting surveys every two or three years as a system of early warning, should a decline actually be occurring.

Figure 2. Subadult Golden eagle (photo by Daniel Driscoll)

Abstract

The Predatory Bird Research Group, University of California, Santa Cruz, has been conducting a long-term field investigation of the ecology of golden eagles (*Aquila chrysaetos*) in the vicinity of the Altamont Pass Wind Resource Area (WRA) where turbine blade strikes kill an estimated 40-60 eagles per year. Our seven-year study was based on the aerial tracking of 257 radio-tagged eagles and an annual nesting survey of 60-70 pairs within about 30-km of the WRA. Of 100 deaths recorded among the tagged eagles, 42 were attributed to wind turbines, although the actual number was higher because the blades occasionally destroyed the transmitter. Comparisons of eagle location data with the distribution of blade-strike fatalities in the WRA showed that conditions within areas containing Type-13 turbines (the Kenetech 56-100 on an 18.3-meter lattice tower) were more dangerous to eagles than those in areas containing other types of turbines. It is unknown whether this lethality arose from the Type-13 configuration itself or from other factors such as spacing between turbines or extraneous environmental influences. Type-13s are set closer together than other turbines in the WRA, and eagles may have particular difficulty passing between (or under) them, especially in conditions of high winds and turbulence. California ground squirrels were the principal prey of golden eagles in the WRA, and eagles were attracted to areas of high squirrel concentration. Reduction of ground squirrel numbers around the wind turbines would reduce the incidence of blade strike deaths. Squirrel control would impact other wildlife in the WRA, but could be partially mitigated by off-site conservation easements. A demographic analysis produced a point estimate of no annual change in population size, but the variance fell equally into the alternatives of increase and decrease. If the point estimate of the model is correct, the population is failing to maintain a contingent of nonbreeding adults (floaters) which buffer the breeding sector in healthy populations. However, throughout the study, virtually all nesting territories occupied by adult pairs in one year were reoccupied the next, suggesting either a demographic balance in the local population or buffering by immigrant floaters.

Figure 3. Southeast Portion of the Altamont Pass WRA (photo by Daniel Driscoll)

1.0 Introduction

Powering of the Altamont Pass Wind Resource Area (WRA) began in 1982 and produced about 6,500 wind turbines by 1987. At some point during this growth period, the U.S. Fish and Wildlife Service began receiving reports of raptors killed by turbine blade strikes. The most numerous fatalities encountered were red-tailed hawks (*Buteo jamaicensis*), American kestrels (*Falco sparvarius*), and golden eagles (*Aquila chrysaetos*), with lesser numbers of turkey vultures (*Cathartes aura*), common ravens (*Corvus corax*), barn owls (*Tyto alba*), and others. In 1994 alone, 348 raptor fatalities in the WRA were reported to Alameda County, 35 of which were golden eagles and 194 red-tailed hawks (Alameda County 1998).

On the basis of foot surveys conducted along the rows of turbines, Orloff and Flannery (1992) estimated in their report to the Commission that about 40 golden eagles and several hundred other raptors died in the WRA each year. During a six-year period (1994-1999), the general magnitude of that estimate was reaffirmed by wind industry employees who, while servicing the turbines, happened upon 21-42 dead golden eagles per year (mean=28). However, these likely represented only a fraction of the total fatalities present, considering the lack of surveys and the incidental nature of the reports. All of these considerations suggested that Orloff and Flannery's estimate of 40 golden eagle fatalities was conservative.

The golden eagle is of particular concern, not only because it is less abundant than most of the other species killed at the WRA, but because it is also naturally slow to mature and reproduce, characteristics that render its populations especially sensitive to increases in adult and subadult mortality. The species has declined in southern California as a result of urban encroachment (Scott 1985, Harlow and Bloom 1987), and the California Fish and Game Department (1992) lists it as a Fully Protected Species and a Species of Special Concern. Moreover, the federal government affords the golden eagle special protection under the Eagle Protection Act as amended in 1963. There are no provisions within the Act that would allow the killing ("taking") of golden eagles.

During 1994-1997, the Predatory Bird Research Group (PBRG) sought to determine the extent to which eagle deaths resulting from wind turbine blade strikes were influencing the trend of the population. The work, funded by the wind industry and by the National Renewable Energy Laboratory (NREL), involved placing radio-transmitters on 179 golden eagles in the vicinity of the WRA and tracking their movements in weekly surveys by airplane over a 48-month period. Each transmitter contained a sensor indicating whether the eagle was alive or dead. Results of the aerial surveys showed that eagles killed by turbines were primarily from a local resident population whose density, as determined in annual nest surveys, was among the highest known in the world. Sixty-nine territorial pairs have been found within 30 km of the WRA boundary (Hunt et al. 1995, 1996, 1999).

The majority of deaths recorded among radio-tagged eagles during the 1994-1997 study resulted from electrical generation or transmission. Most of these were caused by wind turbine blade strikes, the remainder by electrocutions on distribution lines outside the WRA. Additional turbine-related fatalities went unrecorded because blade strikes destroyed the transmitter in an estimated 25 percent of cases. These data on mortality within a continuously monitored sample, together with estimates of golden eagle reproduction in the study area, were sufficiently precise for modeling experts from Colorado State University (Franklin et al. 1998) to estimate (incorrectly, as we shall show) that, during the four-year period, the population was declining at an annual rate of 9.3 percent (SE=3.2 percent). A second, more parsimonious model proposed by PBRG, produced a decline rate of 1.2 percent, a value indistinguishable from a condition of no persistent decline by its standard error (3.9 percent). Neither model precluded the possibility that immigrants from less lethal environments buffered the population. PBRG predicted that, in the absence of turbine-related mortality, the population would be self-sustaining and a source of recruits to the surrounding landscape.

1.1. Project Objectives

In addition to the question of which of the two population models most accurately described the trend of the population, the demographic study also left unanswered that of how eagle deaths in the WRA might be mitigated. At the time of the study's conclusion, it appeared that extensive changes within the WRA were imminent and that these changes might effect a reduction in blade-strike mortality among golden eagles. Of particular interest were industry plans to replace the Kenetech 56-100 turbines on 18.3-meter lattice towers (Type-13) with larger turbines on tubular towers (Section 2.2). The latter, producing far more electrical energy, would replace the Type-13 turbines at a ratio of one new structure for every seven or eight removed. Whether the new, larger turbines were individually more benign was unknown, but biologists noted that eagles were less apt to perch on the tubular towers and speculated that their blades, being higher off the ground, would allow eagles to more easily pass under them. Moreover, the slower rotation of larger turbines might render their blades more visible and more negotiable (Tucker 1996a, b).

PBRG proposed to continue the radio-tagging and tracking of golden eagles as a way of determining the efficacy of these changes, specifically, by comparing new data on eagle distribution and mortality with those recorded during the earlier study. As it turned out, difficulties within the industry postponed the repowering program beyond the time frame of this study. However, as we proceeded, it became clear that factors affecting eagle distribution and mortality could still be investigated, and that we could explore the distribution of eagle deaths relative to existing turbine configurations in an attempt to identify those conditions most lethal. Such an approach offers a measure of prediction of the effects of changes expected to occur in and around the WRA and adds to the scientific foundation upon which regulators and industry can make management decisions. The work is consistent with the mission of PIER funding, namely to "… conduct public interest energy research that seeks to improve the quality of life for California's citizens by providing environmentally sound, safe, reliable, and affordable energy services and products."

1.2. Report Organization

We begin by describing the study area, our general methods, and those aspects of golden eagle life history that pertain to our study. We then explain our findings in the context of the entire investigation dating from 1994. We discuss the numerical and distributional changes we observed within our samples of radio-tagged eagles and detail the numbers and sources of mortality recorded throughout the study area. We then focus on mortality within the WRA and its relationship to the various kinds of wind turbines, with emphasis on those features, including placement that contribute to their lethality. We discuss the relationship of eagles to prey distribution within the WRA. We examine two population models that would predict the population trend, discarding one in favor of another. We end our report with an overview discussion of our findings and recommendations. For further details on methodology and overall findings, we recommend that the reader have on hand copies of our earlier reports to NREL (Hunt et al. 1995, 1996, 1999).

2.0 Background and Project Approach

This study centers on the use of radio-telemetry to monitor the survival and movements of golden eagles in and around the WRA. This approach overcomes the bias associated with observer location and visibility within differing terrain and vegetation typical of other methods. All radio-tagged eagles are equally detectable from an airplane so that virtually all are accounted for within the study area (Hunt 1987). GPS enhances the precision of establishing the location of tagged eagles, and GIS electronic mapping facilitates the comparison of eagle distribution with that of wind turbines and other landscape features.

During the earlier study (1994-1997), we radio-tagged 179 golden eagles within ca. 40 km of the WRA with backpack-style transmitters (Hunt et al. 1995) designed to last four years. The sample included 79 juveniles, 45 subadults, 17 floaters (nonbreeding adults), and 39 breeders. Effective sample sizes in the older stages increased as eagles matured or became territorial. Thus, by the end of the study, we had obtained telemetry data on 106 subadults, 40 floaters, and 43 breeders, in addition to the 79 juveniles. Some of these transmitters were still operating when we began the current study and, to increase the overall sample, we tagged an additional 78 eagles during 1998-1999, including 53 juveniles, 19 subadults, four floaters, and two breeders. Each transmitter contained a motion (mortality) sensor yielding a recognizably faster pulse rate when the instrument was motionless for four or more hours. We monitored eagle movements and fatalities by means of fixed-wing aircraft surveys conducted one to four times per month (weather permitting) through October 2000. We performed final surveys in spring 2001 to determine the number of eagles still residing in and near the study area. We used GPS to fix and record eagle relocations (accuracy within ca. 0.6 km). We traveled without delay to sites where fatalities were detected, collected data on cause of death, and, where possible, identified the responsible turbine. Wounds and / or dismemberment easily identified blade-strike kills, and, in most cases, the latter were in immediate proximity to turbine towers, the location of which was substituted for the less accurate GPS fixes recorded from the airplane. In a few cases, eagles struck by turbine blades survived the event and were encountered and saved, though they remain flightless in animal care facilities. We regarded these casualties as deaths because they were permanently lost to the population.

We used the Kaplan-Meier estimate of stage-specific survival rates as developed by Pollock et al. (1989) for staggered entry of radio-tagged individuals. Assumptions were that (1) individuals were sampled randomly, (2) survival time was independent for each eagle, (3) the radio-tag did not influence survival, and (4) censoring was not related to the eagle’s fate (Heisey and Fuller 1985, Bunck 1987). Censored eagles (those suspended from analysis when their fate was unknown) fell into two classes: those carrying failed transmitters and those absent from the study area, the two possibilities being indistinguishable. Possible causes of transmitter failure included battery discharge, component malfunction, and transmitter destruction, all but the latter fairly regarded as occurring independently of the eagle's fate. The assigned date of deletion was midway between the date of last detection and that of the first indication of signal disappearance. The first assumption that of random sampling, is problematic to the extent that tagging sites were chosen opportunistically. However, the very high mobility of nonbreeding eagles throughout the study area and the long duration of the tracking study render this bias negligible.

Our estimate of reproductive rate was based on the number of fledged young per territorial pair, the latter being only those observed during or before incubation. This method avoids the bias relating to the fact that successful pairs are easier to locate and identify late in the breeding season than pairs that have failed (Steenhof and Kochert 1982, Steenhof 1987). We therefore began our surveys in January and February of each year when eagles were conspicuously engaged in territorial (undulation) displays prior to egg laying. We revisited areas to see whether eagles were incubating, and later returned to nests where we had observed incubation to determine whether broods were present and to count the number and ages of young. Young were considered to have fledged if they reached approximately eight weeks of age.

We used GIS (ArcView™) software to map ranch boundaries and the positions of the 5,382 operational wind turbines in the WRA. Some of the wind companies had electronic data while others provided contour maps of varying scale showing turbine positions. We scanned these and manipulated the resulting images to correspond to electronic topographical maps (Maptech™). We verified the accuracy of turbine positions in the field by spot-checking. Information provided by the wind-energy companies and attached to each data point included turbine serial number, turbine type, tower type, and tower height.

2.1. Study Area

The 9,000 km^2 study area, selected on the basis of the overall movements of radio-tagged eagles, is bounded on the north by the Sacramento River delta, to the east by the San Joaquin Valley, to the west by the urban area along San Francisco Bay, and to the south by State Highway 152 between Morgan Hill and San Luis Reservoir (Figure 4). This largely pastoral region of the Diablo Mountains supports grasslands, oak savanna, oak woodland, chaparral/scrub, and contains a band of urban communities extending from Livermore to Concord.

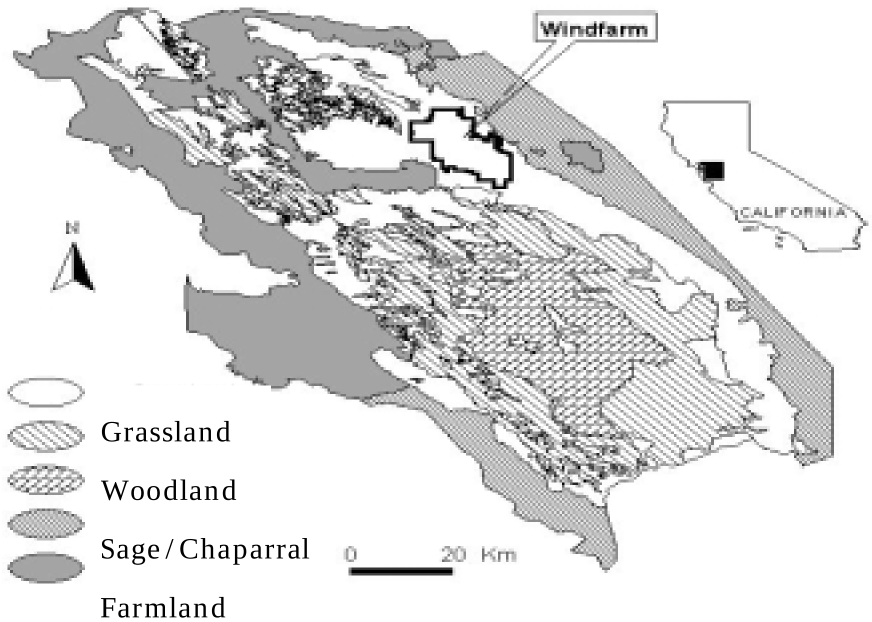


Figure 4. The Diablo Range Study Area

The WRA itself is a 160-km^2 tract of privately owned cattle ranches in hilly grassland (elevation 60-550 m) covered almost entirely by European annual grasses and with occasional oaks (*Quercus* spp.), eucalyptus (*Eucalyptus* spp.), and California buckeye (*Aesculus californica*). Terrain is generally less steep in the eastern portion of the WRA, giving way to continuous farmland. A valley containing urban sprawl lies below the hilly western boundary. Running west to east through the Diablo Mountains and the WRA is Altamont Pass, through which strong winds are drawn from the ocean to the Central Valley, especially during the warmer months.

The California ground squirrel (*Spermophilus beecheyii*), the principal prey of golden eagles in the region, was abundant in portions of the WRA, particularly during the early years of our study (Hunt et al. 1995). Ranchers throughout the region control ground squirrel numbers with summer applications of anticoagulant rodenticides (Section 3.6). Two other important prey species, the black-tailed jackrabbit (*Lepus californicus*) and cottontail rabbit (*Sylvilagus auduboni*) occur within the WRA.

The WRA contains about 5,400 wind turbine structures of about 27 types (Appendix I) operated by a variety of energy companies. Principal differences among the turbines include the degree of power generation (40-750 kW), tower type (e.g., tubular versus lattice structure), blade number (2 or 3), rotor-swept diameter (13-46 m), tower height (14-43 m), and blade rotation axis (horizontal versus vertical) (Figure 5). The most common type is the Kenetech 56-100 on an 18.3 m lattice tower (Type-13) of which there are currently about 3000 (56 percent of total) in service (Figure 6).

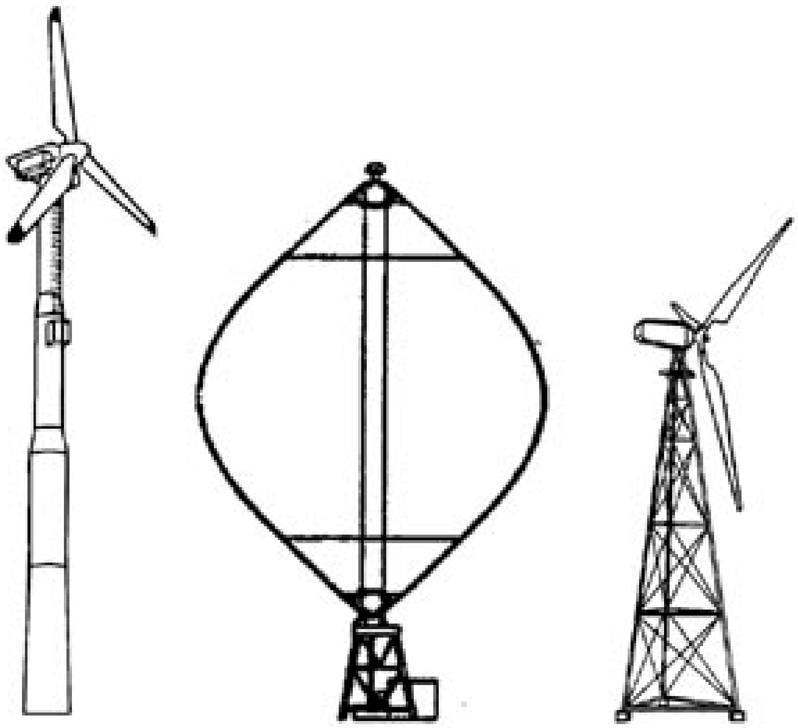


Figure 5. Examples of the Three Basic Wind Turbine Designs in the Altamont Pass WRA: Tubular Tower (Type-8), Vertical Axis (Type-9), and Lattice Tower (Type-13)

2.2. The Repowering Plan

When we proposed this study, the plan for repowering of the Altamont Pass WRA involved the replacement of existing turbines with a lesser number of larger, more energy-productive turbines by three wind-energy developers (Alameda County 1998). Green Ridge Services and Altamont Power proposed to replace existing turbines with NEG-Micon 700 kwh turbines on either 114-foot (34.7 m) or 131-foot (40 m) tubular towers (Type-28). The new turbines would have a 157-foot-rotor-diameter (48 m) and a 22 rpm maximum rotational speed. Green Ridge Services would replace 644 Type-13 (100 kwh lattice tower) turbines, including all those associated with more than one known raptor fatality, with 92 Type-28 turbines, a ratio of seven removed to one constructed. Altamont Power proposed to replace all 194 Flowind Vertical Axis turbines (Type-9) with 45 Type-28 turbines (ratio = 4.3 to 1), and possibly replace 25 Danwin 110 kwh turbines (Type-17) with five of the new turbines (ratio = 5 to 1). Sea-West would replace 432 of the 433 existing turbines with 42-50 NedWind 500 kwh or NEG-Micon 750 kwh or MHI-MWT 600 kwh turbines, replacement ratios from 8.6 to 1 to 10.3 to 1.

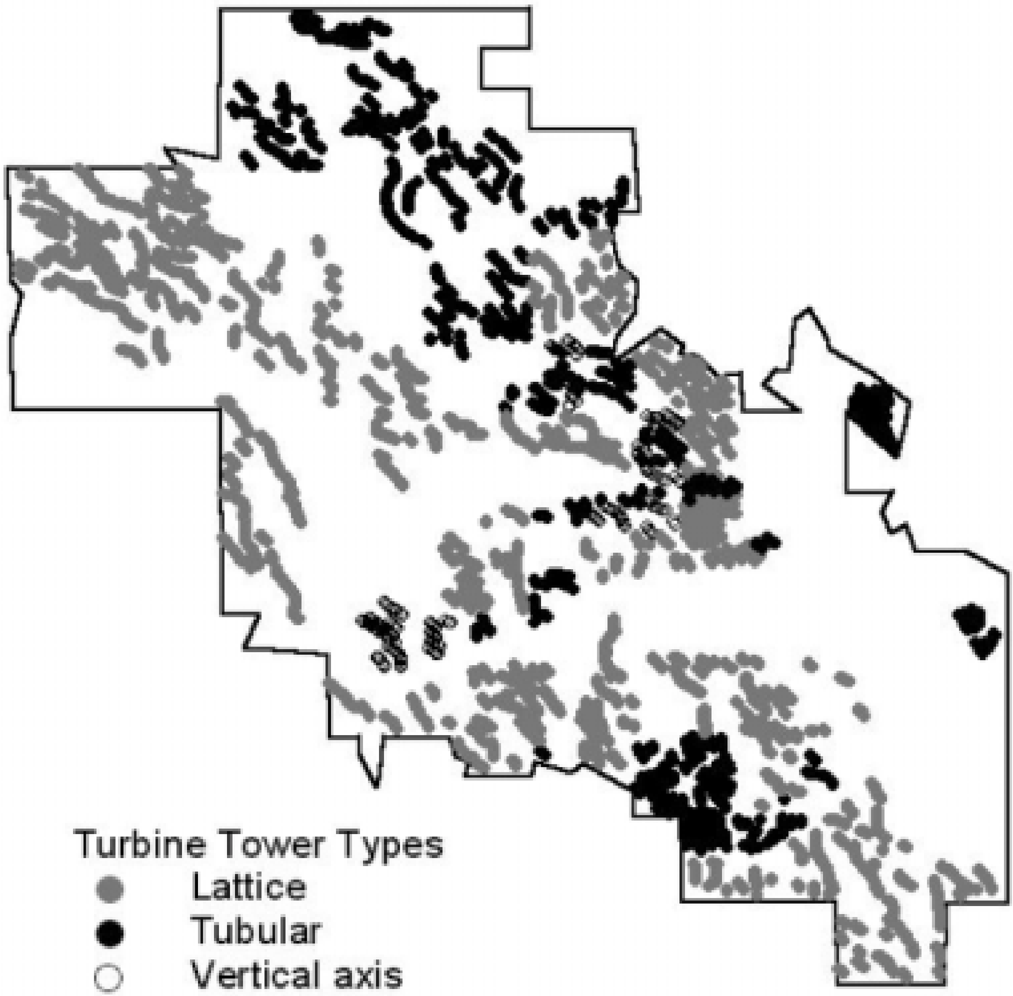


Figure 6. Distribution of the basic Turbine Configurations in the WRA

2.3. Study Species

Golden eagles occur throughout the Northern Hemisphere and are among the largest of raptors, with wingspans of up to 2.2 m and weights approaching 5 kg (Watson 1997). Females are about 25 percent heavier than males, an evolutionary adaptation relating to their divergent roles during the breeding season. Golden eagles in our study area forage primarily on live mammals in open grassland habitats, but in winter may rely heavily on carrion, including deer and cattle carcasses, and may exploit waterfowl concentrations. California ground squirrels are the main prey in the study area. Among 339 prey items from collections made at golden eagle nests in the study area in 1994, we estimated that the California ground squirrel represented 69 percent of prey numbers and 64 percent of prey biomass (Hunt et al. 1995). The second most important species was the black-tailed jackrabbit at 8 percent biomass, and the third was the black-tailed deer (*Odocoileus hemionus*) at 6 percent. In all, mammals accounted for 92 percent of prey biomass, followed by 7 percent for birds, and 1 percent for reptiles.

Although these figures represent only a single breeding season, numerous subsequent observations have verified the predominant role of California ground squirrels in the diet of golden eagles in the WRA and its environs. The reason doubtless relates to the abundance of squirrels in the region and their availability to eagles throughout the year. In this respect, they differ from many other ground squirrel species that aestivate and / or hibernate for long periods. California ground squirrel populations do not appear to cycle in abundance over multi-year periods as do, for example, jackrabbits, the main prey of golden eagles in most western states. However, prolonged winter rainfall in some years may reduce ground squirrel availability and overall numbers (Grinnell and Dixon 1918; this study).

Golden eagles in the interior central coast ranges of California occur primarily in grazed, open grasslands and oak savanna, with lesser numbers in oak woodland and open shrub lands. With increasing urbanization, much of the remaining golden eagle habitat in central and southern California is located within private ranches used for livestock grazing. Over much of their range, golden eagles prefer cliffs for nesting, but these are scant in the Diablo Range study area, and all but a few pairs nest in trees, including four oak species (*Quercus lobata, Q. douglasii, Q. agrifolia, and Q. wislizenii*), three pines (*Pinus sabiniana, P. radiata,* and *P. coulteri*), California bay laurel (*Umbellularia californica*), eucalyptus (*Eucalyptus* spp.), and western sycamore (*Platanus racemosa*). The Diablo Range eagles nest mainly in oak savanna and oak woodland. Open grasslands are generally unsuitable for nesting due to lack of structures, but a few pairs of eagles nest on electrical transmission towers traversing grasslands. Golden eagle pairs in the Diablo Range participate in courtship and nest building in December and January, lay 1–3 eggs in February and March (incubation lasts 6.5 weeks), and fledge their 10- to 11-week-old young from mid-May to late June. Fledglings usually stay within their natal territories until mid-August, although some individuals may remain in the vicinity until December.

Healthy golden eagle populations contain four population segments: breeders, juveniles, subadults, and floaters. Differing environmental and behavioral factors may influence the numbers of each within a population. Breeders are individuals four years old or older that defend breeding territories. Because golden eagle pairs partition the landscape into a mosaic of territories from which other adults are excluded, there is an upper limit to the number of breeders and therefore the number of young produced in any defined area. Territorial boundaries tend to remain fairly stable from year to year (Marzluff et al. 1997, this study), and, in years of low prey availability, eagles may forgo breeding but still occupy and maintain their territories. This tendency for the number of territories to remain somewhat constant, together with the limit on area productivity, form the basis for stability in overall population size, i.e., Moffat’s equilibrium (Hunt 1998).

Juveniles are eagles less than one year old, and subadults are one, two, and three years of age. Floaters are adults without breeding territories (Brown 1969), and their existence implies that territorial pairs occupy all habitat suitable for breeding (Hunt 1988,1998). Floaters effectively safeguard the breeding segment by quickly replacing breeders that have died, but if the proportion of floaters is very large, competition for nesting territories may reduce the reproductive rate and breeder survival (Hansen 1987, Haller 1996). For further information on golden eagle natural history and population ecology, we refer the reader to Haller (1996), Tjernberg (1985), Watson (1997), Kochert et al. (in press), and to Section 3.0 in Hunt et al. 1995 and our other NREL-sponsored reports (Hunt et al. 1997, 1999).

2.4. Other Studies of Avian Fatalities

Several investigations of wind-energy-related bird fatalities have been conducted at Altamont Pass after Anderson and Estep (1988) brought attention to the issue. Howell and DiDonato (1991a) surveyed 359 turbines biweekly from September 1988 to August 1989 and found 42 avian fatalities. They noted that fatalities tended to be associated with topographical features such as swales and the shoulders of hills (Howell and DiDonato 1991b). Howell (1995) compared the Type-13 and the larger more energy-productive Type-12 (33 meter rotor diameter) turbines and found the number of raptor kills per turbine to be equal, i.e., 0.264 and 0.278, respectively.

Orloff and Flannery (1992) documented 182 fatalities in two years, of which 119 (65 percent) were raptors. They found that kills were related to turbine location (end-of-row turbines), topography (near canyons), and tower type (lattice towers). They estimated annual raptor mortality at 164 to 403 birds. They reported that turbine-related mortality did not appear to be related to species abundance, and suggested that other factors such as behavior or flight characteristics may contribute to collisions. Further analysis of their data suggested that some factors specific to turbine types (tip speed, tower type, and the percent of time the turbine was in operation) were significantly correlated with fatalities, while others (rotor diameter, rotor swept area, turbine height, turbine spacing, and rotor orientation) were not (Orloff and Flannery 1996).

Curry and Kerlinger (1998) examined the fatality data submitted to Alameda County and noted that golden eagle and red-tailed hawk fatalities were correlated with turbine location and topography. They determined that end-of-row and second-from-end turbines accounted for 46 and 44 percent of all the golden eagles and red-tailed hawks killed, respectively. Mid-string turbine fatalities of the two species appeared to be associated with topographical features (dips and notches) and gaps (irregular spacing) between turbines. In an analysis of multiple-kill turbines, Kerlinger and Curry (1997a) found that 439 (91 percent) of golden eagle and red-tailed hawk fatalities were at single-kill turbines, 36 (7.5 percent) at turbines responsible for two kills, and 7 (1.5 percent) at turbines connected with three kills.

3.0 Project Outcomes

3.1. Evidence for a Change in Eagle Distribution

Our earlier study showed that subadults and floaters were by far the most frequently killed by turbine blade strikes. We therefore targeted these life-stages for radio-tagging in the current study. However, when we resumed our capture program in fall 1998, it was soon apparent that fewer subadults and floaters were present in the study area than previously encountered. In the early sampling period (January 1994 – July 1996) we had captured 54 subadults/floaters in 100 trapping days for an average of 0.540 individuals per day, whereas later (November 1998 – January 2000) we caught only 28 subadults/floaters in 168 trapping days, or 0.167 eagles per day, a highly significant difference (X^2=28.5, d.f.=1, p<0.001). Trapping techniques, locations, and months of fieldwork were similar during the two periods, so our results could not have arisen from differences in sampling.

Not only were attempts to capture subadults and floaters less successful, but we caught more juvenile eagles (n=28 in 168 days) in the current study than in the earlier one (n=7 in 100 days). The disproportion between the two periods in the number juveniles trapped per day (X^2=3.77, d.f.=1, p=0.052 with Yates' correction) suggests a change in density, but may have resulted not from a greater number of juveniles present overall but from less competition with older eagles for access to the bait stations. The ratios of juveniles to older itinerants (non-territorial eagles) in the capture samples between the two study periods were significantly different: 7:54 (12.9 percent) during 1994-1997 versus 28:28 during 1998-2000 (X^2=20.6, d.f.=1, p<0.001). Figure 7 shows these age-class ratios.

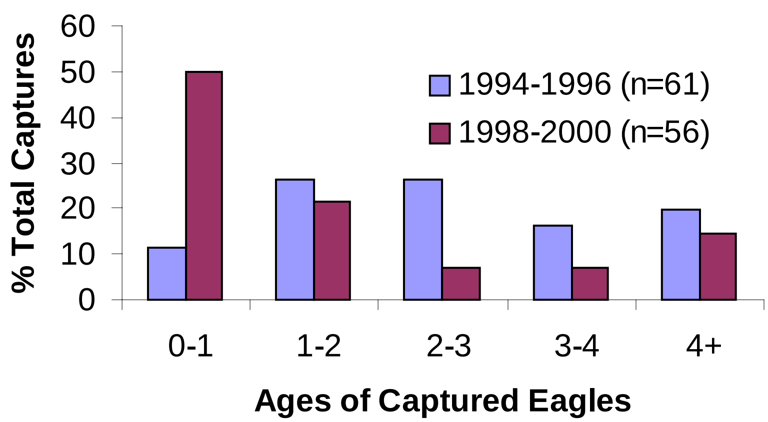


Figure 7. Ages of golden eagles captured in 1994-1996 versus 1998-2000

We thought that annual differences in reproduction (range=0.46–0.90 fledglings per occupied site) might explain the change in age ratios between the trapped samples. However, we found no correspondence. Reproduction was far above average in spring 1994 and yet, among the 19 free-ranging eagles we captured the following spring, only 4 (20 percent) were juveniles. The year 1998 was one of below average reproduction, and yet 18 (47 percent) of 38 itinerants captured the following winter and spring were juveniles (X^2=3.70, d.f.=1, p=0.0544, though p=0.1020 with Yates' correction).

The weight of evidence therefore implies that far fewer free-ranging subadults and floaters existed in the study area during 1998-2000 than were present during 1994-1996, a finding consistent with the modeled (point estimate) predictions of an overall-declining trend in population as reported by Hunt et al. (1999). However, an alternative hypothesis is that free-ranging eagles may have had a greater tendency to emigrate in the later period, e.g., in response to possible changes in prey availability in the study area or elsewhere. Let us examine this possibility.

Figure 8 graphs the behavior of four yearly cohorts of golden eagles (tagged as fledglings) from September of the natal year through the following September. Note the suggestion of an increasing tendency to leave the study area by comparing the proportions of eagles that remained with those that either disappeared or left and returned, the latter being those gone two months or more. Disregarding the proportion of deaths and combining the two classes of emigrants in Figure 8, the difference between the apparent behavior of cohorts in the earlier study (1994-1997) and that fledging in 1999 is significant (X^2=4.72, d.f.=1, p=0.0299, with Yates' correction). The suggestion of a change in tenure is even more convincing when one compares the activities of the 1994–1995 cohorts with those of 1996–1999 (X2=7.46, d.f.=1, p=0.0063, with Yates' correction). We surmise that, although most of the juvenile eagles not detected in the surveys eventually returned, conditions in the study area were less hospitable during the later years of study.

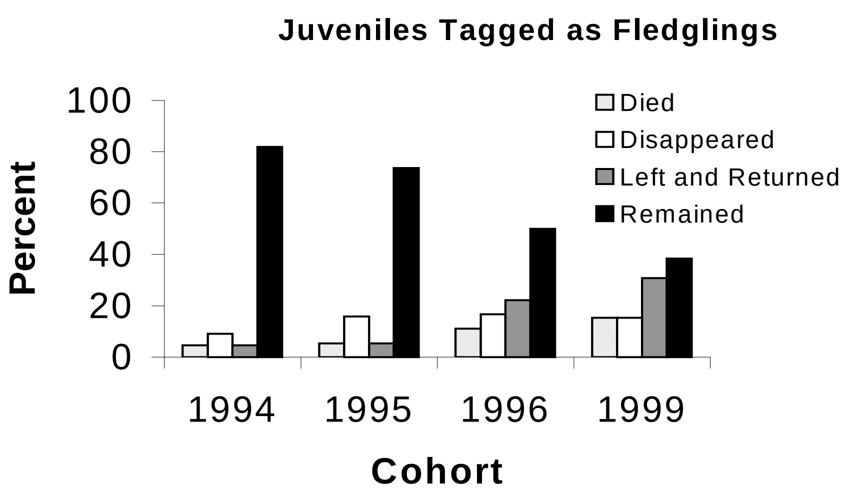
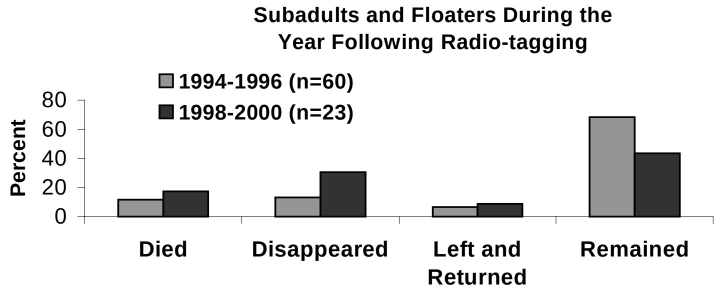


Figure 8. Fates of Tagged Juveniles from September of the Tagging Year through the following September

Sample sizes are as follows: 1994 (n=22), 1995 (n= 19), 1996 (n=18), and 1999 (n=26). Some eagles remained continually within the study area throughout the 13 month period while some temporarily departed. The disappeared category includes eagles that departed the study area and did not return within the year or those whose radios failed, the two possibilities being indistinguishable. Deaths include only those occurring within the study area.

The trend of tenure among radio-tagged subadults and floaters between the earlier study and the current one appears similar to that of the juveniles. Figure 9 graphs the tenure categories of subadult/floater eagles over the 12 months following radio-tagging. Although sample sizes were small in the current study owing to the increased difficulty of catching subadults and floaters for radio-tagging, a comparison between the two study periods yielded a nearly significant difference in behavior between the two periods (X^2=3.03, d.f.=1, p=0.0818, with



Yates' correction). Again, there is the suggestion that a change in habitat quality (e.g., prey densities) has affected golden eagle tenure within the study area.

Figure 9. Fates of Subadult and Floater Eagles during the 12 Months Following Radio-Tagging

Sample sizes are as follows: 1994 (n=24), 1995 (n= 22), 1996 (n=14), 1998 (n=12), and 1999 (n=11).See the Figure 8 legend for explanation of categories.

We conclude from these findings that fewer subadult and floater eagles existed within the study area during 1998-2000 than during 1994-1997. Although one would expect this on the basis of the predictions of population decline detailed in our report to NREL (Hunt et al. 1999, but see Section 3.7), our data suggest a greater tendency for itinerant eagles to leave the study area. Because the overall distribution of radio-tagged subadults and floaters within the study area was somewhat similar between the two study periods (Table 1), one may hypothesize that the difference in itinerant numbers related to broad-scale changes in prey availability.

Table 1. Relocations of Radio-Tagged Subadults and Floaters in the Previous versus the Current Study

	Percent of Relocations			
	Within WRA	Within 5 km	Within 10 km	Within 20 km
1994-1997 (n= 4851)	19.6%	42.0%	58.1%	75.8%
1998-2000 (n= 859)	23.7%	40.7%	53.5%	74.6%

These data include only those aerial surveys during which we recorded the positions of all tagged eagles.

Exploring this and other explanations for why greater proportions of nonbreeding eagles left the area during the second period of our study, we note that a number of habitat alterations and land use changes occurred that may have reduced habitat suitability for foraging eagles. These changes included (1) the creation near the WRA boundary of the 6.3 km^2 Los Vaqueros Reservoir (which filled in winter 1997-1998), an area that had supported high densities of ground squirrels, (2) the conversion of grasslands to vineyards and housing developments in the Livermore Valley and elsewhere, and (3) prolonged rains during winter 1997-1998. The latter may have significantly reduced ground squirrel numbers throughout the study area, i.e., 114 days of rainfall were reported during January – May 1998. Jim Woollett, wildlife biologist for Lawrence Livermore Laboratories told us in 2001 that squirrel numbers had yet to recover at Site-300 along the southeast border of the WRA after the 1997-1998 winter rains flooded the burrows. Jim Smith, biologist for the Alameda County Agricultural Department (ACAD) affirmed that rainfall caused a drastic reduction in ground squirrel numbers throughout the county in early 1998.

3.2. Eagle Mortality

We recorded 113 deaths over 88 months among a radio-tagged sample of 257 eagles. Fifty-two were attributed to wind turbine blade strikes. However, the total sample must be reduced by five deaths occurring after radio failure or censoring, three with transmitters destroyed by turbine blades and found by industry workers, and by five other eagles that died outside the study area. The latter included one killed by a wind turbine blade at the Solano WRA, some 35 km from the Altamont WRA. In all, at least 68 (68 percent) of the 100 uncensored deaths were human-related (Table 2), the unknown category likely containing additional human-caused fatalities, though none were turbine-related. Two of the unknowns were in the WRA but neither involved trauma. Figure 10 shows the distribution of the 42 uncensored blade-strike casualties in the WRA.

3.2.1. Turbine Blade-strike Mortality among the Four Life-stages

The four population segments, i.e., juveniles, subadults, floaters, and breeders, may be expected to experience different mortality regimes owing to differences in life style and experience. Juveniles must learn to survive, and in doing so, they rely more heavily on carrion and piracy than do the older age classes more proficient at capturing live prey. California ground squirrels, the principal prey in the area, reproduce in spring, but it is not until September that most juvenile eagles become independent of their parents, a time when ground squirrels are fully-grown and wary. We believe that juveniles transition to hunting ground squirrels about eleven months after fledging, when an abundance of young, somewhat easy-to-catch squirrels appears above ground. We have also observed numerous young cottontails in portions of the WRA in spring.

Table 2. Causes of Death among 100 Radio-Tagged Golden Eagles

Mortality Agent	Juveniles (17 fatalities)	Subadults (49 fatalities)	Floaters (22 fatalities)	Breeders (12 fatalities)	Total Fatalities
Turbine Blade Strike	5.9%	63.3%	36.4%	16.7%	42
Electrocution	23.5%	10.2%	13.6%	-	12
Fledging Mishap	35.3%	-	-	-	6
Hit by Car	-	6.1%	4.5%	-	4
Wire Strike	5.9%	4.1%	4.5%	-	4
Eagle	-	-	9.1%	16.7%	4
Lead Poisoning	-	4.1%	-	8.3%	3
Botulism	-	-	-	8.3%	1
Brodificoum Poisoning	-	-	-	8.3%	1
Shot	-	-	4.5%	-	1
Hit by Train	5.9%	-	-	-	1
Unknown	23.5%	12.2%	27.3%	41.7%	21

3.2.1.1. Juvenile Mortality

The apparent latency in the onset of active hunting by juvenile golden eagles may confer an immunity to wind turbine interaction, i.e., we found only one turbine blade-strike fatality (0.9 percent) among 117 radio-tagged (free-ranging) juveniles, a profoundly lower incidence than that recorded among subadults and floaters (see below). The single fatality occurred in the last month of the juvenile year. This very low incidence occurred despite the common appearance of juveniles within the WRA, i.e., 264 (13.7 percent) of 1921 relocations during September through May when almost all juveniles had become independent (Hunt et al. 1999).

3.2.1.2. Subadult and Floater Mortality

Unlike juveniles, radio-tagged subadults and floaters are highly vulnerable to turbine blades. We recorded 31 blade-strike fatalities (20.0 percent) within our sample of 155 subadults with working radios and 8 such fatalities (14.8 percent) among 54 floaters. We attribute this susceptibility both to their frequent occurrence in the WRA and their greater tendency, compared with juveniles, to hunt live prey.

Many of these itinerants were originally tagged as fledglings (n=102), and we were able to monitor those remaining in the study area through the three-year period of subadulthood and, in some cases, beyond. The numbers of blade-strike deaths among these subadults and floaters were large among some cohorts. We tagged 25 fledgling eagles in 1994, and a year later, six of these had died or disappeared (emigration plus radio-failure), leaving 19 in the study area as first-year subadults. From January 1995 to November 1999, turbine blades killed 11 of these eagles (including censored ones), an attrition rate of at least 57.9 percent arising from this single mortality agent. Only one was known to have died of other causes within the study area during this period. Of 16 radio-tagged eagles from the 1995 cohort detected in the study area as subadults, six (37.5 percent) were eventually killed by wind turbines (March 1997 – May 1999). There were five blade-strike deaths among 13 subadults and floaters remaining in the study area from the 1996 cohort, a kill rate of 38.5 percent. We have only short-term information for the 1999 cohort, i.e., only one year of subadulthood. Among 19 of these eagles detected in the study area as subadults, four (21.0 percent) have thus far been killed by turbine blades. Note that all these figures on turbine-related mortality represent minimum incidence because the blades destroy the transmitters in a proportion of cases.

We were interested to know if eagles fledging from nests near the WRA were more likely to be killed there than those originating from more distant sites. To test this, we considered only those eagles tagged as fledglings in 1994, 1995, and 1996, the reason being that we were able to monitor them through all subadult years. Our results showed no difference in median or mean distance from the WRA between those killed by turbines and those that were not. The median distance from the natal site to the WRA for 22 turbine-killed subadults and floaters was 11.3 km (mean=13.2, SD=9.1), while the median for 38 such eagles not killed by wind turbines was 11.7 km (mean=13.3, SD=9.1), a near-perfect match.

3.2.1.3. Breeder Mortality

Breeding golden eagles are less exposed to wind turbines than subadults and floaters because of the tendency of breeders to remain within and near their breeding territories, only some of which are near the WRA. There were 12 fatalities among the 47 radio-tagged breeders in the study area, two of which (16.7 percent) were killed by turbine blade strikes. The nesting territory of one of the turbine fatalities was adjacent to the WRA, while the other was some 12.7-km distant. As a matter of interest, we know of 18 regularly occupied golden eagle territories within 10 km of the WRA (minimum density = 1 pair per ca. 30 km^2), 30 in the 10-20 km range, 21 at 20-30 km, 15 at 30-40 km, and 9 territories 40-50 km from the WRA. Our surveys doubtless account for a greater proportion of the actual number of territories in areas closest to the WRA than in zones of greater distance where logistical, landowner, and budgetary restrictions hampered detailed searches.

Thus, in contrast with the other eagle life-stages, the relatively small home ranges of breeding eagles keep most of them out of the WRA (Figure 11, Figure 12, Figure 13, and Figure 14). Only 42 (1.0 percent) of 3986 breeder detections were within the WRA boundary; these visits were by 12 (25.5 percent) of the 47 tagged breeders. This contrasts with 14 percent of juvenile detections being in the WRA (n=1917), 18 percent for floaters (n=2063), and 20 percent for subadults (n=4693). The tendency of breeders to remain within their territories is of particular benefit to the population because the trend in the latter is much more sensitive to adult survival rates than to any other demographic parameter (Hunt 1998, Hunt et al. 1999). We calculate, for example, that a chronic change of two percent in adult survival in this population may exert the same effect on the population trend as a change of about 13 percent in juvenile survival or reproduction.

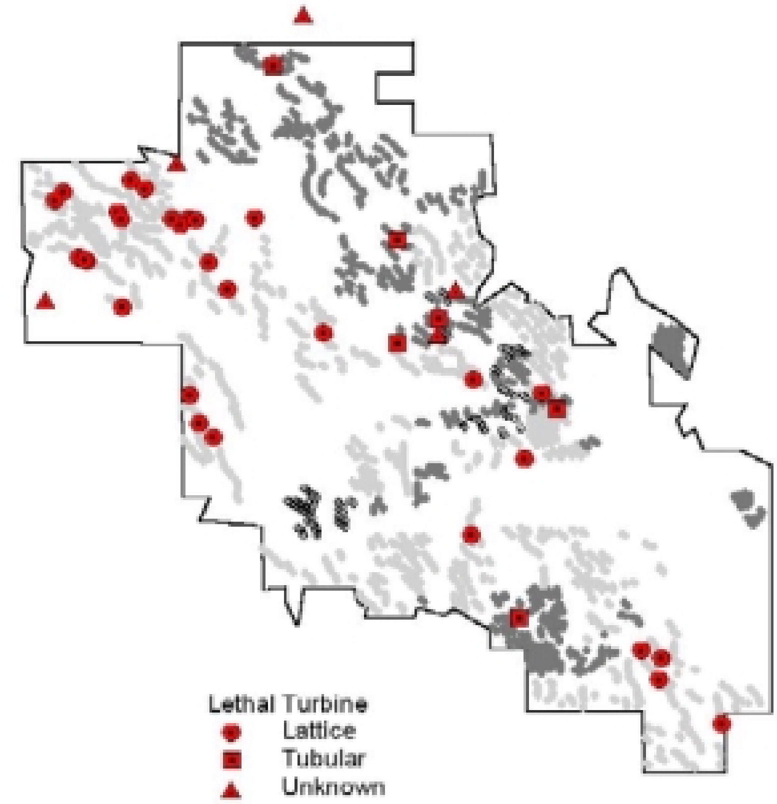


Figure 10. Distribution of 42 Turbine Blade-Strike Casualties of Uncensored, Radio-Tagged Golden Eagles in the WRA

(See Figure 6 and Figure 15 for distribution of turbine configurations.)

The ratio of blade-strike deaths to total relocations within the WRA among breeders (2 / 42 = 0.05), though imprecise as a measure of risk, is comparable with that observed among subadults and floaters (42 / 1412 = 0.03) and suggests that breeders are similarly vulnerable when in the vicinity of wind turbines. Circumstantial evidence suggests that breeding pairs living very close to the WRA experience higher mortality than those living further away. Despite the high apparent suitability as breeding habitat of those portions of the WRA containing trees or small cliffs, we observed very few pairs and those only temporarily.

3.3. Seasonal Differences

One would expect the frequency of blade-strike fatalities to rise and fall in correspondence with the windy season at Altamont Pass which extends from the end of March to the end of September. Indeed, turbines killed 27 tagged eagles in spring and summer (21 March to 21 September) compared with 15 in fall and winter (X^2=3.43, d.f.=1, p=0.064). The latter figure appears (to us) surprisingly high, considering that Green Ridge Services (personal communication) generates only about 20 percent of its power outside the windy season. A goodness-of-fit calculation based on the hypothesis that 80 percent of fatalities would occur during the windy season differed significantly from the expected (X^2=6.48, d.f.=1, p=0.011). Our first thought was that a greater proportion of tagged eagles might visit the WRA outside the windy season, but such was not the case, the proportions being identical, i.e., 23.8 percent of relocations during the windy season were inside the WRA and 23.7 percent during the nonwindy season. These findings suggest the possibility of seasonal differences in eagle hunting behavior, although we know of none, or perhaps that the turbines, spinning only occasionally and therefore unexpectedly in fall and winter, are more likely perceived benign by eagles in their vicinity. The cooler seasons are also times when bad weather, e.g., fog and rain, often obscure visibility.

3.4. Turbine Configuration and Lethality

A variety of considerations reflect upon whether one turbine / tower configuration is more likely to kill golden eagles than another. The first step of inquiry is to determine the kinds of turbines that actually killed the radio-tagged eagles in our sample, considering that there is likely no detection bias associated with the distribution of the 42 uncensored blade-strike casualties. We find that only four or possibly five kinds of turbines are on the list (Table 3) and that, among them, Type-13 accounted for at least 27 (73 percent) of the 37 deaths in which eagles died in the vicinities of the turbines that struck them. Referring to Figure 5 and Appendix I, we see that Type-13 is the Kenetech 56-100 turbine on an 18.3-meter lattice tower.

We are first tempted to compare the allocation of deaths with the relative abundance of Type-13 turbines (n=ca. 2997) versus that of all the other turbines combined (n= ca. 2385), assuming (probably incorrectly) that none of the eight ambiguous fatalities (no assigned turbine type in Table 3) was attributable to Type-13. The result of the comparison is not significant, therefore suggesting that the relative abundance of Type-13 is sufficient to explain its lethality (X^2=1.26, d.f.=1, p=0.26). Also not significant is a comparison of the abundance of Type-13 with the subset of only those types of turbines that killed the eagles in our sample (X^2=0.74, d.f.=1, p=0.38).

However, in looking for differences, we must also consider the distribution of live eagles within the WRA, that is, the pattern of their exposure in relation to the distribution of turbines. For example, a high kill rate by a certain type of turbine would imply a high degree of lethality were eagles known to only rarely visit areas containing it. To examine this possibility we drew a crude set of polygons (Figure 15) around the areas containing Type-13 turbines and another set enclosing the other types (n=1917 turbines), 79 percent of which were of tubular tower configuration, 20.5 percent lattice towers, and less than one percent vertical axis machines. The Type-13 area contains several other types of lattice-tower turbines, making up 12.3 percent of the total.

Figure 11, Figure 12, Figure 13, and Figure 14 compares aerial relocation distributions between breeders, floaters, subadults, and juveniles These distributions represent only those surveys in which we determined the positions of all tagged eagles in the study area. See Figure 4 for habitat types.

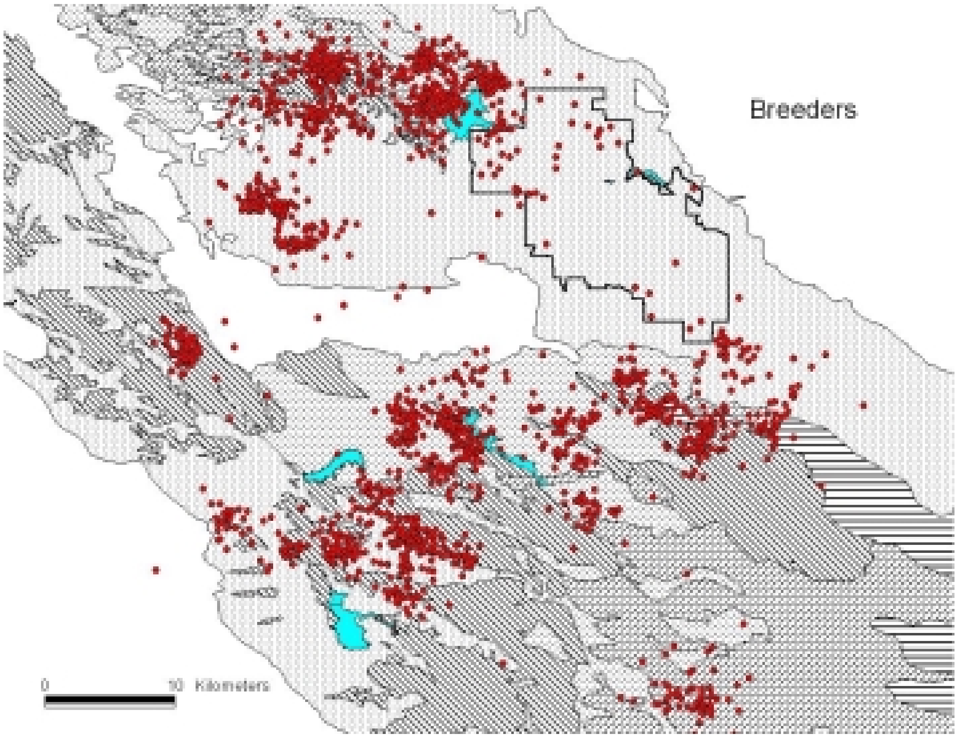


Figure 11. Relocations of Breeders

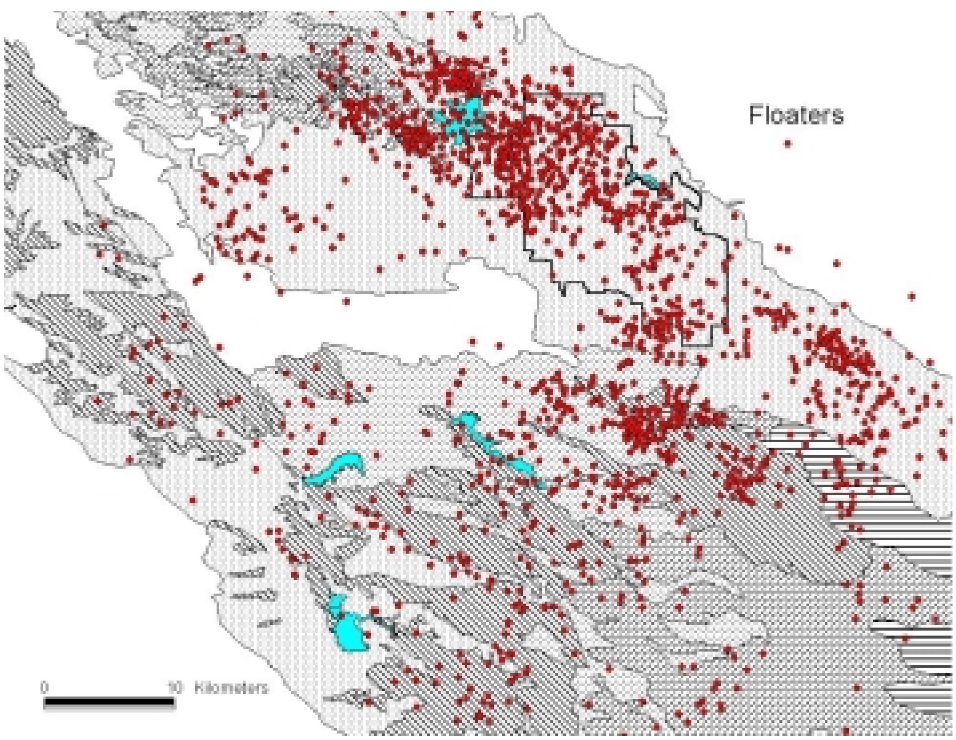


Figure 12. Relocations of Floaters

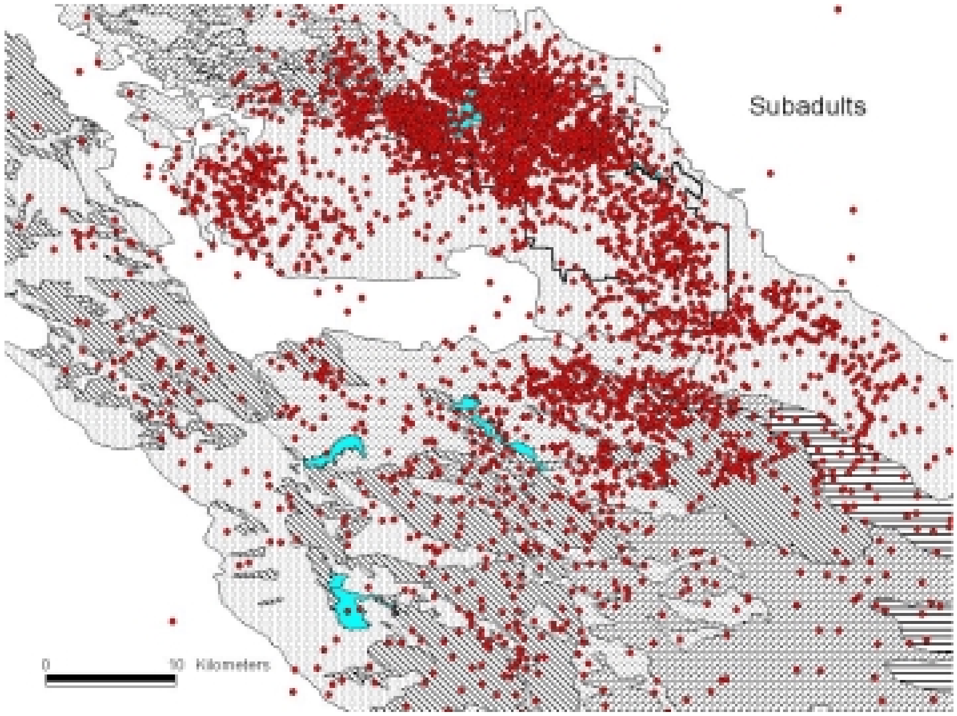


Figure 13. Relocations of Subadults

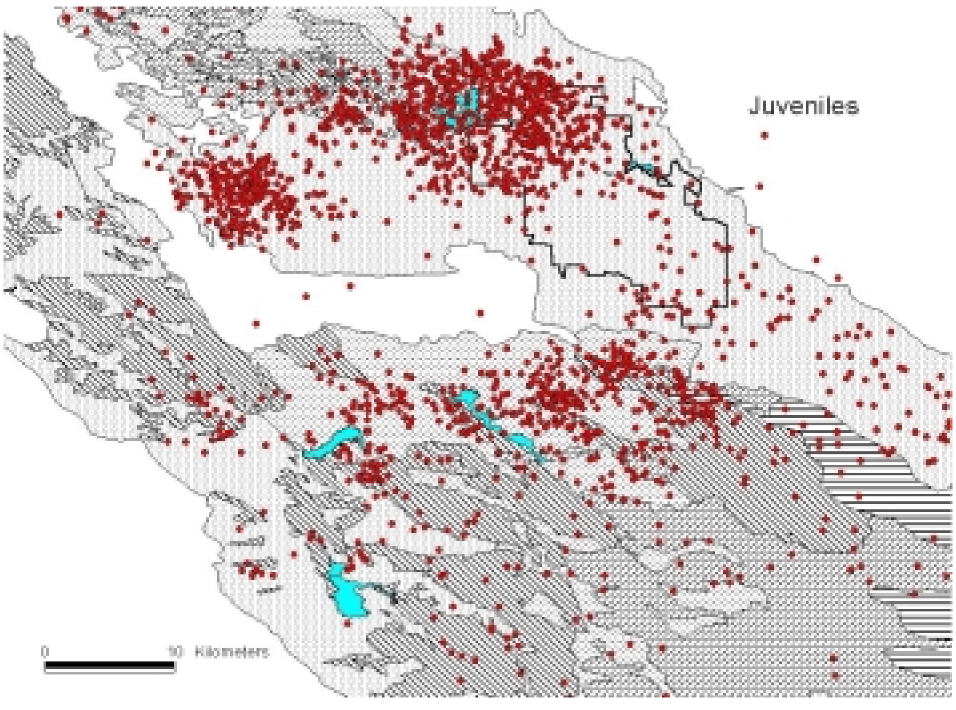


Figure 14. Relocations of Juveniles

Table 3. Wind Turbine Configurations Responsible for killing 42 Radio-Tagged Golden Eagles in the WRA

(See Appendix I, Table 3.)

Type	Turbine	kW	Rotor Dia. (ft.)	Tower	Height (ft.)	Approx. Number	Fatalities
4	Micon	60	52'	tubular	60	219	1
5	Nordtank	65	52'	tubular	80	312	2
8	Dangren Vind/Kraft Bonus	150	76'	tubular	80	100	2
8	Dangren Vind/Kraft Bonus	120	63'	tubular	80	230	1
13	Kenetech 56-100	100	59'	lattice	60	2997	27
23	Kenetech 56-100	100	59'	lattice	140	195	1
13 or 23	--	--	--	--	--		1
12 or 13	--	--	--	--	--		1
8 or 9	--	--	--	--	--		1
Unknown	--	--	--	--	--		5

Table 4 summarizes our calculations of polygon areas, the numbers of turbines they contained, and the overall number of subadult/floater relocations falling within polygon boundaries. We find that turbine and relocation densities are somewhat comparable between the two sets of polygons (84.3 percent and 84.8 percent parity, respectively), whereas the fatality distribution is highly disproportionate (X^2=6.3, d.f.=1, p=0.010). This suggests that eagle distribution is not the sole predictor of blade-strike risk, and that the areas occupied by Type-13 may be more dangerous to eagles than those of other turbines.

Table 4. Densities (km^2) of Turbine Types versus the Densities of Subadult/Floater Relocations and Blade-Strike Fatalities in the WRA

(See Table 3 and Figure 15.)

	Polygons Containing Type-13	Polygons Containing All Other Turbines
Area (km^2)	62.3	40.9
Turbines	3460	1917
Turbine Density (per km^2)	55.5	46.9
Relocations	588	455
Relocation Density (per km^2)	9.4	11.1
Fatalities	30	7
Fatality Density (per km^2)	0.5	0.2

There is bias in these calculations to the extent that the distribution of radio-tagged eagles recorded since the beginning of the study cannot be expected to correspond very well with the distribution of eagles around the time of each fatality. To overcome this, we plotted the distribution within the WRA of 21 eagles killed within the Type-13 area. We then plotted the relocations of those corresponding samples of subadult/floater relocations during the four-month period prior to each fatality that were sufficient in number to provide a ratio of relocations between the two arrays of turbine-specific polygons. Figure 16 provides an example by showing the data layout for one of these eagles, and Table 5 summarizes the results of all 21 comparisons. Note in the table that there is no suggestion of greater use by eagles of the Type-13 areas versus those occupied by other types of turbines. In the months prior to fatalities, relocation density, on average, was actually lower in the Type-13 polygons (median=44.7 percent, mean=44.2 percent) than the others. If these data represent the behavior of eagles comprising the larger sample of 30 fatalities in the Type-13 areas, we would again conclude that conditions there are more hazardous to eagles than conditions in areas occupied by other types of turbines.

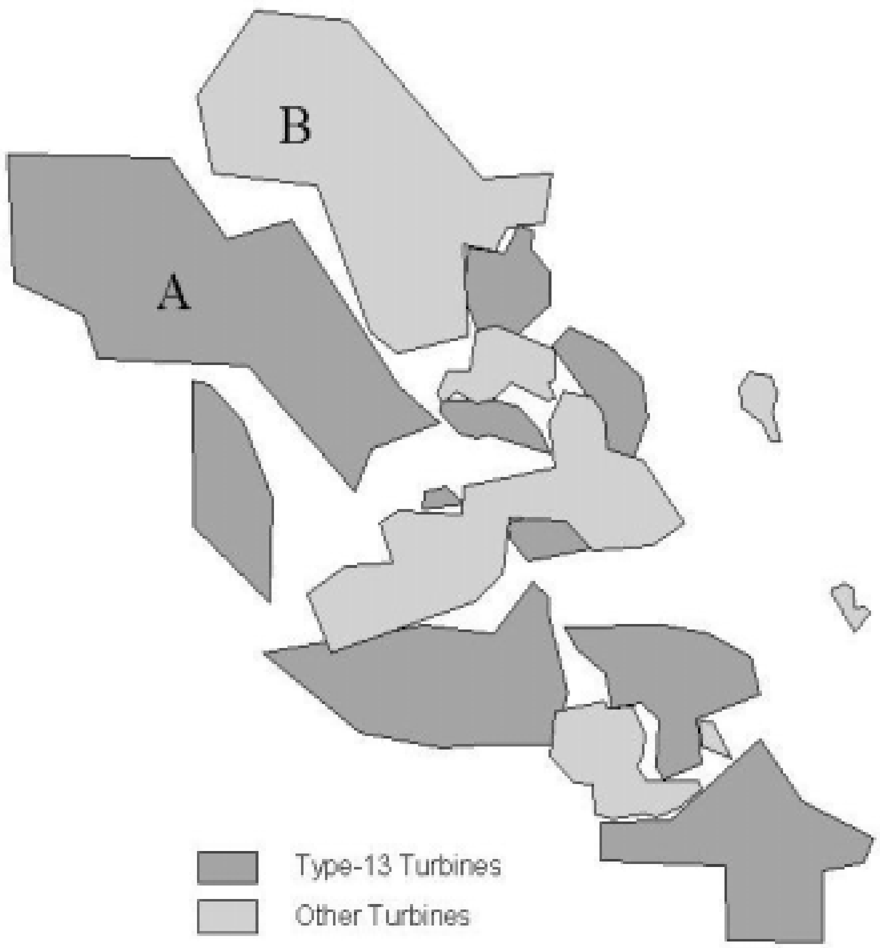


Figure 15. These two sets of polygons enclose the areas containing Type-13 turbines (totaling 62.3 km^2) versus those containing only other types of turbines (40.9 km^2) occurring within the WRA (see text)

Focusing on the entire northern section of the WRA, note in Figure 11, Figure 12, Figure 13, and Figure 14 the high density of subadult and floater relocations there, and then in Figure 10 that the great majority of fatalities lie within the region of lattice (principally Type-13) turbines, while only a few are within the comparable area of other turbines to the northeast. These two adjacent regions are represented in Figure 15 by the two largest polygons (labeled A and B), together containing 71 percent of all WRA relocations. Overall, we find that the Type-13 polygon (Polygon-A, 24.4 km^2) contained 358 relocations, a density over time of 14.7 relocations per km^2, whereas the area of other turbines Polygon-B, 21.7 km^2) contained 455 relocations, a density of 21.0 relocations per km^2. Polygon-A had a higher density of turbines, i.e., there were 47.2 turbines per km^2 as compared with 27.1 per km^2 in Polygon-B (Figure 17). Whereas these comparisons can be regarded as pseudoreplicative to the extent that the relocations of individual eagles are not completely independent, the effect is slight, given the small size and adjacency of the polygons relative to the considerable vagility of these non-territorial eagles (Hunt et al. 1995).

Table 5. Relocation Counts within Areas Containing Type-13 Turbines versus Areas with other Turbine Types as Recorded during the Last Four Months of Life among 21 Subadult and Floater Eagles

			Relocations of Subadults and Floaters				Relative
Fatality	Stage	Lethal Turbine	Type-13 Area	Density (km2)	Other Area	Density (km2)	Density in Type-13 Area
55M51	sub	Type-13	6	0.096	14	0.342	22.0%
97F92	sub	Type-13	19	0.305	28	0.685	30.8%
55M54	floater	Type-13	23	0.369	33	0.807	31.4%
88M111	juv	Type-13	23	0.369	33	0.807	31.4%
66M85	sub	Type-13 or -23	27	0.433	38	0.929	31.8%
52M34	sub	Type-13	42	0.674	53	1.296	34.2%
51F46	floater	Type-12 or -13	33	0.530	33	0.807	39.6%
5AM41	floater	Type-13	66	1.059	62	1.516	41.1%
51M68	floater	Type-23	66	1.059	62	1.516	41.1%
52M38	floater	Type-13	11	0.177	10	0.244	41.9%
42M03	sub	Type-13	16	0.257	13	0.318	44.7%
44M28	sub	Type-13	82	1.316	64	1.565	45.7%
42M02	sub	Type-13	74	1.188	57	1.394	46.0%
53M39	sub	Type-13	78	1.252	57	1.394	47.3%
44F16	sub	Type-13	26	0.417	15	0.367	53.2%
44M27	sub	Type-13	74	1.188	41	1.002	54.2%
44F22	sub	Type-13	90	1.445	46	1.125	56.2%
64F50	sub	Type-13	90	1.445	46	1.125	56.2%
41F08	sub	Type-13	32	0.514	16	0.391	56.8%
44M19	sub	Type-13	79	1.268	35	0.856	59.7%
44F19	sub	Type-13	64	1.027	24	0.587	63.6%

We recorded 19 blade-strike deaths in Polygon-A and only two in Polygon-B. Deaths in Polygon-A included one attributable to a Type-23. The latter, of which there are some 66 machines, representing only 1.9 percent of the turbines in Polygon-A, has the same generator and blades as Type-13 but is situated on a 43-meter lattice tower, rather than the 18-meter tower characteristic of Type-13. Type-23s are virtually always placed parallel and adjacent to Type-13s in a windwall configuration (Figure 18). Polygon-A contains seven windwalls, three of which were associated with eagle fatalities. Table 6 provides data on the relocations of 12 eagles killed in Polygon-A for which subadult/floater relocation samples during the four months prior to each death were sufficient to construct area-use ratios. Again, we calculate a higher average density of relocations in Polygon-B and a higher number of deaths in Polygon-A.

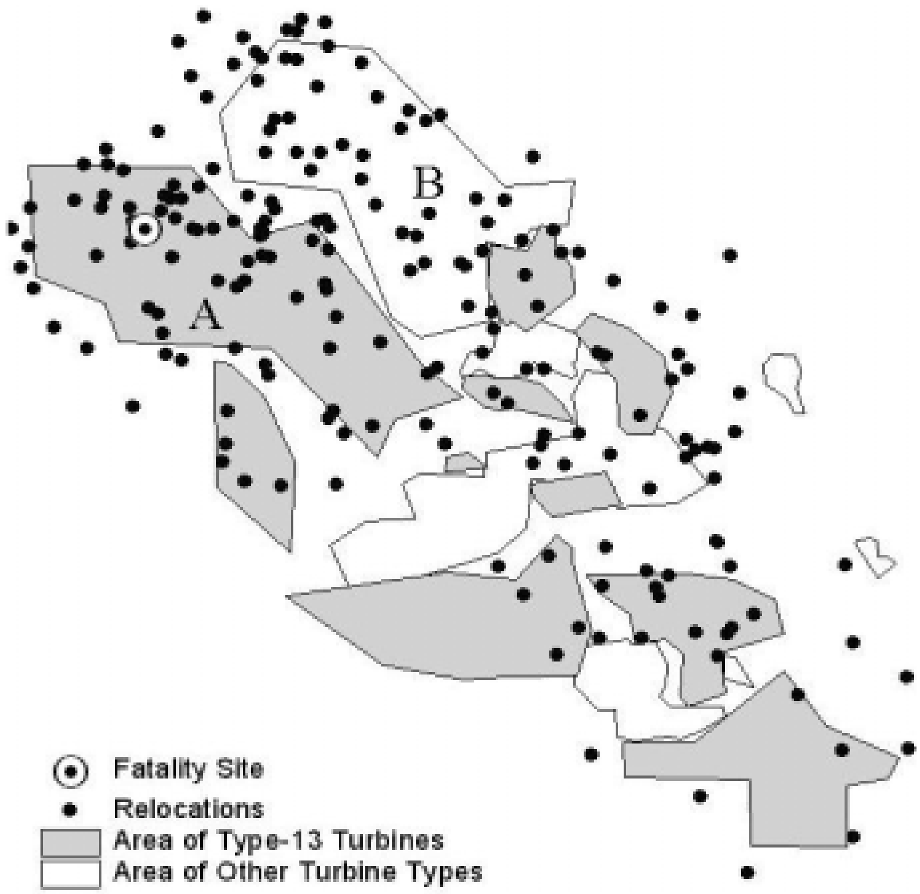


Figure 16. Relocations of Radio-Tagged Subadults and Floaters in the WRA during the Four Months Preceding the Death of Subadult No. 52M27
This example is one of 21 such comparisons.

3.5. Are the Type-13 Turbines in the WRA Particularly Dangerous to Eagles?

Circumstantial evidence presented thus far in our analysis offers grounds for suspecting that Type-13 may be more lethal to eagles than the other turbines, albeit certain types within the latter category might have been suspect were their numbers and the overall sample of fatalities greater. At present, we must ask what features, besides their abundance, distinguish Type-13s from the aggregate of other types and, in particular what features might explain a higher degree of lethality, if such is the case. Our data, being specific to conditions within the WRA, necessarily reflect its peculiarities, and so we must consider that other factors besides the configuration of the turbine itself may contribute to, or even solely account for, its lethality, i.e., we must also acknowledge the possible role of turbine spacing and that of environmental differences between areas containing differing types of turbines.

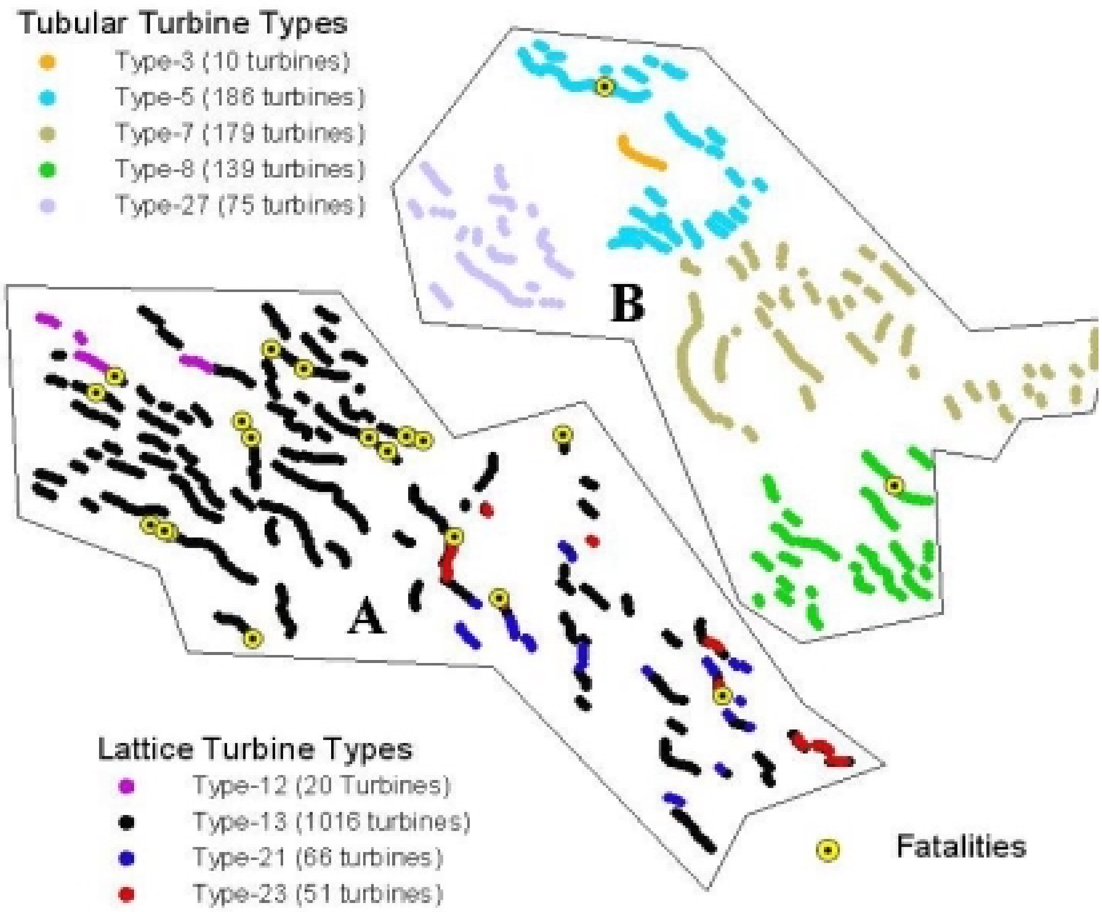


Figure 17. These Two Polygons in the Northern Region of the WRA are the Largest of those Depicted in Figure 19

Polygon-A contains only lattice tower turbines (n=1153), 88 percent of which are of the Type-13 configuration. Polygon-B contains only tubular tower turbines (n=589).

3.5.1. Tower-Height

The Type-13 turbine is positioned on an 18.3-meter tower, shorter than most tubular turbines, 90.5 percent of which are on 24.4-meter structures. Of the 821 lattice turbines other than the 2997 Type-13s, only 33 are on shorter (13.7 m) towers, whereas 171 are on towers of equal size (18.3 m), 422 are on 24.4-meter towers, and 195 are on 42.7-meter towers. Thus, considering that Type-13 turbine towers are shorter than 85 percent of all other towers in the WRA, we should consider whether turbines on short towers might be inherently more lethal than those on taller ones.

Figure 18. A Windwall consisting of a Row Type-13 Turbines and another row of the Taller Type-23 Turbines (photo by Daniel Driscoll)

Table 6. Twelve Golden Eagle Blade-Strike Fatalities that occurred in Polygon-A, together with Counts of Subadult and Floater Relocations occurring within the Previous Four Months in both Polygon-A and Polygon-B (See text)

		Subadult and Floater Relocations				Relative Density
Fatality	Lethal Turbine	Area A	Density A	Area B	Density B	in Area A
55M54	Type-13	11	0.451	28	1.290	25.9%
88M111	Type-13	11	0.451	28	1.290	25.9%
97F92	Type-13	10	0.410	25	1.152	26.2%
66M85	Type-13 or -23	15	0.615	32	1.475	29.4%
51F46	Type-12 or -13	17	0.697	29	1.336	34.3%
51M68	Type-23	33	1.352	54	2.488	35.2%
42M02	Type-13	45	1.844	48	2.212	45.5%
44M28	Type-13	47	1.926	49	2.258	46.0%
53M39	Type-13	46	1.885	45	2.074	47.6%
44M27	Type-13	45	1.844	33	1.521	54.8%
44F22	Type-13	57	2.336	39	1.797	56.5%
44F19	Type-13	42	1.721	23	1.060	61.9%

Our observations in the WRA and elsewhere in the study area confirm that contour hunting is the principal mode by which golden eagles hunt ground squirrels. This well-known behavior involves flying or gliding very low over the ground (1-5 m), often over considerable distances, hugging the terrain and concealing their approach so as to surprise unsuspecting squirrels at close quarters (Carnie 1954, Bergo 1987, Dekker 1985, Watson 1997). Eagles approaching prey may sometimes use fences and other overt objects to hide their approach (Dixon 1937). Golden eagles are particularly apt to contour hunt during windy conditions (Dekker 1985), and in a sample of 41 hunting flights observed in the WRA in spring 1994, 34 (83 percent) were contour hunts (Hunt et al. 1995). Eight of these ended in attempts to seize prey, four of which were successful. Contour hunts may originate from soaring flight, from elevated perches or from the ground. In a sample of 94 sightings of perched eagles in the WRA, 33 (35 percent) were on the ground and 61 (65 percent) were on elevated perches.

Consequently, golden eagles in the WRA are often very close to the ground, especially when hunting. It follows that eagles may occasionally attempt to pass low under the spinning blades of turbines, and although we have not observed this, we should consider the space available for this maneuver. We calculate that the blades of Type-13 pass within about 9.3 meters of the ground. Only 125 (5.4 percent) of 2304 other turbines (for which we have data) have blades that pass closer to the ground than those of Type-13. Of the remainder, 918 (40 percent) pass within 11-15 meters and 1336 (58 percent) more than 15 meters from the ground (Appendix I). While, at most approach angles, the position of the tower likely prevents an eagle from passing below the lowest point of the rotor, the Type-13 turbine is nonetheless among the most likely of turbines in the WRA to strike a low-flying eagle.

3.5.2. Tower Spacing

We observed golden eagles occasionally flying between turbines within a turbine string, a factor suggesting an examination of their spacing. Spacing, though not a property of the turbine itself, may be a component of eagle mortality. Let us examine to what extent the spacing of Type-13 turbines differs from that of other turbines in the WRA.

Using GIS, we measured the distance in meters between 912 Type-13 turbines within 88 strings in Polygon-A. The median distance between them was 25.3 meters (mean=27.1, S.D.=3.9). Likewise, we measured distances between 589 tubular turbines in 100 strings in polygon-B, representing five types. The median spacing was 47.0 meters (mean=48.4, S.D.=13.9). All five types of turbines in Polygon-B were more widely spaced than the Type-13s: the measurements included 10 Type-3s (median spacing=57.3 m), 186 Type-5s (31.8 m), 179 Type-7s (56.6 m), 139 Type-8s (Bonus Mark-150) (41.4 m), and 75 Type-27s (57.5 m) (Appendix I).

The relevant measure of risk to a golden eagle trying to fly between turbines is the distance between the spinning blades rather than the distance between turbine towers. The rotor diameter of Type-13 is 18 meters (59 feet rather than 56 feet as sometimes reported), meaning that the rotor tips of two adjacent, wind-aligned turbines are roughly 18 meters closer together than the vertical centerlines of their towers. Under such conditions, the interblade distance between two Type-13s in Polygon-A is about 7.3 meters. Considering that the wingspan of a female golden eagle is about 2.1 meters (Watson 1997), the distance between blade and wingtip of an eagle flying exactly between two adjacent, wind-aligned rotors of average spacing is 2.6 meters. For the four tubular turbine types we measured in Polygon-B, the average blade-to-wingtip distances would be 5.9 meters (Type-5), 7.0 meters (Type-8), 10.8 meters (Type-27), and 13.7 meters (Type-7), spacing ranging from over twice to more than five times the average of Type-13 clearance.

We measured the spacing from 27 Type-13 turbines that killed radio-tagged eagles to the nearest neighbor turbines in the string. Five (18.5 percent) of the lethal turbines were at the ends of rows (Orloff and Flannery 1992), meaning that the eagle may have been on the outside of the string rather than between turbines when the strike occurred. Of the remainder, nine (33 percent) were killed by the second turbine, two (7.4 percent) by the third, one (3.2 percent) by the fourth, and 10 (37 percent) in the central region (5^{th} to 21^{st} position) of the string. Excluding the five end-of-row kills, we found no difference between a sample of 44 space measurements between lethal Type-13 turbines and adjacent turbines and a sample of 471 spaces between Type-13 turbines that did not kill tagged eagles (t-test, p=0.579). As a matter of interest, the mean number of Type-13 turbines in strings where fatalities occurred was 20.6 (SD=11.4 turbines, range 8-48), as compared with 9.0 for all other Type-13 strings occurring in Polygon-A (SD=7.1, range=2-48) (t-test, p=0.010).

3.5.3. Wind and Terrain

We may conclude from the foregoing that an eagle trying to pass under or through a typical Type-13 turbine string must do so with precision. Strong winds in areas of steep terrain may present additional problems for eagles attempting to negotiate wind turbines. Consider a string of turbines along the top of a ridge, the latter oriented at a right angle to the direction of the wind. A low-flying eagle approaching fast from upwind first encounters an updraft, but as the ridge levels out, downdrafts and turbulence develop, factors that strongly reduce flight control. Even in more gentle terrain, deflected wind almost always produces near-ground turbulence, but all other things being equal, the steeper the terrain, the stronger are the forces affecting eagle flight.

As an example of terrain effects, we quote from the field notes of PBRG biologist Daniel Driscoll:

> "22 April….Wind 35-40 mph from the west…1000 hrs. Pigeons, red-tails, and gulls … having trouble flying in this wind …flying very low to the ground, and when they crest a ridge, the updraft pushes them skyward out of control…1321 hrs. I observed a red-tail flying into the wind above turbine row 4286-4294… was grounded below a powerline, then when it lifted from the ground, it was thrown up and nearly struck the line [being blown]sideways… 1422 hrs. Subadult golden [eagle] slowly slope-soaring [westward] into the wind below [downslope of] turbine row 2950-2972. The eagle appeared to be having difficulty [flying] and was being harassed by a red-tail… [the eagle] was hit by a gust of wind [as it crested the next ridge] and shot up [being blown backwards], just missing the blades of turbine 2915." Note that this ridge slopes very steeply westward some 400 feet to a canyon bottom.

With GIS software, we calculated an index of the overall degree of terrain steepness within Polygon-A (n=19 blade-strike fatalities) and Polygon-B (n=2 fatalities) by measuring contour line density. We began by extending twelve equally-spaced lines from the approximate center of each polygon in a directional rose toward the edges of the polygon. We then counted the number of 20-foot contour intervals encountered by each line and measured line length in kilometers. Our results showed Polygon-A with 29.9 contour-line crossings per kilometer (911 crossings in 30.44 linear km) and Polygon-B with 25.3 per kilometer (756 crossings in 29.92 km). This difference reflects only a 15.6 percent disparity in the relief index between the two polygons.

Figure 19 focuses on a 15 km^2 circle containing 16 of the 19 blade-strike kills in Polygon-A. Note that four turbine strings killed ten (62 percent) of the 16 tagged eagles and that five eagles in the eastern quadrant died within a radius of only about 250 meters. We cannot speculate on why these kill sites are so distributed, but no consistent relationship with distinctive terrain features is apparent, nor is the distribution of kills associated with high eagle relocation densities that might suggest, for example, corresponding prey concentrations.

3.5.4. Tower Perchability

It has been proposed that lattice tower turbines like Type-13 are more perilous to eagles than those on tubular towers because eagles can perch more easily on the former. Indeed, in our experience, eagles often perch on lattice towers and only rarely on tubular towers. From May through November 1994 we conducted weekly road surveys of the entire WRA to determine the extent of perching on wind turbines (Hunt et al. 1995). We recorded 23 incidents of eagles perching on lattice towers, 17 (74 percent) of which were Type-13 turbines, and none on tubular towers. Similarly, of 651 observations of red-tailed hawks perched on turbine towers, 633 (97 percent) were on lattice towers, 513 (79 percent) of which were Type-13s. Of the remaining 18 perchings (three percent of total), 14 hawks perched on the rail cages of non-functional tubular turbines (Type-16), three on Type-9 (vertical axis turbines), and one on a Type-4 tubular tower turbine. These data only partly reflect the greater abundance of lattice towers in the WRA. We constructed perchability indices for both species based on the total numbers of perchings and types of turbine towers surveyed. The results showed that both species conspicuously avoided perching on the 723 tubular tower turbines in our survey (Hunt et al. 1995).

Golden eagles and red-tailed hawks appeared to avoid perching on the towers of spinning turbines. In the only observed instance involving an eagle, the latter had perched on the third cross-member (half-way up the tower) of an end-of-row turbine that was not operating. The turbine powered-up and reached operating speed before the eagle dropped off, flying beneath the arc of the blades. Only 15 (2 percent) of 651 red-tailed hawks were observed perched on operating turbines (Hunt et al. 1995).

One attractive hypothesis that perchable towers present increased risk involves the idea that eagles may grow accustomed to them during the days of little or no wind characteristic of fall and winter. Eagles may thus fail to appropriately regard them as dangerous when the blades begin spinning on windy days. Indeed, the perception of danger is illusive because death or debilitating injury are virtually the only avenues of negative reinforcement, i.e., there is no way to learn. At this time, the question of whether these considerations are factors in eagle mortality remains unanswered.

3.6. Eagles and Ground Squirrels in the WRA

The large size and conspicuousness of both golden eagles and their prey in the open landscape of the WRA made it relatively easy to ascertain which prey species were most important. Numerous field observations of foraging eagles and examination of prey remains (Hunt et al. 1995) quickly led us to conclude that California ground squirrels were the principal prey of golden eagles in and around the WRA during the period of our investigation. Although eagles preyed to some extent on jackrabbits and cottontails, and these may be expected to increase in importance in some years, we hypothesize that the occurrence and distribution of golden eagles in the WRA during the years of our study mainly correlated with the occurrence and distribution of ground squirrels.

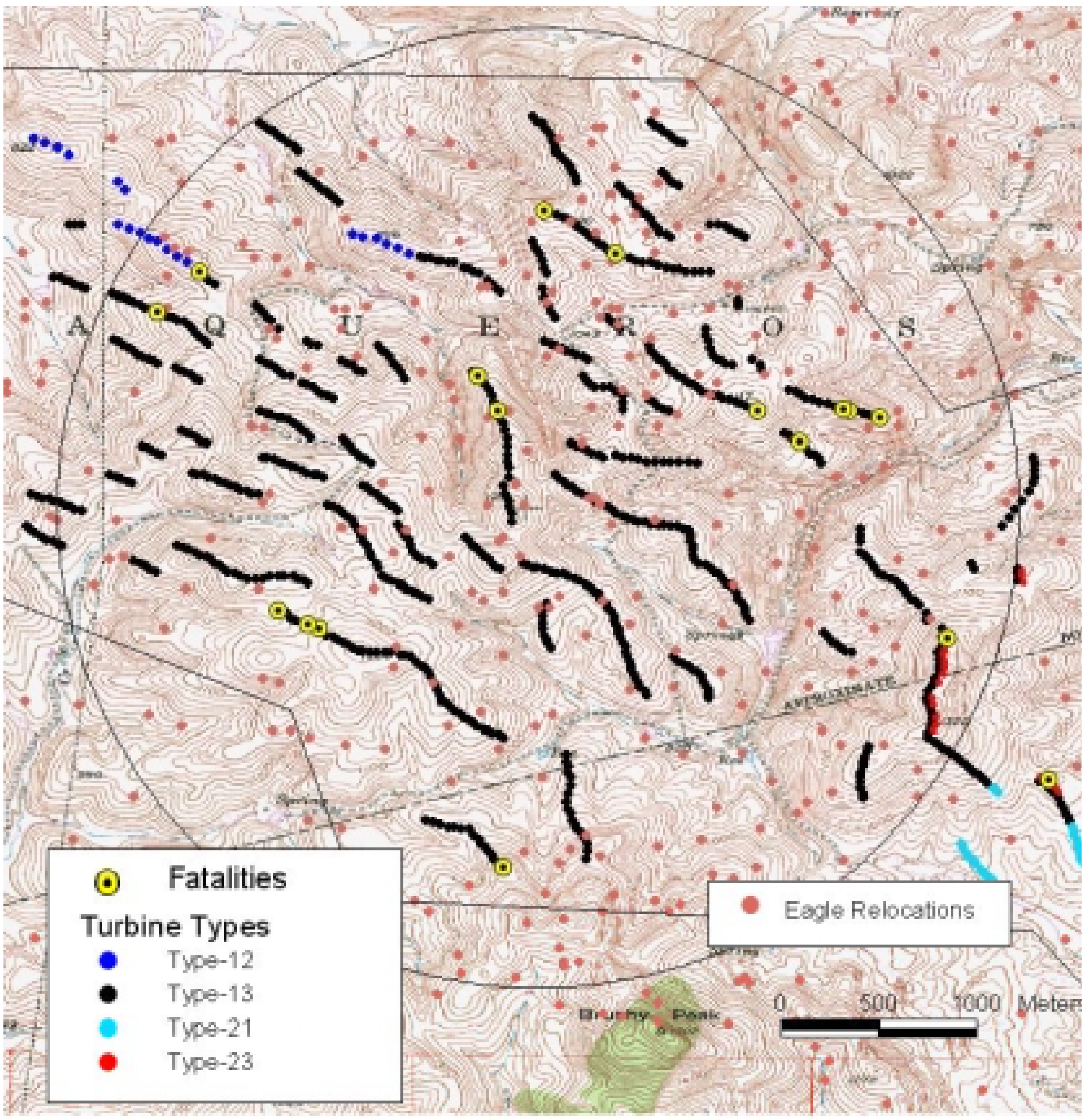


Figure 19. A 15 km^2 circle containing 16 of the 19 blade-strike kills in Polygon-A

To test this, we first examined the eagle relocation data to determine whether gross changes in eagle distribution had taken place in the WRA. Table 7 suggests that the proportional distribution of relocations of subadults and floaters in the northern (108 km^2) versus the southern (51 km^2) section of the WRA (north and south of Interstate 580) did indeed change over the years of our study. Note that the percentages of relocations in the southern portion of the WRA diminished during the 1996-1997 period. The difference between individual eagle use of the southern portion of the WRA in 1994-1995 (n=47 individuals, mean proportional use = 0.27) versus 1996-1997 (n= 72, mean use = 0.16) was significant (t-test, p=0.03), although a comparison between 1996-1997 and 1998-2000 (n=47, mean use = 0.21) was not (p=0.19). \

Table 7. Changes in the Proportion of Subadult and Floater Relocations in the Northern and Southern Areas of the WRA (North and South of Interstate 580)

	Eagle Relocations			Turbine Kills		
Year	North	South	% in South	North	South	% in South
1994-1995	284	84	22.8%	3	1	25%
1996-1997	631	96	13.2%	16	1	6%
1998-1999	149	34	18.6%	12	1	8%
2000-2001	92	44	32.4%	4	3	43%

Wondering if these differences might be related to ground squirrel densities, we visited two large ranches on June 4, 1997, one in the northern and one in the southern section of the WRA. Beginning at 1248 hrs.(cloudy, temperature 71-76 degrees F), we conducted a 22-minute visual survey for ground squirrels on all major roads of a 12.6 km^2 ranch south of Patterson Pass Road and observed one ground squirrel. We quickly traveled to a 3.7 km^2 ranch in the north zone and, beginning our survey at 1330 hrs, we counted 136 ground squirrels in 21 minutes (partly cloudy, temperature 71-74 degrees F). Subadult / floater relocations within the boundaries of the southern ranch during the ten months prior to the survey totaled four (0.3 relocations per km^2), as compared with 26 relocations (7 per km^2) on the northern ranch. The manager of the southern ranch explained that a ground squirrel control program normally in place had lapsed in 1994, but had been resumed in late summer 1995.

Encouraged by these observations, we conducted a visual survey of ground squirrels in the area administered by Kenetech Windpower, Inc., comprising about one-half of the WRA. Green Ridge Services provided funding for the survey, conducted over a 13-day period in mid-June. Two teams, each with two persons, counted ground squirrels by driving all accessible roads at 10-15 mph during periods of highest above-ground activity i.e., in the morning (once sunlight was upon burrows) and early evening (after midday temperature declined), and only when temperatures remained below 32.2˚C (Appendix II). The purpose of the survey was not to estimate the numbers of ground squirrels present, but to identify areas within the WRA containing high and low ground squirrel densities.

We began by surveying the entire area twice. Each survey segment was then categorized as containing high, moderate, or low numbers of ground squirrels, while areas of poor visibility, e.g., due to high, dense vegetation, were excluded from categorization. We defined high-density areas as those where more than 12 ground squirrels were counted per 0.3 mile, and low-density areas as those with less than three seen per 0.3 mile. We repeated surveys (3-5 repetitions) in segments scored as medium-density and some in low-density segments to validate designations. For example, a high-density population might have initially been scored at a lower value because an unseen disturbance (predator, car) prior to our arrival caused squirrels to go into burrows. Thus, we based final determinations on the highest numbers observed, irrespective of a lower count on a different day.

From ground squirrel survey data, we identified five ranches of high squirrel density and four of low density (Figure 20). In gross data on subadult/floater eagle relocations (n=39 eagles) during the 10-month period prior to the surveys, there were 3.5 relocations per km^2 on ranches scoring high in ground squirrel density (93 relocations in 26.5 km^2) and 0.51 per km^2 on the low density ranches (14 in 27.6 km^2), a ratio of seven to one. Note in Figure 20 that areas with medium density scores showed intermediate relocation densities (2.2 per km^2). To correct for pseudoreplication, we compared the relocation frequencies among each of 38 eagles visiting the high- and low-scoring ranches (relocations weighted for the slight difference in ranch areas) and found that 33 (87 percent) favored the ranches with high squirrel density (X^2=19.1, d.f.=1, p=0.0001).

We learned that the distribution of ground squirrels within the WRA has largely to do with whether or not ranchers control their numbers, a practice occurring throughout the pastoral and agricultural regions of California (Alameda County Agriculture Department). The principal control method involves either broadcasting or setting up bait stations of grain laced with the anticoagulants diphacinone and chlorophacinone. The Alameda County Agriculture Department and those of many other counties within California's central valley region have voluntary programs in place for ranchers who wish to control ground squirrels on their lands. Ranchers in Alameda County may receive poison grain from the county for a 50-cent per pound surcharge which supports research on ground squirrels and control methods. The county maintains records of the quantity of grain received annually by each rancher. The ranchers may broadcast the grain themselves, although the county also offers this service. The grain is scattered over the entire ranch, or in selected areas of squirrel abundance, with a subsequent survey to determine effectiveness.

According to Jim Smith (Alameda County Agriculture Department), the county was not highly involved in ground squirrel control on the WRA until the summer of 1996, when rancher awareness of the control program became widespread. In summer 1997, Kenetech, working with Alameda County, initiated a ground squirrel control program on the WRA to assure uniformity of treatment and broad-based rancher participation (Kerlinger and Curry 1997b, Curry and Kerlinger 1998). Since then, the county control agent has regularly treated many ranches within the WRA, although there are large areas of the WRA not included in the program, including the Los Vaqueros watershed extending into the northwest portion of the WRA. Overall, the Department distributes an average of about 42 tons of treated grain annually throughout the county (Jim Smith, Alameda County Agriculture Department, pers. comm.).

Expecting an inverse relationship between the history of rodenticide use and our squirrel density surveys, we consulted the county agriculture departments who provided data on the amount of rodenticide acquired by each ranch in the WRA from 1990-99. Inferring that these purchases reflected use levels, we categorized the ranches based on number of assumed treatments from 1994-1997 as (1) not treated consistently (0-2 years of treatment), and (2) treated consistently (three or more years of treatment). The distributions of ground squirrel density scores (Figure 20) corresponded with the distributions of ranches within these categorical designations as follows: 93.2 percent of the area of high squirrel density was within Category 1, and none in Category 2, whereas 98.5 percent of the area of low squirrel scores was within Category 2.

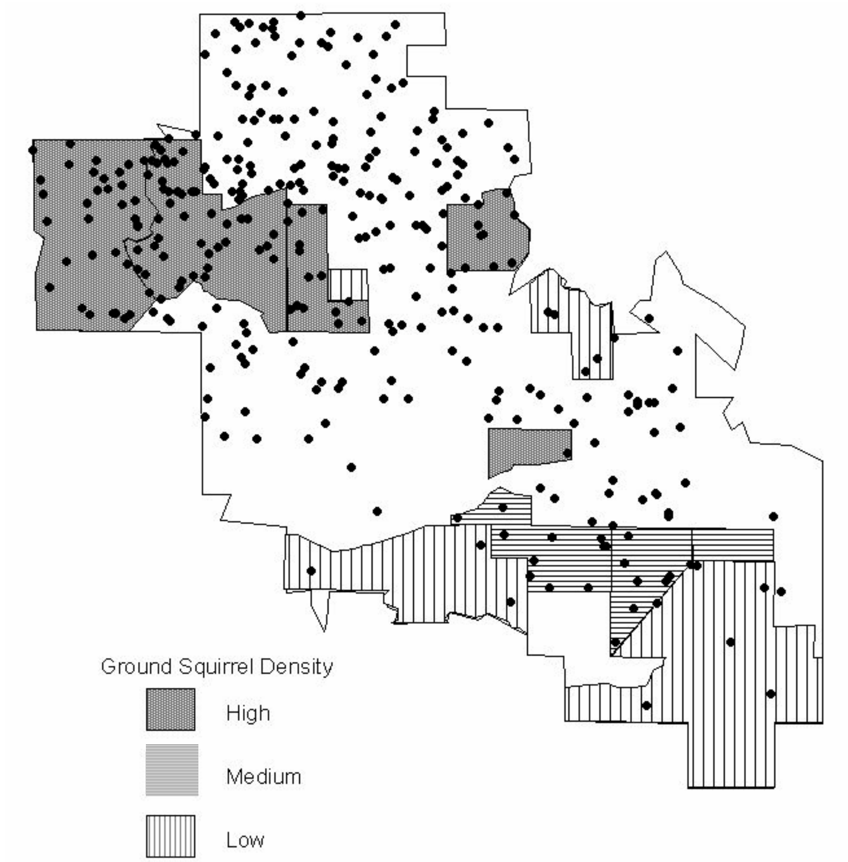


Figure 20. Eagle Relocations in Areas of Differing Ground Squirrel Densities as Estimated from Road Surveys

Relocations are those of subadults and floaters during the ten month period prior to the ground squirrel survey. Undelineated regions of the WRA (in white) were those either not surveyed (outside Kenetech area) or areas of poor visibility or access, the latter comprising ca. 16.3 km^2 (10.2 percent of total area).

3.7. Eagle Population Trend

Our final report to NREL, completed in early 1998, was directed solely toward analyzing the extent to which wind turbines at the WRA were affecting the trend of the golden eagle population inhabiting the surrounding region. Included in the analyses were our estimates of (1) the reproductive rate, as based on annual surveys of the nesting population, (2) survival rates of juveniles, subadults, floaters, and breeders, as obtained from radio-tagging and aerial surveys, and (3) the rate at which floaters became breeders.

3.7.1. The Alpha Model

The last-mentioned parameter was required for a trend analysis model developed especially for our project by a team of researchers at Colorado State University at Fort Collins (CSU) under separate support and direction from NREL (Shenk et al 1996, Franklin et al. 1998). The equations of the Alpha Model (Model #1 in Hunt et al. 1999), solved by matrix algebra, described the eagle life cycle in a graph of transition probabilities from one life-stage to another. This model was intended to produce an estimate of the annual rate of population change (λ). According to its authors, "…λ=1 indicates a stationary population, λ>1 an increasing population, and λ<1 a decreasing population" (Franklin et al. 1998). The Alpha Model, when supplied with data we obtained during 1994-1997, yielded a λ estimate of 0.9068 (SE=0.0322). The 95 percent confidence interval of this estimate (0.8437 - 0.9699) did not include λ=1.0, the minimum value for stability (see below). This meant that, if the model and its assumptions were valid, the population was declining during the period of our study, and if the point estimate for λ was correct, the decline rate was 9.3 percent per annum, an alarming value.

We have since determined that the Alpha Model is fundamentally flawed and therefore invalid. We first observe that the model, typical of Leslie matrix projections, requires that none of its parameters vary over time, a condition that would, in standard models, produce a stable age distribution regardless of population trend. However, one of the parameters of the Alpha Model cannot remain constant in the presence of floaters unless the population is at Moffat's equilibrium (Hunt 1998, Hunt and Law 2000, and see below). This parameter is α, the floater-to-breeder transition rate.

Using an idealized scenario to explain our reasoning, consider a remote island where there is nowhere else to go and only ten places to nest. Each nest is occupied by a pair of adult eagles who produce, on average, one fledgling per year or, collectively, an annual cohort of ten for the entire island. Natural attrition allows only 5 of these to survive the four-and-one-half years to adulthood. Two (10 percent) of the 20 breeders die annually, although a few live as long as 20 years. This means that only two vacancies are available each year for occupancy by the accumulating contingent of nonbreeding adults. However, these do not continue to increase indefinitely because 20 years after all sites are filled, the annual loss comes to match the annual gain, and the population is at Moffat's equilibrium (Hunt 1998). If survival and reproductive rates remain constant, our island population will stabilize at 42 adults and 31 younger eagles at fledging time. As usual, twenty of the adults will be breeders, but 22 will be floaters, unable to obtain a territory until a vacancy appears. In this idealized example of Moffat's equilibrium where vital rates remain constant over time, the proportions of age- and stage-classes will themselves remain constant from year to year.

Note that α is unnecessary in the formulation of Moffat's equilibrium, although the value of α can be easily calculated from the equilibrium number of floaters and the proportion acquiring breeding sites. We must therefore conclude, in this instance that α is not an independent parameter, but rather is determined entirely by the other parameters of the model.

Let us now suppose that our island, where the eagles have for many years been at equilibrium, has acquired through human misadventure a destructive pesticide that attacks eagle eggs to the extent that the annual cohort of fledglings is reduced by 70 percent, i.e., only three appear each spring. If this new reproductive rate remains constant, the population declines at an initial rate of about 16 percent per year (λ=0.84), annually losing a few floaters (some to the breeding segment and some to mortality) until the supply runs out about 14 years after the change in the reproduction. In, say, the fifth year of decline, two of 20 floaters (10 percent) acquire a territory, but by the tenth year, two of only seven remaining floaters (29 percent) so transition (Figure 21).

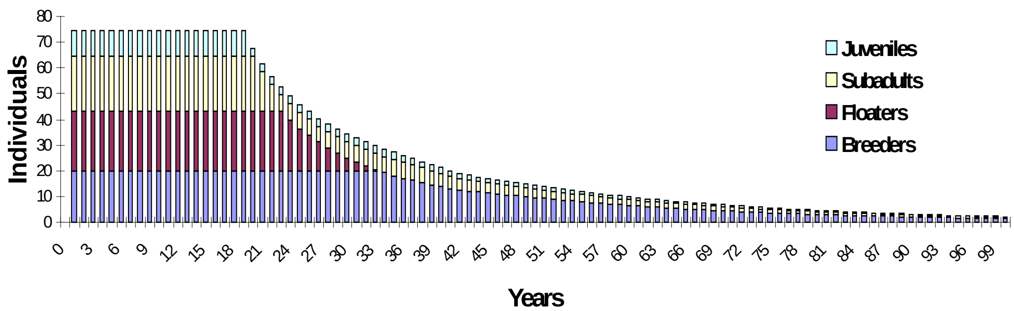


Figure 21. In a Hypothetical Population Declining from Moffat's Equilibrium, the Breeding Segment is Exposed to Decline only after the Loss of the Floating Segment

Obviously, α fails to remain constant in either a declining or an increasing population when floaters are present. The Alpha Model incorporates α, even though, by the nature of the model's mathematics, parameter constancy over time is both assumed and required. A projection from the matrix model based on a particular "snapshot" value of α discounts any further adjustment that true α may make in response to changes in the floater-to-breeder ratio. By placing α within the mathematical context of fixed parameters that effect rather than respond to population change, the Alpha Model is intractable and must be discarded.

3.7.2. A Better Trend Model

A healthy population at Moffat's equilibrium maintains a supply of floaters that buffers the breeding segment against decline. Our island scenario demonstrates that floaters accumulate in populations where (1) breeding opportunities are limited and (2) reproduction and / or survival are robust. The first of these criteria most assuredly applies to the nesting population of golden eagles in the Diablo Mountains where almost every territory known occupied in one year has remained occupied the next, where vacancies arising from breeder deaths have been immediately filled, and where a tightly-packed mosaic of nesting territories in favorable habitat remains virtually constant in structure from year to year (Hunt et al. 1999).

However, the second criterion, that of robust vital rates, cannot be satisfied on the basis of having recently observed floaters, because these may, in reality, be in gradual, collective decline (Figure 21) or may have arrived as immigrants from outside the study area. The question we ask, therefore, is whether the studied population is self sustaining, i.e., whether reproduction and survival are sufficient to generate more adults than there are places for them to nest. If this is not the case, the eagle population is either in decline (λ<1) or poised (if at equilibrium) at its brink (λ=1), although the second of these alternatives has an important exception we shall soon discuss.

It follows that the model we are looking for is one that can distinguish between $\lambda>1$ and $\lambda<1$ by estimating the growth potential (λ_p), i.e., a model that assumes territory acquisition by all maturing eagles. This model is a standard age-based growth model (Model #2 of Franklin et al. 1998) as proposed by PBRG as an alternative to the Alpha Model and discussed by Hunt et al. (1999). As in our island example, parameters include the reproductive rate and the survival rates of juveniles, subadults, and breeders. If these parameters remain constant at all stages of growth or decline, any value for λ_p exceeding 1.0 will predict a current or eventual population at Moffat's equilibrium, and we will then switch to an alternative model to estimate its stable stage distribution (Hunt 1998, Hunt et al. 1999, Hunt and Law, unpublished manuscript). λ_p <1, on the other hand, predicts that the supply of floaters will be exhausted (without immigration), and at that point, both α and floater survival (*f*) become moot as model parameters. We therefore maintain that the correct way of estimating λ_p is to ignore both of them, i.e., why wait to dispense with α and *f* in a declining population when their demise is inevitable? This leaves a model with fewer parameters than the Alpha Model, and we can therefore expect a more precise estimate of population trend, considering that the variance of every parameter adds to the variance of the model estimate (Appendix III).

3.7.3. Survival Estimates

The additional samples of radio-tagged eagles and continued aerial monitoring during 1998-2000 increased the precision of survival estimates and slightly altered their values from those reported by Hunt et al. (1999). For the latter study, the CSU team used Program Mark (White and Burnham 1999) to select the most parsimonious groupings of life-stages and sexes from which to calculate Kaplan-Meier survival estimates. The solution was a pooling of data from juveniles, subadults, and floaters of both sexes to produce a single estimate of annual survival for non-territorial eagles at 0.7867 (SE=0.0263). The estimate for territory-holders (breeders) was 0.8964 (SE=0.0371). In calculating estimates for the current study, which considers all data collected back through 1994, we departed from the CSU grouping in one respect: we considered juveniles separately. We did so because of differences between their lifestyle and that of older eagles (Section 3.2.1) and because the mortality regime for juveniles in our study area is also quite different, i.e., they are rarely killed by wind turbines (Table 2). The new Kaplan-Meier survival estimates are as follows: juveniles = 0.8397 (SE=0.0367), subadults / floaters = 0.7944 (SE=0.0215), and breeders = 0.9087 (SE=0.0246).

3.7.4. Estimate of Reproduction

The current study adds two additional years of data with which to calculate a natality estimate (Table 8). Even though the overall sample of years remains small, these new values reveal greater natural variation than previously observed, i.e., a comparatively high reproductive rate in 1999 (0.90 fledglings per occupied site) and a low one in 2000 (0.46). Parenthetically, 1994 was also a year of high productivity, despite our inability to meet Steenhof's (1987) criteria for a reproductive estimate (Section 2.0). Both 1994 and 1999 were characterized by a lack of prolonged winter rainfall, a factor we believe influences egg laying, egg survival, and ground squirrel availability (Appendix II).

For modeling purposes, the reproductive estimate of this particular golden eagle population must be tempered by the sex ratio. Measurements of eagles tagged as fledglings have indicated a consistent male bias. During the four years of radio-tagging (1994, 1995, 1996, and 1999), the ratios were 18:13, 13:9, 16:9, and 21:8, the aggregate of 107 fledglings for the years of sampling showing a ratio (proportion of males) of 0.63 (males / both sexes), a significant departure from unity (G=7.96, d.f.=1, p=0.005). The samples of free-ranging, nonterritorial eagles showed a similar preponderance of males. Among the eagles captured for radio-tagging in the current study were 34 males and 20 females (0.61 males), and in previous years, the ratio was 42 males and 27 females (.63 males), the pooled samples significantly departing from 1:1 (G=6.90, d.f.=1, p=0.009). The fact that the ratios calculated for fledglings and free-ranging eagles were almost identical gives support to earlier results in Program MARK detecting no sex bias in overall survival rates (Franklin et al. 1998, Hunt et al. 1999). Note that we cannot attest to the perfect accuracy of the ratios we report for these samples because all these sexing data were obtained from body measurements (e.g., hallux, tarsus, culmen, wing chord, etc). While most of these age-specific measurements are virtually non-overlapping between the sexes, and we used a combination of measurements in each case, blood analysis is the unequivocal method.

Table 8. Results of Golden Eagle Nest Surveys in the Study Area

	1994	1995	1996	1997	1998	1999	2000
Pairs surveyed	-	-	59	59	64	69	67
Total young	47	25	39	35	37	62	31
Young per pair	-	-	0.66	0.59	0.58	0.90	0.46
Broods	29	17	27	22	29	40	22
Brood size	1.62	1.47	1.44	1.59	1.28	1.55	1.41
Success rate	-	-	0.51	0.37	0.45	0.65	0.33

The reader, possibly wondering what sex ratio has to do with reproductive rate, may again consider Moffat's equilibrium. Recall that a healthy population of golden eagles fills all serviceable breeding locations, and that floaters of both sexes fill territory vacancies as they become available. As floater numbers dwindle in a declining population, the sex represented by the least number of floaters is depleted first, at which point the number of occupied territories, no longer buffered by floaters of that sex, begins to decline. In most other studied populations of raptors, females have been in surplus to males thereby rendering males the limiting sex (Ian Newton, pers. comm.), whereas our data imply that females, being fewest among the nonbreeding segment, are the limiting sex among golden eagles in the Diablo Range.

We calculated the overall natality estimate for the model by first averaging the annual number of 8-week-old fledglings per territorial pair (Table 8), and then multiplying by the average proportion of females each year. We calculated the standard error of the estimate by the Delta Method applied to the product of the two variables (Appendix III). The resulting productivity estimate was 0.2313 (SE=0.040) female fledglings per female territory-holder.

3.7.5. The Population Trend Estimate and What it Means

With these data on survival and reproduction, the λ_p model projects a potential growth rate of 1.0047 (SE=0.0240, 95 percent CI=0.9577-1.0517), a more encouraging point estimate than that in our previous study where λ_p was 0.9880. The current estimate, with its variance easily falling into the alternatives of both increase and decrease, is ambiguous to the extent that it can firmly predict neither Moffat's equilibrium nor decline (Appendix III). The matrix model overestimates λ_p to the extent that it cannot account for finite longevity, i.e., the oldest band-recovered golden eagle in North America was 23 years 10 months, and the oldest two such eagles in Europe were 26 and 32 years (Watson 1997). To test the effect on λ_p, we employed an age-based Moffat model that truncated longevity at 25 years and calculated $\lambda_p = 0.9982$. Again, both these point estimates, being so near 1.0, must remain ambiguous with respect to indicating the direction of population trend.

We observe that λ_p=1.0 does not imply stability, the latter being the effect of a floater reserve sufficient to comfortably buffer the breeding segment against decline. As explained above, a true value of λ_p=1.0 means that, at equilibrium, the population generates no floater buffer. However, that does not imply that no internally-generated floaters currently exist in the population, i.e., the model cannot ascertain if the population has so recently declined that it retains a remnant of a formerly robust floating segment. All that can be said is that, if λ_p is truly 1.0, the population is unable to maintain a floater buffer and is therefore vulnerable to any decrease in survival or reproduction that might, for example, accompany increasing human development in the landscape.

If, in reality, the population trend is currently negative, an important biological consideration must be taken into account, and that is the likely tendency of adult golden eagles in a reduced population to gravitate toward high quality breeding sites. In a 32-year study of a growing population of a related species, the Spanish imperial eagle (*Aquila adalberti*), Ferrer and Donozar (1996) found that average annual productivity of all occupied territories decreased as the number of territories increased. The reason for the overall decrease in fecundity was that the original pairs had selected sites in the best habitat, leaving new pairs to settle in those of lower quality (see also Dohndt et al. 1992). If golden eagles are similarly proficient in habitat selection, we would expect per capita productivity to increase in a declining population such that the trend might, at some point, stabilize (λ=1), albeit at lower level. Such a population would contain no floaters and yet be at equilibrium. Hunt and Law (2000) refer to this as the "recruitment wave limit" of site occupancy, a condition that derives from the restricted extent to which sites producing surplus recruits can augment those failing to meet that criterion. The alternative, of course, is the "site-serviceability limit" in which all sites that are adaptively suitable (in the evolutionary sense) are occupied, and floaters accumulate, this limit being the natural state for golden eagles.

To illustrate the effect of breeding site preemption (if our golden eagles are so disposed), let us suppose that the population is declining and that remaining breeders perfectly select those territories yielding the highest numbers of offspring (the "ideal preemptive distribution" of Pulliam and Danielson 1991). In our study area, the upper 50th percentile of breeding sites have produced about 0.39 female fledglings per territorial females as compared with 0.10 for the lower 50th percentile. If the breeding segment in this idealized scenario declined to one half its number but perfectly gravitated to the best sites, then λ_p would equal 1.03, a figure that would ordinarily predict a healthy state of Moffat's equilibrium with 0.62 female floaters per female breeder. Of course, this scenario could not obtain in nature because those hypothetical floaters would be occupying that fringe area of low quality sites describing the recruitment wave limit, and λ_p would be 1.0.

3.7.6. Is there Evidence of a Decline?

All this discussion leads to the conclusion that a healthy golden eagle population generates adults in excess of those required to fill breeding vacancies. Without floaters, the breeding segment of a population at the recruitment wave limit responds more or less immediately to vital rate changes, while a population at the site-serviceability limit may be comfortably buffered against change by its floater reserve. We must ask, therefore, if there are signs of breeding site saturation and a floating segment.

Our nesting surveys give no indication of a decline in territory occupancy. Only one nesting territory among 59-69 surveyed became vacant, this one close to activity associated with the development of Los Vaqueros Reservoir and both pair members killed by wind turbines within an 8-month period. Otherwise, throughout our study, all surveyed territories found occupied by pairs in one year have remained occupied by pairs in the next, a sign that floaters filled vacancies. Field evidence of rapid mate replacement include the reoccupancy of a territory where both adults died within two months of one another, and several cases where breeders were killed and replaced by floaters. We observed no nesting territories held by lone adults.

A clear sign of a reduced floating segment would be a high incidence of subadults as members of breeding pairs (Newton 1979, Watson 1997). For example, Bergo (1984) recorded a high proportion of subadult pair members in a Norwegian population of golden eagles that he believed was below carrying capacity. In Idaho, Steenhof et al. (1983) observed more subadult golden eagles as pair members when winter adult densities were low and concluded that subadults were less capable than adults of obtaining and holding territories. We are thus encouraged by a low overall 2.9 percent incidence of territory-holding subadults per surveyed pair in our study area over five breeding seasons (1996-2000) and no apparent trend (2.7 percent, 0.0 percent, 3.1 percent, 4.4 percent, and 1.5 percent in the five years, respectively). Were no adults available to fill vacancies, we would expect the incidence of subadult territory-holders to approximate the breeder mortality rate, about ten percent in our study area. The smaller observed incidence suggests either that floaters are being produced in the study area or they are arriving as immigrants, the number required per year being about 20 per hundred pairs.

3.7.7. The Net Effect of Blade-strike Deaths

In our last report to NREL (Hunt et al. 1999), we modeled the state of the population in the absence of wind turbines. To do this, we recalculated the subadult/floater survival rate after removing all blade-strike kills from consideration, i.e., we censored the eagles killed by the turbine strikes on their estimated death dates. This method has been generally avoided in other survival studies because of the bias of competing risk factors, a reasonable assumption if, for example, the risk were that of predation. The elimination of a predator might simply provide opportunity for another, or for other sources of mortality, such as starvation, associated with increased numbers (Heisey and Fuller 1985). We reasoned that these considerations would apply in the case of eagles and wind turbines only if causal density-dependent (crowding) factors came into play. For example, in the absence of wind turbines, a larger population of eagles might experience increased food competition such that the proportion starving would be comparable to those otherwise lost to wind turbines. Another and more plausible possibility is that increasing numbers of floaters might interfere with nesting success (Haller 1996).

We are skeptical that blade-strike mortality is compensatory. While it is true that density-feedback will inevitably influence vital rates at some point in the course of unlimited growth, the eagle population may settle into Moffat's equilibrium before that point is reached (Hunt and Law 2000). Free-ranging golden eagles have no obvious predators (the role of parasites in eagle demography is poorly known), and insofar as starvation is concerned, golden eagles are highly mobile, have a wide food-niche, and there are large areas of grasslands without trees for nesting (survival habitat), although, admittedly, the latter is being reduced by development. Floater interference with reproductive success might occur if there were large numbers of floaters, and so we must ask what would the floater-to-breeder ratio be in the absence of wind turbines.

Censoring the blade-strikes, the point estimate of subadult/floater survival increases from 0.7944 to 0.8997, and that of breeders from 0.9093 to 0.9240. If these and the other vital rates remained constant, λ_p becomes 1.036, meaning that a population of 100 pairs would reach Moffat's equilibrium at about 241 females at fledging time, and there would be about 61 floaters per 100 female breeders (*F:B*=0.61). Such a population would be considered intrinsically stable, and it is unlikely, in our opinion that a floater reserve of this magnitude would grossly interfere with the reproductive rate. Going a step further, with the censoring of all the known human-related mortality we recorded in our telemetry study, the Moffat model projects an *F:B* of 0.99. For comparison, vital estimates for a bald eagle population in Alaska by Bowman et al. (1995) yielded *F:B*=1.0 at Moffat's equilibrium (Hunt 1998).

4.0 Conclusions and Recommendations

The golden eagle population in our study area is part of a larger population inhabiting the mid-coastal mountains of California, and that population is part of yet a larger one, and so on. This is not to say we chose the dimensions of our study area randomly. In the first two years of study, the movements of subadults and floaters we radio-tagged in the WRA vicinity revealed that the region surrounding the Livermore valley retained the vast majority of them, as well as those eagles we tagged as fledglings (Figure 11, Figure 12, Figure 13, and Figure 14). The urban and delta regions to the west and north gave the appearance of containment, and relocation density attenuated rapidly in the area south of San Luis Reservoir and Hollister, ca. 75 km to the southeast of the WRA. Some eagles emigrated, and we believe a greater proportion did so after 1996 or 1997 (Section 3.1), although the overall proportion of those permanently leaving the study area was obscured by an unknown rate of transmitter failure. Some eagles returned after being away for months, and a few appeared to alternate between widely separated areas.

Wind turbine destruction of golden eagles at Altamont Pass might therefore be regarded as local in its effect on the health of the population of west-central California, the direct influence of the WRA extending southeastward perhaps 60 km and affecting the issue of perhaps 180 pairs. Thus far, no decrease is apparent in the number of territories occupied by adults. However, any reduction in survival or reproduction must decrease the floater-to-breeder ratio, and while it is conceivable that lowering competition might be mitigating this effect, the modeled scenario of life in the absence of turbines increases F:B to only 0.61, an unexceptional value when compared with studies of other raptor species (Newton 1979, Bowman et al. 1995, Watson 1990, Kenward et al. 2000). Our study shows a prevalence of human-related mortality in our study area (Table 2), a situation also expected in many other regions of California. Whereas the annual loss of 50 or more golden eagles to wind turbines, added to other human influences, has the net affect of reducing the overall floater buffer, the latter, whether originating from inside or outside the WRA, has yet to be eliminated, even in areas fairly close to the WRA.

4.1. Conclusions

Regardless of the population impact of blade strike mortality, society nevertheless regards the killing of golden eagles as an impropriety that should be mitigated, an attitude reflected in both state and federal law. While the evidence we report is circumstantial rather than experimental, our findings do suggest solutions, some of which would almost certainly reduce the incidence of golden eagle mortality in the WRA. A prime example would be the reduction of ground squirrel numbers in the vicinities of the turbines. Section 3.6 gives evidence that areas of high ground squirrel density attract golden eagles. The fact that eagles hunt ground squirrels and other prey by gliding close to the ground (contour hunting) brings them well within the horizon of the rotor blades, these being more difficult to avoid when the wind is strong and turbulent near the ground.

Even though ground squirrel control is a well known and frequent practice and would reduce golden eagle blade-strike mortality in the WRA, it is not without secondary environmental costs. Animals, such as badgers, foxes, coyotes, bobcats, rattlesnakes, gopher snakes, and others, prey upon ground squirrels in the WRA. Species such as burrowing owls and snakes depend on their burrows. If, on behalf of eagles, ground squirrel control becomes more widespread in the WRA, it would be proper to mitigate the loss of prey for all predators, including eagles, by encouraging ground squirrels outside the WRA. This might take the form of purchasing conservation easements from ranchers in areas of open grasslands (without suitable nest trees) to attract nonbreeding eagles. An example of such an area is the military installation known as Camp Parks near Dublin, whose policy is to protect ground squirrels and other prey species, and where our telemetry surveys have revealed a concentration of nonbreeding eagles.

Another downside of ground squirrel control is the collateral destruction of non-target species such as mice and rabbits which eat the poison grain. Perhaps the way to reduce ground squirrel numbers in the WRA is to trap them in areas near turbines where the squirrels exceed a threshold density. Such mitigation might be strengthened were repowering to proceed as planned (Section 2.2). Our density comparisons of eagle relocations and fatalities in the two northern polygons, both of which contained relatively high numbers of relocations, suggested that the one containing Type-13 turbines (Polygon-A) was more lethal than that containing other types of turbines (Polygon-B). Whereas we were unable to differentiate the lethal aspects of Type-13's configuration from its spacing, length of strings, or its relationship to terrain features, an absolute reduction in the number of Type-13s as part of the repowering would very likely benefit eagles, especially if the removal of the 644 Type-13s were to occur in areas where eagles concentrate.

Our observations of foraging eagles suggest that the new Type-28 turbines may be safer for eagles than the Type-13 turbines they are intended to replace. The turbines in Polygon-B that killed only two tagged eagles differed from Type-13s (19 died in Polygon-A) in the following ways: (1) the blades of the turbines in Polygon-B were higher off the ground, (2) the towers were more widely-spaced, and (3) their tubular towers offered little perching opportunity. The new Type-28 turbines are expected to have all these characteristics, in addition to a slower rotational speed which may allow eagles to more easily avoid the blades (Tucker 1996 a, b). Whereas the absolute relationship of any one of these factors to eagle mortality is unknown, we can say that eagles attempting to pass between or underneath the Type-28s would have far more room to maneuver. However, even if Type-28 were to prove more lethal on a per-turbine basis, its far greater generating capacity might render it preferable because few are necessary to match the generating capacity of many Type-13s, that is, assuming that overall energy production does not increase in the WRA. Tucker (1996b) incorporates such considerations within his safety index of turbine characteristics.

4.2. Recommendations

For further research, we recommend a continuation of the breeding surveys for golden eagles, perhaps every two or three years, with the purpose of monitoring territory reoccupancy, reproduction, the proportion of subadults as members of breeding pairs, and verification of sex ratio by blood sampling. An increase in the number of subadult territory holders can be expected as an early warning of a decline in territory occupancy and so must be regarded as primary among these objectives. Numerous land-use changes occurring during our studies have had the effect of reducing the overall amount of habitat for both breeding and nonbreeding eagles. Annual field work should include an assessment of these developments in relation to the eagle population to provide insight into ways of accommodating golden eagles within the changing landscape.

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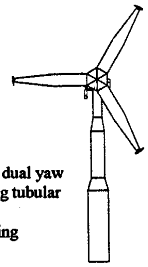
Appendix I

Types of Turbines in the Altamont Pass WRA

TURBINE TOWER TYPES

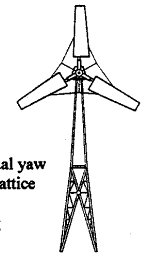
1 HOLEK/POLENKO (Dutch)

Size of Turbine:	100 kW
Rotor Diameter:	59 ft.
Cut-in Speed:	14 mph
Rated Wind Speed:	31 mph
Cut-out Speed:	67 mph
Number Installed:	12
Description:	Upwind, fixed pitch, dual yaw rotors, self-supporting tubular tower
Operator:	Thompson Engineering Management



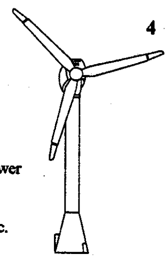
2 HOLEC/WINDMATIC (Danish)

Size of Turbine:	65 kW
Rotor Diameter:	48 ft.
Cut-in Speed:	12 mph
Rated Wind Speed:	35 mph
Cut-out Speed:	56 mph
Number Installed:	26
Description:	Upwind, fixed pitch, dual yaw rotors, self-supporting lattice tower
Operator:	Thompson Engineering Management



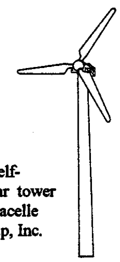
3 HOWDEN (Scottish)

Size of Turbine:	330 kW	750 kW
Rotor Diameter:	102 ft.	149 ft.
Cut-in Speed:	11 mph	12 mph
Rated Wind Speed:	27 mph	29 mph
Cut-out Speed:	55 mph	58 mph
Number Installed:	85	1
Description:	Upwind, steel tubular tower with conical base	
Operator:	Altamont Energy Corp. Howden Wind Parks, Inc.	



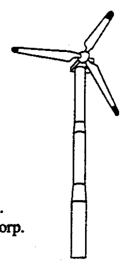
4 MICON (Danish)

Size of Turbine:	60 kW
Rotor Diameter:	52 ft.
Cut-in Speed:	9 mph
Rated Wind Speed:	34 mph
Cut-out Speed:	None
Number Installed:	221
Description:	Upwind, fixed pitch, self-supporting steel tubular tower with inside ladder to nacelle
Operator:	SeaWest Energy Group, Inc.



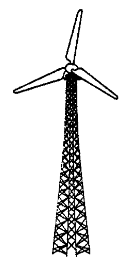
5 NORDTANK (Danish)

Size of Turbine:	65 kW
Rotor Diameter:	52 ft.
Cut-in Speed:	8 mph
Rated Wind Speed:	34 mph
Cut-out Speed:	None
Number Installed:	394
Description:	Upwind, fixed pitch, steel tubular tower
Operator:	Altamont Energy Corp. LFC Power Systems Corp. Wintec Ltd.



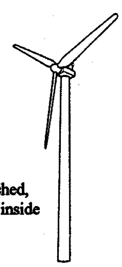
6 VESTAS (Danish)

Size of Turbine:	65 kW	100 kW
Rotor Diameter:	50 ft.	56 ft.
Cut-in Speed:	7 mph	8 mph
Rated Wind Speed:	34 mph	42 mph
Cut-out Speed:	50 mph	62 mph
Number Installed:	2	200
Description:	Upwind, lattice tower	
Operator:	Altamont Energy Corp. Zond Systems, Inc.	



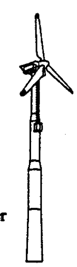
7 HMZ-WINDMASTER (Belgian)

Size of Turbine:	75	200	250	300 kW
Rotor Diameter:	72	72	76	82 ft.
Cut-in Speed:	10	11	11	11 mph
Rated Wind Speed:	20	33	32	34 mph
Cut-out Speed:	50	50	56	56 mph
Number Installed:	5	129	30	15
Description:	Upwind, hydraulically pitched, blades, tubular tower with inside ladder to nacelle			
Operator:	WindMaster			



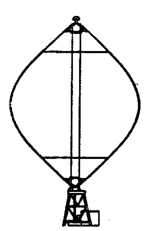
8 DANREGN VIND/KRAFT BONUS (Danish)

Size of Turbine:	65	120	150 kW
Rotor Diameter:	50	63.5	76 ft.
Cut-in Speed:	9	9	9 mph
Rated Wind Speed:	40	40	40 mph
Cut-out Speed:	67	67	67 mph
Number Installed:	211	250	100
Description:	Upwind, fixed pitch, self-supporting steel tubular tower		
Operator:	LFC Power Systems Corp.		



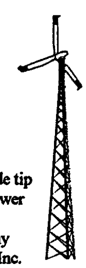
9 FLOWIND

Size of Turbine:	150 kW	250 kW
Rotor Diameter:	56 ft.	62 ft.
Cut-in Speed:	12mph	14 mph
Rated Wind Speed:	38 mph	38 mph
Cut-out Speed:	60 mph	60 mph
Number Installed:	148	21
Description:	Vertical axis steel tubular tower	
Developer:	FloWind Corp.	



10 ENERTECH

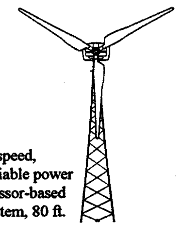
Size of Turbine:	40 kW	60 kW
Rotor Diameter:	44 ft.	44 ft.
Cut-in Speed:	8 mph	10 mph
Rated Wind Speed:	30 mph	35 mph
Cut-out Speed:	50 mph	60 mph
Number Installed:	192	36
Description:	Downwind, free yaw,blade tip brakes, self-supporting tower	
Operator:	Altamont Energy Corp. Altamont Power Company SeaWest Energy Group, Inc.	



11 WIND POWER SYSTEMS

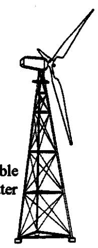
Size of Turbine:	40 kW
Rotor Diameter:	39 ft.
Cut-in Speed:	11 mph
Rated Wind Speed:	30 mph
Cut-out Speed:	60 mph
Number Installed:	20
Description:	Downwind, tilt-down lattice tower, no nacelle
Operator:	American Windpower, Inc.

12 KENETECH



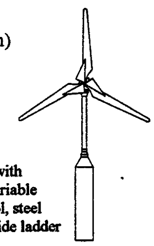
Size of Turbine:	300kW - 400kW
Rotor Diameter:	108 ft.
Cut-in Speed:	9 mph
Rated Wind Speed:	29 mph - 32 mph
Cut-out Speed:	Variable
Number Installed:	38
Description:	Upwind, variable speed, variable pitch, variable power factor, microprocessor-based turbine control system, 80 ft. lattice tower
Operator:	Kenetech Windpower

13 KENETECH



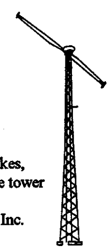
Size of Turbine:	100 kW
Rotor Diameter:	59 ft.
Cut-in Speed:	12 mph
Rated Wind Speed:	29 mph
Cut-out Speed:	44 mph
Number Installed:	3,500
Description:	Downwind, free yaw, variable pitch blades, remote computer control, 60 ft. tripod tower
Operator:	Kenetech Windpower

14 DANISH WIND TECHNOLOGY (Danish)



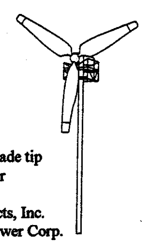
Size of Turbine:	300 kW
Rotor Diameter:	97 ft.
Cut-in Speed:	12 mph
Rated Wind Speed:	30 mph
Cut-out Speed:	56 mph
Number Installed:	3
Description:	Downwind, free yaw with hydraulic damping, variable pitch, computer control, steel tubular tower with inside ladder
Operator:	Atkinson Mechanical

15 ENERGY SCIENCES, INC.



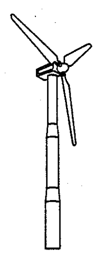
Size of Turbine:	50	65	80 kW
Rotor Diameter:	54	54	54 ft.
Cut-in Speed:	14	11	11 mph
Rated Wind Speed:	30	40	37 mph
Cut-out Speed:	55	55	55 mph
Number Installed:	99	96	109
Description:	Downwind, blade tip brakes, free yaw, tilt-down lattice tower		
Operator:	Altamont Energy Corp. SeaWest Energy Group, Inc. TERA		

16 FAYETTE



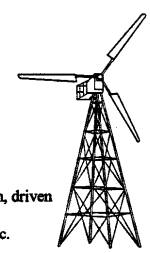
Size of Turbine:	75	95	250 kW
Rotor Diameter:	33	36	80 ft.
Cut-in Speed:	12	12	12 mph
Rated Wind Speed:	40	37	35 mph
Cut-out Speed:	none		
Number Installed:	222	1202	30
Description:	Downwind, free yaw, blade tip brakes, guyed pipe tower		
Operator:	Altamont Energy Corp. American Energy Projects, Inc. Arcadian Renewable Power Corp.		

17 DANWIN (Danish)



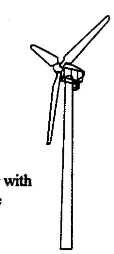
Size of Turbine:	110 kW
Rotor Diameter:	62.3 ft.
Cut-in Speed:	7.8 mph
Rated Wind Speed:	30 mph
Cut-out Speed:	57 mph
Number Installed:	25
Description:	Upwind, tubular tower
Operator:	FloWind

18 BSW/WAGNER (German)



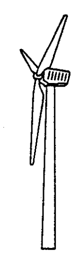
Size of Turbine:	65 kW
Rotor Diameter:	56 ft.
Cut-in Speed:	8 mph
Rated Wind Speed:	30 mph
Cut-out Speed:	67 mph
Number Installed:	15
Description:	Upwind, fixed pitch, driven yaw, lattice tower
Operator:	Energy Projects, Inc.

19 ALTERNERGY/AEROTECH (Danish)



Size of Turbine:	75 kW
Rotor Diameter:	51 ft.
Cut-in Speed:	8.6 mph
Rated Wind Speed:	30 mph
Cut-out Speed:	66 mph
Number Installed:	4
Description:	Upwind, tubular tower with inside ladder to nacelle
Operator:	Tempest, Inc.

20 W.E.G. (Brittish)



Size of Turbine:	250 kW	300kW
Rotor Diameter:	82 ft.	108 ft.
Number of blades:	3	2
Cut-in Speed:	11 mph	11 mph
Rated Wind Speed:	30 mph	26 mph
Cut-out Speed:	56 mph	56 mph
Number Installed:	20	1
Description:	Upwind, tubular tower, variable pitch	
Operator:	U.S. W.E.G.	

21 KENETECH

Size of Turbine:	100 kW
Rotor Diameter:	59 ft.
Cut-in Speed:	12 mph
Rated Wind Speed:	29 mph
Cut-out Speed:	44 mph
Number Installed:	nd
Description:	Downwind, free yaw, variable pitch blades, remote computer control, 80 ft. lattice tower
Operator:	Kenetech Windpower

22 KENETECH

Size of Turbine:	100kW
Rotor Diameter:	59 ft.
Cut-in Speed:	12 mph
Rated Wind Speed:	29 mph
Cut-out Speed:	44 mph
Number Installed:	nd
Description:	Downwind, free yaw, variable pitch blades, remote computer control, 80 ft. tripod lattice tower
Operator:	Kenetech Windpower

23 KENETECH

Size of Turbine:	100 kW
Rotor Diameter:	59 ft.
Cut-in Speed:	12 mph
Rated Wind Speed:	29 mph
Cut-out Speed:	44 mph
Number Installed:	nd
Description:	Downwind, free yaw, variable pitch blades, remote computer control, 140 ft. lattice tower
Operator:	Kenetech Windpower

24 KENETECH

Size of Turbine:	300 kW - 400 kW
Rotor Diameter:	108 ft.
Cut-in Speed:	9 mph
Rated Wind Speed:	29 mph - 32 mph
Cut-out Speed:	Variable
Number Installed:	1
Description:	Upwind, variable speed, variable pitch, variable power factor, microprocessor-based turbine control system, 80-ft. modified tubular tower
Operator:	Kenetech Windpower

25 KENETECH

Size of Turbine:	300 kW - 400 kW
Rotor Diameter:	108 ft.
Cut-in Speed:	9 mph
Rated Wind Speed:	29 mph - 32 mph
Cut-out Speed:	Variable
Number Installed:	1
Description:	Upwind, variable speed, variable pitch, variable power factor, microprocessor-based turbine control system, 120 ft. tubular tower
Operator:	Kenetech Windpower

26 KENETECH

Size of Turbine:	300 kW - 400 kW
Rotor Diameter:	108 ft.
Cut-in Speed:	9 mph
Rated Wind Speed:	29 mph - 32 mph
Cut-out Speed:	Variable
Number Installed:	1
Description:	Upwind, variable speed, variable pitch, variable power factor, microprocessor-based turbine control system, 120 ft. lattice tower
Operator:	Kenetech Windpower

27 BORING

Size of Turbine:	**330 kW**
Rotor Diameter:	**104 ft.**
Cut-in Speed:	**nd**
Rated Wind Speed:	**nd**
Cut-out Speed:	**nd**
Number Installed:	**83**
Description:	**Upwind, tubular tower**
Operator:	**EnXCo**

28 NEG-MICON

Size of Turbine:	**700-750 kW**
Rotor Diameter:	**48 m (157 ft.)**
Cut-in Speed:	**4 m/s**
Rated Wind Speed:	**14 m/s**
Cut-out Speed:	**25 m/s**
Number Installed:	**nd**
Description:	**Upwind, tubular tower**
Operator:	**Green Ridge Services Altamont Power Sea West Energy Group**

nd = no data available

This information was obtained from the *Altamont Pass Wind Power Plant* brochure prepared through the cooperative efforts of the Pacific Gas and Electric Company and Kenetech Windpower, Inc., April 1992. Current information was not available regarding the number installed and numbers may have changed.

Appendix II

General Information on California Ground Squirrels

Early research on the California ground squirrel largely focused on eradication efforts associated with bubonic plague and the cattle industry's concern over the loss of forage to squirrels (Grinnel and Dixon 1918, Snyder 1923, Storer 1930, Evans and Holdenried 1943, Linsdale 1946, Fitch 1948). As knowledge accumulated, it became apparent that geographical variation in temperature and precipitation regimes strongly affected the annual cycles of ground squirrel breeding, aestivation, hibernation, daily activity, and even demography. These and other life history traits indeed vary between populations in different geographic regions of California. Fortunately, in attempting to understand the ecology of the California ground squirrel population at Altamont Pass, we found that many studies were conducted within that region.

Grinnel and Dixon (1918) studied California ground squirrels at various elevations, from sea-level to about 6,000 feet ASL. Variations in the reproductive cycle were reported by Snyder (1923) in Tulare County, and Storer (1930) in a range extending from Ventura and Tulare counties north to Contra Costa and San Joaquin counties. Detailed population and behavior studies were conducted by Evans and Holdenried (1943) at Calaveras Reservoir in Alameda County, Linsdale (1946) at the Hastings Wildlife Reservation, and Fitch (1948) at the San Joaquin Experimental Range near Madera. These early works on ground squirrel life history continue to provide the basis of our ecological understanding of the species, whereas later research has focused largely on specific aspects of behavior. Tomich (1962) studied ground squirrels in the agricultural region near Davis (Yolo and Solano counties), Owings and Borchert (1975) and Owings et al. (1977) at the University of California Davis Wildlife Area, Stroud (1983) at the University of California Hopland Field Station in Mendocino County, Holekamp and Nunes (1989) at the University of California campus in Santa Cruz, and Boellstorff et al. (1994), Boellstorff and Owings (1995) and Trulio (1996) at Camp Ohlone, in Alameda County.

Population Survey Methods

When we began our study of golden eagles in the Altamont Pass area in 1994, we observed ground squirrels throughout the WRA. Our observations of foraging eagles quickly revealed their importance as a prey base and our need of a method to quantify their relative density in the various parts of the WRA. Ground squirrel survey methods varied in the literature, and some promised more accuracy than others.

Social behavior and alarm calls of the ground squirrel make visual surveys difficult. Grinnel and Dixon (1918) and Fitch (1948) noted that when walking transects across study areas, squirrels would call and run into burrows at distances over 100m away and remain underground for extended periods. Emergent young were less conspicuous than older squirrels in visual counts and sometimes retired to burrows for days, making them unavailable to surveys (Fitch 1948). Burrow entrance counts have been found inaccurate when sampling numbers of California ground squirrels and similar species (Fitch 1948, Van Horne et al. 1997a, Powell et al. 1994). For example, Fitch (1948) found burrow systems had an average of 17.2 holes per squirrel. The most accurate population estimates have been obtained by mark-recapture techniques (Evans and Holdenried 1943, Fitch 1948, Van Horne et al. 1997a). Fitch

(1948) noted that virtually every adult squirrel was trapped each year, during late winter and spring, and the numbers trapped approximated the breeding population. The road surveys we conducted in our study were more practical as a means of indexing the relative density of ground squirrels in various regions of the WRA (to compare with eagle use) than to precisely estimate the number of ground squirrels in specific areas.

Daily Activity and Foraging

In regions with annual snowpack, all California ground squirrels hibernate during winter (Fitch 1948, Dobson and Davis 1986), whereas ground squirrels may aestivate where summer food is scarce. However, in milder climates and in habitats offering diverse food sources, such as in our study area, conditions may be favorable for surface activity throughout the year. More, accurately, in such regions, not all sexes or age-classes are simultaneously dormant (Fitch 1948). On a population level, there are great differences from year to year in the frequency and duration of dormancy, correlated with feeding conditions and weight gain in early summer.

In our study area, periods of daily activity can vary according to temperature and other weather conditions. During winter, some activity occurs every day unless rain is continuous.

Squirrels often do not emerge until mid-morning, when the sun is on their burrows, but then remain active until mid-afternoon. The normal winter surface activity period is 1000-1600 hours (Fitch 1948); however, squirrels may become active as early as 0830 hrs. (Holekamp and Nunes 1989). Wind, cold fog, and rain limit surface activity, and if squirrels do emerge, foraging periods are short and hurried. On a warm clear winter day following several cold and stormy ones, squirrel activity is at a peak, each animal foraging ravenously after the period of fasting. Food is usually abundant in winter due to the new growth of herbaceous species, so squirrels forage closer to their burrows than in summer months (Fitch 1948).

Foraging periods lengthen during spring with increased daylight and warmer temperatures. Surface activity becomes bimodal as summer temperatures increase, with squirrels retiring to their burrows or to shaded areas during the mid-day heat. The normal summer surface activity periods are 0500-0900 hrs. and 1600 hrs. to dusk. Squirrels may be active throughout cloudy or unseasonably cool days.

Breeding and Productivity

In Alameda County, the ground squirrel breeding season usually commences in February (Evans and Holdenried 1943). Holekamp and Nunes (1989) found that the gestation period spanned 28-30 days, followed by a lactation interval of six weeks. Young squirrels emerge from burrows during March through June at 6-7 weeks of age. Litter size, averaging about seven, varies with food supply, female condition, and age (Snyder 1923, Van Horne et al. 1997b, Holekamp and Nunes 1989).

Almost all female squirrels in the population breed (Grinnel and Dixon 1918, Evans and Holdenried 1943, Fitch 1948, Tomich 1962), and few are reproductively unsuccessful (Holekamp and Nunes 1989). The period of behavioral estrus for each adult female is 4-5 hours, and she mates with an average of seven males (Beollstorff et al. 1994). Generally, females produce only one litter per year; however, second litters may be produced following the loss of first litters (Grinnel and Dixon 1918, Evans and Holdenried 1943, Fitch 1948, Tomich 1962, Holekamp and

Nunes 1989). Evans and Holdenried (1943) found no evidence of females giving birth during the first year of life.

Timing of the breeding cycle within a population of ground squirrels can vary. Most pregnant females have been captured during January to May, although Storer (1930) found pregnant females in every month of the year. We documented emergent juveniles in the WRA as late as 22 October.

There is some evidence that productivity may be higher in areas where control measures are enforced. Snyder (1923) found consistently larger litters in areas where control operations had been in place for two or more years. He attributed the increase in productivity to increased food availability, resulting from relaxed competition.

Mortality and Survival

Males fight constantly during the breeding season, defending their territory and entering those of others to mate with receptive females. The males often forgo foraging during this period, and their weight drops drastically (Fitch 1948). Weakness and injuries are common, making the males particularly susceptible to predation.

The cohort of emerging young are vulnerable to bobcats, coyotes, foxes, badgers, rattlesnakes, gopher snakes, golden eagles, red-tailed hawks, prairie falcons, northern harriers, great horned owls, and others (Grinnel and Dixon 1918, Evans and Holdenried 1943, Fitch 1948). Fitch (1948) found annual juvenile survival ranged from 36 to 50 percent and that of adults from 40 to 58 percent. Squirrels died most frequently after periods of unusually cold and wet weather in winter and spring. California ground squirrels have been diagnosed with pneumonia and bubonic plague (*Pasteurella pestis*) (Storer 1930, Evans and Holdenried 1943). Grinnel and Dixon (1918) estimated maximum life-span at five to six years.

Population Density

The California ground squirrel population studied by Fitch (1948) was stable, exhibiting an annual cycle of sudden appearance and subsequent gradual attrition of each year's crop of young. During the six years of his study, there was no extensive reduction by disease, plague, or starvation. Grinnel and Dixon (1918) found that, under natural conditions the factors apparently limiting a population of ground squirrels, in order of importance were (1) food supply in summer and fall, (2) predators, (3) weather (especially inundation of burrows), (4) disease, and (5) physiological longevity. Evans and Holdenried (1943) reported a total population density (adults and young) of seven per acre, and Boellstorff et al. (1994) found densities of 70 to 92 adult squirrels per hectare; both studies were in Alameda county.

Home Range and Dispersal

The home ranges of California ground squirrels vary with habitat and food supply, often overlapping the ranges of neighbors (Evans and Holdenried 1943, Fitch 1948, Holekamp and Nunes 1989, Boellstorff and Owings 1995). A male's range is relatively exclusive of other males, wheras the ranges of females overlap extensively (Evans and Holdenried 1943, Owings et al. 1977). The range of an adult male may overlap that of 2-4 adult females (Holekamp and Nunes 1989), while the range of an adult female (100 m^2, versus $50m^2$ for males) can overlap that of seven males (Boellstorff and Owings 1995).

Young males disperse to new areas from July - September (Grinnel and Dixon 1918, Evans and Holdenried 1943), usually remaining within about one km of their natal site. Young females; however, establish burrows in areas overlapping or adjacent to their mother’s home range (Boellstorff and Owings 1995). This behavior leads to groups of related females (siblings and daughters) with adjacent ranges. In a study where squirrels were marked for visual identification, core areas of unrelated females never overlapped (Boellstorff and Owings 1995).

Boellstorff and Owings (1995) found multi-year site fidelity for both sexes at established burrow systems. However, in locations where populations have been depleted by poisoning, squirrels will move from areas of high density toward those of low density, but there is no indication of large-scale emigration over great distances (Evans and Holdenried 1943). Linsdale (1946) noted that ground squirrels disappeared from the Hastings Reservation when grazing was terminated, and Evans and Holdenried (1943) reported ground squirrels were rarely seen in heavy tree and brush growth, or on ungrazed land where grass was dense and exceeded one meter in height.

Appendix III

Potential Growth Model

To write a matrix model for the computation of λ_p, we parameterize the model as a postbreeding-census, birth-pulse model. In this case, the population is presumed censused immediately after "breeding" and so the youngest age class included in the census is that of 0-year olds. With $J(t)$, $S_1(t)$, $S_2(t)$, $S_3(t)$, and B(t) the number of juveniles, one-, two-, and three-year-old subadults, and breeders in year t, respectively, and with *f* the birth rate, and *j*, *s*, and *b* the juvenile, subadult and breeder survival rates, respectively, one has

$$J(t+1) = fB(t+1) = f[S_3 s + bB(t)]$$

$$S_1(t+1) = J(t)j$$

$$S_2(t+1) = S_1(t)s \qquad (1)$$

$$S_3(t+1) = S_2(t)s$$

$$B(t+1) = S_3(t)s + B(t)b$$

and so the matrix model is

$$\begin{pmatrix} 0 & 0 & 0 & fs & fb \\ j & 0 & 0 & 0 & 0 \\ 0 & s & 0 & 0 & 0 \\ 0 & 0 & s & 0 & 0 \\ 0 & 0 & 0 & s & b \end{pmatrix}. \qquad (2)$$

Note that the term *fs* presumes that subadults surviving to adulthood are immediately effective as breeders. While this assumption may be biologically unrealistic, the model thereby produces the largest value of λ_p.

The eigenvalue equation for the matrix (2) is

$$-\lambda(\lambda^4 - b\lambda^3 - jfs^3) = 0 \qquad (3)$$

and so λ_p solves

$$\lambda^4 - b\lambda^3 - jfs^3 = 0\,. \qquad (4)$$

Hence, the value of λ_p for this model is the largest solution of this equation. Equation (4) was solved with MATLAB to yield λ_p = 1.0047 when f = 0.2313 j = 0.8397 s = 0.7944 b = 0.9087

The corresponding stable-stage distribution, scaled so that its components sum to one, is (J, S_1, S_2, S_3, B) = (0.136199,0.113801,0.090028,0.071134,0.588839).

Note that when 1.0047 is substituted into (4) the result is zero to four decimal places, this calculation serving as a check on the value for λ_p.

To compute the variance of λ_p by the delta method, one requires the partial derivatives of λ with respect to each of the other parameters. These partial derivatives may be computed easily by implicit differentiation of equation (4). One obtains:

$$\frac{\partial\lambda}{\partial f} = \frac{js^3}{\lambda^2(4\lambda - 3b)}$$

$$\frac{\partial\lambda}{\partial j} = \frac{fs^3}{\lambda^2(4\lambda - 3b)}$$

$$\frac{\partial\lambda}{\partial s} = \frac{3fjs^2}{\lambda^2(4\lambda - 3b)}$$

$$\frac{\partial\lambda}{\partial b} = \frac{\lambda}{4\lambda - 3b}.$$

The variance-covariance matrix is diagonal since the parameters are independent:

$$\Sigma = diag(Var(f), Var(j), Var(s), Var(b)).$$

If $V = (\frac{\partial\lambda}{\partial f}, \frac{\partial\lambda}{\partial j}, \frac{\partial\lambda}{\partial s}, \frac{\partial\lambda}{\partial b})$ the delta method asserts that

$$Var(\lambda) = V\Sigma V^T,$$

where V^T denotes the transpose of the row vector V. Consequently,

$$Var(\lambda) = Var(f)\left(\frac{\partial\lambda}{\partial f}\right)^2 + Var(j)\left(\frac{\partial\lambda}{\partial j}\right)^2 + Var(s)\left(\frac{\partial\lambda}{\partial s}\right)^2 + Var(b)\left(\frac{\partial\lambda}{\partial b}\right)^2$$

Computation yields $Var(\lambda)$ = 0.00057 and SE(λ) = 0.0240. Hence the confidence interval for λ_p, $\lambda_p \pm$ (1.96)SE(λ), is the interval (0.9577,1.0517).

GUIDELINES FOR SITING WIND TURBINES RECOMMENDED FOR RELOCATION TO MINIMIZE POTENTIAL COLLISION-RELATED MORTALITY OF FOUR FOCAL RAPTOR SPECIES IN THE ALTAMONT PASS WIND RESOURCE AREA

Draft of 23 May 2010

Alameda County SRC

SECTION 1. INTRODUCTION

The Scientific Review Committee (SRC) for Alameda County's Altamont Pass Wind Resource Area (APWRA) avian mortality monitoring program has prepared the following guidelines to assist the wind power companies in the APWRA with re-siting of wind turbines recommended by the SRC for removal or relocation. Relocation or removal recommendations were made for the purpose of minimizing the potential for collision-related mortality of four focal raptor species in the APWRA.

As a result of the SRC's process of identifying hazardous turbines and exploring and evaluating the topographic, wind pattern, bird behavior, and turbine siting variables related to hazardous conditions, the SRC was also able to provide guidance on relocation of hazardous turbines to sites that pose lower hazard to the four focal species.

These guidelines are intended to provide the wind companies with basic information regarding avian collision hazards associated with turbine siting in the APWRA that can be used to evaluate the risk of potential relocation sites as well as the possible increased risk created by non-operational turbines and removal of turbines. Initially released in August 2008, the guidelines were updated following the ratings of additional wind turbines by an SRC subcommittee composed of Jim Estep and Shawn Smallwood during March 2010.

Background

The Altamont Pass Wind Resource Area (APWRA) is known to cause hundreds of raptor fatalities per year due to wind turbine collisions alone (Howell and DiDonato 1991, Orloff and Flannery 1992, Smallwood and Thelander 2004, 2005, 2008, WEST, Inc. 2007). Because collision-related mortality of long-lived, protected species has continued largely unabated since the initial development of the APWRA, the recent renewal of the conditional use permits (CUPs) for the continued operation of existing, old-generation wind turbines proved controversial. To alleviate concerns expressed by members of the public and the resource agencies about the APWRA's impacts on raptors and other birds, the Alameda County Board of Supervisors introduced new requirements along with the renewal of the CUPs.

The Alameda County Board of Supervisors issued a resolution on 22 September 2005, which required the shutdown or relocation of Tier 1 and 2 turbines[1] according to a schedule (Exhibit G-2), as well as the removal of all derelict and non-operating turbines[2] by 22 September 2006. Following a settlement agreement between the County of Alameda and the plaintiffs in a legal challenge of the CUP renewals under the California Environmental Quality Act, the Board of Supervisors amended the resolution and associated CUPs on 11 January 2007. This amendment applied to the wind companies agreeing to the settlement. It maintained the shutdown and relocation requirements, but expanded them to the removal of all Tier 3 turbines by 31 October 2008. It also maintained the requirement that all derelict and non-operating turbines be removed by 22 September 2006. The original and amended resolution included additional requirements, but the most relevant requirements for the foregoing document were the shutdowns and relocations of the most hazardous wind turbines and the removal of derelict and non-operating wind turbines.

The resolution by the Board of Supervisors also required the formation of a scientific review committee (SRC), which was to "investigate, monitor and evaluate the effectiveness of the [Avian Wildlife Protection] Program" (Exhibits G-1 and G-2). After receiving input from the Permittees, the monitoring team, and state-sponsored research, the SRC was also to "recommend adjustments [to the Program], and design and implementation of alternative strategies" (Exhibits G-1 and G-2). The original resolution (Exhibit G-2) charged the SRC with recommending management actions aimed at achieving "progressive and substantial reductions in avian mortality and injuries," whereas the amended resolution (Exhibit G-1) charged the SRC with recommending management actions aimed at achieving a 50% reduction in wind turbine-related mortality of golden eagles, red-tailed hawks, American kestrels and burrowing owls, while also minimizing losses to wind power generation. Thus, the goals were not exactly the same for settling and non-settling companies, but the SRC's role was consistent in terms of recommending management actions to reduce bird mortality.

[1] Most hazardous wind turbines, based on a classification of hazard level developed by Smallwood and Spiegel (2005a,b,c).

[2] The CUPs did not explicitly define the term "derelict," but its use followed from language used in Smallwood and Thelander (2004), who intended it to mean towers lacking turbines or supporting non-functional turbines. Indeed, the CUPs address derelict and "non-operational turbines" in the same phrase. Confusion over the term emerged when the companies said that many of the towers without turbines or with non-functional turbines are simply "vacant," which means they are awaiting repair or new turbines to be mounted on them and placed back into service. Regardless of whether a tower is *vacant* or *derelict*, it poses an increased hazard to raptors, and is essentially the same thing until either the tower is removed or it supports a functional turbine.

As part of the SRC's investigation directed toward management recommendations, the full SRC visited the APWRA on 29 November – 1 December and on 10 December 2007. An SRC subcommittee consisting of Jim Estep and Shawn Smallwood visited the APWRA to rate more wind turbines during March 2010. The SRC relied on available research reports and their combined expertise to review the configuration and environmental setting of wind turbines at sites associated with large numbers of fatalities relative to the majority of the APWRA, and they identified candidate wind turbines that could be deemed relatively more hazardous to raptors (see SRC documents P67, P68, and P69). The SRC evaluated and ranked wind turbines according to their hazard to raptors, with the intent to consider mitigation actions involving permanent shut down and removal of the most dangerous turbines. The SRC ultimately recommended removal of high-ranking wind turbines, as well as removals of additional wind turbines if the wind companies' decided to shutdown all old-generation wind turbines for only part of the winter instead of the SRC's recommended four months over the winter. The SRC specifically recommended the following:

- Remove all towers and turbines rated 8 through 10 (SRC document P69);
- If the winter shutdown is not extended to at least 3 full search rotations (anticipated to be about 3 months), then remove towers and turbines rated 7 and 7.5; and,
- The SRC evaluates turbines and towers not previously evaluated for hazard and removal.

These recommendations were revised slightly based on the March 2010 visit by the subcommittee (see below). The SRC's rankings were later assessed by comparing mortality estimates from recent fatality monitoring data, and were found to contribute disproportionately to the mortality of golden eagles, red-tailed hawks and American kestrels (Smallwood 2008, 2010).

During the field trip, the SRC noticed many derelict or vacant wind towers which sometimes create vertical or lateral gaps[3] that raptors may incorrectly perceive as safer to fly through (SRC document P67). Also, raptors perch disproportionately more often on derelict or vacant towers, or on towers of non-operating turbines (Smallwood and Thelander 2004, 2005; Smallwood et al. 2009), which often places these raptors in close proximity to adjacent, functional turbines. Whenever derelict or vacant towers lure raptors closer to functional wind turbines, whether for

[3] Gaps refer to spacing between functional turbines that are wider than the average spacing along the row of turbines as originally sited or as has emerged due to one or more turbines being removed or becoming non-functional.

crossing perceived gaps or for perching, there is the chance of conspecific[4] or inter-specific interactions that could distract the raptors, leading to collisions.[5]

During the field trips, the SRC observed multiple opportunities for relocating wind turbines from relatively hazardous to safer locations, or to locations where overall safety to birds could be increased. The SRC concluded that the companies could likely relocate at least some of the wind turbines the SRC recommended for removal, with relocation sites subject to SRC approval. In order to provide a common understanding of the safest relocation sites and to facilitate the identification of these sites by wind energy companies, the SRC developed guidelines characterizing preferred relocation sites as well as sites to be avoided (see Section 3). In addition to the need for developing written guidelines, the SRC recognized that consultation with the companies' engineers may be needed to identify opportunities for relocation, as well as technical restrictions.

The primary goal of these guidelines and of subsequent deliberations between the companies and the SRC is to relocate turbines from more hazardous to less hazardous sites and remedy existing hazardous conditions due to vacant or derelict sites, ultimately contributing to a 50% reduction in raptor mortality in the APWRA.

SECTION 2. DESCRIPTION OF SITING FACTORS

The SRC's guidelines are based largely on published and unpublished results of research in the APWRA and personal observations and experience of SRC members. Some of the most influential experience was obtained during the SRC's four-day field trip, when the SRC was able to view the cumulative distribution of fatalities recorded by the Wildlife Reporting and Response system (WRRS)[6] and scientific research studies (Orloff and Flannery 1992, Smallwood and Thelander 2004, and unpublished, on-going monitoring data). The SRC related the distribution of these fatalities to topography and wind patterns, as well as to the arrangement of wind turbines. Research reports that identified factors associated with fatalities included Orloff and

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[4] "Conspecific" refers to individual(s) of the same species.

[5] Smaller birds often harass raptors while they are flying, causing them to defend themselves while fleeing the harassment. Larger-bodied raptors sometimes attack smaller-bodied raptors, in predatory-prey relationships. Also, raptors often chase individuals of the same species to defend territories or foraging space. While raptors are flying they often flush perched raptors, because the perched bird is at a strategic disadvantage. Flying raptors also sometimes change their flight direction to avoid another perched raptor, and if close by, the flying raptor will keep watch of the perched raptor. All of these types of interactions are distracting to a flying bird, and can lead to collisions.

[6] WRRS is the self-monitoring program used by the wind companies.

Flannery (1992, 1996), Smallwood and Neher (2004), Smallwood and Thelander (2004, 2005), Smallwood et al. (2007), and Smallwood et al. (2009). The biological resources section of the repowering EIR (Alameda County 1998) also contributed to the SRC's knowledge of factors associated with raptor fatalities.

The causal factors of raptor collisions with wind turbines appear to be interaction effects of raptor flight patterns with topography, wind patterns, and the arrangement of functional and non-functional wind turbines/towers. Flight patterns associated with foraging, e.g., hovering and kiting, have been most often linked to collisions, largely because most of the eye-witness accounts of red-tailed hawk and American kestrel collisions involved these behaviors. Raptors often forage where they can utilize slope-accelerated winds[7] to power their flights and to hold their positions while scanning for prey items. The spatial patterns of golden eagle fatalities among wind turbines also appear consistent with contour hunting by golden eagles.[8] Clusters of fatalities also occur where raptors have often been viewed foraging and crossing the terrain, including relatively low-lying areas, such as through canyons, ravines, saddles in and between ridges, and at the base of shoulders of hills or ridges. Steeper slopes are also associated with more fatalities.

Raptor fatalities at wind turbines have also been associated with wind turbines at the ends of turbine rows. Behavior data suggest at least some raptor species may perceive both the individual wind turbine and the row of wind turbines as units to be avoided, prompting raptors to more often attempt to fly around the entire turbine row. More frequent flights by the end-of-row turbine may be one reason why these turbines are often associated with more fatalities. Another reason for the association would be the frequent occurrence of end-of-row turbines at locations lower on the slopes, or on steeper slopes, where raptors often fly or where they may have less control of their flights. More recently, the wind companies have left derelict towers at the ends of rows as an alternative to perch-free flight diverters recommended by Richard Curry Associates (1997) and Smallwood and Thelander (2005a,b), and these derelict towers may have increased fatalities at the last functional turbine in the row, next to the derelict tower, because the end-of-row derelict towers likely attract raptors looking for perch sites. Wind turbines next to gaps in turbine strings have also sometimes been associated with fatalities, perhaps because raptors misperceive gaps created by vacant tower pads[9] or derelict or vacant towers as safe

[7] Slope-accelerated winds are winds that are accelerated due to being pushed up the slope or through a ravine or canyon. Typically, winds are strongest at the top of the slope facing the wind, or where the slope facing the wind breaks over to a gentler gradient.

[8] Contour hunting is flying relatively close to the terrain, quickly adjusting flight surfaces in complex winds to maintain a similar distance from the ground while traversing multiple slopes. The strategy is intended to surprise prey items by suddenly appearing from over a narrow ridgeline or from around the corner.

[9] "Vacant tower pads" are turbine addresses lacking turbines or towers.

crossing points through the turbine row. Also, raptor behavior and fatality data have indicated an avoidance of denser turbine fields[10] (Smallwood and Thelander 2004, 2005; Smallwood, Lee Neher, Doug Bell, Joe DiDonato, Brian Karas, Sara Snyder, and Sal Lopez, unpublished data in submitted final report to Public Interest Energy Research Program), and greater mortality at more isolated turbines and at turbines at the edges of the wind farm or local turbine fields (Smallwood and Thelander 2004, 2005).

Additional fatality associations have been documented or suspected, including at wind turbines nearby rock piles, trees, ponds, transmission towers, litter control fences outside the perimeter of the landfill, and electric distribution poles. Some of these features might attract perching raptors, thereby placing perched raptors near functional wind turbines. As suggested earlier, perched raptors can interact with other animals. They can attack prey items from the perch, they can change flight paths of conspecifics or other smaller-bodied raptor species, and they can be flushed by other raptors. These types of interactions can distract birds, leading to collisions with wind turbines.

SECTION 3. SITING GUIDELINES

The siting guidelines apply primarily to wind turbine relocations. *Relocation* refers to turbines that have been recommended for removal due to hazardous conditions for which these guidelines can assist the wind companies in selecting a less hazardous relocation site. The guidelines may also apply to turbines that are removed or become derelict in the future, causing hazardous conditions that can be created by newly vacant or derelict sites. The guidelines may also be useful for siting new wind turbines as part of repowering.[11] However, these guidelines apply specifically to wind turbine 'addresses,' which are the locations permitted for wind turbine operations.

These guidelines, which are not intended for any other locations that were not permitted with an existing wind turbine address as of January 2006, list the features of preferred sites or settings into which wind turbines can be relocated. The guidelines also list features of sites or settings into which wind turbine relocations are discouraged. The guidelines are deliberately not ranked, because the SRC recognizes that each of the thousands of wind turbine addresses in the APWRA have unique combinations of conditions that can mitigate or enhance the hazard associated with individual factors. As the SRC continues its efforts to understand the conditions under which a turbine location presents excessive hazards to birds, then there may be additional settings or

[10] A turbine field is a group of turbines, sometimes but not always of the same model, that are relatively separated from other groups of turbines. An example would be the AES-owned Micon 65-KW turbines near Mountain House.

[11] Repowering is the replacement of existing, old-generation wind turbines with new, modern turbines.

situations not covered in these guidelines that the SRC later determines to be too hazardous for a wind turbine relocation.

Preferred Relocation Sites or Settings

a. Hill peaks, ridge crests, and relatively even terrain to fill gaps due to presently derelict or vacant towers, or empty pads (Photos 1 and 2);

b. Wind walls[12] where vacant or derelict towers create vertical or lateral gaps between functional turbines (Photo 3);

c. Into turbine rows that already occur in high density, i.e., to increase the density of an already dense turbine field (Photo 4);

d. Interior to the turbine row to fill small gaps created by the removal of a turbine or where vacant towers occur as potential perch sites, except in cases where a gap in the interior of a turbine row is large enough to provide a safe flight path, and where relocating a turbine into that gap would result in a smaller unsafe gap (Photos 5 and 6);

e. Slopes that are leeward to one or two prevailing wind directions or that are set back from slopes facing prevailing wind directions (Photo 7); and,

f. Interior to a turbine field, unless the location is within a ridge saddle or on a steep slope, or unless other factors about the site outweigh the hazard reduction that may be achieved by the site's interior location.

Discouraged Relocation Sites or Settings

a. Sites classified as Tier 1, Tier 2, or Tier 3 according to any of the Tier classifications developed by Smallwood and Spiegel (2005a,b,c), unless the proposed new turbine arrangement creates a situation where a relocation to one of these addresses would improve safety to birds;

b. Ends of turbine rows, especially where the end of the row is at the edge of a steep slope, on a steep slope, or in a saddle, ravine, or canyon (Photo 8);

[12] Wind walls are rows of wind turbines mounted on towers at two heights above the ground, so that turbines on shorter towers are immediately in front of turbines on taller towers.

c. Where raptor fatalities have been reported previously, or potential flight paths have been identified such as through excessively long rows, unless the conditions associated with greater hazard have since changed so that the particular locations are no longer as hazardous;

d. Saddles of ridges or saddles between ridges, and especially where saddles form the apex of ravines that face a prevailing wind direction (Photos 9 through 13) or especially where these types of slope conditions occur in combination with nearby electric distribution lines (Photo 14) or other tall structures;

e. On benches of hill slopes or ridges, or just at the base of shoulders of hills, i.e., in locations of sudden elevation changes, where a raptor more often decides to fly while contouring around the slope (Photos 15, 16, and 20);

f. On or immediately adjacent to steep slopes (Photo 17);

g. At the edges of turbine fields or at the edge of the wind farm, unless the relocation somehow reduces the hazard posed by other nearby wind turbines occurring at the edge;

h. Next to artificial rock piles or natural rock formations, so long as addresses of equal or lesser hazard are available where there are no rock piles or rock formations within 100 meters (Photo 18);

i. Next to streams or ponds (Photo 13);

j. Next to transmission towers, electric distribution poles, or litter control fence around the landfill (Photos 19 and 20);

k. Where slope-accelerated winds would likely position a raptor at the height domain of the rotor plain of functional turbines (Photo 21), including where lips in the slope can locally accelerate winds used by hovering or kiting American kestrels (Photo 22);

l. Gaps in strings that are large enough for birds to safely cross (Photo 223);

m. Locations remote from other functional wind turbines, or more isolated locations; and,
n. Where turbine rows suddenly change directions (Photo 24).

Photo 1. The two derelict towers to either side of this functional turbine on the ridge crest should either be removed or put back into service. If the derelict towers are removed, then the interior functional turbine should also be removed.

Photo 2. A derelict tower interior to the turbine row and at the top of the hill would be a relatively safer relocation site.

Photo 3. Turbines missing from tall towers in wind walls (e.g., red highlight at left) can create vertical and lateral gaps in turbine operations, which might be misperceived by raptors as safe perches or fly-through locations. Turbines removed from shorter towers, such as the functional one highlighted on the right, can also create vertical and lateral gaps.

Photo 4. Where possible, turbine relocations should be directed to the interior aspect of relatively denser turbine fields.

Photo 5. Turbine relocations would be relatively safer at towers interior to the turbine rows and atop a hill or ridge.

Photo 6. Turbine relocations would be relatively safer at towers interior to the turbine rows and atop a hill or ridge.

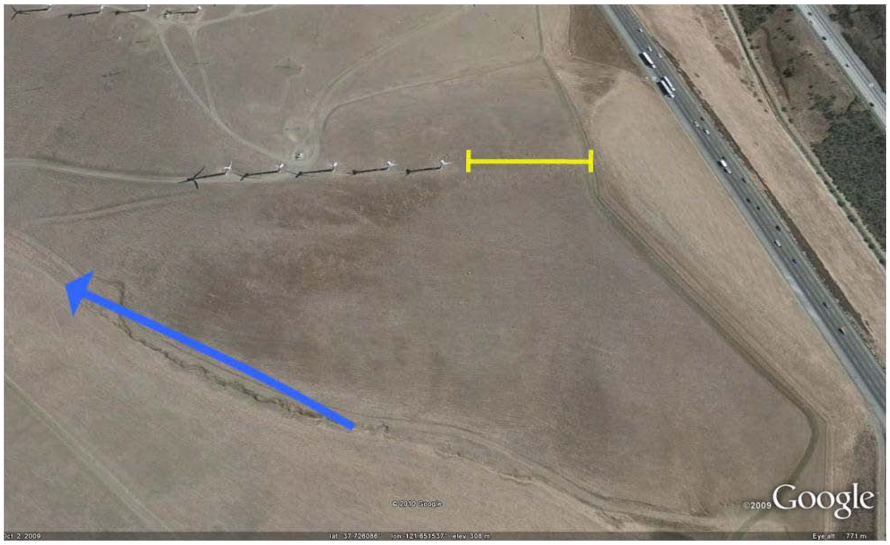

Photo 7. Turbine relocations would be relatively safer where they are set back (see yellow bar) from steep slopes facing prevailing wind directions (blue arrow).

Photo 8. Turbines should not be relocated to ends of turbine rows, especially where the towers are next to steep slopes or ravines, such as the derelict tower on the right side of the turbine row in the foreground.

Photo 9. Turbines should be relocated to hill peaks or ridge crests (e.g., green highlight), but not to saddles in the ridge (red highlight).

Photo 10. Turbines should not be relocated to ridge saddles, especially in a situation like above, where trees and rock formations occur nearby.

Photo 11. Turbines should not be relocated to ridge saddles, especially where declivity winds from a prevailing wind direction funnel into the saddle, as in the red zone at the right side of this photo.

Photo 12. Wind turbines should not be relocated to saddles formed by the meeting of two ridges.

Photo 13. Wind turbines should not be relocated to saddles or to the lower aspects of a ravine or canyon, especially not next to a pond or stream.

Photo 14. Slope-accelerated winds can be hazardous where wind turbines are sited, and especially if electric distribution lines or other tall structure provide American kestrels or other raptors additional perching opportunities near the wind turbines.

Photo 15. Wind turbines should not be relocated to shoulders of the ridge or hill, or where the slope suddenly changes, such as seen in this photo.

Photo 16. Wind turbines should not be relocated to shoulders of the ridge or hill, or where the slope suddenly changes, such as seen in this photo. This is especially true for long turbine rows like this one, where opportunities for raptors to fly through gaps are absent.

Photo 17. Derelict towers should not be put back into service where they abut steep slopes or ravines.

Photo 18. Derelict towers should not be put back into service where they occur near rock piles or trees or other structures that may be attractive for perching or hunting. In the photo above, rock piles appear just this side of the derelict tower, which should be removed. Note, however, that removing the derelict tower would result in a potentially hazardous gap in the turbine string, suggesting the importance of fully evaluating all hazardous conditions before a relocation or removal decision is made.

Photo 19. Avoid relocating wind turbines next to transmission towers or other perch sites.

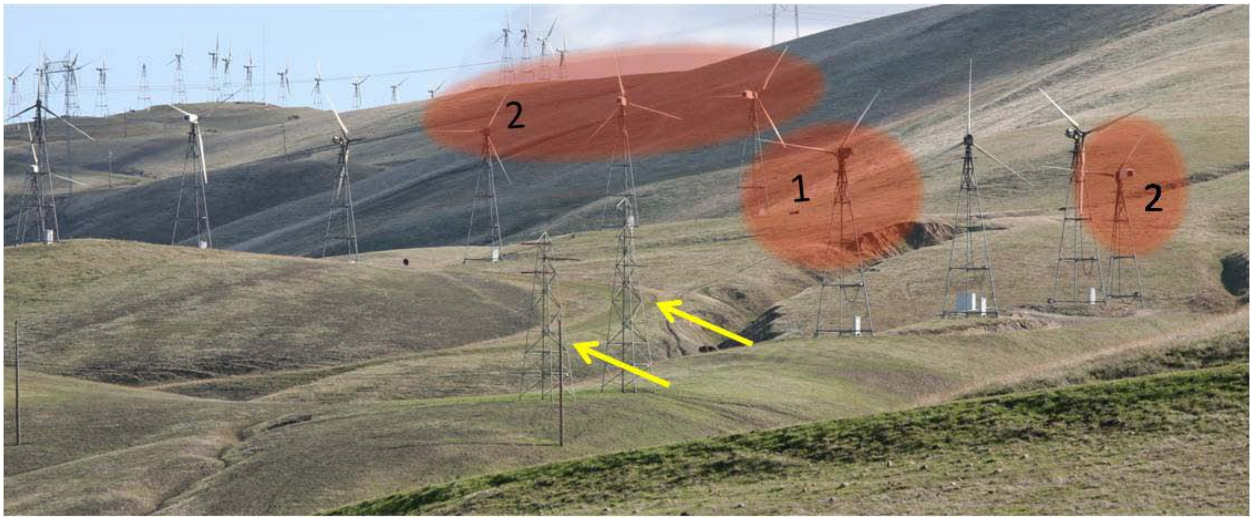

Photo 20. Avoid relocating wind turbines near transmission towers (1) or other perch sites, or to shoulders of the hill (2).

Photo 21. Wind turbines should not be relocated to locations on the slope where downslope hill morphology pushes the wind toward these locations from two different prevailing wind directions. In this photo, the red highlight identifies a portion of the air space where winds will be pushed to greater speeds by winds blowing from the northwest, west, southwest, and south.

Photo 22. Lips formed in the slope either naturally or due to grading for roads or wind turbine laydown areas might also encourage American kestrels to hover or kite in moderate and strong winds in front of wind turbines.

Photo 23. Wind turbines should not be relocated to towers within otherwise wide gaps between other turbines, such as seen above.

Photo 24. Wind turbines can be more hazardous where turbine rows zig-zag in direction (yellow arrow), especially where slope-accelerated winds (blue arrows) intersect the change in direction of the turbine row.

SECTION 4. IMMEDIATE NEXT STEPS

The SRC proposes the following steps for developing a near-term relocation plan:

1. The companies decide how many and which of the wind turbines they wish to relocate rather than remove, following the SRC's recommended removals of identified wind turbines;

2. The companies decide where they would prefer to relocate the removed turbines, and then provide a map of these locations to the SRC, as well as all current locations of potential other relocation addresses (empty pads, and derelict or vacant towers);

3. The SRC reviews the proposed relocation sites and considers other identified addresses, if needed;

4. The companies' engineers inform the SRC of which of their suggested alternative relocation addresses are infeasible and why; and

5. The SRC recommends a final relocation plan following steps 1-4, and which is directed toward immediate implementation.

The final relocation plan would be intended for immediate implementation for the purpose of achieving a 50% mortality reduction of raptors during the interim period preceding repowering of the Altamont Pass Wind Resource Area. Following the final relocation plan, the SRC recommends a relocation program for the future, during which the companies take the lead on using the SRC's relocation guidelines to evaluate the hazards associated with candidate relocations.

SECTION 5. RELOCATION PROGRAM FOR THE FUTURE

Given that wind turbine removal and relocations will continue throughout the time when wind turbines are operating in the Altamont Pass, and given that these removals and relocations will change the arrangement of wind turbines, there is a need to initiate a program to assess the collision hazards of wind turbines as they are removed or relocated. As wind turbines are removed or relocated, not only will the hazard status of the relocated turbines change, but so will the adjacent turbines from where the turbine was removed and to where the turbine will be relocated. The SRC recommends that the companies regularly update the SRC or a subcommittee of the SRC on planned or recent turbine removals and relocations. Alternatively, the companies could work with the SRC to train a company employee to assess the hazard status of turbines as removals and relocations are planned. These steps are necessary to ensure sustained confidence by the SRC in effectiveness of the turbine relocation management strategy outlined in these guidelines.

The final near-term relocation plan recommended by the SRC (see step 5 in Section 4) could identify turbine addresses to where the SRC feels it would be safer to relocate turbines during the subsequent relocation program. The SRC should meet and confer annually to identify new candidate relocation sites in order to remain current with changes in the APWRA. These new candidate addresses could be put into map form for implementation by the designated company employee or the SRC subcommittee.

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Bird Mortality in the Altamont Pass Wind Resource Area, California

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ABSTRACT The 165-km^2 Altamont Pass Wind Resource Area (APWRA) in west-central California includes 5,400 wind turbines, each rated to generate between 40 kW and 400 kW of electric power, or 580 MW total. Many birds residing or passing through the area are killed by collisions with these wind turbines. We searched for bird carcasses within 50 m of 4,074 wind turbines for periods ranging from 6 months to 4.5 years. Using mortality estimates adjusted for searcher detection and scavenger removal rates, we estimated the annual wind turbine–caused bird fatalities to number 67 (80% CI = 25–109) golden eagles (*Aquila chrysaetos*), 188 (80% CI = 116–259) red-tailed hawks (*Buteo jamaicensis*), 348 (80% CI = −49 to 749) American kestrels (*Falco sparverius*), 440 (80% CI = −133 to 1,013) burrowing owls (*Athene cunicularia hypugaea*), 1,127 (80% CI = −23 to 2,277) raptors, and 2,710 (80% CI = −6,100 to 11,520) birds. Adjusted mortality estimates were most sensitive to scavenger removal rate, which relates to the amount of time between fatality searches. New on-site studies of scavenger removal rates might warrant revising mortality estimates for some small-bodied bird species, although we cannot predict how the mortality estimates would change. Given the magnitude of our mortality estimates, regulatory agencies and the public should decide whether to enforce laws intended to protect species killed by APWRA wind turbines, and given the imprecision of our estimates, directed research is needed of sources of error and bias for use in studies of bird collisions wherever wind farms are developed. Precision of mortality estimates could be improved by deploying technology to remotely detect collisions and by making wind turbine power output data available to researchers so that the number of fatalities can be related directly to the actual power output of the wind turbine since the last fatality search. (JOURNAL OF WILDLIFE MANAGEMENT 72(1):215–223; 2008)

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KEY WORDS Altamont Pass, bird fatalities, mortality estimate, raptor mortality, wind energy, wind turbine.

The Altamont Pass Wind Resource Area (APWRA) began operations during the 1980s and by 1998 included about 5,400 wind turbines of various models (Fig. 1). The rated capacities of these wind turbines ranged from 40 kW to 400 kW but most ranged from 100 kW to 150 kW. If the APWRA were to generate the 580 MW of capacity for which the wind farm was rated, it would have supplied emission-free electric power sufficient for the needs of about 230,000 homes. However, beginning with the first installations, these wind turbines also killed birds that flew into the rotating blades, most species of which are protected by the Migratory Bird Treaty Act (MBTA) and some of which are protected by other state and federal laws (Table 1). Accurate estimates of the APWRA's impacts on birds are needed to decide how much effort to direct towards mitigating the impacts and to alert decision-makers of the potential impacts on birds that could be caused by other wind farms.

Annual deaths previously attributed to the APWRA's wind turbines included 28–43 golden eagles (*Aquila chrysaetos*) reported by the wind power companies (Hunt et al. 1999). Scientific estimates during 1989 and 1990, respectively, were 81 ± 112 (95% CI) and 0 ± 112 golden eagles, 121 ± 136 and 104 ± 234 medium-sized raptors such as Buteo hawks, 227 ± 416 and 82 ± 451 American kestrels (*Falco sparverius*), and 429 and 186 raptors of all species (Orloff and Flannery 1992). Estimates of annual mortality during 1998–2003 were 76–116 golden eagles, 881–1,300 raptors, and 1,767–4,721 birds (Smallwood and Thelander 2004, 2005), though these estimates were admittedly crude.

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Our first objective was to estimate mortality, which could serve as a comparative baseline to assess the effectiveness of future mitigation measures and to assess potential impacts of other proposed wind farm projects. Mortality estimates also may help with formulation of compensatory mitigation and might contribute to cumulative impacts analysis of other proposed activities in the region. Our second objective was to critically assess the precision of estimates to identify needed improvements in methodology applied to mortality monitoring. This assessment is needed because mortality estimates are being compared among wind farms for hypothesis testing (Madders and Whitfield 2006, Barclay et al. 2007) and for assessing the relative magnitude of impacts caused by wind turbines (Erickson et al. 2001), even though most estimates compared have not been peer reviewed or examined closely for consistency in methods and assumptions.

STUDY AREA

The APWRA encompassed about 165 km^2 of hilly terrain covered mostly by nonnative, annual grasses in eastern Alameda and southeastern Contra Costa Counties, California, USA (Fig. 1). Grasses and forbs grew during the rainy months of January through March, and were dead or dormant by early June. Elevations ranged from 78 m to 470 m above mean sea level. Ridges and hills generally extended northwest to southeast, bisected by intermittent streams and ravines. Cattle grazers held most of the land, leasing out wind energy rights to wind power companies.

Wind turbines were arranged in rows of up to 62 turbines, typically along ridge crests (i.e., peaks of the ridge features)

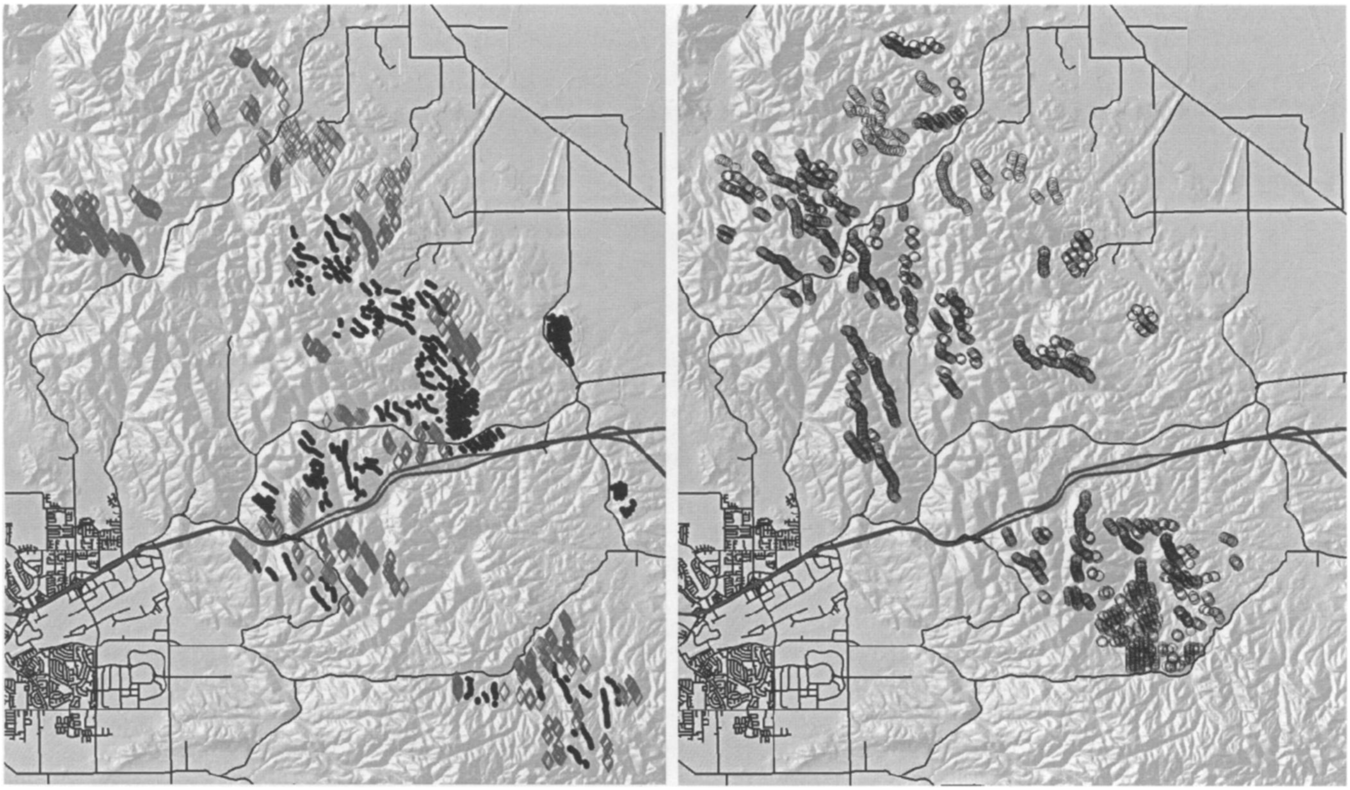

Figure 1. Relative search effort devoted to each wind turbine in the study in the Altamont Pass Wind Resource Area (APWRA), California, USA. In the left map solid circles denote turbines searched between March 1998 and September 2002 (set 1) and open diamonds denote wind turbines not searched (set 3), and in the right map open circles denote turbines searched November 2002 until May 2003 (set 2). Livermore appears at the lower left corners, and the thick line cutting through the APWRA from Livermore is Highway 580. Other lines represent paved roads in the area. The east–west extent of each map is about 17.7 km.

and ridgelines extending down toward ephemeral streams. Wind turbine rows also occupied slopes, valleys, and hill peaks and all operated in winds from any direction, although most winds originated from the northwest or southwest. Wind turbines in the APWRA included KCS-56 100-kW turbines on lattice towers (Kenetech Windpower Inc., Livermore, CA), 120-kW and 150-kW turbines on tubular towers (Bonus Wind Turbines, Inc., Brande, Denmark), 150-kW and 250-kW vertical axis turbines (FloWind Corp., San Rafael, CA), 40-kW turbines on lattice towers (Enertech Corporation, Norwich, VT), and Micon 65-kW turbines on tubular towers (Moerup Manfacturing Co., Randers, Denmark). Others on tubular towers included 330-kW (James Howden and Company, Renfrew, Scotland), 110-kW (Danwin A/S, Helsingor, Denmark), 65-kW (Nordtank Energy Group, Balle, Denmark), 250-kW (Wind Energy Group, Ltd., Southall, Middlesex, England), Polenko 100-kW (Holec Power Systems, Inc., Livermore, CA), and 75-kW to 300-kW turbines (Windmaster, Byron, CA). Others on lattice towers included 65-kW (Windmatic, Herring, Denmark) and 100-kW turbines (Vestas Wind Systems A/S, Randers, Denmark). KVS-33 400-kW turbines (Kenetech Windpower Inc.) occurred on both lattice and tubular towers. Tower heights ranged from 14 m to 43.1 m above ground, with blades extending from 4 m to 52 m above ground at their lowest and highest reaches, respectively.

METHODS

We searched for bird carcasses at 1,526 wind turbines in 182 rows from March 1998 through September 2002 (hereafter set 1). We added groups of wind turbines into set 1 as we gained access, and we searched all of them 6–34 ($\bar{x} = 18$) times. From November 2002 until May 2003 we searched another 2,548 turbines arranged in 380 rows (hereafter set 2). We accessed set 2 turbines 6 months before our study ended, and searched them only twice. We selected set 2 turbines systematically from the unsearched turbines to achieve maximal north–south, east–west representation of the APWRA and to intersperse the unsearched turbines (hereafter set 3). In total, we searched for bird fatalities at 75% of the APWRA's wind turbines (Fig. 1), and we performed 32,439 fatality searches, where a fatality search was one search covering 50 m around one turbine.

Because wind turbines in our study area were arranged in rows, we searched them efficiently by walking strip transects along both sides and around the ends. Two field biologists explored the ground, maintaining about 4–6 m between parallel transect segments, which extended to 50 m away from the centerline of the wind turbine row. An earlier study in the APWRA found 96% of the carcasses deposited by wind turbines were $\leq$50 m from the turbine (Orloff and Flannery 1992), and we found 85–88% of the carcasses $\leq$50 m from the turbine (Smallwood and Thelander 2004). Our

Table 1. Status and summary of birds found killed by wind turbines in the Altamont Pass Wind Resources Area, California, USA, May 1998–May 2003.[a]

Species or taxonomic group	Species name	Status	All wind turbine–caused fatalities	Carcasses used in mortality estimates
Golden eagle	*Aquila chrysaetos*	BGEPA, CSC, CFP, PBP	54	29
Red-tailed hawk	*Buteo jamaicensis*	PBP	213	156
Ferruginous hawk	*Buteo regalis*	CSC, PBP	2	2
Buteo spp.	*Buteo* spp.	PBP	23	0
Northern harrier	*Circus cyaneus*	CSC, PBP	3	3
White-tailed kite	*Elanus leucurus*	CFP, PBP	1	0
Prairie falcon	*Falco mexicanus*	CSC, PBP	3	3
American kestrel	*Falco sparverius*	PBP	59	55
Turkey vulture	*Cathartes aura*	PBP	6	3
Barn owl	*Tyto alba*	PBP	50	40
Great horned owl	*Bubo virginianus*	PBP	18	11
Burrowing owl	*Athene cunicularia hypugaea*	PBP	70	67
Raptors		PBP	17	4
Double-crested cormorant	*Phalacrocorax auritus*	CSC	1	1
Black-crowned night heron	*Nycticorax nycticorax*		2	2
Cattle egret	*Bubulcus ibis*	exotic	1	1
Mallard	*Anas platyrhynchos*		35	26
Ring-necked duck	*Aythya collaris*		1	1
American avocet	*Recurvirostra americana*		3	3
Lesser yellowlegs	*Tringa flavipes*		1	1
Ring-billed gull	*Larus delawarensis*		4	4
California gull	*Larus californicus*	CSC	7	7
Gulls	*Larus* spp.		18	8
Northern flicker	*Colaptes auratus*		6	6
Mourning dove	*Zenaida macroura*		34	34
Rock dove	*Columba livia*	exotic	196	183
Wild turkey	*Meleagris gallopavo*	exotic	1	1
Common raven	*Corvus corax*		12	9
American crow	*Corvus brachyrhynchos*		5	4
Brown-headed cowbird	*Molothrus ater*		2	2
Brewer's blackbird	*Euphagus cyanocephalus*		13	13
Red-winged blackbird	*Agelaius phoeniceus*		12	12
Tricolored blackbird	*Agelaius tricolor*	CSC	1	1
Blackbirds			1	1
European starling	*Sturnus vulgaris*	exotic	67	57
California horned lark	*Eremophila alpestris actia*	CSC	23	22
Western meadowlark	*Sturnella neglecta*		96	96
Western kingbird	*Tyrannus verticalis*		1	1
Pacific-slope flycatcher	*Empidonax difficilis*		1	1
Loggerhead shrike	*Lanius ludovicianus*	CSC	5	4
Cliff swallow	*Hirundo pyrrhonota*		5	5
Violet-green swallow	*Tachycineta thalassina*		1	1
Northern mockingbird	*Mimus polyglottos*		1	1
Mountain bluebird	*Sialia currucoides*		5	4
Yellow warbler	*Dendroica petechia brewsteri*	CSC	1	1
Savannah sparrow	*Passerculus sandwichensis*		2	2
House finch	*Carpodacus mexicanus*		14	12
House sparrow	*Passer domesticus*	exotic	1	1
Cockatiel	*Nymphicus hollandicus*	exotic	1	1
Passerine			16	12
Unknown small birds			42	27
Raptors as a group		PBP	519	373
All birds as a group			1,157	941

[a] The following abbreviations represent special status of the species: BGEPA = Bald and Golden Eagle Protection Act, CFP = California Fully Protected, CSC = California Department of Fish and Game listing of California Species of Concern, and PBP = Protection of Birds of Prey under California Fish and Game Code 3503.5. The Migratory Bird Treaty Act protects all species in the table except wild turkey, rock dove, European starling, house sparrow, and cockatiel.

carcass searches averaged 8–10 minutes per wind turbine, which we performed 5 hours per day using 2-person crews, so each crew searched 30–40 wind turbines per day. Most set 1 turbines were given roughly similar search effort over the time spans searched ($\bar{x} = 7.2$ searches/yr).

We documented as fatalities all carcasses or body parts we found, such as groups of flight feathers, head, wings, tarsi, and tail feathers. When possible, we identified carcasses to species, age class, and sex, and we classified each species as either small-bodied ($\leq$38 cm in body length) or large-bodied ($>$38 cm). We assigned each carcass a probable cause of death based on injuries and proximity to hazards such as wind turbines, roads, or electric distribution poles. We attributed predation to carcasses with feathers plucked and scattered. Wind turbine injuries included severed or twisted torso, decapitation, severed wing(s), tail, or leg(s), and other forms of blunt force trauma. We estimated the number of days since death by assessing carcass condition. Generally we assumed carcasses older than 90 days if the enamel on culmen and talons had separated from the bone, flesh was gone, and bones and feathers were bleached, but we used considerable judgment because carcass decomposition rates vary according to environmental conditions. The presence of blood generally indicates <4 days since death, but the onset of rigor mortis, odor, and maggots or other insect larvae vary greatly with temperature, so we had to use these signs as guides in the context of current environmental conditions to estimate the number of days since death. We photographed most carcasses upon discovery, and we placed some in cages in the field to monitor decomposition. We reported all fatalities to the wind turbine owners, who collected the carcasses and deposited them with the United States Fish and Wildlife Service.

Within each turbine row we expressed unadjusted mortality (M_U) as number of fatalities/MW/year, where MW was the sum of the megawatts of rated power outputs for all of the wind turbines in the row surveyed. Although individual turbines killed birds, we used the wind turbine row as our study unit because we believed birds often sensed and reacted to the wind turbine row as a barrier or threat. We added 3 months to the number of years used in the mortality estimate, to represent the time period when carcasses could have accumulated before our first search. We excluded from mortality estimates all fatalities estimated to have occurred >90 days before discovery, and we excluded 9 carcasses found incidentally after all search rotations had ceased at a particular row. We included carcasses found outside the search radius during searches because we assumed the likelihood of seeing carcasses outside the search radius would not vary significantly among turbine rows in the APWRA's short-stature grassland.

We adjusted our mortality estimate, M_A, for carcasses not found due to searcher detection error and scavenger removals as

$$M_A = \frac{M_U}{pR} \quad (1)$$

where M_U was unadjusted mortality expressed as number of fatalities/MW of rated capacity per year, p was the proportion of turbine-caused bird fatalities found by searchers during searcher detection trials, R was the estimated proportion of carcasses remaining since the last fatality search and estimated by scavenger removal trials (Smallwood 1997). We calculated its standard error, SE[M_A], using the delta method (Goodman 1960):

$$\mathrm{SE}[M_A] = \left[\left(\frac{1}{pR} \times \mathrm{SE}[M_U]\right)^2 \times \left(\frac{M_U}{p} \times \frac{-1}{R^2} \times \mathrm{SE}[R]\right)^2 \times \left(\frac{M_U}{R} \times \frac{-1}{p^2} \times \mathrm{SE}[p]\right)^2\right]^{1/2}. \quad (2)$$

We did not perform searcher efficiency and scavenger removal trials in the APWRA but instead used estimators of searcher detection and scavenger removal rates developed by Smallwood (1997), who synthesized results from reported searcher detection and scavenger removal trials performed in wind farms throughout the United States.

Search detection rates were 51% (SE = 2.133%) for small nonraptor birds, 78% (SE = 5.384%) for medium and large nonraptor birds (including rock doves [*Columba livia*]), 75% (SE = 9.129%) for small raptors, and 100% (SE = 0%) for large raptors, based on averages among reports of searcher detection trials in grasslands across the United States (Smallwood 1997). To predict the proportion of carcasses remaining after each successive day into scavenger removal trials or into the periods intervening fatality searches, we used logarithmic models developed using least squares regression for small-bodied nonraptor birds (SE = 0.158), medium and large-bodied nonraptor birds (SE = 0.129), small-bodied raptors (SE = 0.040), and large-bodied raptors (SE = 0.089), and we used a linear model developed for rock dove (SE = 0.080; Smallwood 1997, table 4).

Assuming wind turbines will deposit carcasses at a steady state, for each species group we averaged the above model predictions across the number of days equaling the average number of days between fatality searches for all set 1 and set 2 turbines:

$$R_C = \frac{\sum_{I}^{i=1} R_i}{I \times 100} \quad (3)$$

where R_C was the cumulative carcasses remaining, R_i was the percent of carcasses remaining by the ith day following the initiation of a scavenger removal trial and corresponding with the number of days since the last fatality search, and I was the average number of days between fatality searches among set 1 and set 2 turbines.

We made no adjustment for background mortality, which is usually small, nor did we adjust estimates for crippling bias, search radius bias, and carcasses removed by wind turbine maintenance personnel or by administrators of the Wildlife Response and Reporting System (WRRS), which was the industry's system of reporting of carcasses found incidentally by turbine maintenance personnel. Background mortality is mortality caused by factors independent of the wind turbines and their supporting infrastructure. Crippling bias refers to number of birds mortally injured by the wind turbines but which die undetected somewhere else. Search radius bias refers to number of birds killed by wind turbines but thrown beyond the search radius and not found. Most of these potential adjustments would increase mortality estimates by unknown degrees by adding undiscovered fatalities to the total. Another potential source of error is the proportion of turbine rows where we recorded zero fatalities but where scavengers might have removed carcasses prior to our searches, or where our searches missed carcasses. We did not adjust these zero-values for searcher detection and scavenger removal errors because zero divided by p or R equals zero.

For each species, we estimated mortality separately for set 1 and set 2 turbines, even though mortality did not differ between the sets for 75% of the species. We calculated the APWRA-wide mean mortality as the weighted mean from sets 1 and 2:

$$M_{A,3} = \frac{(M_{A,1} \times 153.25 \text{ MW}) + (M_{A,2} \times 267.09 \text{ MW})}{418.255 \text{ MW}} \quad (4)$$

where $M_{A,1}$, $M_{A,2}$, and $M_{A,3}$ were adjusted mortality estimates for turbine sets 1, 2, and 3, respectively, and set 3 represented the 25% of the turbines not searched and which equaled the weighted mean adjusted mortality across the APWRA. Set 1 wind turbines composed 153.25 MW of rated capacity and set 2 composed 267.09 MW. The set 3 wind turbines were interspersed with the turbines we searched (Fig. 1), and they were of the same models. We treated the set 2 mortality estimates as if they were annual estimates, but we did not search the set 2 turbines during summer. All mortality estimates represented mortality caused directly by wind turbines and did not include fatalities caused by electrocution on the power collection system, collisions with overhead power lines, or collisions with automobiles traveling the wind turbine service roads.

RESULTS

We found 1,157 bird fatalities attributed to wind turbine collisions (Table 1). Of these, we excluded 216 from mortality estimations because they were either estimated to have been killed >90 days before discovery or they were found after the last of the searches at a particular wind turbine row (Table 1). To the unadjusted mortality estimates (Table 2), we used equations 1–3 to factor in search detection and scavenger removal rates quantified from other studies to arrive at adjusted mortality estimates (Table 3).

Adjusted mortality differed significantly between sets 1 and 2 for American crow (*Corvus brachyrhynchos*), California gull (*Larus californicus*), cliff swallow (*Hirundo pyrrhonota*), great horned owl (*Bubo virginianus*), house finch (*Carpodacus mexicanus*), California horned lark (*Eremophila alpestris actia*), mallard (*Anas platyrhynchos*), mourning dove (*Zenaida macroura*), ring-billed gull (*Larus delawarensis*), rock dove, red-winged blackbird (*Agelaius phoeniceus*), and turkey vulture (*Cathartes aura*; $P < 0.05$ in each case), so we used equation 4 to calculate APWRA-wide adjusted mortality as the weighted mean between turbine sets 1 and 2. Before adjusting mortality estimates for searcher detection and scavenger removal rates, we estimated the APWRA's wind turbines annually killed ≥56 golden eagles, 168 red-tailed hawks (*Buteo jamaicensis*), 55 American kestrels (*Falco sparverius*), 80 burrowing owls (*Athene cunicularia hypugaea*), 434 raptors, and 1,058 birds (Table 3). After adjusting estimates for searcher detection and scavenger removal rates, we estimated wind turbine collisions in the APWRA annually killed 67 (80% CI = 25–109) golden eagles, 188 (80% CI = 116–259) red-tailed hawks, 348 (80% CI = −49 to 749) American kestrels, 440 (80% CI = −133 to 1,013) burrowing owls, 1,127 (80% CI = −23 to 2,277) raptors, and 2,710 (80% CI = −6,100 to 11,520) birds (Table 3).

DISCUSSION

We estimated collisions with wind turbines in the APWRA killed 434 raptors and 1,058 birds before factoring in carcasses not found due to searcher detection error and scavenger removal. Factoring in search detection and scavenger removal, we estimated the APWRA's wind turbines killed 1,127 raptors and 2,710 birds, and possibly as many as 2,277 raptors and 11,520 birds. Follow-up fatality monitoring in the APWRA in 2005–2006, using similar methods and assumptions, preliminarily supported equal if not greater estimates of wind turbine–caused mortality of raptors and other birds (W. P. Erickson, WEST, Inc., unpublished data), so levels of mortality we detected have continued into 2006. However, because the follow-up monitoring used similar methods, uncertainty ranges will be similarly large.

Even though we performed many more fatality searches over twice as long a time period compared to past research efforts in the APWRA, our mortality estimates were imprecise. The lower bound annual mortality estimate of most species was <0. A principal source of our imprecision was long intervals between fatality searches, averaging 53 days between searches in set 1 and 90 days in set 2. Scavenger removal trials indicated that our average search interval among set 1 turbines would on average present our fatality searchers with only 21% of small-bodied bird carcasses and 18% of small-bodied raptor carcasses deposited by the wind turbines since the previous fatality search (Smallwood 1997). Scavenger removal trials indicated our search interval among set 2 turbines would on average present fatality searchers with only 12% of small-bodied bird carcasses and 11% of small-bodied raptor carcasses. Thus, mortality estimates for these groups of birds were increased 5- to 10-fold due to scavenger removal, but only at wind turbine rows where we found ≥1 carcass. We made no adjustments at the many wind turbine rows where we found zero birds.

Our mortality estimates are not alone in their imprecision. Most of the lower limit estimates of the 90% confidence interval were <0 at the Tehachapi and San Gorgonio Wind Resource Areas, California, even though these mortality estimates were made for multispecies groups such as raptors, waterbirds, and passerines (Anderson et al. 2004, 2005). Most of the lower limits of the 95% confidence interval were <0 at Foote Creek Rim Wind Plant, Wyoming, USA (Young et al. 2003). All of the mortality estimates of multispecies groups in the APWRA during 1989–1991 were associated with 95% confidence interval lower limits <0 (Orloff and Flannery 1992). It appears mortality monitoring at wind farms has repeatedly produced imprecise mortality

Table 2. Summary of unadjusted mortality estimates for 2 sets of wind turbines in the Altamont Pass Wind Resources Area, California, USA, searched at different time periods and for different durations and intersearch intervals.[a]

Species or taxonomic group	Mortality (deaths/MW/yr)					
	Set 1 turbine rows		Set 2 turbine rows		All turbine rows	
	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Golden eagle	0.0359	0.0118	0.1384	0.0679	0.0967	0.0477
Red-tailed hawk	0.3245	0.0656	0.2652	0.0885	0.2893	0.0805
Ferruginous hawk	0.0000	0.0000	0.0382	0.0273	0.0227	0.0175
Northern harrier	0.0029	0.0018	0.0000	0.0000	0.0012	0.0007
Prairie falcon	0.0047	0.0030	0.0000	0.0000	0.0019	0.0011
American kestrel	0.0703	0.0166	0.1115	0.0390	0.0947	0.0310
Turkey vulture	0.0108	0.0064	0.0000	0.0000	0.0044	0.0023
Barn owl	0.0720	0.0256	0.0315	0.0161	0.0480	0.0197
Great horned owl	0.0309	0.0128	0.0043	0.0043	0.0151	0.0074
Burrowing owl	0.1789	0.0325	0.1110	0.0692	0.1386	0.0561
Raptor spp.	0.0000	0.0000	0.0605	0.0346	0.0359	0.0221
Double-crested cormorant	0.0037	0.0037	0.0000	0.0000	0.0015	0.0014
Black-crowned night heron	0.0020	0.0014	0.0000	0.0000	0.0008	0.0005
Cattle egret	0.0000	0.0000	0.0027	0.0027	0.0016	0.0017
Mallard	0.0697	0.0258	0.0121	0.0121	0.0356	0.0172
Ring-necked duck	0.0000	0.0000	0.0036	0.0036	0.0021	0.0023
American avocet	0.0121	0.0102	0.0000	0.0000	0.0049	0.0037
Lesser yellowlegs	0.0010	0.0010	0.0000	0.0000	0.0004	0.0004
Ring-billed gull	0.0155	0.0095	0.0000	0.0000	0.0063	0.0035
California gull	0.0158	0.0073	0.0000	0.0000	0.0064	0.0027
Gull spp.	0.0076	0.0042	0.0137	0.0087	0.0112	0.0071
Northern flicker	0.0152	0.0096	0.0204	0.0169	0.0183	0.0143
Mourning dove	0.1705	0.0571	0.0231	0.0122	0.0830	0.0287
Rock dove	0.5244	0.1120	0.1248	0.0468	0.2873	0.0709
Wild turkey	0.0028	0.0028	0.0000	0.0000	0.0011	0.0010
Common raven	0.0230	0.0148	0.0097	0.0097	0.0151	0.0116
American crow	0.0284	0.0169	0.0000	0.0000	0.0115	0.0062
Brown-headed cowbird	0.0033	0.0033	0.0241	0.0241	0.0157	0.0166
Brewer's blackbird	0.0230	0.0106	0.0512	0.0342	0.0397	0.0257
Red-winged blackbird	0.0399	0.0135	0.0000	0.0000	0.0162	0.0050
Tricolored blackbird	0.0020	0.0020	0.0000	0.0000	0.0008	0.0007
Blackbird spp.	0.0049	0.0049	0.0000	0.0000	0.0020	0.0018
European starling	0.1329	0.0302	0.1362	0.0657	0.1349	0.0530
Horned lark	0.0468	0.0122	0.0000	0.0000	0.0190	0.0045
Western meadowlark	0.2197	0.0440	0.2024	0.0783	0.2095	0.0661
Western kingbird	0.0013	0.0013	0.0000	0.0000	0.0005	0.0005
Pacific-slope flycatcher	0.0033	0.0033	0.0000	0.0000	0.0013	0.0012
Loggerhead shrike	0.0218	0.0150	0.0000	0.0000	0.0089	0.0055
Cliff swallow	0.0154	0.0079	0.0000	0.0000	0.0063	0.0029
Violet-green swallow	0.0012	0.0012	0.0000	0.0000	0.0005	0.0005
Northern mockingbird	0.0048	0.0048	0.0000	0.0000	0.0019	0.0018
Mountain bluebird	0.0056	0.0049	0.0183	0.0150	0.0131	0.0114
Yellow warbler	0.0018	0.0018	0.0000	0.0000	0.0008	0.0007
Savannah sparrow	0.0043	0.0043	0.0043	0.0043	0.0043	0.0043
House finch	0.0515	0.0198	0.0000	0.0000	0.0209	0.0072
House sparrow	0.0000	0.0000	0.0080	0.0080	0.0048	0.0051
Cockatiel	0.0015	0.0015	0.0000	0.0000	0.0006	0.0006
Passerine spp.	0.0370	0.0142	0.0256	0.0231	0.0302	0.0199
Unknown small bird	0.0420	0.0130	0.0654	0.0243	0.0559	0.0203
All raptors as a group	0.7309	0.1761	0.7604	0.3469	0.7484	0.2860
All birds as a group	2.2869	0.6661	1.5060	0.7365	1.8236	0.7144

[a] Set 1 included 153.25 MW of rated capacity from 1,526 wind turbines in the search rotation through May 1998 September 2002. Set 2 included 267.09 MW from 2,538 wind turbines in the November 2002 through May 2003 rotation. We calculated the values in the all turbine rows columns as the weighted means from sets 1 and 2.

estimates. The methodology needs to be changed (see Management Implications).

Our mortality estimates did not include birds killed by autos, guyed meteorological towers, and the power collection system (i.e., overhead power lines and energized pole-mounted equipment), though we did record these fatalities when we found them. Our estimates also did not include injured birds dying undetected elsewhere or birds removed by the wind turbine owners without our knowledge. (A postproject review of WRRS indicated some birds were

Table 3. Summary of adjusted mortality estimates for two sets of wind turbines in the Altamont Pass Wind Resources Area, California, USA, searched at different time periods and for different durations and intersearch intervals.[a]

Species or taxonomic group	Unadjusted annual deaths	Adjusted mortality (deaths/MW/yr)		Adjusted annual deaths		
		$\bar{x}$	SE	$\bar{x}$	Lower bound of 80% CI	Upper bound of 80% CI
Golden eagle	56.1	0.115	0.056	66.7	24.7	108.7
Red-tailed hawk	167.8	0.324	0.096	187.8	116.4	259.3
Ferruginous hawk	13.2	0.028	0.021	16.1	0.5	31.7
Northern harrier	0.7	0.001	0.001	0.7	0.1	1.2
Prairie falcon	1.1	0.002	0.001	1.1	0.2	2.0
American kestrel	54.9	0.599	0.540	347.6	−53.7	748.8
Turkey vulture	2.6	0.004	0.003	2.5	0.6	4.5
Barn owl	27.8	0.052	0.022	30.2	13.5	46.9
Great horned owl	8.8	0.016	0.008	9.1	2.9	15.3
Burrowing owl	80.4	0.759	0.771	440.0	−133.4	1013.4
Raptor spp.	20.8	0.044	0.027	25.5	5.4	45.5
Double-crested cormorant	0.9	0.002	0.004	1.3	−1.4	4.0
Black-crowned night heron	0.5	0.001	0.001	0.7	−0.3	1.7
Cattle egret	0.9	0.003	0.006	2.0	−2.5	6.5
Mallard	20.6	0.058	0.052	33.8	−4.8	72.3
Ring-necked duck	1.2	0.005	0.008	2.7	−3.4	8.7
American avocet	2.8	0.007	0.010	4.2	−3.3	11.7
Lesser yellowlegs	0.2	0.001	0.001	0.3	−0.4	1.1
Ring-billed gull	3.7	0.010	0.009	5.5	−1.3	12.4
California gull	3.7	0.010	0.007	5.6	0.3	10.9
Gull spp.	6.5	0.022	0.025	12.9	−5.4	31.1
Northern flicker	10.6	0.066	0.361	38.3	−230.5	307.1
Mourning dove	48.1	0.208	0.594	120.7	−320.9	562.3
Rock dove	166.6	0.325	0.157	188.6	72.2	305.0
Wild turkey	0.6	0.002	0.003	1.0	−1.0	3.0
Common raven	8.8	0.027	0.035	15.4	−10.7	41.4
American crow	6.7	0.017	0.017	9.8	−2.7	22.4
Brown-headed cowbird	9.1	0.065	0.427	37.9	−279.3	355.1
Brewer's blackbird	23.0	0.153	0.831	88.6	−529.4	706.5
Red-winged blackbird	9.4	0.035	0.060	20.1	−24.7	65.0
Tricolored blackbird	0.5	0.002	0.007	1.0	−4.2	6.2
Blackbird spp.	1.2	0.004	0.017	2.5	−10.3	15.2
European starling	78.2	0.469	2.177	271.8	−1346.9	1890.5
Horned lark	11.0	0.041	0.062	23.6	−22.5	69.8
Western meadowlark	121.5	0.716	3.193	415.1	−1959.1	2789.3
Western kingbird	0.3	0.001	0.005	0.7	−2.7	4.0
Pacific-slope flycatcher	0.8	0.003	0.011	1.7	−6.9	10.2
Loggerhead shrike	5.2	0.019	0.055	11.0	−29.7	51.7
Cliff swallow	3.7	0.013	0.031	7.8	−15.1	30.6
Violet-green swallow	0.3	0.001	0.004	0.6	−2.6	3.8
Northern mockingbird	1.1	0.004	0.017	2.4	−10.0	14.8
Mountain bluebird	7.6	0.052	0.310	30.3	−200.1	260.8
Yellow warbler	0.5	0.002	0.006	0.9	−3.9	5.7
Savannah sparrow	2.5	0.015	0.087	8.6	−55.7	73.0
House finch	12.1	0.045	0.084	26.0	−36.3	88.3
House sparrow	2.8	0.021	0.140	12.0	−92.3	116.3
Cockatiel	0.3	0.001	0.005	0.8	−3.2	4.7
Passerine spp.	17.5	0.099	0.483	57.1	−302.2	416.5
Unknown small bird	32.4	0.206	1.000	119.5	−623.9	862.9
All raptors as a group	434.1	1.943		1,127.2	−22.8	2,277.2
All birds as a group	1,057.7	4.672		2,710.0	−6,099.8	11,519.8

[a] Set 1 included 153.25 MW of rated capacity from 1,526 wind turbines in the search rotation through May 1998 September 2002. Set 2 included 267.09 MW from 2,538 wind turbines in the November 2002 through May 2003 rotation.

removed without our knowledge.) Therefore, our estimates were incomplete in their representation of the APWRA's overall impacts on birds. Furthermore, we were unable to assess how the fatalities affected local or regional bird populations or whether the birds killed were residents or migrants.

Hunt (2002) concluded the local golden eagle population appeared stable during his 1994–2000 study, which overlapped ours, despite the wind turbine–caused mortality. W. G. Hunt (Santa Cruz Predatory Bird Research Group, personal communication) also concluded the golden eagles killed in the APWRA were local birds. However, we have not seen evidence refuting the possibility that many of the golden eagles killed by APWRA wind turbines may have been floaters from populations elsewhere in the western United States, Mexico, and Canada. If recruitment from other populations can continue to replace members of the local nesting population, despite the number killed by wind turbines, then the local number of nesting pairs may not change noticeably. If local bird populations produce fewer birds than the numbers killed by the wind turbines, then we would regard the APWRA as an ecological sink because more birds would be coming into the APWRA than leaving it.

Smallwood et al. (2007) concluded the APWRA might serve as an ecological sink to burrowing owls because turbine-caused mortality might equal or exceed local production. However, Smallwood et al. (2007) estimated annual mortality of 99–380 burrowing owls in the APWRA, which was lower than our estimate of 345–1,219. Our estimate is greater because Smallwood et al. (2007) relied on results of a scavenger removal trial using surrogate, nonraptor species in eastern Oregon, USA (W. P. Erickson and J. Jeffrey, WEST, Inc., unpublished data), whereas we relied on a recently developed predictive model (Smallwood 1997) based on a removal trial using small-bodied raptor species in the APRWA (Orloff and Flannery 1992).

Our incorporation of the set 2 turbines likely introduced a seasonal bias to our mortality estimates because we conducted no fatality searches during summer. Also, the longer search interval used among set 2 turbines usually produced larger standard errors for species and species groups found at both set 1 and set 2 turbines. However, we felt the bias and statistical error introduced by incorporating set 2 turbines were offset by the spatial distribution of these turbines across the full north–south and east–west extent of the APWRA. Including the set 2 turbines offset the bias of extrapolating the mortality estimates from the set 1 turbines, which were clustered in the east-central portion of the study area.

MANAGEMENT IMPLICATIONS

Despite low precision in estimated numbers of birds killed annually by APWRA wind turbines, our fatality counts and resulting mortality estimates demonstrated that ongoing operations kill relatively large numbers of raptors and other birds protected by the MBTA and other environmental laws. Regulatory agencies and the public need to decide whether to enforce laws intended to protect species killed by APWRA wind turbines, and whether to enforce the wind power companies' compliance with their conditional use permits. Alternative, safer wind turbine designs could be explored, as well as preproject site screening for likely wildlife impacts. Replacing the existing wind turbines with new-generation models on taller towers might reduce the APWRA's bird mortality $\geq$70% (K. S. Smallwood, unpublished data; W. P. Erickson, unpublished data). Unavoidable impacts could be compensated through habitat protections.

Assessments of proposed new wind power projects should regard existing reports of mortality as imprecise and likely lower than actual mortality levels. Until the uncertainties and biases of mortality estimates can be reduced through directed research, mitigation plans should account for the imprecision in mortality estimates by using adaptive management principles. Funds are needed to support monitoring and research and could be provided as part of the cost of wind farm development and operation. To improve precision of mortality estimates, fatality monitoring should include shorter search intervals (e.g., every other day at a sufficient sample of turbines), and needs to last $\geq$3 years. Fatality monitoring needs species-specific scavenger removal rates based on methods improved through directed research, and the extent of crippling bias needs to be learned. Mortality estimates should be expressed in terms of kilowatt-hours, so fatality monitors should be provided power output data from each wind turbine on a schedule corresponding with the fatality searches. Developing technologies to remotely detect collisions could vastly improve mortality estimation, while also cutting costs. Also, resident birds need to be tagged and monitored to learn the extent to which wind turbine collisions affect local populations.

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Subcontractor Report

Bird Risk Behaviors and Fatalities at the Altamont Pass Wind Resource Area

Period of Performance: March 1998–December 2000

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EXECUTIVE SUMMARY

It has been documented that wind turbine operations at the Altamont Pass Wind Resource Area kill large numbers of birds of multiple species, including raptors. We initiated a study that integrates research on bird behaviors, raptor prey availability, turbine design, inter-turbine distribution, landscape attributes, and range management practices to explain the variation in avian mortality at two levels of analysis: the turbine and the string of turbines. We found that inter-specific differences in intensities of use of airspace within close proximity did not explain the variation in mortality among species. Some species, however, spent more time flying within 50 m of turbines than expected based on the area within this proximity zone, and they spent less time within 51-100 m or 101-300 m, indicating that these species were drawn into the lands near turbines for some reason(s).

Unique suites of attributes relate to mortality of each species, so species-specific analyses are required to understand the factors that underlie turbine-caused fatalities. We found that golden eagles are killed by turbines located in the canyons and that rock piles produced during preparation of the wind tower laydown areas related positively to eagle mortality, perhaps due to the use of these rock piles as cover by desert cottontails. The degree of clustering of pocket gophers around wind towers related positively to red-tailed hawk mortality, and the degree of clustering of gophers appeared to be greatest on steeper slopes into which laydown areas and access roads were cut, thereby producing increased lateral and vertical edge (which gophers prefer for constructing their burrow systems).

Tubular towers killed more red-tailed hawks and other raptors than would be expected from their numbers within our study area, and this pattern was even stronger for areas in which the tubular towers occurred on ridge tops and other landscape features that produced strong declivity winds. Rotor speed correlated positively with mortality, as did rotor height above the ground and rotor diameter. The windswept area of the turbine string, meaning the cumulative rotor-swept areas of all turbines in the string, correlated positively with mortality of several avian species. Factoring in the windswept area eliminated the effect of turbine position in the string, which some had thought to be an important factor for avian mortality, and which was verified by our data prior to factoring in the windswept area. Raptor fatalities did not correspond well with the distribution of California ground squirrels. Other similar relationships between fatalities and environmental factors are identified and discussed. The tasks remaining to complete the project are summarized.

1.0 INTRODUCTION

Research has consistently documented since about 1989 that wind turbines in the Altamont Pass Wind Resource Area (APWRA) kill a large number of birds, especially raptors (Orloff and Flannery 1992, 1996; Howell 1997; Howell and DiDonato 1991). Early researchers mainly focused on locating kills and quantifying bird fatality rates. Although these researchers hypothesized various causes and mechanisms associated with these fatalities, their research results were too cursory to lend much confidence even to the hypothesis tests that were performed. It soon became evident that if solutions to the problem were to be developed, then it would be necessary to conduct a risk assessment and a risk reduction study (Anderson et al., 1999).

In March 1998, the National Renewable Energy Laboratory (NREL) initiated research to address some complex questions that affect both wind energy development and wildlife conservation. What is the full extent of bird fatalities in the APWRA? What are the underlying causes of the fatalities? Are these events non-random and therefore, predictable? If they are, then what management options might be developed to reduce risk? In an effort to reduce the complexity surrounding these questions, we present the following framework for addressing and interpreting factors related to bird fatalities at the APWRA.

Step 1	Natural behaviors, geographic distributions, and ecological relationships that predispose wildlife to harm due to turbine operations	→	Sensitivity
Step 2	Placement and operation of wind farm structures and related management activities that pose threats to wildlife	→	Vulnerability
Step 3	Mortality due to wind farm operations; proportions of populations killed (risk)	→	Impacts
Step 4	Reliable prediction of impacts from indicators of sensitivity and vulnerability	→	Solutions

In the above framework, the integration of Steps 1 through 3 leads to Step 4 and its solutions. An empirical model developed in Step 4 can be broadly applied to predict *impacts* using quantitative measurements of factors that relate to *sensitivity* and *vulnerability*, terms which are drawn from the ecological indicators framework (Rapport, Reiger, and Hutchinson 1985; Cairns and McCormick 1992; O'Neill et al., 1994; Rotmans et al., 1994; Schultze et al., 1994; USDA 1994; Battaglin and Goolsby 1995; for an example, see Zhang, Geng, and Smallwood 1998) and defined below.

These terms are useful for our purposes because, although we would like to estimate levels of risk for each bird species at the APWRA, we cannot do so because we cannot enumerate each species at and around the APWRA. A true estimate of risk requires that the estimate of mortality be put into context with the total population size. Whereas the risk per species would be the preferred product of our research, solutions to avian mortality at the APWRA can be efficiently derived from the above framework.

1.1 Natural Behaviors and Ecological Relationships: Sensitivity

Birds die when attempting to pass through the rotor plane or when flying into guy wires or perching atop electrical distribution poles that service the wind farm. These attempts to fly through the rotor plane ultimately express natural behaviors, but in an artificial context in which the rotor plane has been introduced along with the other land uses and structures that are characteristic of wind farms. Natural behaviors and ecological relationships of birds contribute to their inherent sensitivity to wind turbines. Since each bird species exhibits unique suites of behaviors, geographic distributions, and ecological relationships, each also possesses unique sensitivities to wind farms. For example, if golden eagles (*Aquila chysaetos*) spend most of their foraging time in canyons, then they may be more sensitive to the placement of wind turbines in canyons. Red-tailed hawks (*Buteo jamaicensis*) may be less sensitive to turbine placement in canyons and perhaps more sensitive to turbines placed on ridgelines, if ridgelines happen to be where they fly most often. Burrowing owls (*Athene cunicularia*) might be most sensitive to turbine placement in areas where they conduct most of their courtship displays or where their foraging takes them into the altitudes of the rotating turbine blades. Thus, sensitivity is estimated by measuring and comparing behaviors that could cause individual species to collide with wind turbines should these behaviors continue unaltered after wind turbines are placed into operation.

Orloff and Flannery (1996) suggested that some birds try to pass through the rotor plane because they simply cannot see rotating turbine blades, or in the case of raptors, because they are fixated on a perch or prey item situated beyond the blades. Raptors may identify a perch or prey item and continuously observe it until they capture or land on it. If the raptor’s target is located behind the rotating blades of a turbine, then the raptor may not see the blades or may see them when it is too late to avoid them. The relative effects of retinal smear (Hodos et al., 2001) versus fixed focus on prey items remains unknown, as does the degree to which these two factors might interact. But the frequent fatalities of non-raptorial birds summarized in this report indicate that fixed focus on prey items is not the only reason birds attempt to pass through the rotor plane.

Certain flight behaviors might influence a species' sensitivity to wind turbines, such as their long-distance flight behaviors during migration and their use of declivity winds, which are strong winds passing over ridge tops as they are forced upslope. Patterns of perching might connote various levels of sensitivity, if, for example, certain birds are prone to perching on wind towers because these towers simulate trees with which the species is familiar. Certain mating behaviors might distract individuals regardless of whether turbines are operating in the vicinity. Nocturnal predators may be more sensitive than diurnal predators due to differences in sensory perception relied upon by animals during the night versus the day. Lastly, some bird species that occur in relatively high numbers in the study area may only fly at heights well above the current rotor blades, thus indicating low sensitivity to the wind farm. For these and other potential inter-specific differences in sensitivity associated with flight behaviors, future changes in turbine design, operation, and placement might yield different mortalities among bird species at the APWRA.

The best approach for estimating sensitivity is to do so in a study with a before-after control impact (BACI) design with replication of impact and control treatments (Anderson et al., 1999). However, our study could not implement such a design because we were working with wind towers that were developed prior to the initiation of our study. In the absence of the ideal study design, in which we characterize bird behaviors at the APWRA prior to wind turbine operations, we made what inferences we could about sensitivity of bird species to placement and operation of wind turbines (summarized in the Preliminary Results section).

1.2 Exposure to Wind Farm Operations: Vulnerability

The placement and operation of wind turbines can make birds vulnerable to turbine collisions when and where these birds are already sensitive to turbines due to relative abundance, behaviors, and ecological relationships (e.g., predator-prey interactions). Vulnerability is a relative term that requires the measurement of sensitivity and impact across ranges of environmental conditions within the study area. Quantifying vulnerability requires a comparison of both the bird use of the environment near turbines and bird deaths to the availability of wind turbines within the environmental elements of interest, such as types of physical relief, seasons, and proximity to prey species.

Measures of vulnerability can be based on relative abundance near wind turbines and/or on the relative mortality of avian species at turbines with particular attributes. In both cases, a use-and-availability analysis using chi-square test statistics is an effective means of testing whether particular levels of vulnerability are significant.

As an example of applying use-and-availability analysis, relative abundance can be measured as the proportion of the sampling periods that each bird species is observed flying over landscape element A, and this proportion of flight time is related to the proportion of landscape element A occurring within the study area. Bird mortality can be measured as the proportion of the sample of individuals killed at turbines of a particular type or environmental setting relative to the proportion of those types or settings in which the turbines in the study area occur.

Vulnerability due to placement of wind turbines on certain landscape elements (as an example of any environmental element that one wishes to measure) can be expressed by the following model:

$$\frac{\chi^2 \ Observed}{\chi^2 \ Expected} = \frac{n_i}{N p_i},$$

where, in the case of measuring use of the areas near turbines, n = flight time of a particular species near turbines on landscape element i, N = total flight time of the species on the sampled landscape; and where, in the case of measuring mortality, n_i = number of individuals of the species killed at wind turbines on landscape element i, and N = total number of the species killed within the landscape area being sampled; and in both cases, p_i = proportion of the sampled landscape composed of landscape element i. In summary, our study attempts to identify the vulnerability of bird species to strikes with wind turbines based on our weighted measurements of sensitivity and impacts.

1.2.1 Wind Tower Design, Location, and Operation

Orloff and Flannery (1992, 1996) and Hunt (1994) suggested that wind turbines placed near gullies and turbines located at the ends of strings might be more dangerous to birds. The inter-tower spacing and the height of turbine towers and rotor diameters might interact to affect a species' vulnerability to turbine collisions. In addition, the percent of time that wind turbines operate may also be an important factor in bird collisions (Orloff and Flannery 1996).

Orloff and Flannery (1992) suggested that birds perched on certain turbine/tower configurations more often than they did on others, thus increasing the birds' risk at these sites because of the proximity to the turbines' rotating blades. In their comparative analysis of fatality rates among five tower configurations (lattice towers, horizontal cross, vertical axis, guyed pipe, and tubular), Orloff and Flannery (1992) reported significantly higher fatality rates at sites with horizontal lattice towers (i.e., at Kenetech 56-100 units). Certain characteristics of these facilities are believed to have contributed to high bird mortality, including numerous potential raptor perch sites created by the horizontal reinforcing crossbars, a high percentage of time in operation, and a relatively fast "tip speed," which is the rotational velocity of the tip of the rotor blade.

Wind turbines may be especially dangerous during unsettled weather conditions or in periods of poor visibility, such as during fog, rain, darkness, dusk, or dawn (Avery, Springer, and Cassel 1977; Taylor and Kershner 1986; Morrison 1996). Even inoperative turbines may be dangerous. Furthermore, during spring or fall bird migrations, the absolute number of bird fatalities might increase simply in proportion to the larger number of individuals passing through the APWRA, or migrants may be more or less sensitive to turbines than are residents. (Note that migrating raptors often fly at much lower altitudes than migrating passerines.)

The development of wind resource areas can sometimes bring with it numerous additional artificial perching and nesting sites, such as wires that support wind towers, the towers themselves, electrical distribution poles, meteorological towers, and transmission lines. These facilities could attract birds to a wind resource area, thus bringing them closer to turbine blades (Orloff and Flannery 1992). Some of these facilities of the wind resource area pose potential additional hazards to that of rotating turbine blades, such as stationary obstacles encountered during flight and energized elements used for perching.

Some researchers have suggested that modifying the structure or color of the towers or the turbine blades may reduce bird fatalities. For example, modifying towers might reduce perching, and painting disruptive patterns on turbine blades might make them more evident to birds (Kerlinger and Curry 1997). A recently proposed rotor blade painting scheme might enable birds to more clearly see rotating blades at shorter distances than unpainted rotating blades (Hodos et. al, 2001). Reducing golden eagle prey populations in the APWRA through intensive ground squirrel population control programs might modify that species' habitat use and thus might reduce risk of being killed by a turbine (Kerlinger and Curry 1997; G. Hunt, pers. comm.), although the overall risk of death to the eagle might increase as local prey availability declines. These suggestions have not been sufficiently tested to justify their implementation as solutions.

1.2.2 Altered Prey Availability

The development of the APWRA likely affected the distributions, abundance, and availability of prey species (Morrison 1996). Soil disturbance may have increased the numbers of ground squirrels (*Spermophilus beecheyi*), and the reduction of grass height in the presence of cattle grazing may have increased squirrel vulnerability to raptors (Morrison 1996). It may be possible to use habitat alterations to reduce prey vulnerability near turbines, thereby reducing raptor use of these areas as well as fatalities. This suggestion also remains untested.

Raptor mortality at wind turbines has been attributed to the occurrence of prey species near the wind turbines. At the APWRA, the principal prey species of interest to past researchers has been California ground squirrels, based on its status as a major prey item of golden eagles in central California (University of California, 1998). However, pocket gophers (*Thomomys bottae*) are abundant throughout the APWRA, whereas ground squirrels have an uneven, patchy distribution, as we will demonstrate with data in this and future reports. Red-tailed hawks and great horned owls rely heavily on pocket gophers (Fitch, Swenson, and Tillotson 1946; Craighead and Craighead 1956; Orians and Kuhlman 1956), whereas golden eagles rely more heavily on larger prey items, such as ground squirrels and lagomorphs (Carnie 1954, Olendorff 1976). California vole (*Microtus californicus*) populations likely also influence the distributions of raptor species, as likely do small reptiles, amphibians, and arthropods, which are fed upon by burrowing owls and American kestrels, as examples. Each raptor species foraging in the APWRA responds uniquely to prey species availability and thus requires independent analysis. (Previous studies have tended to group species into *raptors* and *nonraptors* for analysis.)

1.3 Measuring Effects on Birds: Impacts

Avian mortality studies conducted at wind resource areas have produced a variety of mortality estimates. Howell and DiDonato (1991) sampled the APWRA's turbines in 1988-89 and reported 0.05 deaths per turbine per year (n = 17 fatalities). Orloff and Flannery (1996) conservatively estimated that 39 golden eagles were killed during a 1-year period in the APWRA, and they estimated raptor mortality to range from 0.02-0.05 deaths/turbine/year. During a 1-year period, Howell (1997) confirmed 72 turbine-caused fatalities during an 18-month period at two wind resource areas, the APWRA and the Montezuma Hills WRA. Bird fatalities consisted of 44 raptors and 28 non-raptors with a mean raptor mortality of 0.03 deaths/turbine/year.

The effects of turbine operations on birds can be interpreted from two perspectives: legal and biological. From a legal perspective, individual fatalities can be considered significant effects and subject to civil or criminal penalties. Federal laws protecting raptors specifically include the Migratory Bird Treaty Act (MBTA), the Bald Eagle and Golden Eagle Protection Act, and the Endangered Species Act. Raptors are also protected under California Fish and Game Code 3503.5, which makes it illegal to take, possess, or destroy any bird in the Order Falconiformes or Strigiformes. The MBTA prohibits killing any bird species designated as fully protected. The U.S. Fish and Wildlife Service (USFWS) considers “take” to be any injury or fatality of any raptor from a collision with a wind turbine or ancillary facilities in the APWRA, and therefore, a violation of the MBTA (S. Pearson, pers. comm.., Senior Resident Agent, USFWS). Bird fatalities attributable to wind turbines are significant effects, from a legal perspective, because they violate the MBTA.

Comparing the turbine-caused mortality to both the natural mortality and the recruitment rate of each affected species effectively measures the biological importance of turbine-caused fatalities. Doing so yields estimates of the degree to which wind turbines adversely affect a species' population size, stability, and distribution. However, to do so requires extensive information about the distribution and demographic structure of populations occurring at and around the APWRA. Simply counting living birds at the APWRA would be inadequate for this purpose because the numbers of multiple species would change dramatically throughout the year due to migrations. The numerical estimates made at the APWRA would be, in multiple cases, contaminated by individuals that live most or part of their lives elsewhere. The APWRA may directly affect any number of bird species that occur over a broad geographic area. Thus, the geographic scale required for estimating impacts to avian species would be much larger than the APWRA itself. Our scope of study will not allow inferences of population-level or regional impact assessments to be made, but it is important to consider that these impacts are possible and should be estimated by additional research.

Among the raptor species killed in the APWRA, golden eagles and burrowing owls are probably the species of greatest concern because they are California Species of Special Concern. Although no detailed studies are currently underway to address burrowing owls, a recent study of mortality factors and golden eagle population regulation over a broad geographic region specifically included the APWRA within its overall study area (Hunt 1994, 1997, 2002). In recent years, golden eagle deaths in the area have been attributed to wind turbines. Preliminary research results indicate that the additional effect of the turbine-related fatalities might be contributing to a long-term decline in the region's golden eagle population (Hunt 1994, 1997, 2002). Therefore, although turbines might not cause a species to decline across its entire geographic range, the cumulative effect of human-caused fatalities may extirpate a species over a portion of its range.

Until more rigorous research efforts like the one for golden eagles are conducted at the APWRA for each bird species adversely affected by wind turbines, the full environmental impact of the APWRA will remain unknown. We will not know how the killing of *individual* birds affects their *populations*. In lieu of more rigorous research on population-level impacts, it would be prudent to implement effective management practices that will demonstrably reduce the vulnerability of bird species to the APWRA. In addition, demonstrating a reduction in bird fatalities within the APWRA would likely enable Alameda County (1998) to permit an increase in generating capacity that is available to the wind industry.

1.4 Relating Impacts to Causal Variables: Predictions and Solutions

Holding aside effects of season, weather, and turbine design and operation, if individuals of a bird species were randomly killed at wind turbines among measured environmental elements on the APWRA, then the probability of an individual being killed by a turbine occurring on a particular environmental element would equal the proportion of the turbines associated with that environmental element multiplied by the total number of that species killed in the study area. For example, if 20% of the turbines in a study area occurred on southeast-facing slopes, then a random distribution of 100 red-tailed hawk fatalities at wind turbines should have included about 20 birds killed by turbines on southeast-facing slopes. This product of total number killed (N) and the incidence of turbines on the ith landscape element is an expected kill rate at the ith landscape element. The number of fatalities at the ith landscape element can then be compared to the expected number of fatalities, where the distribution of mortality is random. For example, had 40 red-tailed hawks been killed by turbines on southeast-facing slopes, this observed frequency was twice the frequency expected of a random or uniform distribution of fatalities.

When the observed and expected frequencies of fatalities are equal, then the observed frequency cannot be attributed statistically to anything other than turbine numbers. However, when the converse is true, a relationship exists between that environmental element and mortality. If the relationship is less than 1, then there may be an avoidance of one environmental element and the possible selection of another. By identifying environmental elements where mortality exceeded expectations due to turbine numbers alone, we are able to identify which environmental factors might have a causal relationship. This approach allows us to assess vulnerability.

At selected wind turbines within the APWRA, we compiled separate data files for bird behaviors, wind turbine and tower characteristics, fatality searches, fatality search results, maps of rodent burrow systems, and various other physical and biological factors. This progress report summarizes the preliminary results of our integration of these data. This attempt at data integration brings us another step closer to developing a predictive model for bird mortality at wind turbines based on turbine location on the landscape, turbine location relative to other turbines, turbine design and operation, the distribution of raptor prey species near turbines, and other potential predictor variables.

We believe that in the future, such an approach will lead to a model that will reliably predict how many birds per species are likely to be killed at individual turbines or at strings of turbines per year. Most important, such a model can be used as a tool to identify zones of vulnerability when siting new wind turbines in the APWRA.

2.0 OBJECTIVES

The primary objectives of this current phase of the research were: (1) to quantify bird use, including characterizing and quantifying perching and flying behaviors exhibited by individual birds around wind turbines; (2) to evaluate the flying behaviors and the environmental and topographic conditions associated with flight behaviors; and (3) to identify possible relationships among bird mortality and bird behaviors, wind tower design and operations, landscape attributes, and prey availability. A fourth objective, to be achieved after the fieldwork is completed, is to develop a predictive, empirical model that identifies areas or conditions that are associated with high vulnerability. Such a model could one day be used in the APWRA to identify locations and conditions of high versus low vulnerability, or to accurately identify those turbines that have demonstrated their ongoing threat to birds.

We began the project by quantifying bird use and bird fatalities associated with that use. Only about 24% of the APWRA's total turbine population was included in the project due to limited access. We quantified bird flight and perching behaviors at the various turbine types and examined whether the frequencies of these behaviors at turbines were related to environmental factors such as weather, topography, habitat features, prey availability, and others.

As our study progressed, unexpected patterns prompted us to add certain focused subtasks and activities to complement the basic goals of the project. Such patterns included ground squirrel distribution and abundance not relating to raptor mortality; pocket gophers clustering near wind towers on steep ridgelines; and raptors generally avoiding perching on wind towers/turbines. We added research on rodent distribution in relation to tower locations, bird use, and fatality locations. We also examined topographic and landscape features and related these to bird use and bird fatalities. In general, the topics we examined fell into three broad categories: (1) bird flight behaviors; (2) turbine/tower design, placement, and operations; and (3) raptor prey availability and distribution in relation to individual turbines and turbine strings.

3.0 STUDY AREA

The APWRA is located 90 km east of San Francisco, within eastern Alameda and southeastern Contra Costa counties in central California (Figure 1). Within the APWRA, which is the largest wind energy facility in the world, some 8,200 turbines were originally approved with as many as 7,200 installed at one time. When the current study began approximately 5,400 turbines were operating (Alameda County 1998). The output capacity of the installed turbines is about 580 megawatts. They are distributed over approximately 150 km^2 (50,000 acres).

The APWRA facility first reached significant levels of energy generation during the mid-1980s, when most of the wind towers now in existence were erected (Hunt 1997). Turbines are generally grouped under common ownership. At least 13 companies manage the energy that is produced in the APWRA, and a variety of different tower/turbine configurations are installed.

The Altamont Pass region exhibits a wide diversity in topographic relief. Hilltop elevations range from 230-470 m above sea level. Valley elevations range from about 78-188 m above sea level (Howell 1997). Livestock grazing and dry farming constitute the primary land use in the area (University of California, 1998).

Steady winds from the southwest blow across Altamont Pass from about April to October. Differential air temperatures form as the warmer Central Valley east of Altamont Pass draws in cooler, marine air from San Francisco Bay to the west. Winds are more erratic at other times of the year. They can originate from any direction. Wind speeds average 25-45 km/hr between April and September, during which time the APWRA produces 70%-80% of its power. During the summer months, wind speeds are sufficient to operate the turbines beginning about midafternoon and increasing during the evening hours. During winter, wind speeds average 15-25 km/hr. Dense fog can occur in the Altamont Pass during summer and winter. Severe winter fog conditions often linger for many consecutive days.

The vegetation is predominately non-native annual grassland consisting of soft chess (*Bromus hordeaceus*), rip-gut brome (*Bromus diandrus*), foxtail barley (*Hordeum murinum ssp. leporinum*), Italian rye grass (*Lolium multiflorum*), and wild oats (*Avena fatua*). Common forbs include black mustard (*Brassica nigra*), fiddle-neck (*Amsinckia menziesii ssp. intermedia*), chick lupine (*Lupinus microcarpus var. densiflorus*), bush lupine (*Lupinus albifrons*), and wally baskets (*Triteleia laxa*). Grasses and forbs grow during the rainy months of January, February, and March, then die or go dormant by the beginning of June. The APWRA includes the following physiographic elements that harbor characteristic groups of species: annual grassland, alkali meadow, emergent marsh, riparian woodland and scrub, creeks and drainages, stock ponds, cultivated land, and rock outcrops. At least 18 special-status wildlife species occur in the area, including San Joaquin kit fox (*Vulpes macrotis mutica*), California red-legged frogs (*Rana aurora draytonii*), San Joaquin pocket mouse (*Perognathus inornatus inornatus*), American badger (*Taxidea taxus*), Swainson's hawk (*Buteo swainsoni*), peregrine falcon (*Falco peregrinus anatum*), California tiger salamander (*Ambystoma californiense*), two species of fairy shrimp, and others. In addition, the area supports as many as 15 special-status plant species (Alameda County 1998).

4.0 METHODS

Wherever applicable, the methods used in our project adhere to guidelines developed and recommended for such studies by the Avian Subcommittee of the National Wind Coordinating Committee (Anderson et al., 1999).

4.1 Study Plots and Wind Energy Facilities Sampled

We sampled 1,110 individual tower and turbine configurations from March 1998 through December 2000 (Table 1). During the project, we added groups of turbines as they became available to us. In particular, Altamont Infrastructure Company (AIC) wind towers (n = 425) were added to our study much later than the others. By December 2000, we had sampled these turbines only one-third as many times as we did the other turbines in our sample. This differential search effort would confound our analysis if we included all turbines being surveyed as of 31 December 2000. Therefore, we have separated many of the analyses in this report into AIC and non-AIC wind turbines. Unless specifically indicated, the findings presented in this report represent results only for non-AIC turbines/towers (Table 2; n = 685).

4.2 Bird Fatalities

Gauthreaux (1996) suggested that searches for bird fatalities around individual turbines should be circular, with the minimum radius determined by the height of the turbine. Since all wind towers in our study area were arranged in strings, we searched them efficiently by walking strip transects along both sides and around the ends.

Data on each fatality included season, tower type, turbine type, tower location within the string, the aspect of the slope on which the string of turbines was situated, and attributes of the physical relief of the study plot. Except for season and weather, these same variables were recorded for all wind towers and turbines where birds were not killed, as well. We used a global positioning system (GPS) device to record these data. The GPS data dictionary used to collect data is included in the Appendix.

Two people explored the ground around each string of wind towers, using one of two searching methods, one for level terrain and the second for hillsides (Figure 2). In either case, each person walked in line with the string, 50 m away from the first tower and 50 m in the opposite direction away from the string centerline. Previous studies reported that about 77% of all carcasses were found within a 30-40 m radius from the wind towers, mostly in the area behind the rotor (Orloff and Flannery 1992; Munsters, Noordervliet, and Ter Keurs 1996; Howell 1997). Both searchers walked toward and outward from the string line in a zigzag pattern from wind tower to wind tower until they reached the last one.

On hillsides or steep terrain, the searchers walked parallel to the string line, whereas on level terrain they walked perpendicular to it. The distance between each zigzag characterizes a different approach to this technique as compared with previous fatality search studies (i.e., Orloff and Flannery 1992). In this study, we kept a tight, closed, zigzag pattern, approximately four meters between each turn. The expected advantage of this ground-surveying technique was to increase the probability of detection of all bird remains, including small passerines.

All carcasses or body parts, such as groups of flight feathers, head, wings, tarsi, and tail feathers, found during each search within a 50-m radius of the wind tower were documented and flagged as fatalities. We carefully examined these to determine species, age, sex, and probable cause of death. The time since death was estimated by carefully analyzing the carcass condition (e.g., fresh, weathered, dry, bleached bones) and decomposition level (e.g., flesh color, presence of maggots, odor), using methods and standards described in the following paragraphs.

To determine the cause of death, we evaluated the general condition of intact carcasses. For dismembered or mutilated remains we evaluated carcass position, the distance and compass reading to the nearest wind turbine or electrical distribution pole or wire, and the type(s) of injury. Each fatality was classified as a "fresh kill" or as "old remains" depending on the estimated time since death. Fatalities were considered fresh when carcasses and small remains were found during our searching cycle of from 1 to 60 days. Old remains included highly decomposed and dismembered carcasses with weathered and discolored feathers, missing flesh, and bleached, exposed bones. These carcass characteristics led observers to believe that the time since death was before the start of this project. The above data, as well as the distance and angle to the wind tower closest to the carcass, were recorded on a standard data sheet. Observers photographed each fatality at the time of discovery.

The ground around each wind tower was searched in 8-10 minutes. Five hours per day were devoted to fatality searches, and two-person crews managed to search 30-40 turbines per day. With two to three people searching 120-150 wind towers per week, all 685 turbines were sampled once every five to six weeks, thus completing approximately eight fatality search cycles in 12 months. Not all strings were searched every month due to changes in field strategies or for reasons out of our control, such as fire hazards and flooded roads.

From 26 March 1998 to 29 February 2000, we searched each of 685 wind turbines 16 times. We also present all fatality records through December 2000, but we discontinued collecting flying and perching behaviors after 29 February 2000 due to budget limitations. These additional fatality data are useful for estimating vulnerability for reasons other than behavior.

We analyzed mortality at two levels of resolution. The finest resolution of analysis was at the turbine level, in which we examined the number of fatalities of each species associated with each wind tower. At the turbine level of analysis, we relied on chi-square analysis derived from the model described above. We analyzed turbine-caused mortality among bird species with which we had gathered at least 20 records, except for golden eagles, which had only 12 records but was a principal species of concern in the study due to its rarity, low productivity (University of California, 1998), and special status under environmental laws.

The coarsest resolution of analysis was at the string level. In this case, we examined the number of fatalities of each species associated with entire strings of wind towers. At the string level of analysis, we relied on Pearson correlation and linear, least-square regression analyses. These analyses always started with examination of scatter plots of mortality on the Y-axis and predictor variables on the X-axis in order to identify patterns in the data, and progressed to a systems analysis approach to explaining the variation in fatality rates (Watt 1966, 1992). This systems analysis approach relies on saving unstandardized residuals from linear regression analysis, then systematically plotting these residuals against each of the other predictor variables. Residuals are the vertical, Y-axis distances measured between each data point and the estimated line representing the regression slope. Residuals represent the variation in the dependent variable that is not explained by the predictor variable. The new plots of residuals from one predictor variable plotted against another predictor variable can reveal meaningful patterns in the residual variation of the dependent variable, which can then be explained by both predictor variables in multiple regression analysis (Watt 1966).

The statistics we present in this report are consistent with the objectives of the corresponding hypothesis tests. For example, correlation analyses are summarized by the coefficient of determination, R^2, when prediction is the ultimate objective. They are summarized by Pearson's correlation coefficient when the objective is simply to summarize the degree of correlation. We will report weak and non-significant correlations when doing so meets our objectives.

Because R^2 is based on two independent factors— the steepness of the regression slope and the precision of the data relative to the regression line—we often also include the root mean square error (RMSE), which measures the latter. R^2 alone is an inefficient summary statistic for many of our hypothesis tests.

Although we use analysis of variance (ANOVA) to test some hypotheses in this study, key assumptions of ANOVA cannot be met due to the lack of any sort of block design or related controls on treatment replication or interspersion. Even though we are studying an anthropogenic system, ours is a non-manipulative study. Our "replicates" and our degrees of interspersion of "treatments" were established by the placement of wind towers by the industry prior to our study. As a mensurative study, the chi-square family of statistical tests is most efficient for testing many of our hypotheses (Smallwood 1993, 2002).

In all of our hypothesis testing, we relied on an α-level of significance of 0.05. However, we also took note of P-values less than 0.1 as indicative of trends worthy of further research or consideration. The observed divided by expected values derived from χ^2 tests are used as measures of effect and need to be interpreted based on the P-value of the test, whether the expected number of observations was larger than 5 (smaller than 5 is generally regarded as unreliable), and the magnitude of the ratio. These latter considerations for assessing the significance of particular observed/expected values we leave to the reader.

4.2.1 Scavenging Activities

Orloff and Flannery (1992) reported little evidence of raptor carcass removal by scavengers during their research at Altamont. However, not documenting the full effect of scavenging may cause an underestimation of the number of dead birds found during our searches. We left in the field each bird carcass we found. Having recorded its exact location using GPS and flagging, we then visited each carcass location at least every 3 days or until the proper authorities collected it. During the time the carcass was in the field, we recorded data on the condition of the carcass, amounts of decomposition over time, and any evidence of scavenging at an interval of once per week. Even though the U.S. Fish and Wildlife Service required immediate reporting of carcasses found and endeavored to pick up all of these carcasses from the field soon after reporting, carcasses occasionally remained in the field for up to 1 month before authorized personnel retrieved them. Thus, we conducted a non-systematic scavenging rate evaluation by recording signs of scavenging activity at the time of the finding and occasionally throughout the times that carcasses were left in the field by the U.S. Fish and Wildlife Service.

At our ENRON study site, due to differences in county regulations, carcasses and remains were reported to the supervisor on site but never picked up from the field. This situation presented us with an opportunity to monitor the scavenging and decomposition rates of those carcasses for longer periods than others. Information about change in carcass condition over time and the period carcasses remained in the field helped us assess the effectiveness of fatality searches in discovering fatalities and how long they remain to be discovered. We calibrated our estimates of time since death by comparing the decomposition level of a specific fatality since the known time of death.

4.3 Bird Behaviors

Two biologists spent 303 days in the field collecting bird behavior data within 20 study plots during 26 March 1998 through 30 March 2000. The boundaries of these study plots were determined by including only those wind turbines easily visible to the observers from a fixed observation point. The result of this plot selection process was a mosaic of irregular shaped, non-overlapping polygons, each about 3 km^2 (Table 2).

The plots where we collected behavior data contained 685 turbines, with 25-45 turbines per plot, representing 98% of all turbines accessible to us at that time. We classified each turbine string by slope aspect, average grade, and average elevation. Slope aspect was classified as facing north, northeast, east, southeast, south, southwest, west, northwest, or located in a valley. Average grade was classified as Level 1 = 0%-9% grade, Level 2 = 10%-19%, Level 3 = 20%-29%, and Level 4 = 30%-39%. Average slope elevation was classified into three groups: high elevation, including slopes 250-324 m above sea level; medium elevation slopes (175-249 m); and low elevation slopes (100-174 m).

We also recorded the topography on which turbine strings were situated, such as on ridges, slopes, swales, peaks, or plateaus, and we recorded the direction to which these topographic features face (as described above for individual turbines). Turbine sites refer to the positions of turbines within a string, such as end of the string, second to the end, interior to the string, or separated from other turbines by a gap created by an inoperable turbine or a gully, as examples. Of the turbines sampled, there were 210 end-of-the-row wind towers, 152 second-to-the-end wind towers, 93 third-to-the-end wind towers, and 217 interior wind towers.

We quantified bird behaviors by recording the number of birds detected within specific study plots and categorizing their specific activities while in those plots (Table 3). Within each study plot, a location was selected from which behavioral observations took place. The observation point was a fixed location used for all behavioral data collection and at which the observer had the best view of the wind towers and the surrounding terrain within the study plot. This approach ensured that each bird species was identified and their activities around the turbines documented. Each observer carried maps of the plots in order to identify each turbine by location and number where each bird flew or perched.

Before the behavioral observations commenced, and for the specific purpose of this study, a field data sheet was developed to record many aspects of bird behavior, as well as the environmental conditions at the time of the observation session. Bird behavior was recorded with alphanumeric codes onto a standardized data sheet, along with temperature, wind speed, turbine operations, and cloud cover at the beginning of each 30-min observation session. We measured temperature with a hand-held thermometer. We evaluated wind force by looking at the observable wind characteristics and measured using the Beaufort scale (0-7). The scale numbers were later transformed into km/hr and grouped according to three wind speed levels: low wind speed levels (0-15 km/hr), medium (16-30 km/hr), and high winds (31-50 km/hr). When the wind speed reached > 55 km/hr (near gale winds), the managers of the facilities advised us to leave the premises for safety reasons.

A single observer completed each sampling event with 8x40 binoculars and performing circular visual scans (360^o), also called variable distance circular point observations (Reynolds, Scott, and Nussbaum 1980). Each visual circular-scanning event lasted 30 min and corresponded to one observation session.

Once a bird crossed the boundary into the study plot, we identified it and continuously followed it until it left the plot. For each sighting, we recorded the species, number of birds in a flock, the times when the bird was detected and when last seen, predominant flight behavior, flight direction, distance to the nearest turbine, type of turbine, number of passes by a turbine, and flight height relative to the windswept zone, which is the height above ground from the lowest to the highest reaches of the turbine blades.

We considered two major bird behavior categories—flying and perching—but classified 18 flying activities (Table 3). The focus of the behavioral observations was to determine how close to a turbine each bird flew, and what types of behaviors it exhibited near the "zone of vulnerability." The zone of vulnerability in this study represents the reach of the rotating turbine blades or rotor swept area, within 50 m of the blades (Figure 3).

The estimation of the closest pass to the zone of vulnerability was vital to this study. Therefore, both field assistants practiced calibrations on height and depth measurements of known objects every six months.

A proximity value was assigned to each behavior in terms of how close that behavior was performed in relation to the turbine blades and according to the length of time birds spent doing that behavior near the blades. Proximity Level 1 involved behaviors performed within 1 – 50 m of the turbines. Proximity Level 2 involved behaviors seen within 51-100 m. Proximity Level 3 behaviors were performed farther from the turbine at 101-300 m.

Three hundred meters represented the farthest distance in which many flying birds could be clearly identified to species, their behavior followed, and their distance estimated, so only birds observed within that distance were recorded during the behavioral observations. If the biologists observed the bird perching, they recorded the time and specific perching structure. Perching was recorded on 21 structures within our study site (Table 4).

A bird's "utilization duration" was the amount of time it was observed during a 30-min observation session. We attempted to accurately quantify the amount of time spent flying and perching in order to determine the extent of both activities. After the observation period ended, the observer moved to the next sampling plot to complete another 30-min observation session.

Our biologists sampled all 20 plots at least once every week, stratified by morning and afternoon sessions. The morning session started at 07:00 and continued until 12:00. The afternoon session lasted from 12:01 until dusk. We observed behaviors throughout the year in nearly every weather condition, unless rain or fog reduced observer visibility to <60%, which was too poor to track bird activity accurately. We completed two sessions simultaneously, averaging 6-8 observation sessions per field day. We conducted all simultaneously occurring 30-min sessions on non-adjacent plots to ensure independence among observation sessions.

We calculated the mean minutes of flying and perching behaviors among the 30-min observation sessions for each bird species. Mean minutes of flying and perching behaviors were related to seasons, wind speed levels, topographic features, and wind turbine characteristics to determine whether these variables might affect mean flight time among raptor and non-raptor species. These factors were treated as independent variables in one-way analysis of variance (ANOVA) tests (Zar 1996) on the minutes of flying and perching activities per bird species.

When any of the ANOVA tests rejected the null hypothesis, we used the Tukey test (Zar 1996) to determine where differences existed. The mean minutes of each bird behavior were also considered in one-way ANOVA to identify significant differences for the raptor and non-raptor species among independent variables such as seasons, wind speeds, topographic characteristics, and turbine types.

Statistical tests were performed only for bird species observed in at least 10% of the sessions because the results of tests involving small sample sizes are unreliable and we had enough bird species with larger sample sizes to recognize general inter-specific patterns. In cases where subdivision of the data by years reduced the sample size substantially, we grouped data and analyzed them across both years. We performed Student t-tests (Zar 1996) to determine whether significant differences in flying and perching time occurred between years. The species included in our more rigorous analyses reported herein include American kestrel, red-tailed hawk, turkey vulture, golden eagle, burrowing owl, common raven, loggerhead shrike, and several other passerine species. We will provide analyses for the rarer species in the final report.

4.3.1 Observer Bias

To reduce the effects of observer bias in estimating and reporting distances and bird behaviors, paired observations were conducted for 1 month at the beginning of the study. At this time, we calibrated differences between observers in terms of distances, turbine and tower sizes, and depth perception. We also recorded bird behavior to become familiar with the data sheet and to standardize the names for all bird activities, behavior categories, and perching devices. Once the observers were achieving similar records and behavior interpretations, observers began conducting separate 30-min observation sessions. We completed the first calibration period in 18 observation sessions. We repeated these calibration sessions every 6 months in four observation sessions for a period of 1 to 2 days. The observers recorded the behavioral information simultaneously but independently on separate data sheets. At the end of each calibration session, we compared and discussed the information to help ensure consistency of the behavioral interpretations.

4.4 Landscape Features

We used a Trimble Pathfinder Pro-XR GPS to map the location of each wind tower with sub-meter accuracy. At each of these locations, we also recorded attributes of the tower/turbine and the landscape. These attributes were stored in a spatially explicit database (GIS). We recorded the type of turbine, whether it had an anemometer (in order to test whether its availability as a perching structure might relate to fatality rates), whether the turbine faced toward or away from the wind, the turbine's position within the string, the number of turbines in the string, and whether the turbine was part of a windwall, which is composed of turbines at two or more heights above the ground and which together extend the windswept zone. We recorded the physical relief, such as whether the tower/turbine was on a ridgeline, peak, slope, or swale. In addition, we recorded the slope aspect on which the tower/turbine occurs, the elevation in meters above sea level, and various notes about the site.

We mapped the location of each tower by using the offset function of the GPS because we wanted to avoid inaccuracies possibly caused by the electromagnetic field of operating wind turbines. We stood ≥5 m from each tower and input the distance, compass bearing to the tower, and degrees of inclination, if any.

We also mapped the locations of many of the fatalities. This data collection is ongoing and will allow us to complete this task later so that we can detect directional and distance patterns of where fatalities end up on the ground. Recognizing whether the locations of fatalities relate to local topographic and wind patterns might increase the efficiency of future fatality searches.

We mapped the perimeters of stock ponds and natural water bodies to test the effect of proximity to water body on the fatality rates. We mapped the perimeters of rock piles to test for any relationship between raptor fatality rates and proximity to cottontail denning habitat (rock piles). In some cases, pushing together rocks to clear space for the wind tower platforms had artificially created these features. We also mapped the distribution of fossorial rodents. We describe these maps below in more detail.

4.5 Burrowing Rodents

We mapped rodent burrows near 98 wind turbines composing nine turbine strings in the APWRA (see Figures 4 and 5). One string of 38 diagonal lattice turbines operated by ENRON is located on the south side of Altamont Pass Road. EnXco (formerly FORAS) operated eight of the turbine strings (60 tubular tower turbines) on the north side of Altamont Pass Road. These eight strings were selected to provide a wide range of fatality rates while at the same time to span the breadth of our EnXco sampling area. The ENRON string was selected due to its known high fatality rate. Our sampling scheme was intended to establish on a trial basis whether the distribution of rodent burrow systems around wind turbines might relate to fatality rates of raptors. Because of this trial, we have since expanded our sampling effort, but the results are not yet ready to present.

We mapped with GPS the approximate centers of pocket gopher, ground squirrel, and cottontail burrow systems. We located burrow systems based on freshly excavated soil or scats at the burrow entrance, which indicated the burrows were occupied. Although we easily recognized the boundaries of most individual pocket gopher and ground squirrel burrow systems, a pacing method (Smallwood and Erickson 1995) was used to separate burrows when continuity of sign rendered inter-burrow system distinctions difficult. This pacing method is worked out for pocket gophers, but not for ground squirrels, so the maps made of ground squirrel burrow systems are still preliminary. We mapped burrows used by cottontails and burrowing owls as we encountered them. The presence of scat at each burrow entrance helped identify them.

Our search for burrows began in the string of turbines. A 7.5-m-wide strip transect was walked from 15 m beyond the turbine at one end of the string to 15 m beyond the turbine at the other end. Then perimeter transects were walked at 15 m, 30 m, and 45 m away from the turbine string, thus covering increasingly larger areas around the turbine strings (Figure 4A). These 15-m intervals correspond with the distance across the largest burrow systems of male pocket gophers (Smallwood and Erickson 1995).

A laser rangefinder was used to maintain the intended distances away from the turbines while searching along perimeter transects. We estimated densities of gopher and ground squirrel burrow systems within each of the corresponding areas searched. Using least squares linear regression, densities of burrow systems were then regressed on the corresponding search areas and the steepness of the regression slope used as an indicator of contagion relative to the location of each turbine string. Also, we estimated the density of burrows within 55 m of each turbine string (Figure 4B) and compared these data to fatality rates of raptor mortality. The distance of 55 m was established by including 10 m of search area beyond the 45-m buffer described above.

We also measured the distance between the turbine and each burrow system, and we counted the burrow systems of each species occurring within 55 m of each turbine (e.g., Figure 4B). We aggregated these counts into zero, 1-2, and ≥ 3 burrow systems in order to facilitate χ^2 tests with adequate cell values. In addition, we classified red-tailed hawk fatalities as either zero or ≥ 1.

Since this preliminary study of animal burrow patterns around wind turbines, we have searched 43 additional turbine strings out to 80 m from each string. We have also begun monitoring the pattern of burrow systems across seasons of the year. The results of these studies are not included in this report.

5.0 PRELIMINARY RESULTS

5.1 Bird Use

We observed at least 36 bird species during the behavioral observations. Sightings averaged 3.2 birds per observation session. We observed no birds in 184 of the 1,958 observation sessions.

Sixty-nine percent of all bird sightings were raptors (n = 3,765), and 31% were non-raptors (n = 2,371). The most frequent raptor species sighted during the behavioral observation sessions was red-tailed hawk (n = 1,820, 48%), followed by turkey vulture (n = 801, 21%), American kestrel (n = 446, 12%), golden eagle (n = 424, 11%), and northern harrier (n = 117, 3%). The most common non-raptor bird species sighted was common raven (n = 837, 35%), gull species (n = 519, 22%), several blackbird species (combined; n = 396, 17%), and rock dove (n = 139, 6%). (These sightings consisted of individuals as well as flocks or small groups, so more birds were actually seen than the n-values reported herein.)

5.2 Bird Behaviors

We recorded 31,317 minutes of bird activity representing 6,146 behavioral sightings. The 13,725 minutes spent flying (44%) were nearly as many as the 17,592 minutes spent perching (56%) (Table 6).

For individual species, the total time spent flying versus perching (Table 7) varied considerably. Therefore, it is likely that there are considerable differences in the sensitivity of each species to turbine operations. For example, American kestrels, burrowing owls, western meadowlarks, and European starlings were usually observed perching, whereas turkey vultures, northern harriers, prairie falcons, mallards, and mourning doves were usually observed flying. One might conclude that the latter group of species would be more sensitive to turbine collisions if it were not for additional factors that influence fatality rates, such as exactly where these birds fly, when they fly there, and how much time they spend flying near turbine blades.

We recorded 6,377 observations of birds in flight, including multiple flights for the same bird. Fly-through behavior was the most common type of flight recorded for all bird species (27%, n = 1,726 sightings), followed by gliding (18%, n = 1,141) and soaring (16%, n = 1008). However, soaring lasted longest on average ($\bar{x}$ = 3.6, SD = 3.5), followed by gliding ($\bar{x}$ = 2.8, SD = 3.3) and fly-through ($\bar{x}$ = 1.22, SD = 0.54).

Raptor species flew more during medium and high wind speeds, with red-tailed hawks spending the greatest amount of time flying during these conditions (Figure 6). In general, larger bird species were seen in the air more often than smaller species. By examining each species' flight time within the species' range of flight times, species-specific use of wind patterns are evident (Figure 7). For example, flight time increases consistently with increasing wind speeds for northern harriers and American kestrels. This relationship plateaus after medium wind speeds for turkey vulture, golden eagle, and prairie falcon, and it drops substantially at medium wind speeds for burrowing owls. There is a noticeable peak for red-tailed hawks. Thus, species appear to differ in their sensitivity to turbine operations due to wind speeds.

Raptors performed 17 of the 19 behaviors observed for all species. Raptors differed significantly by mean flight time per proximity level (ANOVA, $F = 105.60$, $P = 0.001$, $df = 2, 4{,}333$) (Table 8). Raptors spent significantly more time flying at close proximity to turbine blades ($\bar{x}$ = 4.59 minutes, SD = 5.04) than 51-100 m away ($\bar{x}$ = 3.34, SD = 3.48) or >100 m away ($\bar{x}$ = 2.12, SD = 1.98) (Tukey's test, $P < 0.05$).

Among raptor species, red-tailed hawks performed 66% (n = 748) of the flight behaviors we thought made them most vulnerable to turbine collisions (i.e., flying within the height domain of the rotor plane and within 50 m of the turbines), golden eagles performed 15% (n = 170), and American kestrels performed 10% (n = 112) of them, respectively (Table 9).

American kestrels performed the highest percentage of flights within 50 m of the turbines (45% of 112 flights), followed by northern harriers (39% of 52 flights), and red-tailed hawks (38.6% of 748 flights). Turkey vulture and burrowing owl had the lowest frequency of flights within 50 m of the turbines (Table 10).

American kestrels differed by mean flight time within proximity levels (ANOVA, F = 7.85, P < 0.001, df = 2, 366), spending significantly less time per flight 101-300 m from the turbine blades compared to 0-50 or 51-100 m (Table 11, Fig. 8). Based on mean values, red-tailed hawks spent significantly more time per flight within proximity level 1 compared to farther away (ANOVA, F = 57.89, P = 0.001, df = 2, 2,146; Table 11, Fig. 8). Burrowing owls did not differ significantly by mean flying time among proximity levels (ANOVA, P = 0.15, F = 2.07, df = 2, 23), nor did golden eagles (ANOVA, P = 0.460, F = 0.77, df = 2, 577), northern harriers (ANOVA, P = 0.15, F = 1.92, df = 2, 130), and prairie falcons (ANOVA, P = 0.15, F = 1.93, df = 2, 79) (Table 11, Fig. 8). Turkey vultures did differ significantly by mean flight time within proximity levels (ANOVA, P = 0.001, F = 74.03, df = 2, 981), spending significantly more time flying per observation within proximity levels 1 and 2 (Table 11, Fig. 8).

Analysis of the mean flight time did not consider the number of times each species flew within proximity levels. Therefore, we examined the total number of minutes each species flew within each proximity level. Figure 8 illustrates the dramatic differences in interpretation when using total flight time rather than the mean flight time. Red-tailed hawks appear to spend the greatest average time per flight within proximity level 1, but considering the total minutes, this species spent more than four times the amount of time in proximity level 1 compared to other species. In proximity level 2, red-tailed hawks averaged no more time than did the other species, but they spent nearly twice as much time there than did turkey vultures and much more time than did the other species.

Total flight time by a species more closely indicates the differences in use of proximity levels than does the mean time per flight. Based on the mean time per flight, red-tailed hawks spent twice the time flying within proximity level 1 compared to proximity level 3, but based on the total time, red-tailed hawks spent more than four times the amount of time flying in proximity level 1 compared to proximity level 3. Factoring in the proportion of the APWRA occupied by these three proximity levels (by applying GIS coverages) will reveal the degree to which each species uses each proximity level relative to chance. This type of analysis will be forthcoming.

We approximated the proportion of the 2,780 ha of our study area composed of proximity levels 1, 2, and 3. Proximity levels 1, 2, and 3 occupy about 15%, 22%, and 63%, respectively, of the total area encompassed by all three proximity levels. Multiplying the total number of minutes of red-tailed hawk flight time by these proportions yields expected flight times of 1,241, 1,821, and 5,214 minutes in proximity Levels 1, 2, and 3, respectively. The observed flight times were 4,069, 3,598, and 609 minutes, respectively. Red-tailed hawks flew within 50 m of the turbine blades about 3.3 times longer than expected by chance, within 51-100 m of the blades 2.0 times longer than expected by chance, and within 101-300 m about 0.1 times the total flight time expected by chance.

Based on this preliminary analysis, it appears that red-tailed hawks are strongly attracted to lands within 50 m of wind turbines in the APWRA, and they seem to avoid lands located farther away from turbines. Analyzing the total number of minutes of flight time reveals that something about wind turbines may attract red-tailed hawks to fly near turbines and at dangerous heights.

Similarly, American kestrels flew in proximity level 1 nearly four times longer than expected by chance, golden eagles two times longer, and northern harriers three times longer. Burrowing owls flew in proximity level 1 only 0.67 times as long and turkey vultures only 0.2 times as long as expected by chance. Figure 9 shows the amount of time each of several raptor species flew within each proximity level relative to the availability (area) of each proximity level. All of these relationships were highly significant, based on the χ^2 test of association ($P < 0.0001$ for all of them).

This type of approach can also reveal important interaction effects, such as between wind levels and the number of passes made within 50 m and farther than 50 m of turbine strings. The proportion of the observation periods during a particular measured wind speed can be multiplied by the proportion of the area composed of proximity levels 1 or 2 to yield the proportion of the time that winds of that particular speed likely blew within that proximity level. This new proportion can then be multiplied by the total number of passes made by a species within each proximity level, and χ^2 analysis can be performed.

For example, Figure 10 illustrates the insight gained by deriving the observed ÷ expected number of passes made by red-tailed hawks during the behavioral observation sessions. Whereas the number of passes peaked during moderate wind levels at the APWRA, and whereas the number of passes was always greater within 50 m as compared to farther than 50 m for each wind speed level (Figure 10, left panel), the disparity in the number of passes between proximity levels is heightened when comparing the observed and expected values or the interaction effect (Figure 10, right panel).

Red-tailed hawks are strongly selecting to pass closely by the wind turbines during moderate wind speeds but are avoiding making passes >50 m from the wind turbines during all wind speeds, based on the availability of the area in proximity level 2 ($\chi^2 = 618$, d.f. = 15, $P < 0.0001$).

This result suggests that our distinction between sensitivity and vulnerability already has been contaminated by the placement of the turbines on the APWRA, meaning that any true observations of sensitivity, *per se*, would need to be made at one or more locations with similar environmental conditions but without the presence of the wind turbines. The placement of wind turbines in the APWRA has fundamentally changed the flight behavior of red-tailed hawks there. Specifically, 18% of the passes made by red-tailed hawks were closer to the turbine strings during winds of 1-34 kph than would be expected by chance based on areas and wind speed as the only factors. We expect that the clustering of prey species around wind turbines is the underlying reason for this altered raptor flight behavior. This same type of analysis remains to be performed for the other species in our study.

5.3 Fatality Searches

We found 439 dead birds and four dead mammals among 31 bird and one mammal species (Table 12). These fatalities included 226 (53%) raptors, 209 (49%) non-raptorial bird species, and 4 (1%) hoary bats. Of these bird carcasses, 372 (87%) were confirmed to be the result of turbine collisions, 11 (3%) we believe resulted from predation by other species, and the cause of death was undetermined for 43 (10%).

We did not find a raptor fatality at most of the turbines we sampled. Of the 1,110 turbine locations sampled from 12-30 months, only 272 (24%) have been recorded to cause one or more fatalities (Table 13). The left-skewed, leptokurtic distributions of mortality among turbines and turbine strings (Figure 11), coupled with the inter-specific correlations at turbines, pose the possibility that mortality among multiple avian species can be reduced by changing turbine and tower design, tower placement, and range management practices. That is, because multiple species are killed by the same subset of turbines, focusing on the factors common to that subset of turbines might benefit multiple species.

5.3.1 Scavenging Effects

Data from the fatality searches indicate that scavenging has little effect on the results, especially for medium to large birds. For example, three dead barn owls monitored for their duration of detectability remained visible in the field for 90, 120, and 150 days. For 17 freshly killed red-tailed hawks monitored for detectability, each remained visible for at least 180 days, with five visible for at least 360 days.

A comprehensive assessment of the role scavenging plays in carcass detection will be provided in the final report; however, at this point we have little reason to suspect that it affects the overall results of our fatality data.

5.4 Seasonal Use Patterns

5.4.1 Flight Time by Season

Mean flight time of raptor species combined varied throughout the seasons and years (Table 15). We found significant differences between years and seasons. These factors also strongly interacted (two-way ANOVA, season: $F = 8.374$, $P = 0.001$, df = 3; year: $F = 18.789$, $P = 0.000$, df = 1; season by year: $F = 6.929$, $P = 0.001$, df = 3, 2793).

The mean flight time of raptors differed by season during 1998-99 (ANOVA, $F = 5.724$, $P = 0.001$, df = 3, 865), averaging lowest during summer ($\bar{x} = 1.91$, SD = 1.47, n = 255) and highest during fall ($\bar{x} = 2.75$, SD = 3.03, n = 276). Mean flight time of raptors differed between summer and fall (Tukey's, $P < 0.05$), but not between summer and winter ($\bar{x} = 2.56$, SD = 2.43, n = 257), nor spring ($\bar{x} = 2.63$, SD = 3.10, n = 81), fall, and winter (Tukey's $P > 0.5$).

The highest mean flight time of raptors occurred during winter, 1999-00 ($\bar{x} = 4.05$, SD = 5.42, n = 381) and lowest in fall ($\bar{x} = 2.73$, SD = 3.36, n = 624). It differed by season during 1999-00 (ANOVA, $F = 12.220$, $P = 0.001$, df = 3, 1928), averaging the highest during winter (Tukey's, $P < 0.05$), but not differing in spring ($\bar{x} = 2.78$, SD = 2.52, n = 325), summer ($\bar{x} = 2.88$, SD = 2.52, n = 602), and fall.

Mean flight time of raptors did not differ significantly during spring (*t*-test, $P = 0.644$) and fall (*t*-test, $P = 0.934$), but it did during summer (*t*-test, $P = 0.001$) and winter (*t*-test, $P = 0.001$).

5.5 Physical Features

Certain avian species were clearly vulnerable to collisions with turbine rotor blades operating on a variety of tower types. In one instance, we observed a lone rock dove that flew upwind into a rotor and was struck by a rotor blade. We conclude that the majority of the dead birds we found would not have died where we located them had the wind turbines not been located there. Therefore, some aspect or combination of aspects of wind turbine operations resulted in these birds being vulnerable to injury or death.

Operation of these wind turbines also made certain avian species vulnerable to electrocution on electrical distribution poles because we found electrocuted raptors under distribution poles that otherwise would not be located on the APWRA in the absence of the wind turbines. The data presented below focus on various vulnerabilities that may contribute to bird fatalities caused by rotating turbine blades atop wind towers, plus rotations of vertical axis wind turbines.

The fatality rates of some species are correlated. The number of red-tailed hawk fatalities per string correlated with the number of fatalities of American kestrel ($r_P = 0.455$, $P < 0.001$), barn owl ($r_P = 0.325$, $P < 0.05$), burrowing owl ($r_P = 0.210$, $P < 0.05$), golden eagle ($rP = 0.270$, $P < 0.05$), and all non-raptor species combined

($r_P = 0.271$, $P < 0.05$). This indicates that patterns related to fatality rates observed for one can sometimes be used to represent the patterns expected of others, however weakly. Because fatality rates are correlated inter-specifically and because it appears that some turbine strings kill more individuals of multiple species, solutions to reduce the fatality rate of one species might be solutions for other species also.

5.5.1 String Size

The number of red-tailed hawk fatalities at a string correlated with the number of wind towers in the string ($r_P = 0.515$, $P < 0.001$), as did the number of fatalities of American kestrel ($r_P = 0.345$, $P < 0.001$), burrowing owl ($r_P = 0.219$, $P < 0.05$), and barn owl ($r_P = 0.353$, $P < 0.001$). These correlations might be significant simply because avian vulnerability to wind turbines increases with the number of wind towers present; that is, a string of 21 wind turbines poses a greater danger to birds than does a string of two wind turbines.

Table 16 includes regression coefficients around which residuals can be calculated and used to uncover relationships between fatality rates and other factors that otherwise may have been masked by the effect of the number of turbines composing a string (i.e., increased probability of fatalities occurring at a string because there are more opportunities for fatalities with more turbines present). If the size of the string is not factored into the analysis, then patterns of fatality rates related to other variables might be hidden and others might be spurious. We made use of these residuals in the analyses that follow.

5.5.2 Windswept Area

The number of fatalities at a turbine string increased with the total windswept area of the string (Table 17), where the windswept area included the sum of all windswept areas of only those wind towers that were operational spanning most of the period during our fatality searches. Windswept area of the string explained more of the variation and tended to be more significant than was the number of turbines in a string. This is evident by comparing the summary statistics provided in Tables 16, 17, and 18. In addition, the average windswept area generally increased with the number of fatalities of each taxonomic group (Figure 12), as well as with individual species (Figure 13).

This relationship indicates that other string-level analyses should also be adjusted by the string's windswept area, which appears to substantially increase vulnerability. We made this adjustment using unstandardized residuals that were calculated from the regression models in Table 17. We made use of these residuals in the analyses that follow.

5.5.3 Tower Type

Avian fatality rates associated non-randomly with tower types (Figure 14; Table 18). Bonus tubular towers killed 1.4 to 2.1 times more red-tailed hawks, golden eagles, burrowing owls, and barn owls than expected by chance. Vertical axis towers killed less than the expected number of red-tailed hawks, golden eagles, and American kestrels, ranging from none to 29% of the expected fatality rates. Diagonal lattice towers killed 1.4 times more American kestrels than expected by chance. Danwin tubular towers killed only one red-tailed hawk. These relationships appear to be closely linked to attributes of the towers, which are described below.

5.5.4 Rotor Diameter

Avian fatality rates associated non-randomly with rotor diameters (Figure 15; Table 18). The two largest diameter rotors killed 1.3 to 2.4 times more red-tailed hawks, golden eagles, burrowing owls, and barn owls than would be expected by chance. The smallest-diameter rotor killed about one-third of all red-tailed hawks but only because there were so many of these small rotors. Rotor diameter appeared not to affect American kestrel fatality rates.

At the string level of analysis, rotor diameter appears to slightly influence red-tailed hawk fatality rates (r^2 = 0.08, regression b = 0.23, df = 1, 107, $P < 0.05$), but factoring in string size revealed a stronger correlation, but still weak overall (r^2 = 0.17, regression b = 0.28, df = 1, 107, $P < 0.001$).

5.5.5 Rotor Speeds

Avian fatality rates associated non-randomly with turbine rotor speeds (Figure 16; Table 18). The faster turbines killed 1.2 to 2.1 times more red-tailed hawks, golden eagles, burrowing owls, and barn owls than would be expected by chance, given the frequency distributions of rotor speeds. Turbine rotor speed appears to be unassociated with the fatality rate of American kestrels, however. Interestingly, the average rate of the turbines correlated negatively with the number of turbines in the string ($r_P = - 0.38$, $P < 0.001$), indicating that some of the relationships with rotor speed may have been hidden by the strong positive correlations between fatality rates and number of turbines in the string (or windswept area). In addition, average rotor speed correlated positively with rotor diameter ($r_P = 0.48$, $P < 0.01$), turbine size ($r_P = 0.35$, $P < 0.01$), and tower height ($r_P = 0.21$, $P < 0.05$).

5.5.6 Tower Height

Avian fatality rates associated non-randomly with wind tower heights (Figure 17; Table 18). Towers with rotors that were centered 24 m above ground killed 1.1 to 1.3 times more red-tailed hawks, golden eagles, American kestrels, burrowing owls, and barn owls than would be expected by chance, given the frequency of each tower height in the sample. Although most of the wind towers were 24 m tall, these towers killed more than the expected number of each species compared to a random (uniform) distribution of kills. This attribute of wind towers might explain most of the relationship between Bonus tubular towers and their greater-than-chance fatality rates with several of the avian species we studied. Bonus tubular towers are 24 m tall.

However, tower height interacted with landscape features that are related to declivity winds for some species and with other landscape conditions for other species (see below).

5.5.7 Turbine Position in String

Avian fatality rates associated non-randomly with the position of the wind tower in the string (Figure 18; Table 18). Table 19 summarizes the frequency distribution of wind tower positions within the strings that we searched for fatalities in the APWRA.

At the turbine string level of analysis, a majority (68%) of red-tailed hawk fatalities occurred at 56% of the strings. In these strings, the end towers composed only 10%-50% of the string. It would appear, based on examination of the scatter plots (Figure 19), that red-tailed hawk fatalities were more frequent at turbine strings composed of fewer end and gap towers (i.e., edge towers; a gap within a string is defined as 25% greater distance between towers than the average inter-tower distance) and more interior towers. However, end towers composing 10%-50% of the string indicate that these strings were moderate in size because only two towers can be end towers on any given string. The string level of analysis was confounded by the effect of the number of wind towers composing the string and by the windswept area of the string.

Therefore, we calculated the unstandardized residuals from the regression models in Table 16 and then related these residuals to the position of the wind tower in the string (Figure 20). The residuals from the model in Table 16 did not regress significantly on turbine position in the string (Table 20). They increased, however, with increasing numbers of derelict turbines in the string among those strings that had derelict turbines (Figure 21), suggesting that an increasing proportion of derelict turbines in a string might confuse red-tailed hawks flying by them. It is even possible that derelict turbines are more visible because their rotor blades are not moving and so are not causing retinal smear. Red-tailed hawks might fly farther around them and into the rotor blades of adjacent turbines that *are* operating.

Similarly, American kestrels and barn owls appeared to be killed at an increasing rate with a smaller percentage of the string composed of end turbines and with a greater percentage of interior turbines, but these relationships vanished when adjusted by windswept area (Table 20). Golden eagle and burrowing owl fatality rates, however, demonstrated no relationships with turbine position in the string, except that the golden eagle fatality rate adjusted by windswept area increased with a greater percentage of end and gap turbines and with lower percentage of interior turbines (Table 20). However, even this latter relationship might have been influenced by a positive correlation between the percentage of the string composed of end and gap turbines and percentage of the string occurring within canyons ($r_P = 0.25$, $P < 0.01$).

Another inter-variable correlation to consider for future analysis of fatality rates includes the one between percentage of the string composed of end and gap towers and rotor speed ($r_P = 0.35$, $P < 0.01$). Apparently, turbine strings with more gaps and fewer interior turbines maintain higher rotor speeds, which might increase the vulnerability of avian species to turbine strikes. Furthermore, more of these strings also occur within canyons ($r_P = 0.25$, $P < 0.01$). More research is needed to fully understand the contribution of these relationships to fatality rates.

5.5.8 Type of Physical Relief

Avian fatality rates associated non-randomly with types of physical relief (Figure 22), but not significantly (Table 18). Compared to chance, wind towers on ridge tops and swales killed 1.2 and 2.9 times more red-tailed hawks than expected, respectively. Towers situated on slopes killed 1.4 times more golden eagles than expected due to chance. Otherwise, the physical relief appeared to not influence the fatality rates of the species we examined. However, whether the wind towers were located within one of three major canyons within our study area did relate to fatality rates (see Section 6.5.10).

5.5.9 Declivity Winds

Avian fatality rates associated non-randomly with whether the wind towers were placed to take advantage of the declivity winds (Figure 23), but not significantly for golden eagles, barn owls, and burrowing owls (Table 18). Red-tailed hawks were killed 1.3 to 2.1 times more often than expected by chance at 24-m towers placed on swales, ridgelines, and peaks, at 30-m towers on swales, and at 14-m towers on slopes. American kestrels collided with turbines 2.7 to 7.0 times more often than expected by chance at 24-m towers on ridgelines and at 24- and 30-m towers on swales. Thus, it appears that there is an interaction effect between physical relief and tower height for these species. Tall towers on swales or low spots along ridgelines often formed at the junction of two ridges appear to be especially troublesome for red-tailed hawks and American kestrels.

Obviously, the physical relief affects the declivity winds, so ultimately physical relief significantly affects turbine-caused mortality. To recognize the effect of physical relief, the analyst must factor in tower height in this case.

5.5.10 Canyon Effects

Avian fatality rates associated non-randomly with whether turbines were located in or out of canyons (Figure 24; Table 18). Wind towers located in one of the three major canyons in our study area killed 1.8-3.6 times the number of red-tailed hawks, golden eagles, burrowing owls, and barn owls that would be expected by chance given the frequencies of towers in or out of canyons. The rate of American kestrel fatalities did not relate to whether the towers were located in canyons. All the golden eagle fatalities we found occurred within canyons.

The percentage of the string occurring within the three major canyons within our study area also correlated positively with the average turbine-caused mortality ($r_P = 0.40$, $P < 0.001$), average rotor diameter ($r_P = 0.46$, $P < 0.001$), and negatively with average tower height ($r_P = -0.23$, $P < 0.05$). Thus, the relationships between raptor fatality rates and whether turbines occurred in canyons could instead be due to the relationships between fatality rates and these other tower/turbine attributes, or vice versa. More research is needed to isolate the contribution of each of these relationships.

5.5.11 Slope Aspect

Avian fatality rates associated non-randomly with slope aspect (Figure 25; Table 18). Wind turbines located on northwest-facing slopes killed more red-tailed hawks, golden eagles, and barn owls than would be expected by chance, given the proportion of turbines on these slopes. Towers on south-facing slopes killed more red-tailed hawks, American kestrels, and burrowing owls than would be expected by chance. Turbines located on southeast slopes killed more golden eagles than would be expected by chance.

5.5.12 Additional Features

At the time of this writing, at least three other related and important topics remain to be analyzed using GIS capabilities: percent slope, elevation, and complexity of relief. Data have been collected on these topics and the analyses will be completed for inclusion in the final project report.

5.6 Burrowing Rodents

As summarized in the introduction, ground squirrels have been thought to be the principal prey species of raptors at the APWRA. However, given the numbers of raptors killed on the south side of Altamont Pass Road, we suspected that ground squirrels might not be the species of principal interest to raptorial birds. Also, previous experience has led us to believe that pocket gophers are important prey of raptorial birds and that gopher burrow systems serve as habitat for various other prey species of raptorial birds. Pocket gophers appear to be abundant in the APWRA on both sides of Altamont Pass Road, whereas ground squirrels appear to be abundant only on the north side. During 2000 and 2001, we found 1,272 ground squirrel burrow systems within the 173.5 ha searched at EnXco for a density of 7.3 burrow systems per ha, which was 30.5 times more dense than the 18 ground squirrel burrow systems we found within the 74.2 ha searched at ENRON for a density of 0.24 burrow systems per ha (these are preliminary results only).

During a previous study we observed that raptorial birds spend a disproportionately large fraction of their flight time directly over pocket gopher burrow systems while capturing pocket gophers, voles, snakes, and black-tailed jackrabbits. Therefore, we decided to map the locations of pocket gopher and ground squirrel burrows in and around selected strings of wind turbines. Our objectives for this activity were to compare the mortality of raptorial birds to the densities and degree of contagion of burrow systems actively used by potential prey species around individual turbines and around turbine strings. Usually, pocket gophers clustered within close proximity to the wind turbines, whereas ground squirrels established colonies farther away from the turbines (Figure 5).

The results presented here are preliminary and therefore not conclusive. Our initial sample sizes were too small to lend much confidence to the results. Continued fieldwork will sufficiently increase the sample sizes of fatalities and turbine strings around which fossorial mammals are mapped, which will add considerable confidence to our results.

5.6.1 Intra-String Comparisons

Red-tailed hawk fatalities *tended* to occur at turbines with one-two gopher burrows more often than expected by chance, and less often at turbines without gopher burrows within 55 m ($\chi^2 = 5.28$, df = 2, P = 0.07). However, red-tailed hawk fatalities did not relate significantly to the occurrence of ground squirrel burrows at turbines ($\chi^2 = 2.88$, df = 2, P = 0.24).

Golden eagle fatalities occurred more often than expected by chance at turbines with ≥ 3 ground squirrel burrows within 55 m ($\chi^2 = 7.72$, df = 2, $P < 0.05$). However, half of the contingency table's expected cell values were less than 5, a condition that requires cautious interpretation of the test result.

Burrowing owl fatalities also occurred more often than expected at turbines with ≥ 3 ground squirrel burrows within 55 m ($\chi^2 = 13.35$, df = 2, $P < 0.001$). Burrowing owl fatalities occurred at the two turbines with the greatest numbers of burrowing owl burrows within 55 m (6 and 7 burrows, respectively; no statistical test performed). Golden eagle and burrowing owl fatalities did not relate significantly with the density of pocket gopher burrow systems around turbine strings. Pocket gophers are not considered a major prey item for either species.

These data suggest that red-tailed hawks and golden eagles, which differ in their foraging behavior and prey selection, were vulnerable to turbine collisions for different reasons. Moreover, the distribution of ground squirrels and pocket gophers near turbines may be used to predict risk for certain raptor species.

5.6.2 Inter-String Comparison

At the inter-string level of analysis, pocket gopher density consistently decreased as larger areas were searched around each turbine string (Figure 26). All turbine strings demonstrated a relationship between gopher burrow density and study area size that was similar to the pattern reported by Smallwood and Morrison (1999). Steeper regression slopes indicated greater clustering of gopher burrow systems in the immediate vicinity of the turbines. Ground squirrel burrows did not occur within 55 m of four of the nine turbine strings, and ground squirrel burrow density increased as larger areas were searched at another turbine string (Figure 27). At yet another string, the slope value of negative one between log ground squirrel burrow density and study area size was determined by only one burrow, which occurred along the interior transect. Dividing a constant number (one, in this case) by a variable area forces a slope value of negative one.

As was the case for pocket gophers, the density of burrow systems for all species declined as larger areas around the turbine strings were included it the search effort (Figure 28). This multi-species pattern was likely driven by the pocket gopher pattern, as many fossorial species take advantage of the burrows that are abandoned by gophers. Indeed, many gopher burrows were found near the 98 turbines that lacked ground squirrel burrows, but most ground squirrel burrows occurred near turbines that also had gopher burrows. By June 2001, we observed ground squirrels establishing new burrow systems where gopher burrows were previously mapped in the absence of ground squirrel burrows during 1999 and 2000. Pocket gophers are attracted to the vertical and lateral edge created by the access roads and tower laydown areas cut into the steep slopes.

Except for the turbine string at ENRON, which has a distinct assembly of rodent species compared to the EnXco turbine strings and is geographically separated, the number of red-tailed hawk fatalities per turbine string increased with an increasing slope of log gopher burrow density regressed on log study area size (Figure 29):

$$\text{Hawk fatalities} = -3.68 - 7.01 \times \text{Regression slope coefficient}$$

$r^2 = 0.58$, Root MSE = 0.97, df = 1,7, $P < 0.05$ (not including the ENRON string).

The number of fatalities did not correlate significantly with the intercept of log gopher burrow density regressed on log study area size, nor did it correlate with the overall density of gopher burrows within the areas searched, nor with the maximum density recorded within the interior 7.5-m strip transect.

The turbine string at ENRON, which is south of Altamont Pass Road, had accumulated the largest number of red-tailed hawk fatalities, although it only had one ground squirrel burrow. The larger area of the ENRON operations had very few additional ground squirrel burrows on the premises. Instead, the ENRON turbine strings were home to many cottontails, which live under the tower platforms. The ENRON turbine strings will need to be analyzed separately from the EnXco turbine strings when we search for relationships between raptor fatality rates and prey distributions based on our larger data set.

Of the remaining EnXco tubular turbine strings with ground squirrel burrows, the number of red-tailed hawk fatalities did not relate significantly with the regression slope of log ground squirrel burrow density and log study area size (Figure 30):

Hawk fatalities = 1.510-2.476 Regression slope coefficient

r^2 = 0.48, Root MSE = 2.54, df = 1,4, P = 0.20.

We note, however, that our original maps of gopher and ground squirrel burrow systems did not include cottontail burrows, which is a species we have since observed in abundance at this outlier ENRON turbine string and which lives in burrows excavated under the concrete platforms of the turbines. New data are being collected on this aspect of the analysis.

6.0 DISCUSSION

This report describes the progress to date of research designed to identify the factors responsible for avian fatality rates at Altamont Pass Wind Resources Area, and to establish the empirical basis for developing a predictive model. This project is ongoing. Therefore, readers should consider these findings as preliminary and subject to revision. A comprehensive final report is scheduled for completion in late 2003.

Based on 372 carcasses resulting from confirmed collisions with turbines, the combined average annual fatality rate was 0.19 fatalities/turbine/year. Table 14 presents the average annual fatality rates for each of eight individual tower/turbine configurations. These data indicate that collision rates vary considerably when compared based solely on facility configurations. However, other physical features, landscape characteristics, and biological factors may affect the comparative fatality rates.

Our fatality data were derived from only 24% of the turbine population in the APWRA. Nevertheless, assuming our sample is representative of the entire APWRA and applying the fatality rate of 0.19 fatalities/turbine/year to 5,400 active turbines in the APWRA, one may estimate that as many as 1,026 birds are killed per year in the APWRA. Of these, approximately 50% are expected to be raptors.

To date, golden eagles represent 2.4% of the total bird fatalities in our study. This percentage yields an estimated 24 golden eagle deaths per year in the APWRA. Our estimate is fewer than Orloff and Flannery's (1992, 1996) estimate of 39 golden eagle fatalities per year and Hunt’s (2002) estimate of 40 to 60 golden eagle fatalities per year.

Similarly, burrowing owls represent 9% of the fatalities in our study. Extrapolating this percentage across all wind towers in the APWRA yields an estimated 93 fatalities per year. Red-tailed hawks represent 24% of the fatalities in our study, suggesting fatalities number 244 per year in the APWRA. The APWRA has been in operation with more than 4,000 turbines since about 1984. The turbine population peaked in 1987-88 at some 7,000 operating turbines. During the past several years, 5,000-5,400 turbines have consistently remained in operation. These estimates of total annual fatalities for golden eagles, red-tailed hawks, and burrowing owls warrant continued research, monitoring, and management programs designed to reduce these rates.

Despite the higher mortality reported here, it is not possible to conclude that more bird fatalities per turbine occurred between 1998 and 2000 than in previous years. These data probably reveal, however, that historically the full extent of the bird fatality problem has been underestimated. In addition, the fatalities are continuing.

As expected, each species using the APWRA exhibits a somewhat different suite of behaviors. It appears, at least for raptors, that differences in their foraging behaviors and their selection of prey species are closely related to their relative vulnerability to turbines. Our data on gopher burrows indicate that gophers more frequently occur near turbine strings than they do away from turbine strings. Furthermore, the distribution and occurrence of gopher burrows is related to raptor fatalities at turbine strings. From these findings, we conclude that lack of prey availability on the slopes away form turbines encourages red-tailed hawks to hunt near the turbines, thereby increasing the vulnerability of this species to operating turbines.

The number of bird fatalities per turbine string increases in relation to the total rotor swept area of the strings. This factor tended to be more significant than was the relationship between fatality rates and the number of turbines in each string. From these data, it is reasonable to infer that reducing the number of turbines in a particular area will not result in a reduction in bird fatalities unless the total rotor swept area is also reduced. These results contradict the results of Howell (1997), who found that rotor swept area did not explain the difference in fatality rates between two turbine types with different rotor swept areas.

Each of the various turbine/tower configurations has been suspected of causing different bird fatality rates (Howell 1997; Orloff and Flannery 1992, 1996; Anderson et al., 1999). Our data confirm this suspicion, but it appears that these differences may be due to certain turbine attributes or other factors that associate with the distribution of each of these turbine types. It appears that factors other than tower type play more of a role in whether a particular turbine is associated with one or more fatalities, such as prey distribution about the tower's base, physical relief, and presence of declivity winds. Regardless, the number of fatalities at tubular towers was higher than at horizontal lattice towers. This is contrary to previous research results (Orloff and Flannery 1996, Howell and DiDonato 1991). The repowering Environmental Impact Report (EIR) (Alameda County 1998) concluded that replacing horizontal lattice towers with tubular towers to support the new, larger turbines would reduce the number of fatalities post-repowering. The results of the present study do not substantiate the findings of the repowering EIR regarding the likelihood that using tubular towers will significantly reduce bird fatalities.

Past researchers have reported that wind turbines located at the ends of strings kill most of the raptors (Orloff and Flannery 1992, 1996; Hunt 1994). Using a single factor approach, this observation appears correct, but factoring windswept area of the string eliminated the previously apparent effect of turbine position in the string. The exception was the number of derelict turbines in the string, which appeared to increase along with the number of red-tailed hawk fatalities in the string.

Red-tailed hawks fatalities occur more frequently than expected by chance at turbines located on ridgelines than on hillsides. The reverse appears to be true for golden eagles. This finding highlights the need for a species-specific approach to reducing bird fatalities in the APWRA and for a better understanding of the effects of multiple environmental and landscape factors on bird risk.

A relatively large number of burrowing owls were killed at wind turbines in the APWRA, at least in the areas that we have sampled thus far. This species is becoming increasingly rare throughout California. It is possible that the regional impact of turbine fatalities in the APWRA, especially in terms of maintaining a stable population size, will be more significant to this species than is reported for golden eagles nesting in the region. We observed that burrowing owls exhibit unique flight and foraging behaviors, and they nest in relatively large numbers in the immediate area of operating wind turbines. To address this unique circumstance, more research is needed on the effects of turbine kills on this local population of burrowing owls and possible emergency management options that will reduce those impacts.

The recent EIR prepared by Alameda County (Alameda County 1998) assessed the potential impacts of a partial repowering proposal in the APWRA. One of its conclusions was that replacing smaller turbines with larger ones at a 7:1 ratio was likely to result in substantially fewer bird fatalities. The EIR failed to address, however, that converting to fewer turbines would result in a slight net increase in the total rotor swept area. Based on data presented here, it is reasonable to expect that the number of bird fatalities at fewer post-repowering turbines should remain nearly equal to the number of kills reported at the more numerous pre-repowering turbines. This hypothesis remains to be tested as the repowering effort proceeds.

Overall, our results have broadened understanding of bird use, fatality rates, risk behaviors, and the interactions of a variety of landscape elements in relation to risk and fatalities. The results are promising, and we believe that they may eventually lead to a solution to the overall objective of reducing bird kills in the APWRA. For this to occur, however, additional research using comparable methods conducted over a larger percentage of the APWRA's operating turbines is needed.

Eventually we expect patterns to emerge that can be used to identify high risk factors. The distribution of most of these factors is uneven in the region. By quantifying and mapping them, it may be possible to predict where bird fatalities are most likely to occur or where placing new turbines might kill the fewest numbers of birds. Such a model would have wide applicability and might one day help to effectively reduce the number of fatalities well below those that have occurred virtually unabated since the mid-1980s.

6.1 Summary of Key Findings

The following are key findings derived form our results to date. They are provided in no particular order. We intend to discuss their importance in detail in the final report.

- The frequency of sightings of species on the APWRA did not correspond strongly with turbine-caused mortalities among species.

- American kestrels and red-tailed hawks made more flights and spent more time flying within 50 m of the turbines than 51-100 m or 101-300 m away.

- We found 426 dead birds (including 226 dead raptors) and four dead mammals at 685 turbines that were searched 8-16 times each over 12-30 months.

- Fatality rates of raptor species correlated positively with the number of turbines in the string and the windswept area of the string.

- Turbines with larger rotor diameters killed more than the expected number of birds based on turbine numbers alone.

- Turbines with faster rotor-tip speeds killed more than the expected number of birds based on turbine numbers alone.

- Turbines with rotors 24 m above ground killed more than the expected number of birds based on turbine numbers alone, and the majority of these were tubular towers.

- Turbines at the ends and gaps of strings killed more than the expected number of birds based on turbine numbers alone, but factoring in windswept area of the string eliminated this effect.

- Factoring in windswept area, the presence of derelict turbines in the string emerged as a significant associate of red-tailed hawk fatalities.

- Turbines on swales and ridge tops killed more than the expected number of birds based on turbine numbers alone, and tower heights of 24 m and 30 m increased the effect of these landscape features apparently due to the interactions of declivity winds with these tower heights.

- Red-tailed hawk fatalities increased in strings with greater degrees of clustering of pocket gopher burrows.

- Raptor fatalities did not correspond well with the distribution of California ground squirrels.

6.2 Tasks Remaining

We continue to collect data that we believe will eventually contribute a better understanding of avian fatality rates and fatality mechanisms. For example, we are extending the coverage of rodent burrow maps to 80 meters from the turbine string, and we have added maps of burrow systems at about 30-40 turbine strings. In addition, some of our data have yet to be tested analytically because they are still being processed. A good example is the collection of spatial data and our use of GIS to process it. Elevation contours are being estimated using a digital elevation model, against which some of our variables will be compared. We will use landscape complexity measurements from the spatial data we have collected and that we are obtaining from off-site sources. Finally, our results may change as the sample size for total fatalities increases, and as we rule out the contributions of possibly spurious relationships. The statistical power of our analyses will increase with sample size, as will the confidence in our conclusions.

6.3 Management Implications

The need exists for a better, more accurate method of monitoring bird fatalities than the Wildlife Response and Reporting System (WRRS), which is the one on which regulatory agencies currently rely. This is particularly true for the APWRA, where bird fatalities have been chronic and substantial. The WRRS is not a scientifically defensible sampling program. It includes no searches for bird carcasses, no regularity of visitation to turbines, and overall no resemblance to scientific monitoring methods. A partial analysis of data obtained using the WRRS compared to the results of the present study revealed that the WRRS underreports raptor fatalities by at least a factor of eight (Thelander and Smallwood 2002). The level of underreporting is much higher for non-raptors. This assessment is based on a comparison of this study's fatality survey results for May 1998 thru March 2000 (n = 213 non-raptor fatalities found at only 12% of APWRA turbines) to the additional fatalities (n = 166) reported to Alameda County and the USFWS by Green Ridge Services/AIC for the balance of the turbines where reporting is required (i.e., no reporting is required for turbines in adjacent Contra Costa County).

A systematic monitoring protocol, one based on a standardized and systematic sampling methodology with statistical validity, needs to be implemented throughout the APWRA. By doing so, documenting future fatality rates and long-term trends can be monitored with more accuracy than is currently being provided by the WRRS methodology. Also, the results of the various groups collecting fatality data in the APWRA would be comparable.

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9.0 TABLES

Table 1. Number of Individual Wind Turbines/Towers Sampled with Their Output and Physical Characteristics

Tower Type	Output (kW)	Rotor Diameter (m)	Tower Height (m)	No. Sampled	Percent
Vertical Axis	150	17	30	20	2
Vertical Axis	250	19	30	119	11
Tubular	110	19	24	25	2
Tubular	120	19	24	220	20
Tubular	150	23	24	100	9
Horizontal Lattice	100	17	18	367	33
Diagonal Lattice	100	17	43	38	3
Diagonal Lattice	300	33	42	16	1
Diagonal Lattice	100	17	24	169	15
Diagonal Lattice	100	17	24	6	1
Diagonal Lattice	100	17	14	30	3
Total				**1,110**	

Table 2. Plot Number, Plot Size, Tower Type, and Turbine Output Characteristics for 685 Non-AIC Turbines Included in Behavioral Observation Sessions (Turbines on Horizontal Lattice Towers Were Not Included in This Sample)

			TURBINE FREQUENCY						
			Tubular			Vertical Axis		Diagonal Lattice	
Plot No.	Area (Km^2)	Strings in Plot	120 kW	150 kW	110 kW	150 kW	250 kW	100 kW	Total
1	3.5	14	33	0	0	25	0	0	58
2	2.2	5	26	0	0	5	0	0	31
3	3.8	7	0	27	0	9	0	0	36
4	3.2	9	24	0	0	11	0	0	35
5	1.9	3	6	8	0	0	0	0	14
6	3.3	2	0	27	0	0	0	0	27
7	3.6	5	23	14	0	0	0	0	37
8	2.2	5	25	0	0	0	0	0	25
9	3.8	9	29	13	0	0	0	0	42
10	3.5	3	4	11	0	0	0	0	15
11	3.0	6	5	0	0	0	20	0	25
12	4.3	9	16	0	7	22	0	0	45
13	4.0	5	0	0	0	48	0	0	48
14	2.5	6	9	0	8	0	0	0	17
15	2.3	2	14	0	0	0	0	0	14
16	3.0	7	6	0	10	0	0	45	61
17	2.0	4	0	0	0	0	0	52	52
18	2.2	3	0	0	0	0	0	37	37
19	2.6	2	0	0	0	0	0	28	28
20	2.6	3	0	0	0	0	0	38	38
Total	**59.5**	**109**	**220**	**100**	**25**	**120**	**20**	**200**	**685**

Table 3. Flight Behavior Categories Used to Record Observations during 30-Min Observation Sessions in the Study Plots

Flight Behaviors	
1. Fly through	10. Being mobbed
2. Gliding	11. Column soaring
3. Soaring	12. Surfing
4. High soaring	13. Ground hopping
5. Contouring	14. Hawking insects
6. Circling	15. Fleeing
7. Kiting/Hovering	16. Interacting
8. Diving	17. Flocking
9. Mobbing	18. Flushed

Table 4. Possible Perching Structures Used during the 30-Min Observation Sessions

PERCHING STRUCTURES	
1. Tree	11. Vertical axis tower (inner framework)
2. Fence post	12. Vertical axis tower (guy wire)
3. Ground	13. Turbine motor (top)
4. Rock/vegetation	14. Turbine motor (inside)
5. Electrical distribution pole (top)	15. Turbine blade tip/side
6. Electrical distribution pole (wire)	16. Turbine propeller cone
7. Electrical distribution pole (crossarm)	17. Catwalk of wind tower
8. Anemometer tower	18. Side ladder of wind tower
9. Electrical tower	19. Diagonal lattice tower (top)
10. Vertical axis tower (top)	20. Diagonal lattice tower (mid-framework)
	21. Diagonal lattice lower (lower framework)

Table 5. Bird Species Composition and Frequency (*N* = 5,283 Sightings) of Sightings Recorded during the Behavioral Observation Sessions

Common Name	Scientific Name	Count	Common Name	Scientific Name	Count
Great blue heron	*Ardea herodias*	6	Mourning dove	*Zenaida macroura*	10
Mallard	*Anas platyrhynchos*	25	Burrowing owl	*Athene cunicularia*	56
Common goldeneye	*Bucephala clangula*	1	Northern flicker	*Colaptes auratus*	4
Turkey vulture	*Cathartes aura*	740	Say's phoebe	*Sayornis saya*	7
White-tailed kite	*Elanus leucurus*	6	Loggerhead shrike	*Lanius ludovicianus*	100
Northern harrier	*Circus cyaneus*	96	American crow	*Corvus brachyrhynchos*	39
Golden eagle	*Aquila chrysaetos*	381	Common raven	*Corvus corax*	667
Cooper's hawk	*Accipiter cooperii*	1	Horned lark	*Eremophila alpestris*	25
Red-tailed hawk	*Buteo jamaicensis*	1,519	Cliff swallow	*Petrochelidon pyrrhonota*	12
Rough-legged hawk	*Buteo lagopus*	4	Mountain bluebird	*Sialia currucoides*	24
Ferruginous hawk	*Buteo regalis*	10	European starling	*Sturnus vulgaris*	69
American kestrel	*Falco sparverius*	351	American pipit	*Anthus rubescens*	6
Prairie falcon	*Falco mexicanus*	59	Western meadowlark	*Sturnella neglecta*	55
Killdeer	*Charadrius vociferus*	7	Red-winged blackbird	*Agelaius phoeniceus*	81
American avocet	*Recurvirostra americana*	1	Tricolored blackbird	*Agelaius tricolor*	30
Long-billed curlew	*Numenius americanus*	4	Brewers blackbird	*Euphagus cyanocephalus*	40
Ring-billed gull	*Larus delawerensis*	111	House finch	*Carpodacus mexicanus*	19
California gull	*Larus califfornicus*	81	Unidentified Laridae		276
Band-tail pigeon	*Columba fasciata*	1	Unidentified raptor		44
Rock dove	*Columba livia*	134	Unidentified Icterid		85
			Unidentified passerine		28

Table 6. Summary of Time during Which Birds Were Observed Flying Versus Perching. More than One Perch or Flight Behavior May Be Recorded Per Bird Sighting. The Mean Refers to the Minutes of Activity Per Observation Session

	Total Minutes	Mean (Min)	SD
Flight Time	13,725	186.02	2428.45
Perch Time	17,592	11.87	135.86
Total Flying and Perching	31,317	235.53	2515.21

Table 7. Number of Minutes Flying and Perching for Species with 20 or More Sightings. Flying: *n* = 4,585 Sightings, 11,382 Minutes. Perching *n* = 1,520 Sightings, 13,189 Minutes. Total Sightings and Time: *n* = 5,161 Sightings in 24,556 Minutes

	Flying Activity				Perching Activity				Percent Time
Species	***n***	**Mean**	**SD**	**Sum**	***n***	**Mean**	**SD**	**Sum**	**in Flight**
Red-tailed hawk	1,254	3.47	4.03	4,351	600	11.16	9.07	6,696	39
Turkey vulture	737	2.21	2.48	1,629	15	5.00	6.13	75	96
Corvids	666	1.72	1.46	1,145	174	5.15	5.55	896	56
Gull species	468	2.42	3.89	1,133	0	0.00	0.00	0	100
Golden eagle	355	3.12	2.97	1,108	89	8.53	9.07	759	59
American kestrel	270	1.78	1.93	481	239	7.26	6.97	1,735	22
Generic blackbird	219	1.93	3.21	423	64	7.64	8.19	489	46
Rock dove	131	1.31	2.54	172	12	4.67	8.26	56	75
Generic passerine	101	1.71	2.18	173	74	5.01	5.94	371	32
Northern harrier	95	2.51	2.90	238	11	4.64	7.42	51	82
Prairie falcon	58	1.90	1.57	110	9	7.56	7.23	68	62
Loggerhead shrike	57	1.51	1.04	86	92	5.89	6.45	542	14
Swallow species	46	3.15	5.75	145	0	0.00	0.00	0	100
Western meadowlark	41	1.22	0.82	50	30	8.68	8.43	260	16
European starling	37	1.24	1.04	46	53	11.17	9.71	592	7
Mallard	25	1.04	0.20	26	0	0.00	0.00	0	100
Burrowing owl	24	2.46	4.36	59	54	12.61	9.92	681	8

Table 8. Raptor Flying Time (Minutes) According to Proximity Level. An Asterisk Indicates the Corresponding Mean Differed Statistically from the Others at α = 0.05

Proximity Level	*n*	Mean	SD	Total
0-50 m	1,112	4.59*	5.04	5,104
51-100 m	2,187	3.34	3.48	7,305
101-300 m	686	2.12	1.98	1,454

Table 9. Frequencies of Proximity Level 1 Flights by Raptor Species (AMKE = American Kestrel, BUOW = Burrowing Owl, GOEA = Golden Eagle, NOHA = Northern Harrier, PRFA = Prairie Falcon, RTHA = Red-Tailed Hawk, TUVU = Turkey Vulture). Data Are for Raptor Species with More than 20 Behavior Sightings (*n* = 3,985; March 1998 – March 2000)

	Frequency of Sightings													
	AMKE		BUOW		GOEA		NOHA		PRFA		RTHA		TUVU	
Flight Behavior	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*
Contouring	0.8	2	4.0	1	18.2	105	6.0	8	2.5	2	7	135	0.8	8
Kiting	4.8	12	0.0	0	1.6	9	1.5	2	0.0	0	15.3	296	0.0	0
Hover/Surfing	17.3	43	0.0	0	1.7	10	3.0	4	8.9	7	5.8	107	0.6	6
Diving	11.3	28	8.0	2	2.4	14	3.8	5	10.1	8	5.4	108	0.1	1
Mobbing	9.3	23	0.0	0	2.6	15	1.6	2	7.6	6	2.5	48	0.4	4
Interacting	0.8	2	0.0	0	0.5	3	2.3	3	0.0	0	2.3	44	0.0	0
Flushed	0.8	2	0.0	0	1.9	11	0.0	0	0.0	0	0.6	11	0.0	0
Fleeing	0.0	0	0.0	0	0.5	3	0.0	0	0.0	0	0.1	2	0.0	0
Gliding	9.7	24	16.0	4	23.1	133	12.8	17	17.7	14	17.8	345	33.3	328
Soaring	6.5	16	4.0	1	22.0	127	12.0	16	7.6	6	19.7	383	27.9	225
Circling	9.3	23	0.0	0	9.7	56	9.0	12	16.5	13	10.8	209	13.5	133
Hawking Insects	1.6	4	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Flocking	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Flying Through	25.8	64	48.0	12	6.3	36	20.3	27	22.8	18	7.7	150	15.0	148
High Soaring	0.8	2	0.0	0	9.2	53	6.0	8	5.1	4	5.4	104	8.0	79
Ground Hopping	1.2	3	20.0	5	0.2	1	0.8	1	0.0	0	0.1	1	0.2	2
Soaring in Column	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
TOTAL		**248**		**25**		**576**		**133**		**79**		**1,940**		**984**

Table 10. Frequencies of Proximity Level Flights by Raptor Species for March 1998 – March 2000

	Frequency of Sightings in Proximity Levels to Turbines					
	≤50 m		51-100 m		101-300 m	
Species	**%**	***n***	**%**	***n***	**%**	***n***
American kestrel	45	112	30.0	67	25.0	5
Burrowing owl	12.0	3	20.0	5	68.0	17
Golden eagle	29.5	170	54.9	316	15.6	90
Northern harrier	39.1	52	33.8	45	27.1	36
Prairie falcon	29.1	23	41.8	33	29.1	23
Red-tailed hawk	38.6	748	48.3	937	13.1	255
Turkey vulture	1.9	19	74.8	736	23.3	229
Total	**28.3**	**1,127**	**53.7**	**2,139**	**18.0**	**719**

Table 11. Mean Flying Time for Raptors by Proximity Level for March 1998 – March 2000.

Asterisk Indicates a Statistically Significant Difference between Means

	Flight Time (Minutes) per Observed Flight						
		≤50 m		51-100 m		101-300 m	
Species	***N***	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
American kestrel	369	2.11	1.88	2.55	3.22	1.39*	1.04
Burrowing owl	26	1.67	1.15	4.83	7.96	1.24	0.44
Golden eagle	580	3.75	3.89	3.67	3.19	3.23	2.82
Northern harrier	133	3.29	3.66	2.96	2.49	2.08	1.79
Prairie falcon	82	2.35	1.70	2.21	1.95	2.54	0.76
Red-tailed hawk	2,149	5.44*	5.61	3.84	3.95	2.39	2.15
Turkey vulture	984	3.74*	3.59	2.65*	2.74	1.83	1.64

Table 12. Summary of 439 Fatalities Divided between Raptors and Non-Raptors

Species/Group	Raptor Fatalities	Non-Raptor Fatalities
Red-tailed hawk	103	
Burrowing owl	51	
Barn owl	26	
American kestrel	24	
Golden eagle	11	
Great horned owl	6	
Northern harrier	2	
Prairie falcon	1	
White-tailed kite	1	
Buteo sp.	1	
Rock dove (pigeons)		60
Western meadowlark		49
European starling		19
Mallard		16
House finch		15
Horned lark		10
Passeridae sp. (sparrows)		8
Mourning doves		8
Icterinae sp. (blackbirds)		7
Laridae sp. (gulls)		5
Cliff swallow		4
Hoary bat		4
Black-crowned night herons		2
Common raven		2
Loggerhead shrike		2
Northern flicker		1
Wild turkey		1
Total	**226**	**213**

Table 13. Summary of Individual Tower/Turbine Configurations Involved in Bird Collisions

Type	Rotor Diameter (m)	Height (m)	Towers Sampled	Years Sampled	Towers with Collisions
Vertical Axis 150 kW	17	30	20	2.5	4
Vertical Axis 250 kW	19	30	119	2.5	27
Tubular 150 kW Bonus	23	24	100	2.7	43
Tubular 120 kW Bonus	19	24	220	2.7	78
Tubular 120 kW	19	24	25	2.5	1
Diagonal Lattice 100 kW	17	43	38	1.0	1
Diagonal Lattice 300 kW	33	42	16	1.0	5
Diagonal Lattice 100 kV	17	24	6	1.0	0
Diagonal Lattice 100 kW	17	24	169	2.5	52
Diagonal Lattice 100 kW	17	14	30	2.5	5
Horizontal Lattice 100 kW	17	18	367	1.0	6
			1,110		**272 (24%)**

Table 14. Summary of Bird Collisions Per Turbine Per Year by Tower and Turbine Type

Tower/Turbine/Output	No. Towers	No. Bird Collisions	Collisions/Tower/Year
Tubular Bonus 150	100	75	0.27
Tubular Bonus 120	220	109	0.18
Tubular Danwin 110	25	1	0.02
Vertical Axis 150	20	4	0.08
Vertical Axis 250	119	28	0.09
Diagonal Lattice 100	243	88	0.17
Diagonal Lattice KVS-33	16	5	0.31
Horizontal Lattice 56-100s	367	59	0.16

Table 15. Mean Flying Time (in Minutes) for Raptors by Season.

Asterisk Indicates a Statistically Significant Difference between Means

	1998-1999				1999-2000			
SEASON	*N*	*Mean*	*SD*	*Total*	*N*	*Mean*	*SD*	*Total*
Spring	81	2.63	3.10	213	325	2.78	2.52	904
Summer	255	1.91	1.47	487	602	2.88	2.94	1734
Fall	276	2.75	3.03	759	624	2.73	3.36	1704
Winter	257	2.56	2.43	658	381	4.05	5.42 *	1543

Table 16. Statistics Summarizing Fatality Rate Regressed on Number of Turbines in a String

Dependent Variable	a	b	r^2	RMSE	P
Red-tailed hawk	-0.0746	1.4100	0.27	1.23	0.001
Golden eagle	-0.0740	0.0059	0.01	0.34	0.36
American kestrel	-0.0058	0.0258	0.12	0.37	0.001
Burrowing owl	0.1070	0.0300	0.05	0.70	0.023
Barn owl	-0.0200	0.0339	0.13	0.47	0.001

Table 17. Raptor Fatalities per Turbine String Regressed on Windswept Area of Turbine String

Dependent Variable	a	b	r^2	RMSE	P
Red-tailed hawk	-0.27	0.00062	0.41	1.10	0.001
Golden eagle	0.015	0.00006	0.06	0.34	0.015
American kestrel	-0.006	0.00009	0.12	0.37	0.001
Burrowing owl	0.031	0.00015	0.10	0.68	0.001
Barn owl	-0.052	0.00014	0.17	0.46	0.001

Table 18. Chi-Square (χ^2) Test Results between Fatalities of Five Raptor Species and Attributes of the Wind Tower/Turbine

VARIABLE RELATED TO FATALITIES	χ^2 value	d.f.	P-value
Turbine/Tower Type (Fig. 14)			
Red-tailed hawk	22.0	3	$P < 0.01$
Golden eagle	13.6	3	$P < 0.01$
American kestrel	3.4	3	ns
Burrowing owl	15.3	3	$P < 0.01$
Barn owl	5.6	3	ns
Turbine Rate/Speed (Fig. 16)			
Red-tailed hawk	16.1	2	$P < 0.01$
Golden eagle	13.7	2	$P < 0.01$
American kestrel	2.3	2	ns
Burrowing owl	15.3	2	$P < 0.01$
Barn owl	5.4	2	ns
Turbine Orientation Relative to Wind			
Red-tailed hawk	17.9	1	$P < 0.01$
Golden eagle	3.0	1	ns
American kestrel	2.3	1	ns
Burrowing owl	0.1	1	ns
Barn owl	0.5	1	ns
Rotor Diameter (Fig. 15)			
Red-tailed hawk	29.3	4	$P < 0.01$
Golden eagle	13.8	4	$P < 0.01$
American kestrel	1.3	4	ns
Burrowing owl	13.9	4	$P < 0.01$
Barn owl	6.6	4	ns
Turbine Size (kW/h)			
Red-tailed hawk	3.4	4	ns
Golden eagle	8.6	4	ns
American kestrel	1.6	4	ns
Burrowing owl	15.8	4	$P < 0.01$
Barn owl	4.5	4	ns
Anemometer			
Red-tailed hawk		1	
Golden eagle		1	
American kestrel		1	
Burrowing owl		1	
Barn owl		1	

Tower Height (Fig. 17)			
Red-tailed hawk	18.2	2	$P < 0.01$
Golden eagle	4.0	2	ns
American kestrel	3.5	2	ns
Burrowing owl	1.7	2	ns
Barn owl	1.3	2	ns
Whether Part of a Windwall			
Red-tailed hawk		1	
Golden eagle		1	
American kestrel		1	
Burrowing owl		1	
Barn owl		1	
Position in String (Fig. 18)			
Red-tailed hawk	0.5	3	ns
Golden eagle	6.2	3	ns
American kestrel	3.1	3	ns
Burrowing owl	19.0	3	$P < 0.01$
Barn owl	1.4	3	ns
Whether in Canyon (Fig. 24)			
Red-tailed hawk	15.9	1	$P < 0.01$
Golden eagle	21.3	1	$P < 0.01$
American kestrel	0.1	1	ns
Burrowing owl	7.2	1	$P < 0.01$
Barn owl	20.5	1	$P < 0.01$
Slope Aspect (Fig. 25)			
Red-tailed hawk	11.8	8	ns
Golden eagle	9.5	8	ns
American kestrel	4.7	8	ns
Burrowing owl	10.0	8	ns
Barn owl	15.8	8	$P < 0.05$
Physical Relief (Fig. 22)			
Red-tailed hawk	4.2	4	ns
Golden eagle	2.5	4	ns
American kestrel	5.2	4	ns
Burrowing owl	1.5	4	ns
Barn owl	1.2	4	ns
Declivity (Fig. 23)			
Red-tailed hawk	24.6	14	
Golden eagle	6.9	14	ns
American kestrel	50.9	14	
Burrowing owl	3.8	14	ns
Barn owl	5.2	14	ns

Table 19. Frequency of Tower/Turbine Position within Strings of Turbines, where 2nd and 3rd Refer to Their Relative Locations from the End Turbines. These Frequencies Were Factored into the Chi-Square Tests as the Available Positions within the String, whereas the Frequencies in the Bottom Table Compose the Use, where Use Was Indicated by Fatalities

Position in String	Frequency	Percentage
End	183	26.8
2nd	129	18.9
3rd	82	12
Middle	176	25.8
Gap	97	14.2
Total	667	100

Simplified from Above:

Position in String	Frequency	Percentage
End	183	26.8
Gap	97	14.2
2nd	129	18.9
Middle	387	37.8
Total	667	100

Number of Fatalities:

Species	Total	End	Gap	2nd	3rd	Middle
Red-tailed hawk	88	24	15	16	9	24
American kestrel	17	4	4	1	3	5
Golden eagle	12	6	3	2	1	0
Burrowing owl	32	18	7	1	1	5
Barn owl	21	8	3	3	0	7

Table 20. Raptor Fatalities per Turbine String Regressed on the Percentage of Turbines Located at Particular Positions in the String. The Number of Raptor Fatalities Adjusted by Windswept Area Regressed on the Percentage of Turbines at Particular Positions in the String

	Dependent Variable: Fatalities per Turbine String					Fatalities per Turbine String Adjusted by Windswept Area of the String				
Predictor Variable: Percent of String	**a**	**b**	**r^2**	**RMSE**	**P**	**a**	**b**	**r^2**	**RMSE**	**P**
Red-tailed hawk										
End towers	1.332	-0.012	0.07	1.38	0.005	-0.057	0.0014	0.00	1.23	0.72
Gap towers	0.807	0.0005	0.00	1.43	0.920	-0.013	0.0009	0.00	1.23	0.84
Ends and gaps	1.654	-0.015	0.09	1.37	0.002	-0.225	0.004	0.01	1.10	0.29
Middle towers	0.152	0.016	0.11	1.36	0.001	0.017	-0.0004	0.00	1.23	0.92
Golden eagle										
End towers	0.143	-0.0008	0.01	0.34	0.475	-0.027	0.0007	0.00	0.34	0.527
Gap towers	0.079	0.0022	0.03	0.34	0.085	-0.030	0.0021	0.03	0.33	0.093
Ends and gaps	0.058	0.0009	0.01	0.34	0.429	-0.147	0.0026	0.05	0.33	0.023
Middle towers	0.134	-0.0006	0.00	0.35	0.629	0.092	-0.0022	0.04	0.33	0.045
American kestrel										
End towers	0.266	-0.0026	0.04	0.38	0.031	0.007	-0.0002	0.000	0.37	0.882
Gap towers	0.158	-0.00003	0.00	0.39	0.984	0.003	-0.0002	0.000	0.37	0.872
Ends and gaps	0.340	-0.0033	0.06	0.38	0.015	0.023	-0.0004	0.000	0.37	0.752
Middle towers	0.012	0.0035	0.07	0.38	0.006	-0.027	0.0007	0.000	0.37	0.589
Burrowing owl										
End towers	0.400	-0.0025	0.01	0.71	0.262	-0.061	0.0015	0.00	0.68	0.490
Gap towers	0.255	0.0028	0.01	0.71	0.289	-0.036	0.0025	0.01	0.68	0.320
Ends and gaps	0.333	-0.0007	0.00	0.72	0.792	-0.223	0.0004	0.03	0.67	0.089
Middle towers	0.260	0.0009	0.00	0.72	0.713	0.155	-0.0038	0.03	0.67	0.098
Barn owl										
End towers	0.366	-0.0041	0.07	0.49	0.008	0.018	-0.0004	0.00	0.46	0.756
Gap towers	0.169	0.0017	0.01	0.50	0.357	-0.021	0.0014	0.01	0.46	0.400
Ends and gaps	0.397	-0.0036	0.04	0.49	0.036	-0.039	0.0007	0.00	0.46	0.664
Middle towers	0.077	0.0029	0.03	0.50	0.089	0.060	-0.0015	0.01	0.46	0.342

10.0 FIGURES

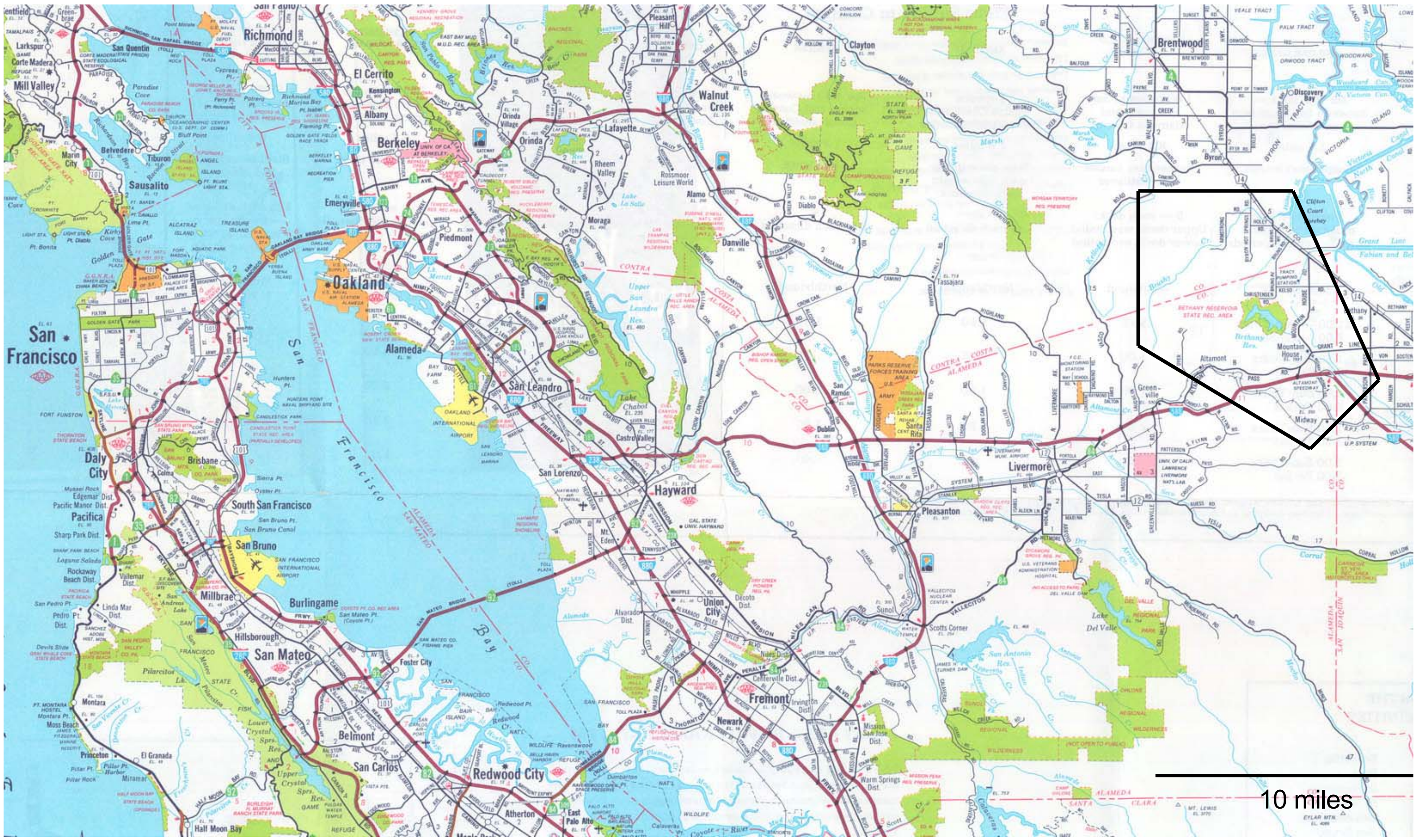

Figure 1. Approximate boundaries (outlined polygon) of the Altamont Wind Resource Area, located in Alameda and Contra Costa counties east of San Francisco, California.

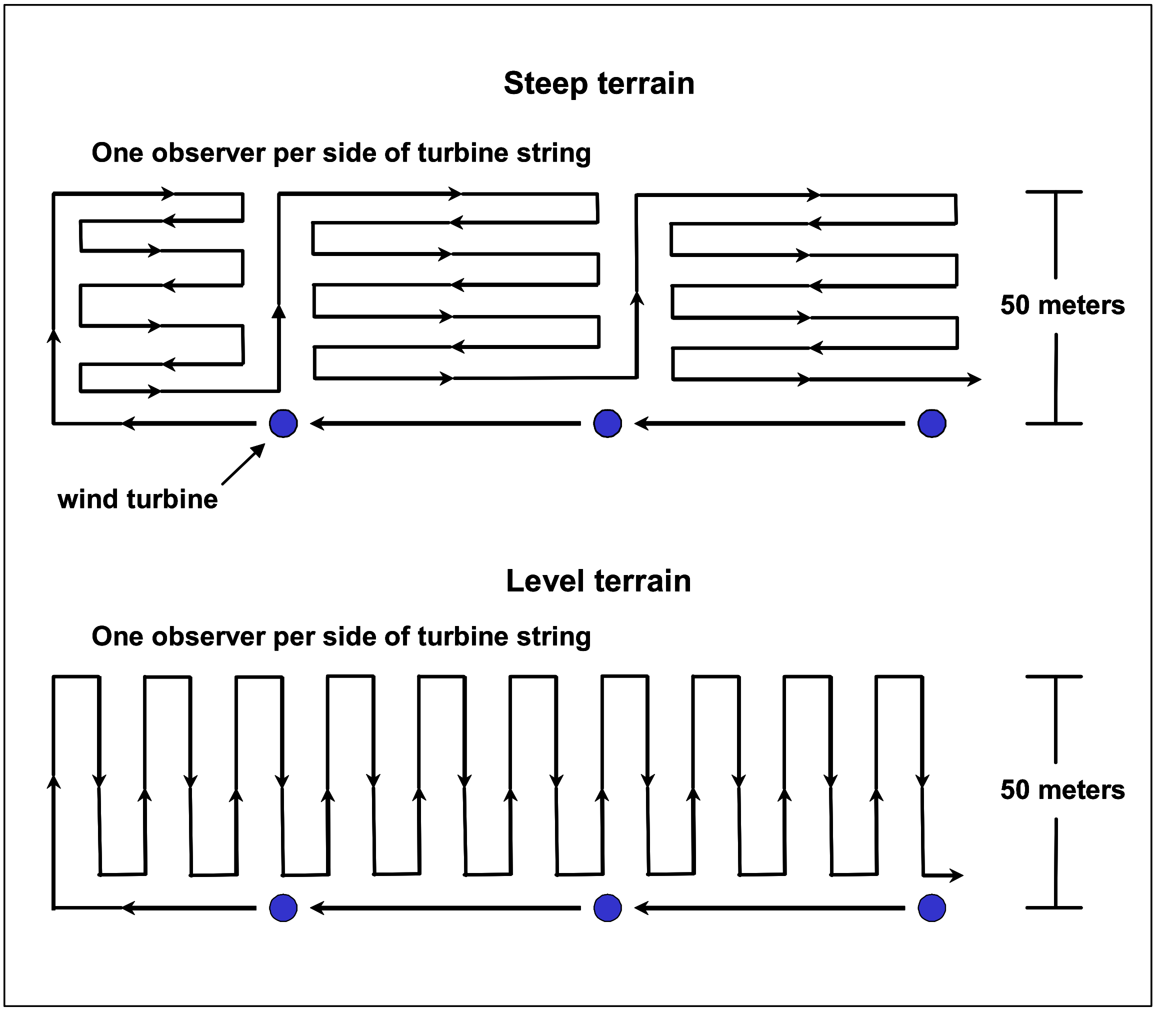

Figure 2. Searching pattern for the location of bird fatalities around wind turbines (search pattern is depicted for only one side of turbine string).

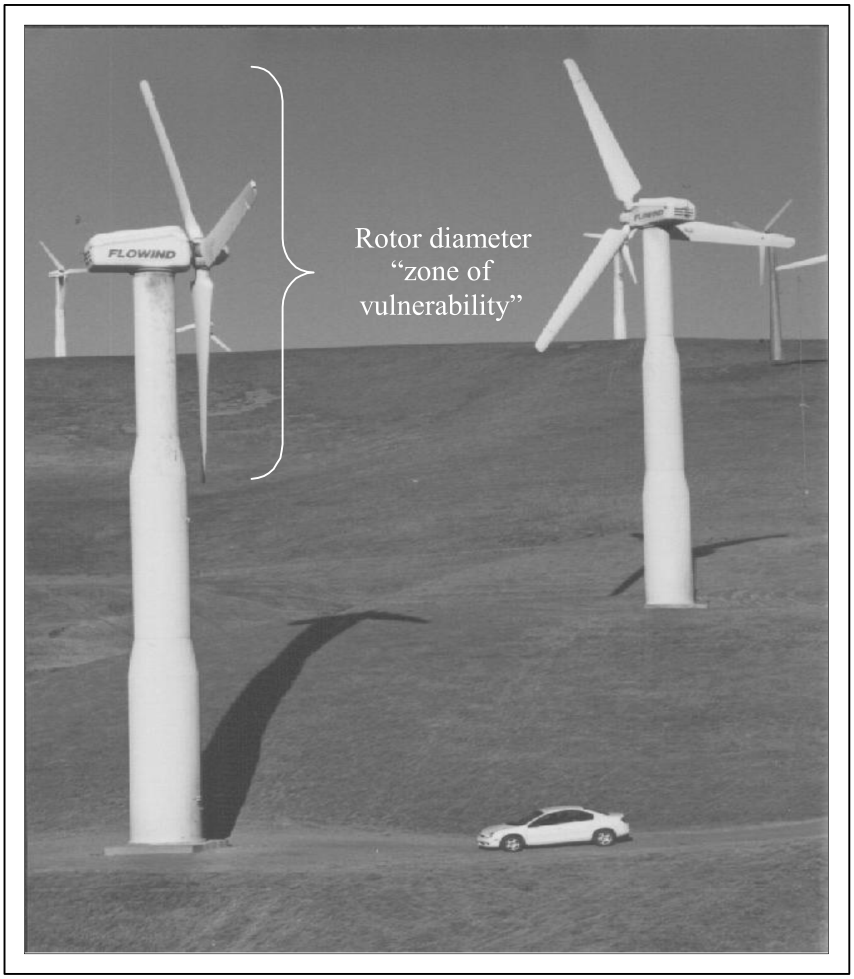

Figure 3. Wind turbine rotor diameter area or "zone of vulnerability."

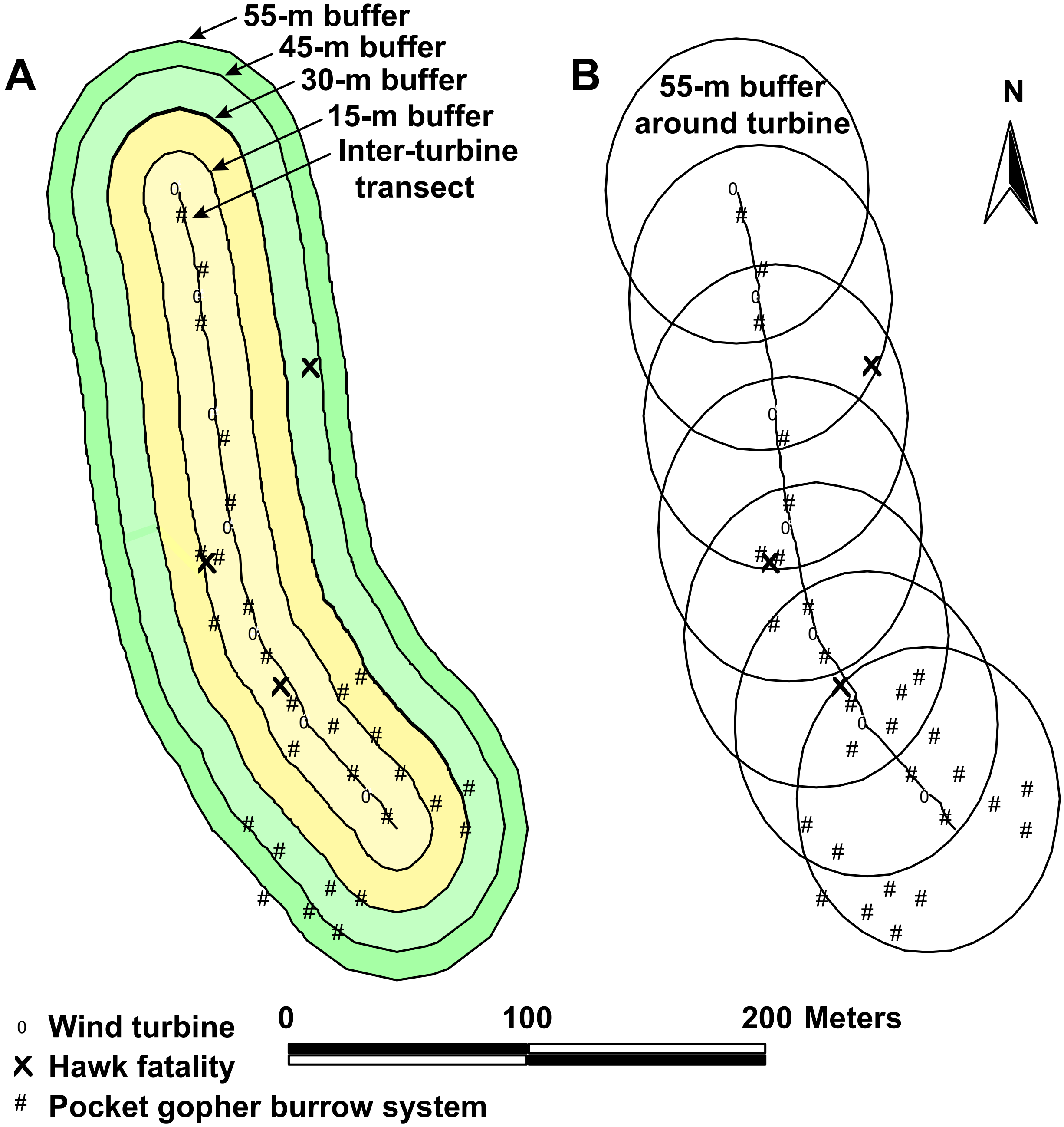

Figure 4. The density of pocket gopher burrow systems at Turbine String 9 (shown above) was calculated within each search area identified by the boundaries expanding away from the inter-turbine transect (A) and within 55 m of each turbine (B). Note that the gopher burrow systems are most strongly clustered near the wind turbines, and there is an additional cluster extending to the southwest of the turbine string.

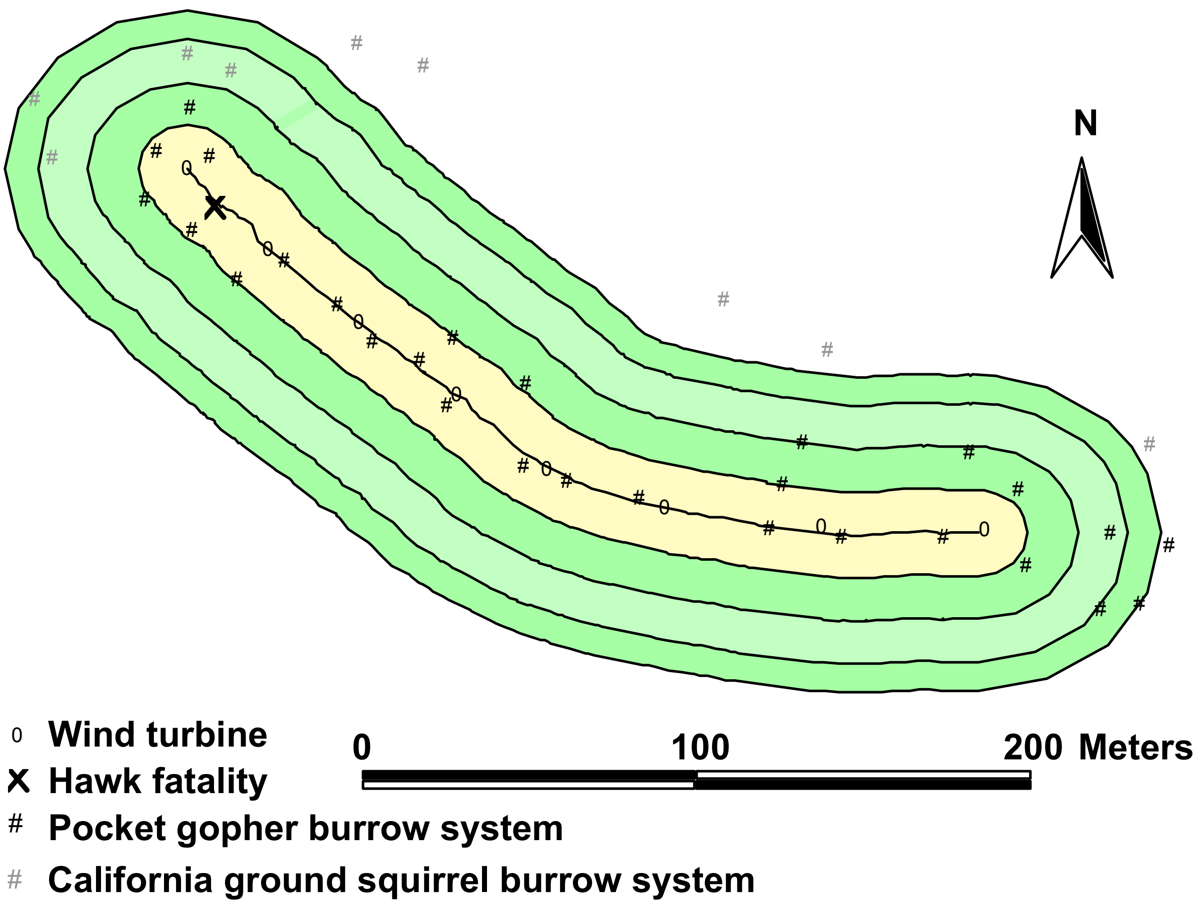

Figure 5. Gopher burrow systems are clustered within Turbine String 3 (shown here), whereas ground squirrel burrow systems are farther away. The largest portion of the ground squirrel colony is located north of this map beyond the search area.

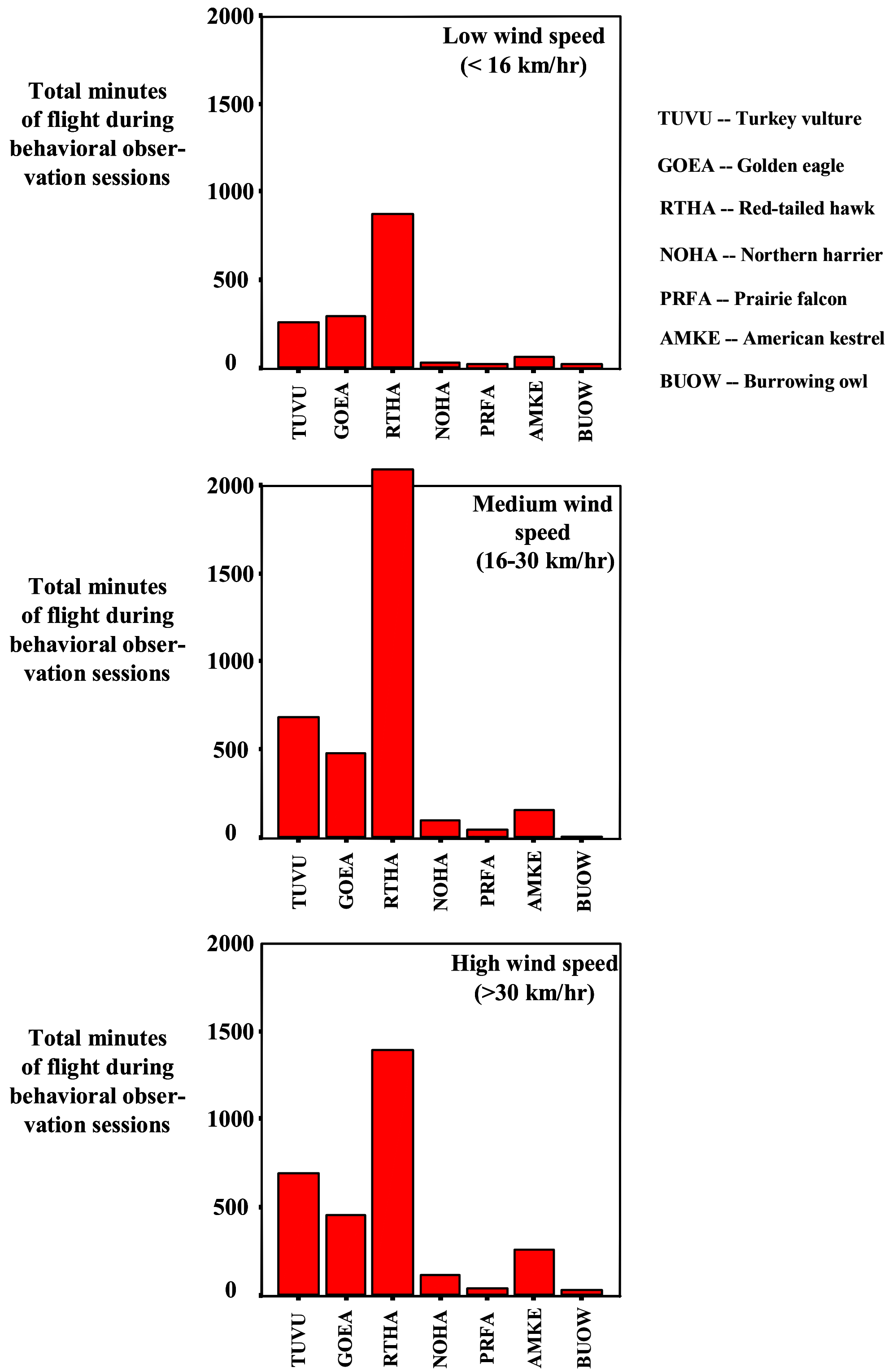

Figure 6. Comparisons of total flying time among raptor species during low (< 15 km/hr), medium (16-30 km/hr), and high (>31 km/hr) winds.

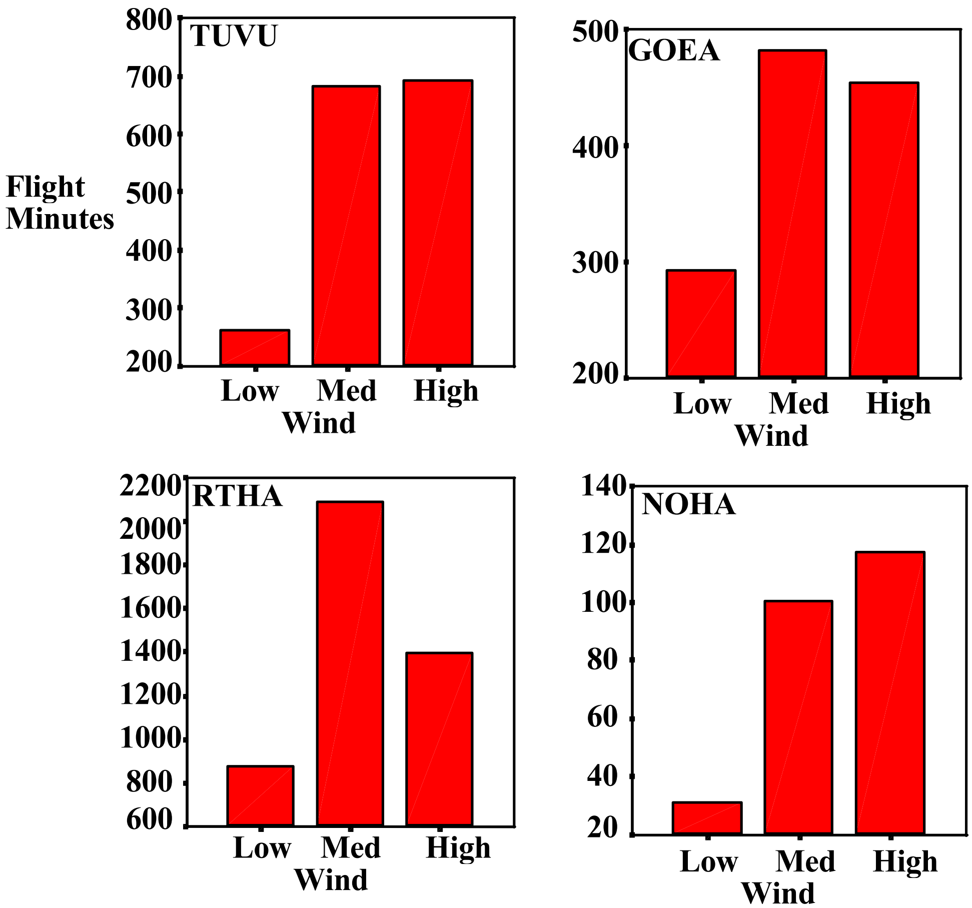

Figure 7. Total number of minutes flying in low, medium, and high winds for raptor species. TUVU = turkey vulture, GOEA = golden eagle, RTHA = red-tailed hawk, NOHA = northern harrier.

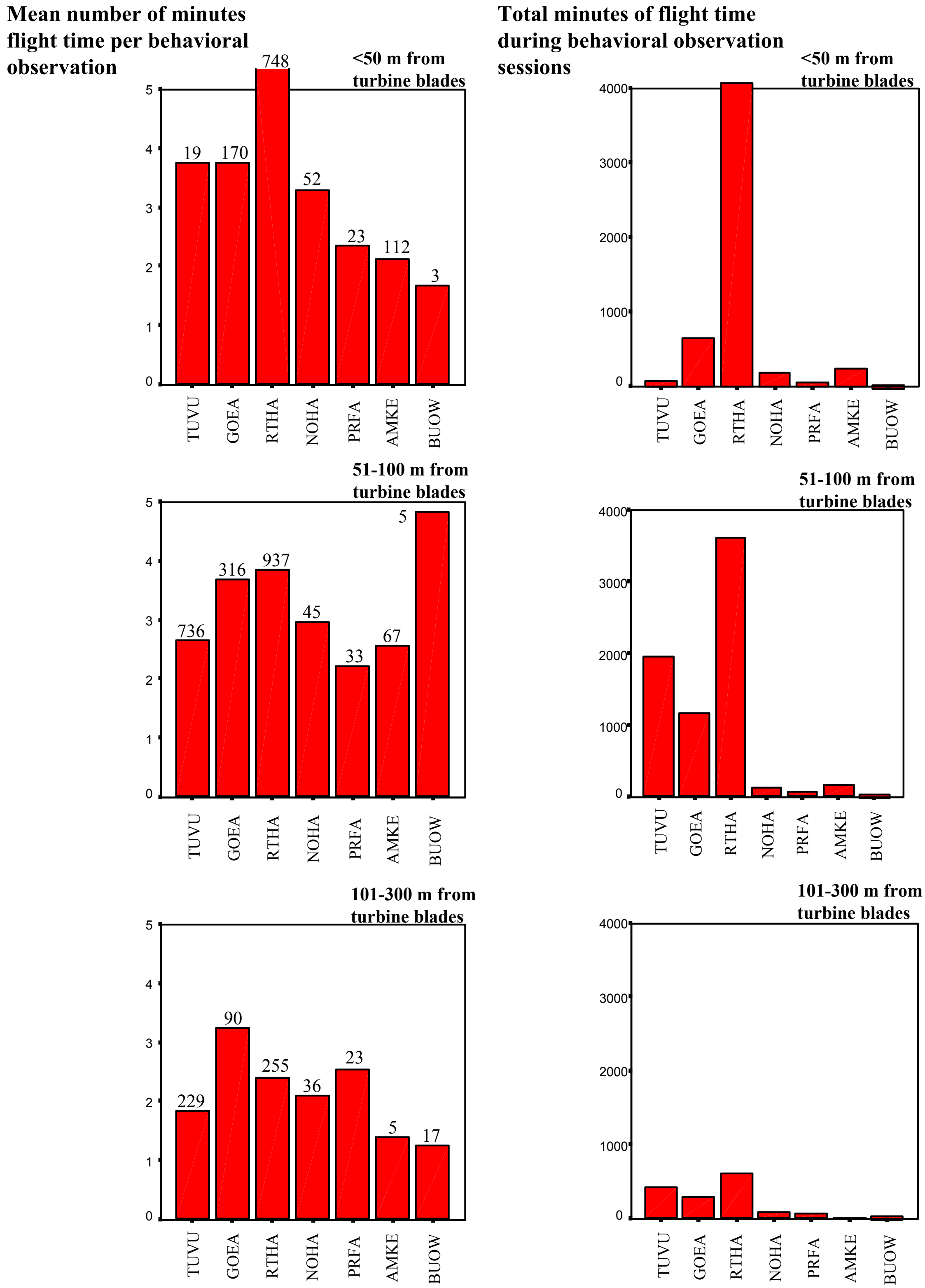

Figure 8. Differences between mean and total flight time of raptor species within proximity Level 1 (<50 m), Level 2 (51-100 m), and Level 3 (100-300 m). The species designations on the X-axis are American Ornithologist's Union acronyms: TUVU = turkey vulture, GOEA = golden eagle, RTHA = red-tailed hawk, NOHA = northern harrier, PRFA = prairie falcon, AMKE = American kestrel, and BUOW = burrowing owl.

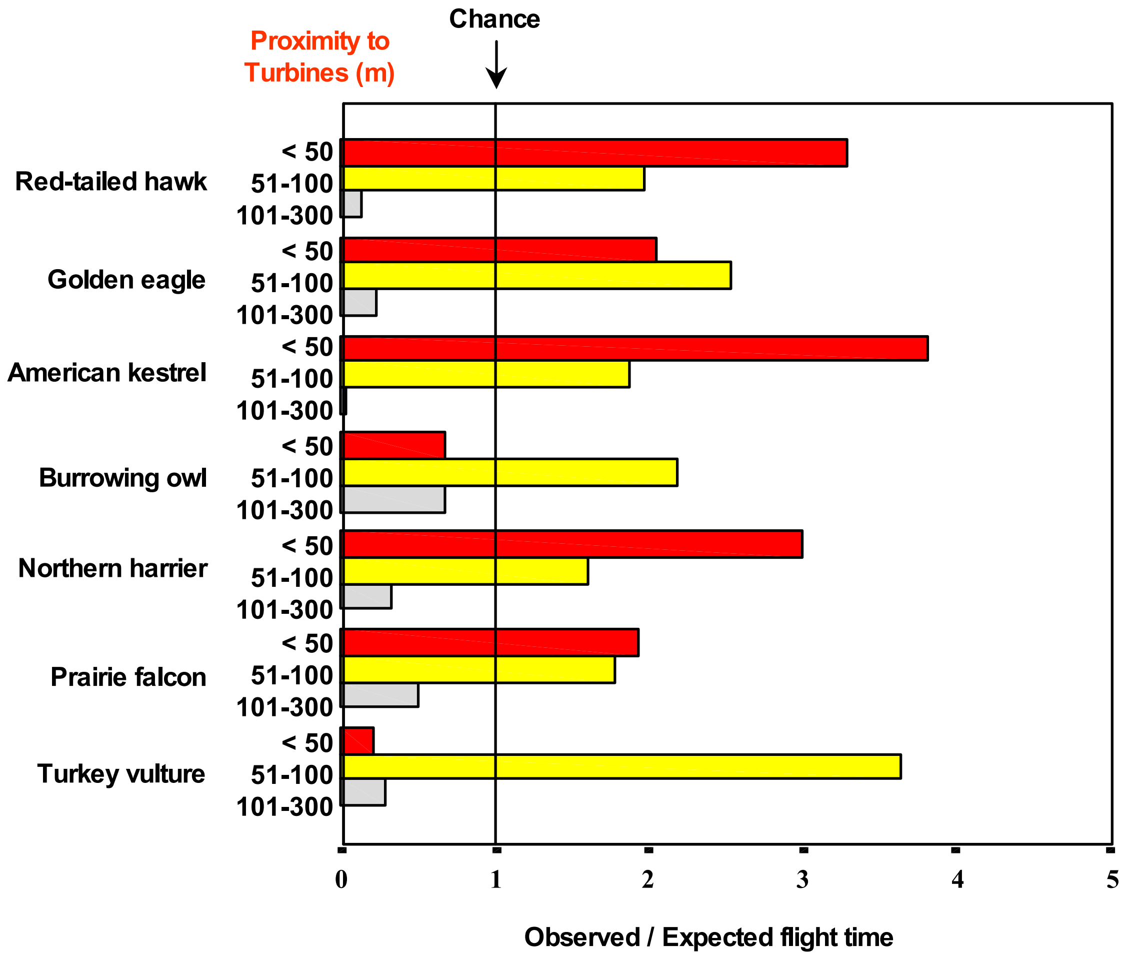

Figure 9. Associations between flight time and proximity to turbines among raptor species, where the total minutes of flying time within each proximity level was compared to the availability of the proximity level based on its approximate geographic area. Observed/expected values greater than 1 indicate the degree to which the observed value exceeds the expected value based on chance.

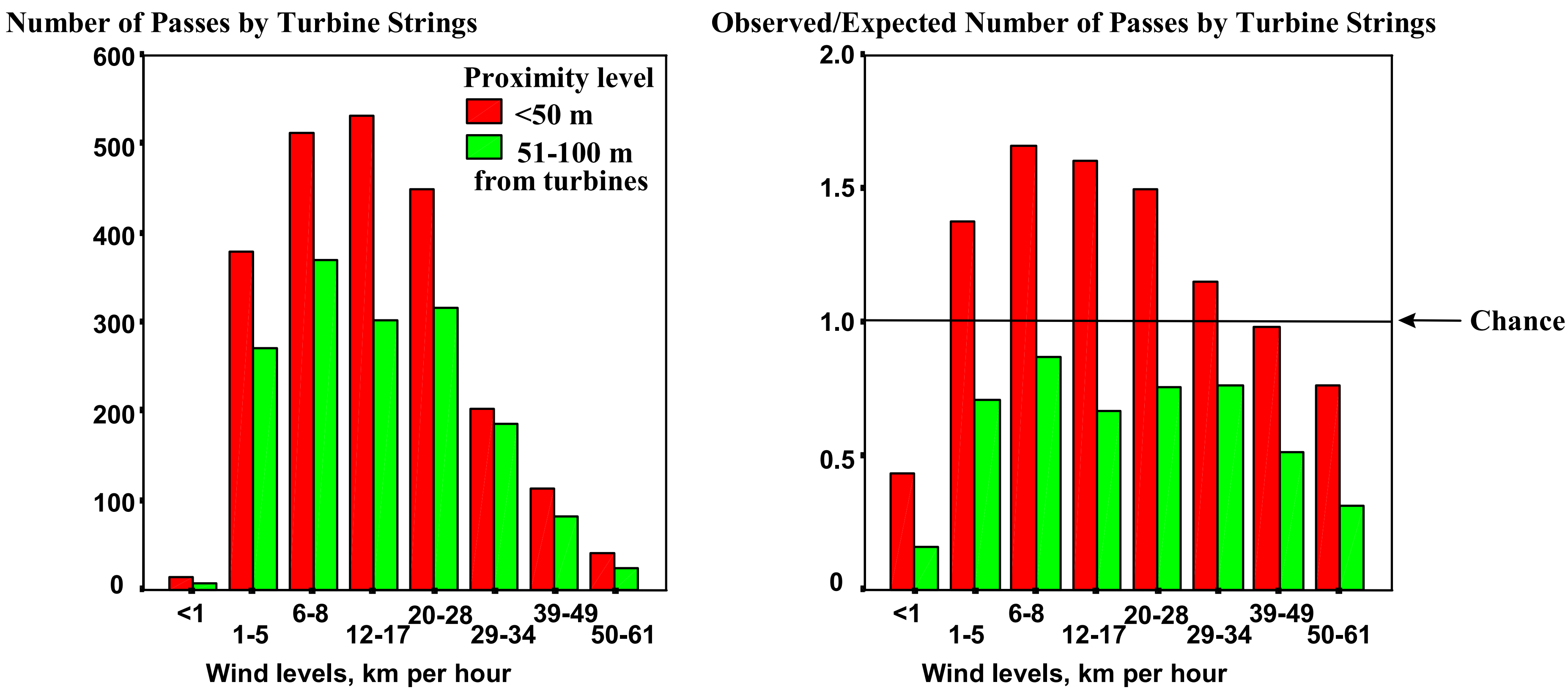

Figure 10. Left panel: Comparison of the number of passes by red-tailed hawk by turbine strings within and farther away than 50 m and at eight levels of wind speed. Right panel: A comparison of the observed and expected number of passes under these conditions, factoring in the proportion of observation sessions having a particular wind speed and the proportion of the area composed of proximity levels 1 and 2.

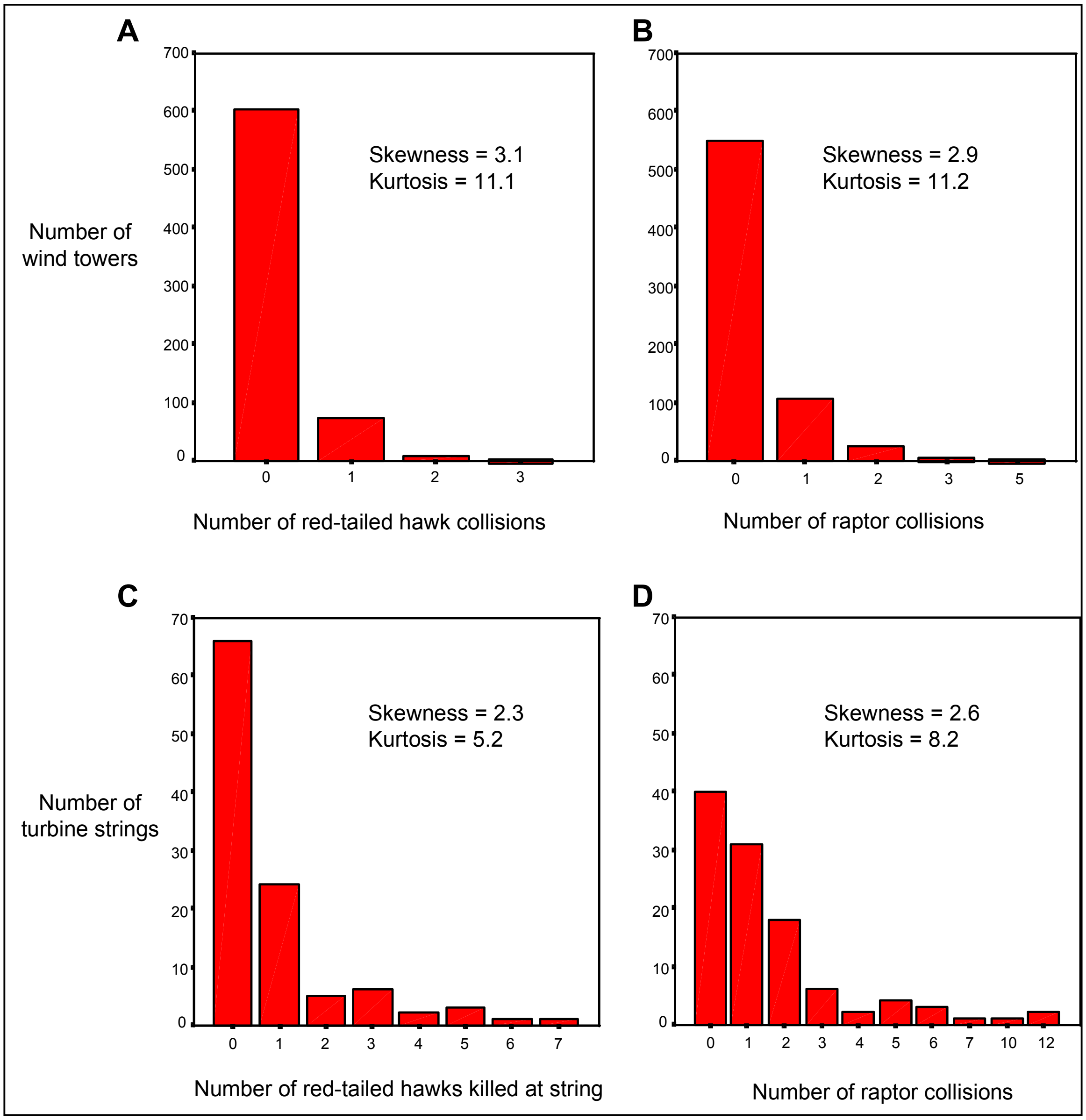

Figure 11. Frequency distributions of red-tailed hawk and all raptor fatalities among all wind towers (Graphs A and B, respectively) and among turbine strings (Graphs C and D, respectively).

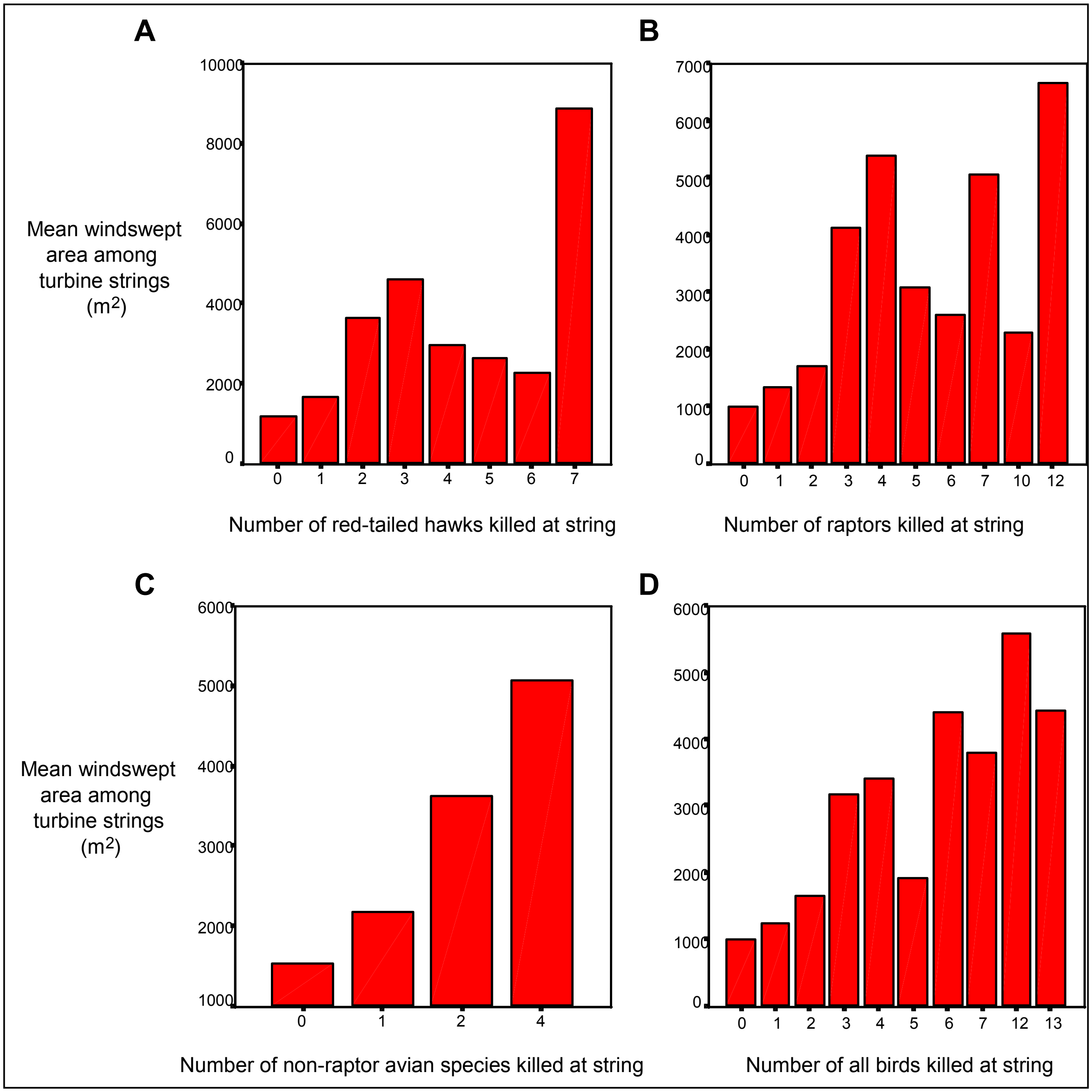

Figure 12. Mean windswept area per turbine strings associated with increasing numbers of fatalities of (A) red-tailed hawks, (B) all raptors, (C) non-raptor species, (D) all bird species.

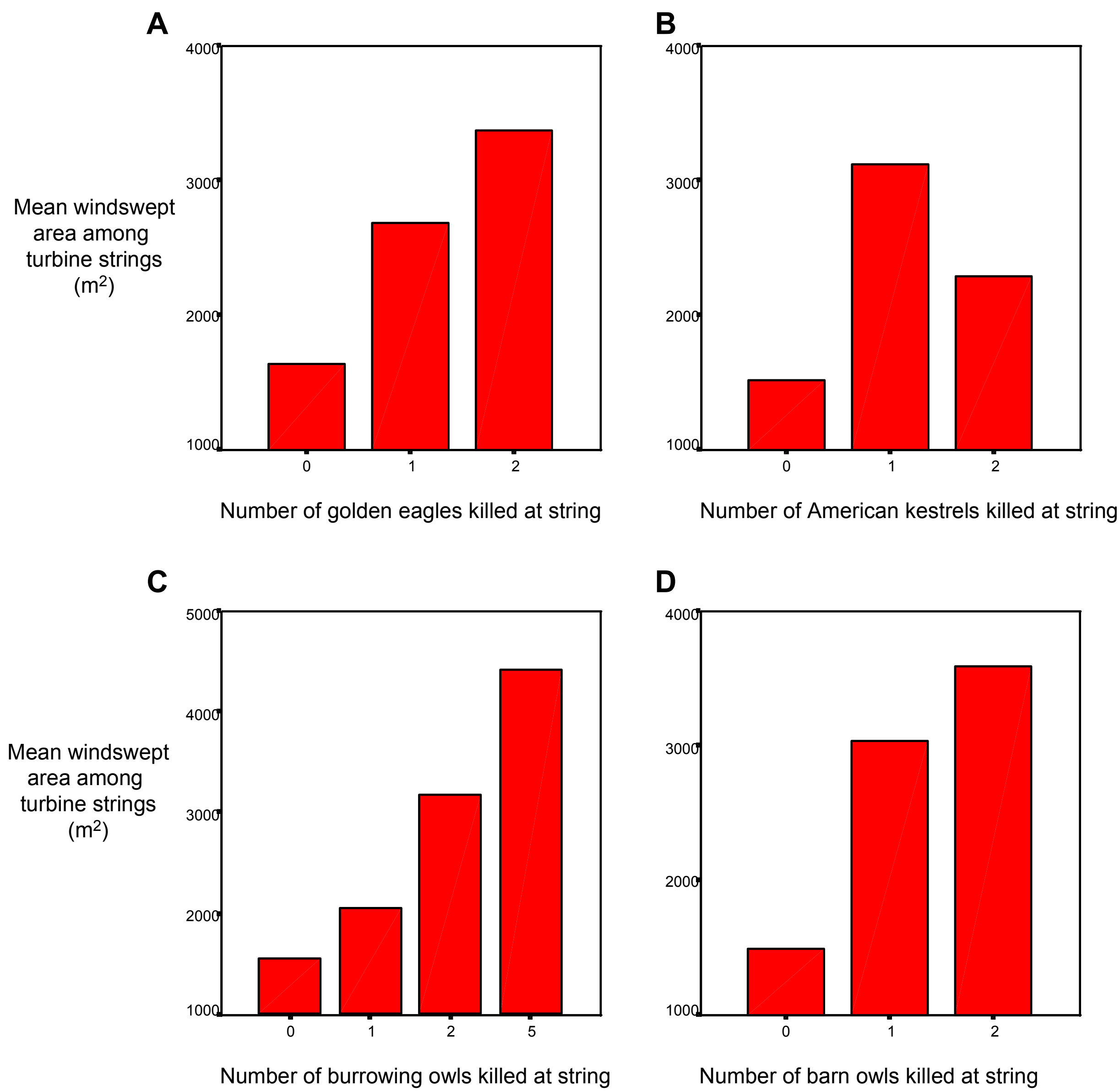

Figure 13. Mean windswept area per turbine strings associated with increasing numbers of fatalities for (A) golden eagles, (B) American kestrels, (C) burrowing owls, and (D) barn owls.

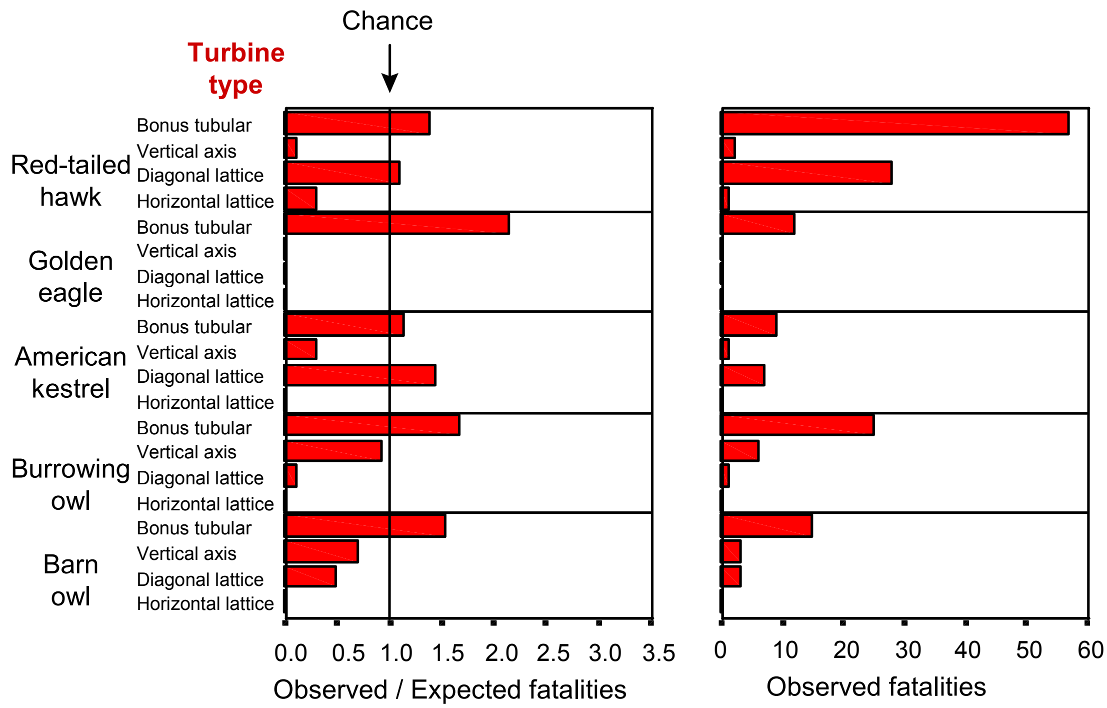

Figure 14. Associations between fatalities and tower/turbine type among raptor species. Observed/expected values greater than 1 indicate the degree to which the observed value exceeds the expected value based on chance.

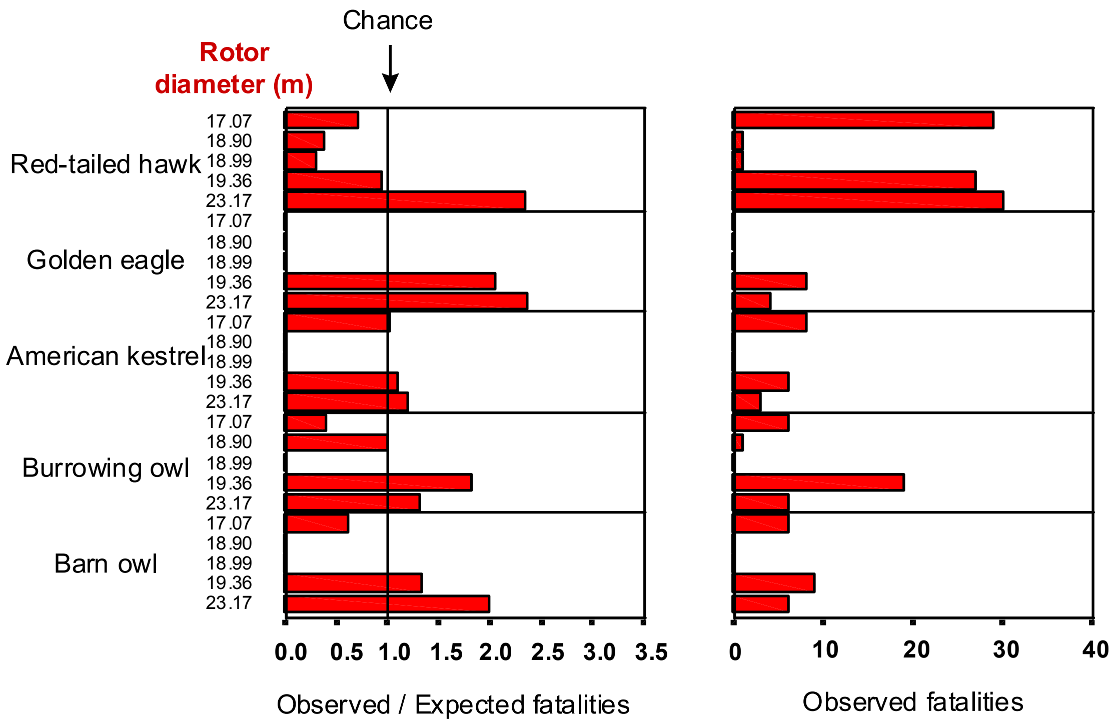

Figure 15. Associations between fatalities and rotor diameter among raptor species. Observed/expected values greater than 1 indicate the degree to which the observed value exceeds the expected value based on chance.

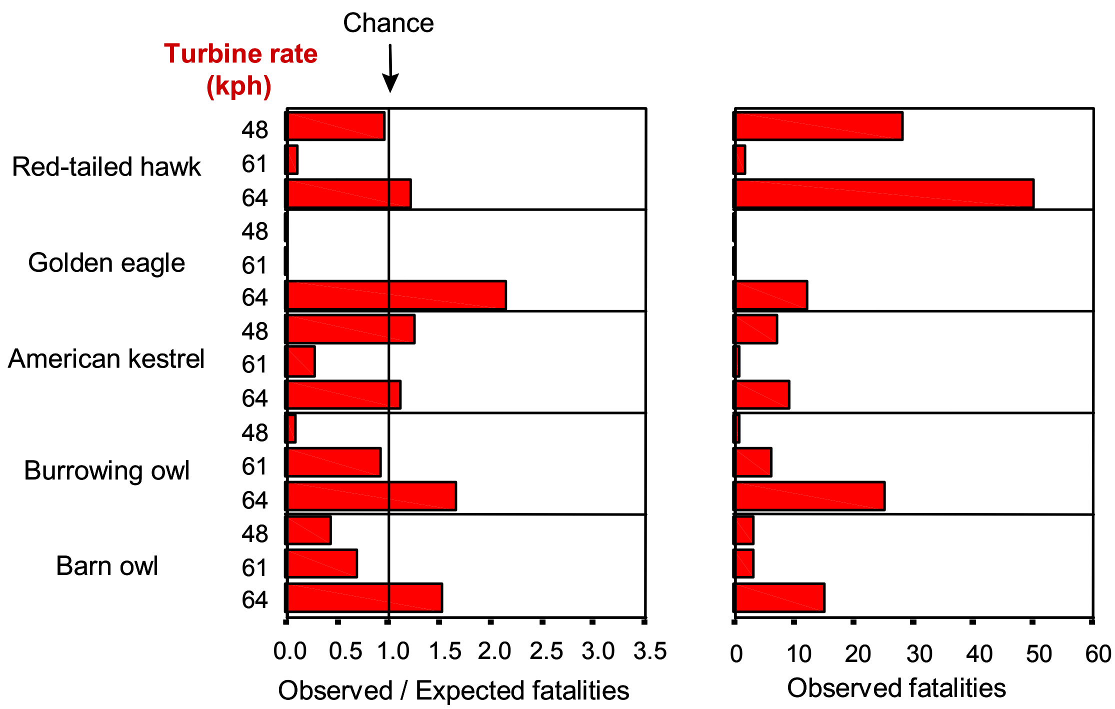

Figure 16. Associations between fatalities and rotor speed (kilometers per hour) among raptor species. Observed/expected values greater than 1 indicate the degree to which the observed value exceeds the expected value based on chance.

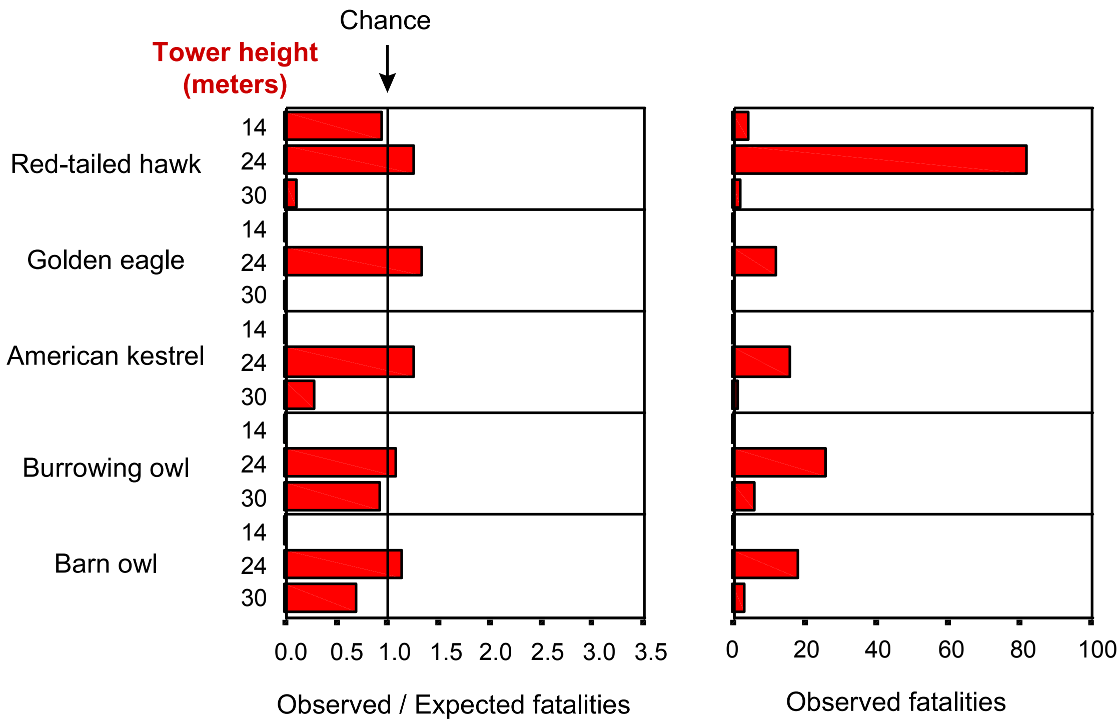

Figure 17. Associations between fatalities and tower height among raptor species. Observed/expected values greater than 1 indicate the degree to which the observed value exceeds the expected value based on chance.

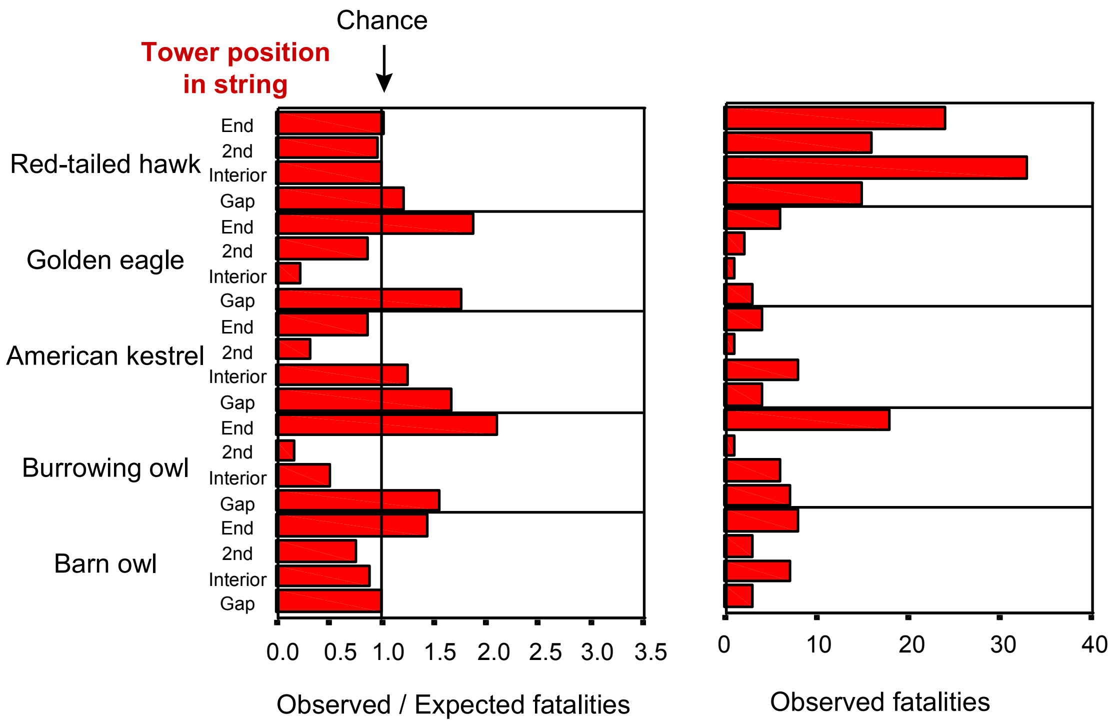

Figure 18. Associations between fatalities and tower position in the string among raptor species. Observed/expected values greater than 1 indicate the degree to which the observed value exceeds the expected value based on chance.

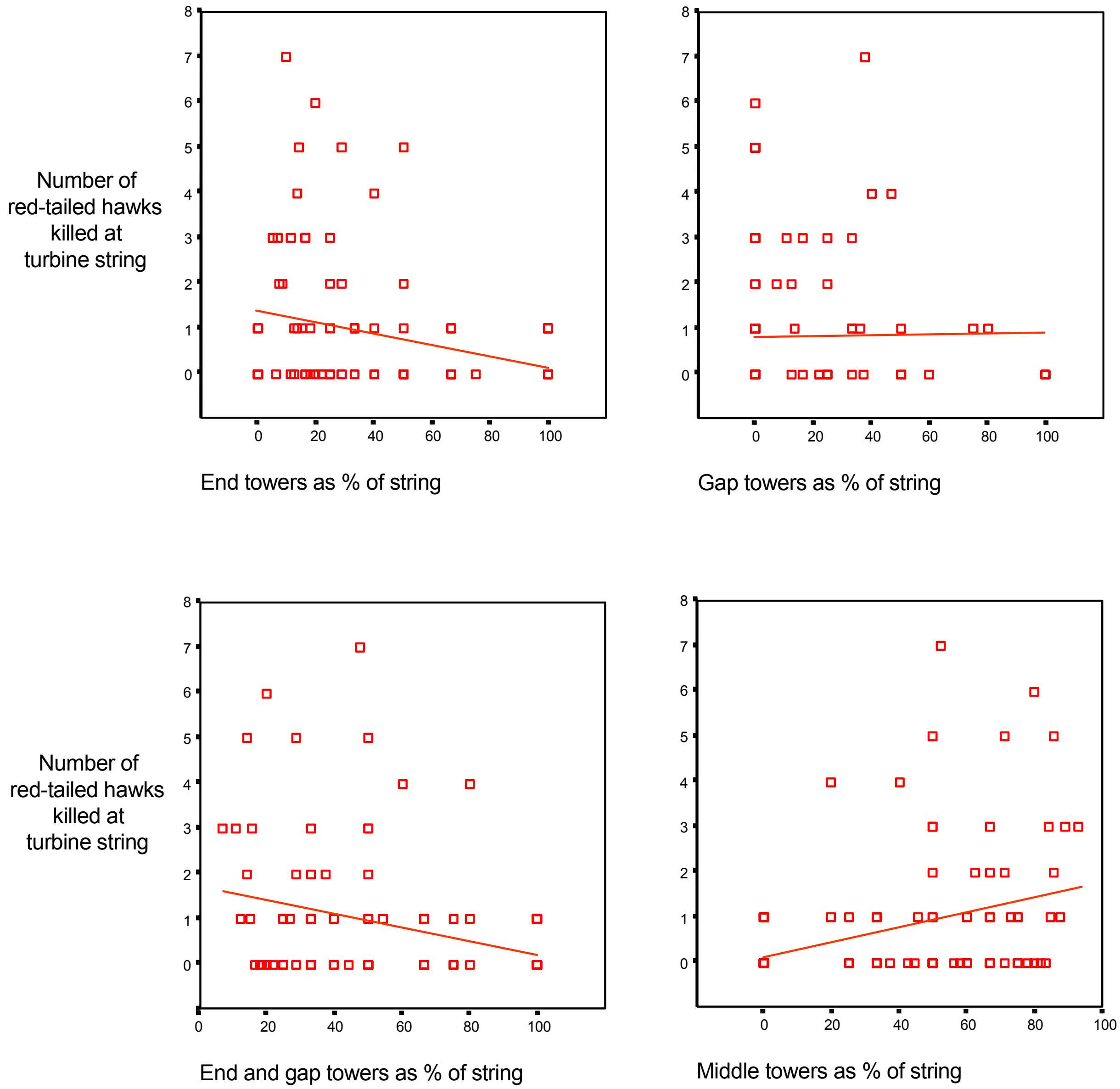

Figure 19. The number of red-tailed hawks plotted against the percentage of the string composed of end towers, gaps, ends and gaps, and interior towers.

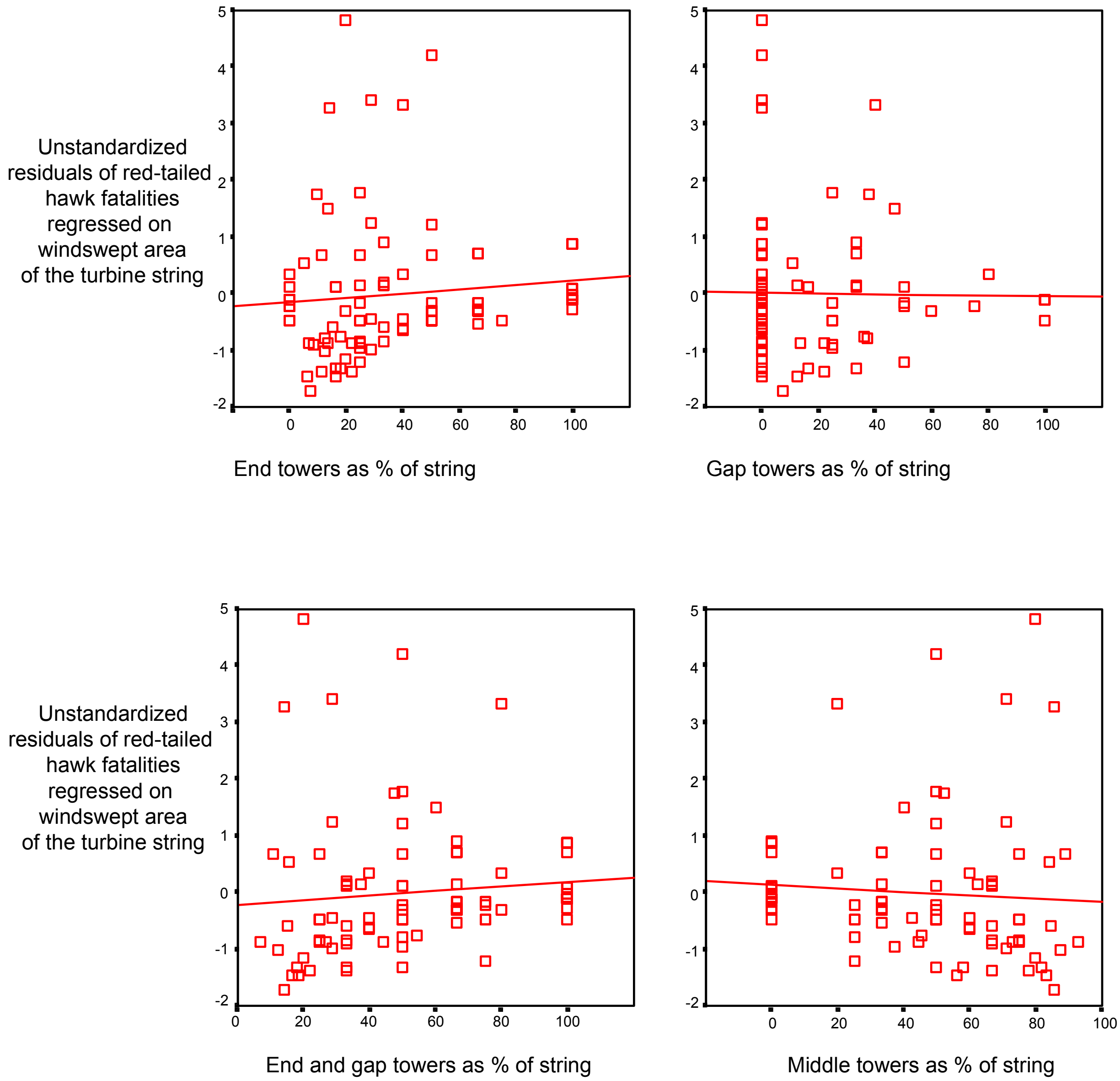

Figure 20. The residuals of number of red-tailed hawks regressed on windswept area, then plotted against the percentage of the string composed of end towers, gaps, ends and gaps, and interior towers. Note that strings with two towers are those with end towers composing 100% of the string.

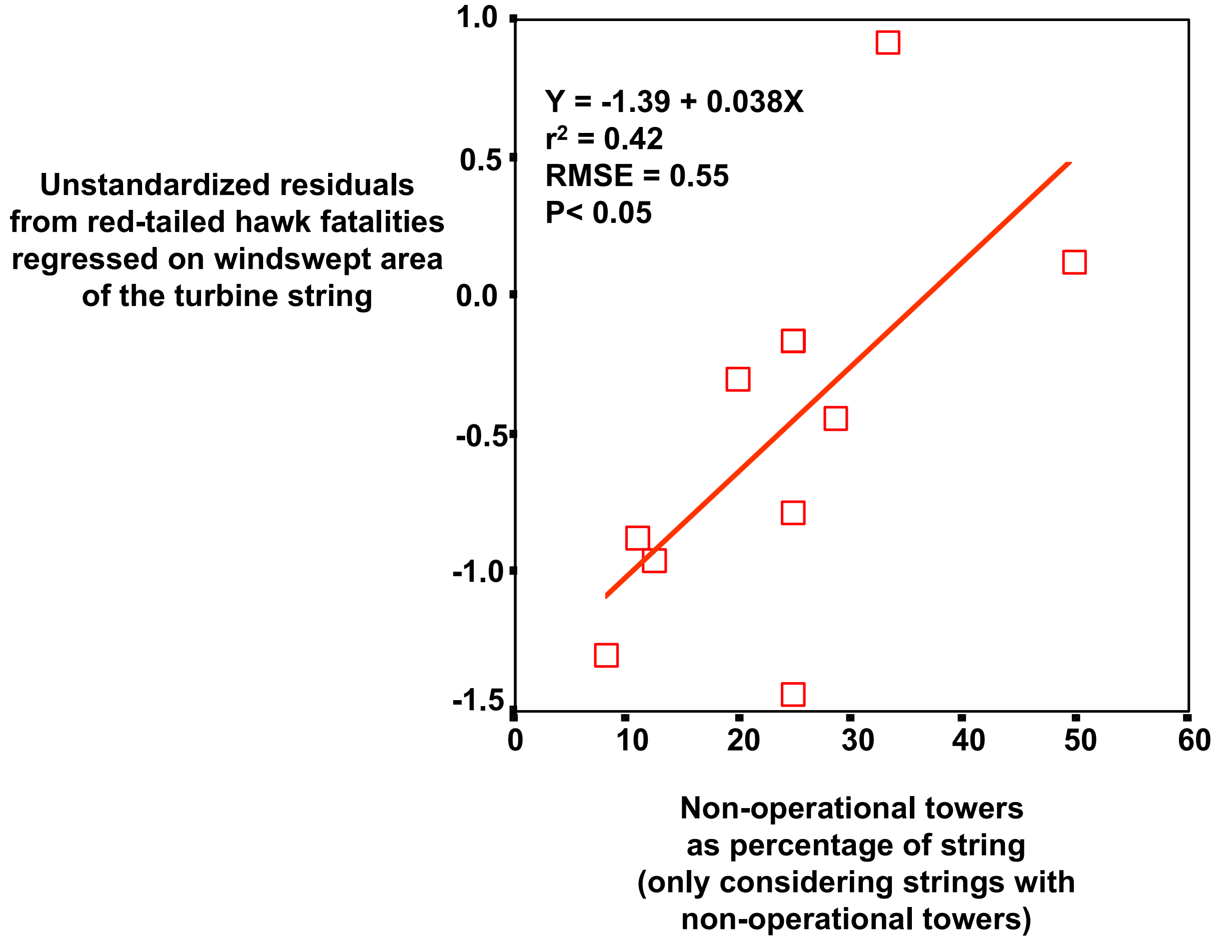

Figure 21. The residuals of number of red-tailed hawks regressed on windswept area, then plotted against the percentage of the string composed of non-operational towers.

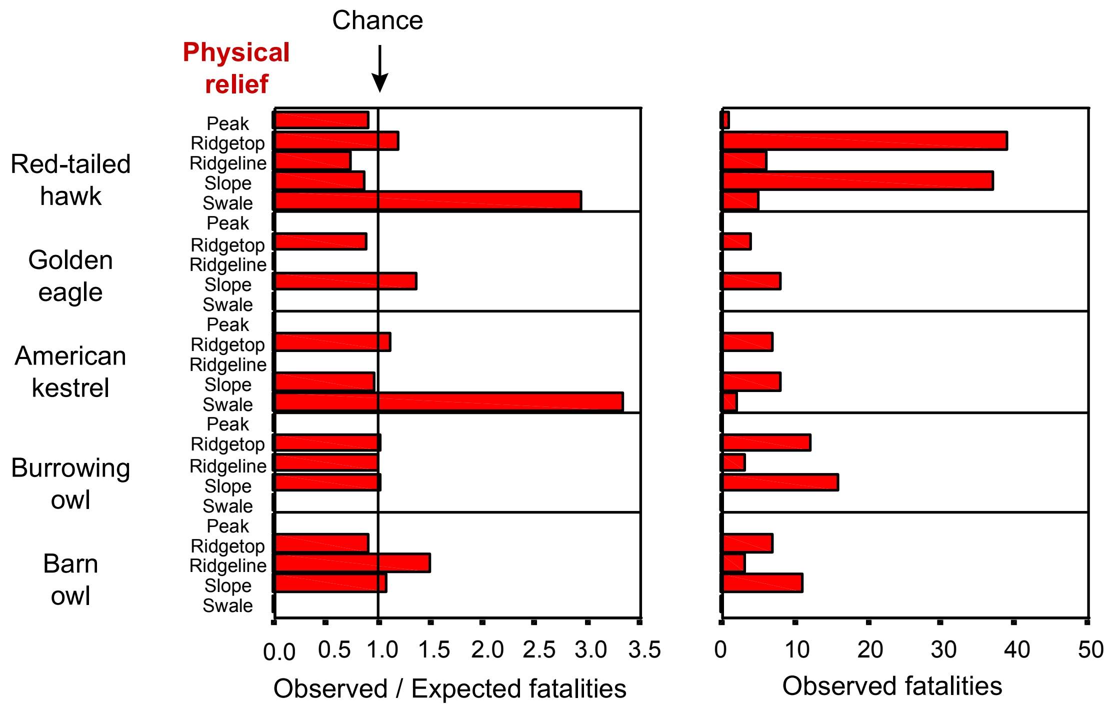

Figure 22. Associations between fatalities and physical relief among raptor species. Observed/expected values greater than 1 indicate the degree to which the observed value exceeds the expected value based on chance.

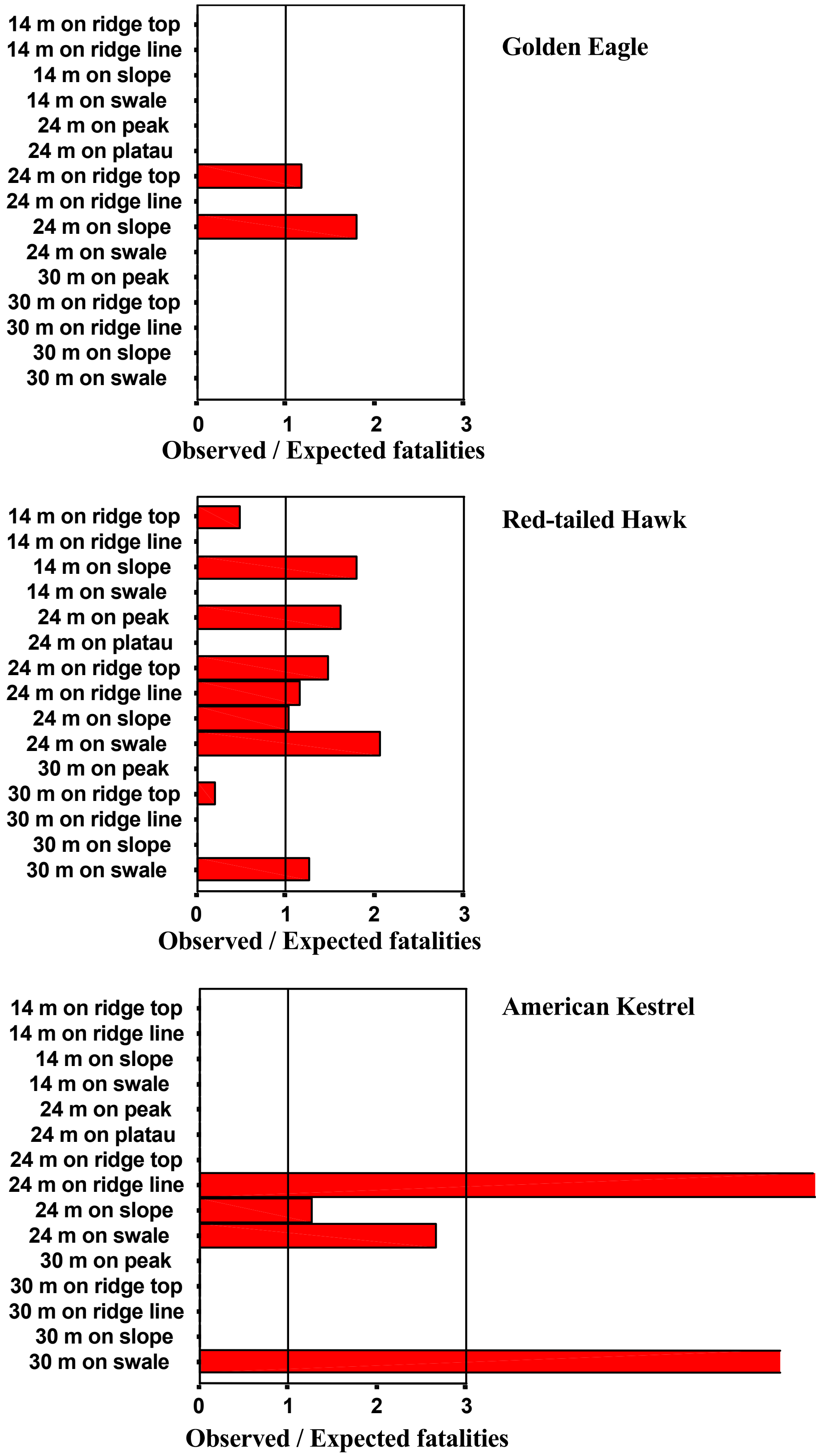

Figure 23. Associations between raptor fatalities and the interaction between physical relief and tower height.

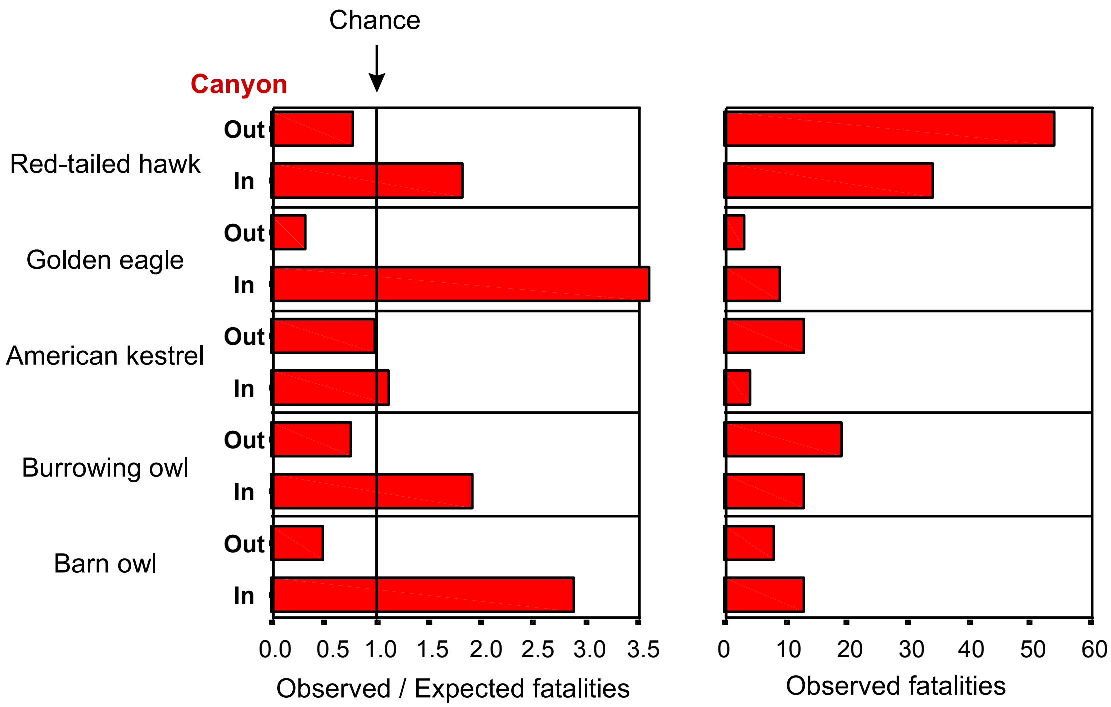

Figure 24. Associations between fatalities and whether in or out of canyons among raptor species. Observed/expected values greater than 1 indicate the degree to which the observed value exceeds the expected value based on chance.

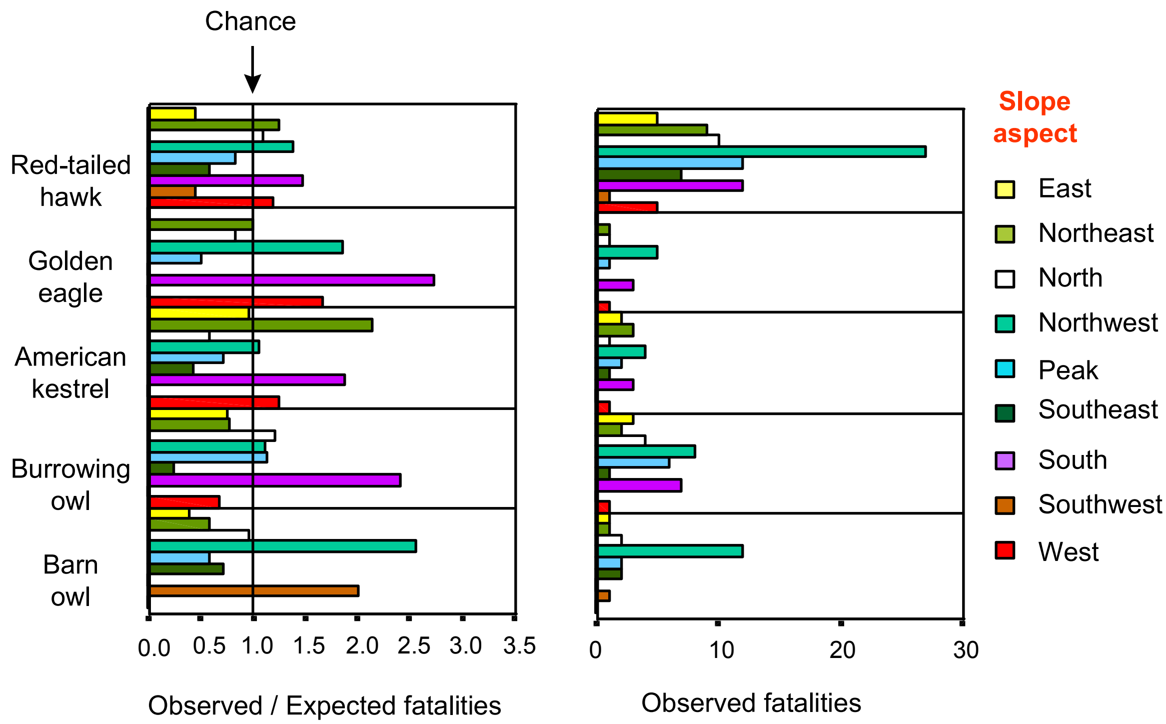

Figure 25. Associations between fatalities and slope aspect among raptor species. Observed/expected values greater than 1 indicate the degree to which the observed value exceeds the expected value based on chance.

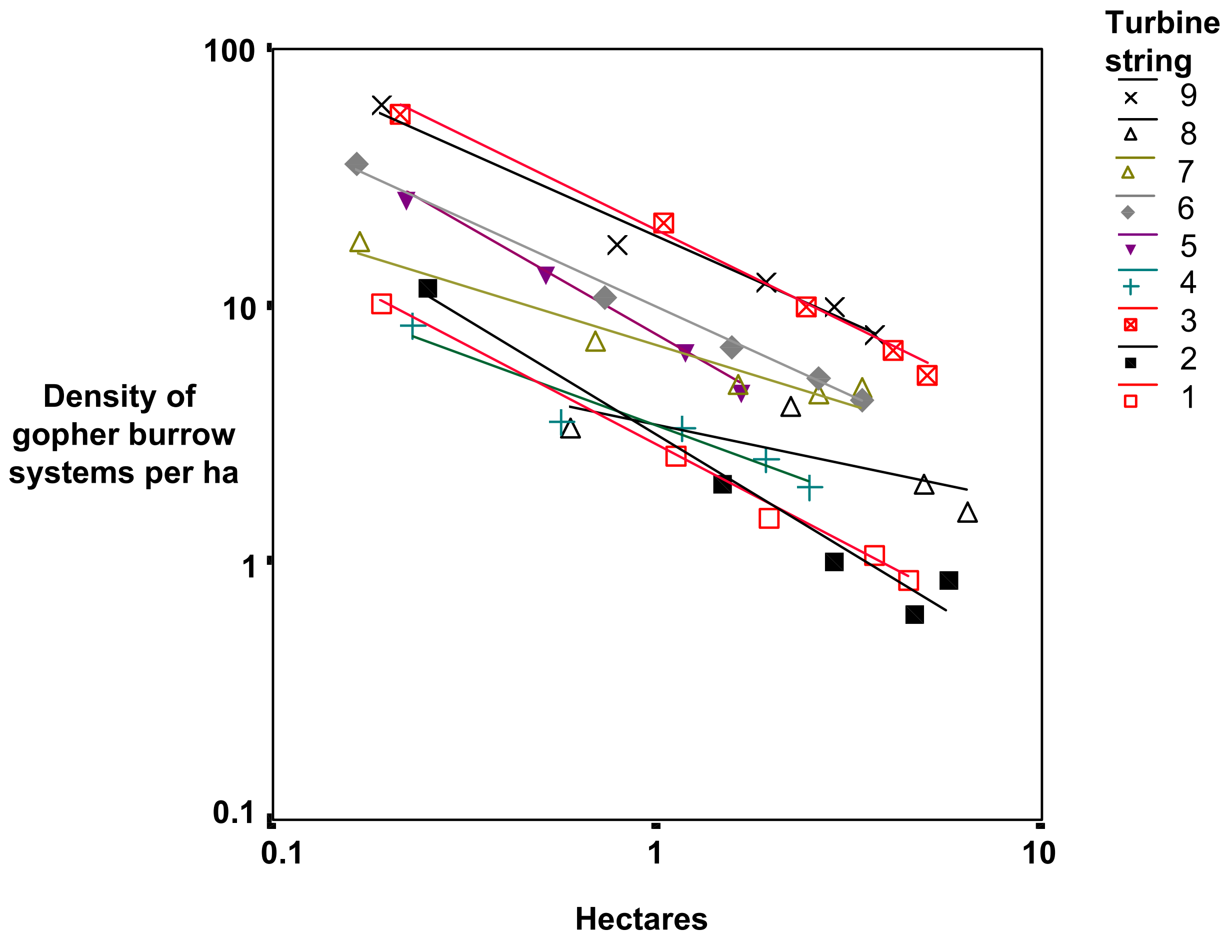

Figure 26. Pocket gopher burrow density displays an inverse power relationship to the search area surrounding each turbine string.

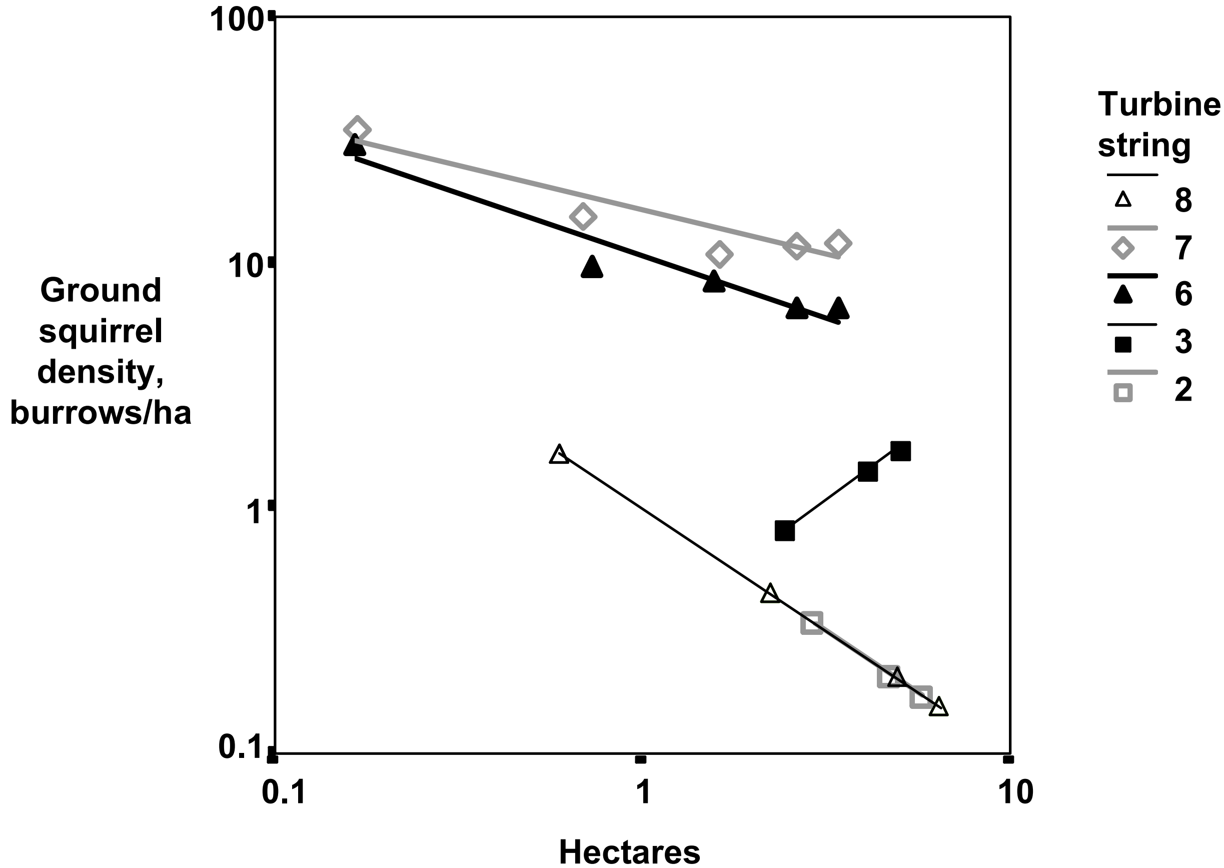

Figure 27. Ground squirrel burrow density displays two well-founded inverse power relationships to the search area surrounding the turbine string, but two others are based on one burrow system, and ground squirrels were absent at the other four turbine strings.

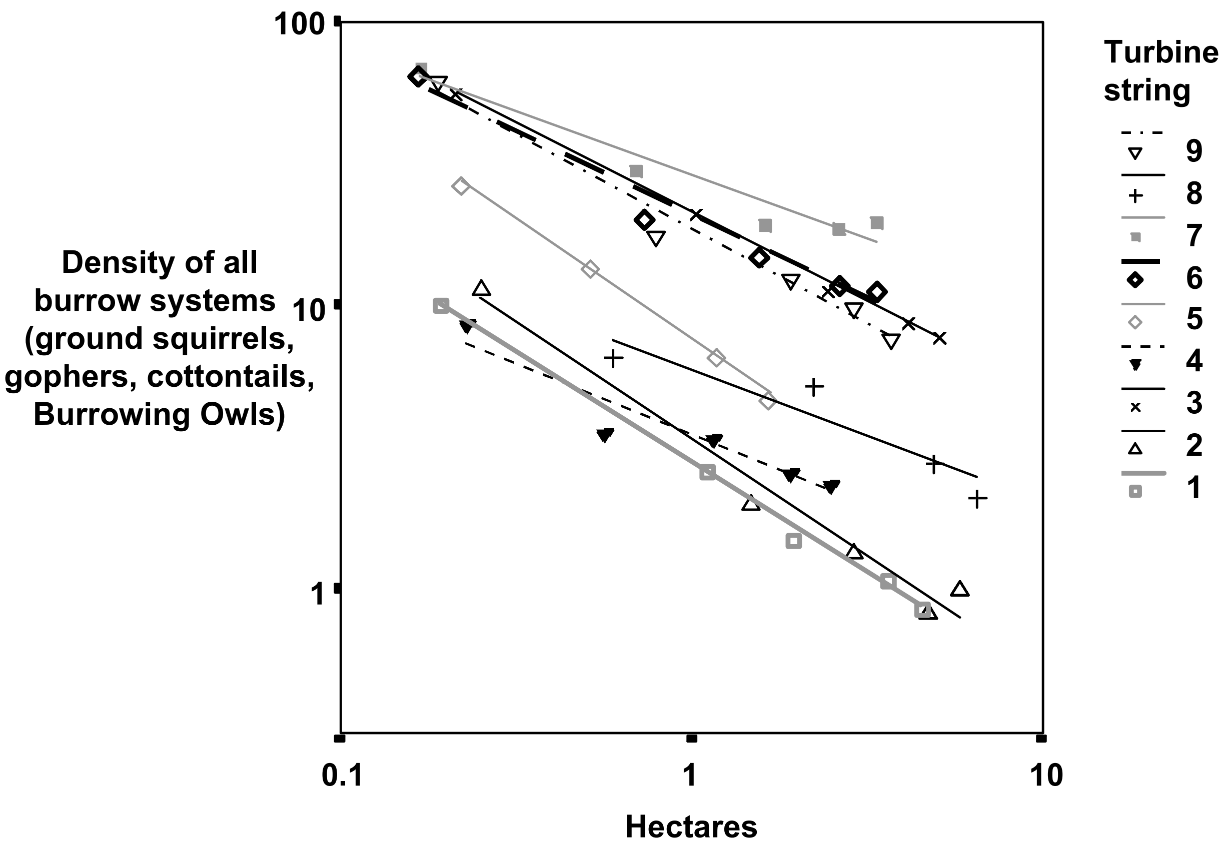

Figure 28. The density of all animal burrow systems displays an inverse power relationship to the search area surrounding each turbine string, but is likely driven mostly by the clustering of pocket gophers around the turbines.

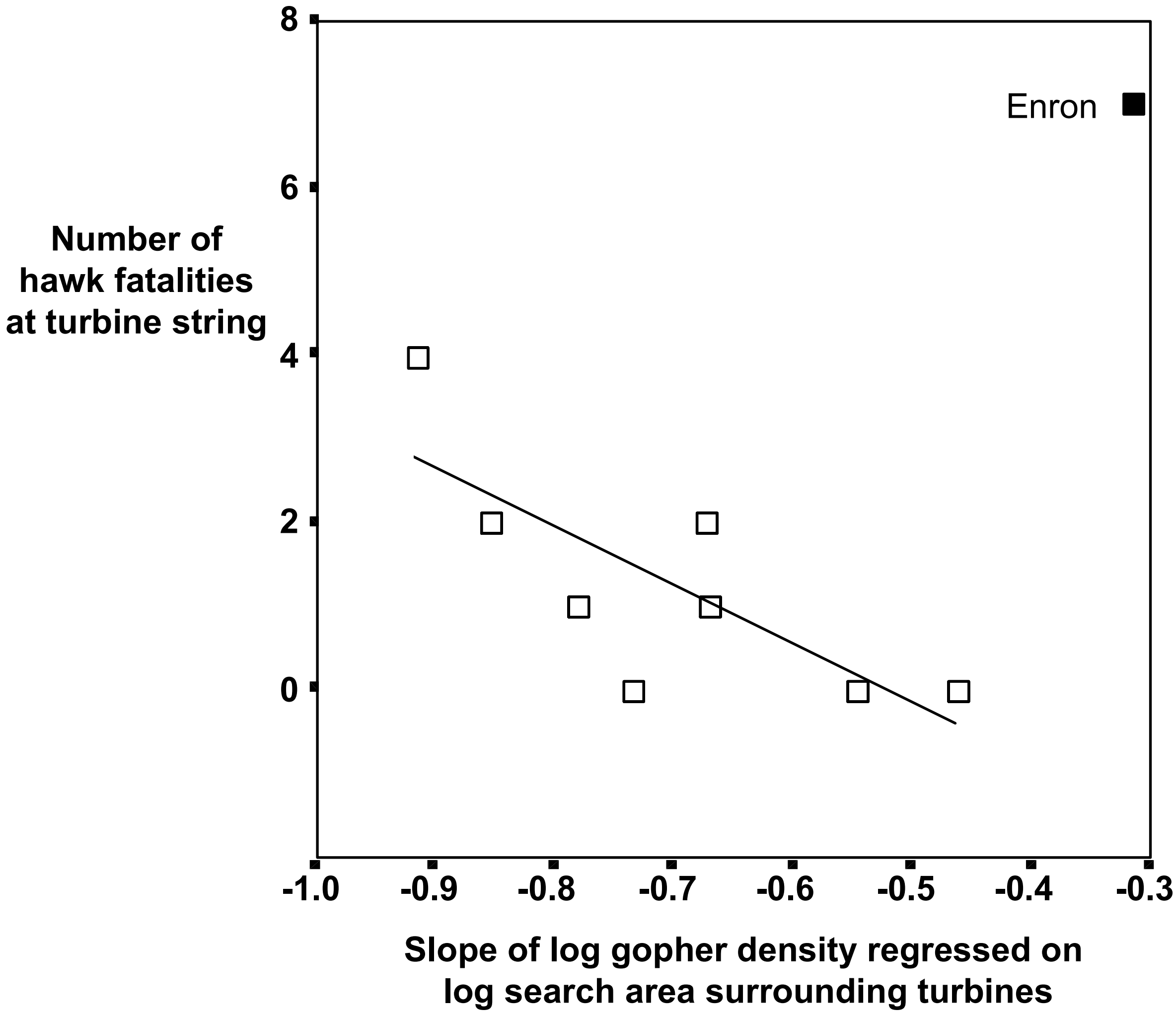

Figure 29. The number of hawk fatalities decreased with shallower slopes of log density of pocket gopher burrow systems regressed on log study area size.

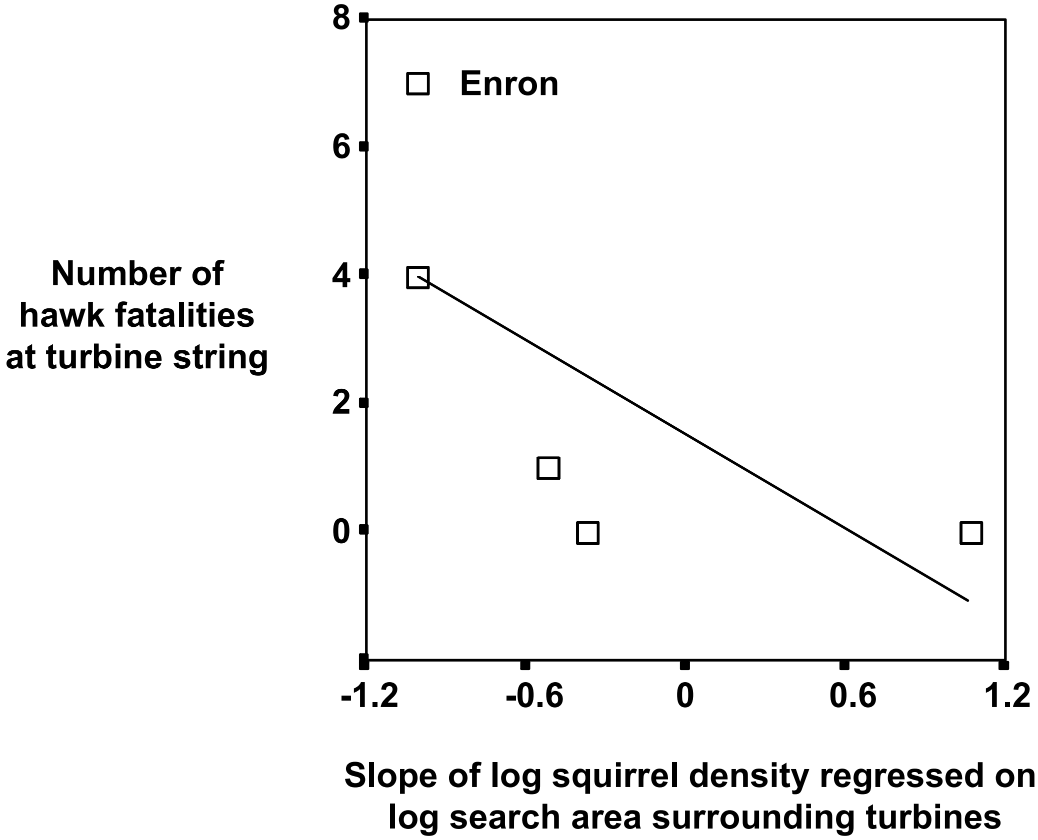

Figure 30. The number of hawk fatalities decreased with shallower slopes of log density of ground squirrel burrow systems regressed on log study area size, although the regression was not statistically significant.

APPENDIX: DATA DICTIONARY

```
"Altamont", Dictionary, "Turbines and fatalities @ Altamont Pass"
"Turbine", point
  "Type", menu,
    "Tubular Bonus"
    "Tubular Danwin"
    "Vertical Axis"
    "Diagonal Lattice"
    "Horizontal lattice", default
  "Row", numeric, 0, 0, 1000, 1
  "Number", numeric, 0, 0, 10000, 1
  "String", numeric, 0, 1, 100, 1, "Number of turbines in string"
  "Anemometer?", menu,
    "yes"
    "no", default
  "Location", menu,
    "Edge"
    "Interior", default
  "Height", menu,, "Relative height of turbine"
    "Tall"
    "Short", default
  "Topography", menu,
    "Ridge top", default
    "ridgeline"
    "Peak"
    "Slope, convex"
    "slope, concave"
    "slope, convex break"
    "slope, concave break"
    "swale"
    "plateau"
    "Ravine"
  "Aspect", menu,, "Direction faced by slope"
    "Peak", default
    "north"
    "northeast"
    "east"
    "southeast"
    "south"
    "southwest"
    "west"
    "northwest"
  "Notes", text, 30
  "Photo 1", filename
  "Photo 2", filename


"Fatality", point, "Attributes of killed bird"
  "Number", numeric, 0, 1, 1000, 1, "corresponding with data base key"
```

```
  "Species", text, 30
  "Type", menu,
    "Turbine collision", default
    "Electrocution"
    "Old bones"
    "Undetermined"
    "Predation"
    "Other"
  "Date", date, auto, dmy, "Date carcass was located"
  "Associated structure", menu,
    "Turbine"
    "Utility pole"
  "Notes", text, 30
  "Topography", menu,
    "Ridge top", default
    "Ridgeline"
    "Slope"
    "Slope Convex"
    "Slope concave"
    "Slope break, convex"
    "Slope break, concave"
    "Peak"
    "Ravine"
    "Stream"
    "Swale"
    "Plateau"
  "Aspect", menu,, "Direction faced by slope"
    "Peak", default
    "north"
    "northeast"
    "east"
    "southeast"
    "south"
    "southwest"
    "west"
    "northwest"
  "Photo 1", filename
  "Photo 2", filename
  "Photo 3", filename
  "Photo 4", filename

"Pond", area
  "Inundation", menu,
    "Perennial", default
    "Seasonal"
  "Photo 1", filename
  "Photo 2", filename

"Tree", point
  "Species", text, 30
```

```
  "Height", numeric, 0, 1, 100, 9, "in meters"
  "Photo", filename

"Plot number", point
  "Number", numeric, 0, 1, 20, 1
  "Notes", text, 30

"Topography", line
  "Topography", menu,
    "Ridgetop", default
    "Ridgeline"
    "Slope, Convex"
    "Slope, concave"
    "Slope break, convex"
    "Slope break, concave"
    "Swale"
    "Plateau"
    "Stream"
    "Ravine"
    "Ravine bottom"
    "Pond"
  "Aspect", menu,
    "Peak"
    "North"
    "Northeast"
    "East", default
    "Southeast"
    "South"
    "Southwest"
    "West"
    "Northwest"
  "Transect width", numeric, 0, 1, 30, 15, "Distance observable to either side"

"Burrow", point
  "Species", menu,
    "Pocket gopher", default
    "Ground squirrel"
    "Rabbit"
    "Badger"
    "Coyote"
    "Fox"
    "Burrowing Owl"
  "Notes", text, 30
  "Photo", filename


"Turbine count area", area, "for burrow counts"
  "Notes", text, 30
  "Photo 1", filename
  "Photo 2", filename
```

"Gopher burrow", point

"Gr squirrel burrow", point

"Burrowing owl", point

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13. ABSTRACT *(Maximum 200 words)*
It has been documented that wind turbine operations at the Altamont Pass Wind Resource Area kill large numbers of birds of multiple species, including raptors. We initiated a study that integrates research on bird behaviors, raptor prey availability, turbine design, inter-turbine distribution, landscape attributes, and range management practices to explain the variation in avian mortality at two levels of analysis: the turbine and the string of turbines. We found that inter-specific differences in intensities of use of airspace within close proximity did not explain the variation in mortality among species.

Unique suites of attributes relate to mortality of each species, so species-specific analyses are required to understand the factors that underlie turbine-caused fatalities. We found that golden eagles are killed by turbines located in the canyons and that rock piles produced during preparation of the wind tower laydown areas related positively to eagle mortality, perhaps due to the use of these rock piles as cover by desert cottontails. Other similar relationships between fatalities and environmental factors are identified and discussed. The tasks remaining to complete the project are summarized.

14. SUBJECT TERMS
wind energy; wind turbines; birds; avian issues; Altamont Pass Wind Resource Area; California.

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Influence of Behavior on Bird Mortality in Wind Energy Developments

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ABSTRACT As wind power generation is rapidly expanding worldwide, there is a need to understand whether and how preconstruction surveys can be used to predict impacts and to place turbines to minimize impacts to birds. Wind turbines in the 165-km^2 Altamont Pass Wind Resource Area (APWRA), California, USA, cause thousands of bird fatalities annually, including hundreds of raptors. To test whether avian fatality rates related to rates of utilization and specific behaviors within the APWRA, from March 1998 to April 2000 we performed 1,959 30-minute behavior observation sessions (360° visual scans using binoculars) among 28 nonoverlapping plots varying from 23 ha to 165 ha in area and including 10–67 turbines per plot, totaling 1,165 turbines. Activity levels were highly seasonal and species specific. Only 1% of perch time was on towers of operating turbines, but 22% was on towers of turbines broken, missing, or not operating. Of those species that most often flew through the rotor zone, fatality rates were high for some (e.g., 0.357 deaths/megawatt of rated capacity [MW]/yr for red-tailed hawk [*Buteo jamaicensis*] and 0.522 deaths/MW/yr for American kestrel [*Falco sparverius*]) and low for others (e.g., 0.060 deaths/MW/yr for common raven [*Corvus corax*] and 0.012 deaths/MW/yr for turkey vulture [*Cathartes aura*]), indicating specific behaviors or visual acuity differentiated these species by susceptibility to collision. Fatality rates did not correlate with utilization rates measured among wind turbine rows or plots for any species except burrowing owl (*Athene cunicularia*) and mallard (*Anas platyrhynchos*). However, mean monthly fatality rates of red-tailed hawks increased with mean monthly utilization rates ($r^2 = 0.67$) and especially with mean monthly flights through turbine rows ($r^2 = 0.92$). Fatality rates increased linearly with rates of utilization ($r^2 = 0.99$) and flights near rotor zones ($r^2 = 1.00$) for large raptor species and with rates of perching ($r^2 = 0.13$) and close flights ($r^2 = 0.77$) for small non-raptor species. Fatalities could be minimized or reduced by shutting down turbines during ≥ 1 season or in very strong winds or by leaving sufficiently large areas within a wind farm free of wind turbines to enable safer foraging and travel by birds. (JOURNAL OF WILDLIFE MANAGEMENT 73(7):1082–1098; 2009)

DOI: 10.2193/2008-555

KEY WORDS Altamont Pass, behavior, birds, fatality rate, utilization, wind turbine.

The Altamont Pass Wind Resource Area (APWRA) has caused numerous bird fatalities due to collisions with wind turbines, electrocutions on electric distribution poles, and other causes related to the wind farm (Howell et al. 1991; Orloff and Flannery 1992, 1996; Smallwood and Thelander 2008). Wind turbine–caused fatality rates were recently estimated at 2,710 (SE = 11.848) birds per year in the APWRA, including 1,127 (SE = 1.547) raptors per year (Smallwood and Thelander 2008). As a result of these high fatality rates, bird mortality has been investigated at other wind farms throughout North America, and bird behaviors and activity levels have been investigated at some of these (Janss and Clave 2000; Kerlinger 2000; Anderson et al. 2004, 2005; Hoover and Morrison 2005). These investigations attest to the importance attributed to bird behaviors and activity levels in relation to bird collisions with wind turbines.

Investigators have often monitored live birds at wind farms pre- and postconstruction, usually due to operating permit requirements but sometimes for research purposes. Bird monitoring has been directed toward measuring site utilization and identifying behaviors that are more hazardous and which might be exploited to mitigate wind turbine collisions. At wind farms these objectives are usually pursued simultaneously using visual scans over timed sessions to not only count birds using the area, but also to identify flight paths and frequencies of behaviors that might help guide wind turbine placement and tower height, inter-turbine arrangement, timing of operations, and land management practices.

During the last 2 decades, it has been hypothesized that specific behaviors predispose certain species to more likely collide with operating wind turbines (e.g., Orloff and Flannery 1992; Erickson et al. 1999; Strickland et al. 2001*b*; Smallwood and Thelander 2004, 2005). It has been hypothesized that the amount of time a species uses a wind farm, referred to as utilization rate, also contributes to wind turbine collision rates (Morrison 1998, Anderson et al. 2001, Strickland et al. 2001*a*, Hunt 2002). We related wind turbine–caused fatality rates to rates of utilization and specific behaviors. We also related bird behaviors and activity levels that were associated with wind turbines to environmental conditions in the APWRA. We hypothesized that birds lose track of wind turbines while focused on diving for prey items, fly-catching, and hovering.

STUDY AREA

The APWRA occupied about 16,450 ha of mostly annual grassland in eastern Alameda County and southeastern Contra Costa County, California, USA. It ranged from 78 m to 470 m above mean sea level, composed of hills, ridges, and valleys, and including stock ponds, small seasonal ponds, and marshes. Most ridges were oriented northwest to southeast, bisected by seasonal streams. Other

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physiographic elements included alkali meadow, emergent marsh, riparian woodland and scrub, and rock outcrops. Landowners principally grazed livestock but also leased land to wind turbine owners.

When our study began, the APWRA included about 5,400 wind turbines of various models with a total rated capacity of about 580 megawatts (MW). These wind turbines were owned by multiple companies and were mounted on 3 tower types with rotor hubs of vertical-axis turbines ranging from 14 m to 43 m above ground. Many were on ridge crests or ridgelines descending into ravines from the ridge crests. Smallwood et al. (2007) and Smallwood and Thelander (2008) provided additional details on APWRA land uses, wind turbines, and other aspects of the study area.

METHODS

Field Methods

Two biologists collected bird behavior data in 28 study plots from 26 March 1998 through 18 April 2000. Study plots were nonoverlapping and ranged from 23 ha to 165 ha ($\bar{x}$ = 94 ha) in area due to complex terrain and the irregular arrangement of wind turbines. Plots contained 10–67 turbines each, totaling 1,165 turbines, or all of the turbines accessible to us in 1998–2000. All the turbines in each plot were visible from a fixed observation point. Twelve plots included wind turbines on lattice towers only, 8 included turbines on tubular towers only, 7 included both tubular towers and vertical-axis turbines, and one included tubular and lattice towers. Observers carried plot maps to identify each turbine and to link it to recorded bird activities. Each observer performed circular visual scans (360°), also called variable distance circular point observations (Reynolds et al. 1980), using 8 × 40 binoculars out to 300 m from the wind turbines in the plot or shorter if the plot boundary was defined by topography (i.e., visibility) or where distances were equal between turbines in the plot under observation and those in the adjacent plot. Observation sessions lasted 30 minutes, and we often performed 2 sessions simultaneously on nonadjacent plots to improve our degree of independence between sessions. We typically completed 6–8 sessions per day.

We sampled all 28 plots once per 10–20 days on average, stratified by morning (0700 hr to 1200 hr) and afternoon (1201 hr to dusk), but most sessions started between 0900 hours and 1700 hours. We visited 20 plots 60–120 times each, and we added another 8 in October 1999 and visited them >20 times each. To represent behaviors in all weather conditions, we observed behaviors throughout the year, unless rain or fog reduced observer visibility to <50% of the turbines in the plot. Sessions were infrequent during January and May but were otherwise distributed evenly among seasons. Most occurred during moderate temperatures, from 10° C to 27° C.

We identified each bird entering the study plot and continuously followed it until it left the plot. We recorded species, number of birds in a flock, times of first and last detection, predominant flight behavior, and number of

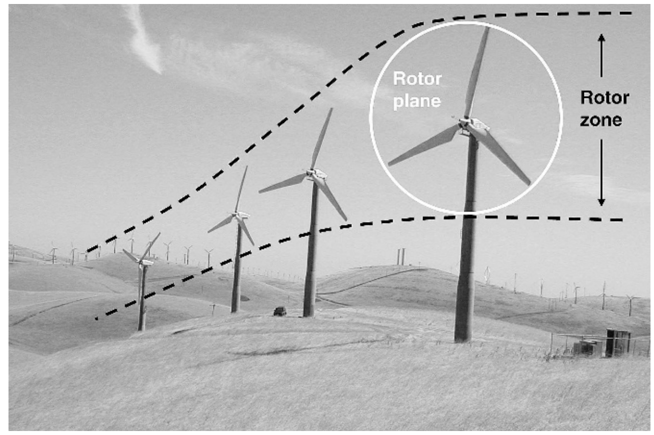

Figure 1. Rotor plane of a Bonus 150-kilowatt wind turbine (Bonus Wind Turbines, Inc., Brande, Denmark) in the Altamont Pass Wind Resource Area, California, USA, 1998–2003, and the upper and lower reaches of the rotor zone of the turbine row, where the rotor zone also extends 50 m laterally in all directions.

passes by a turbine. While the bird made its closest pass to the rotor zone, we recorded flight direction, distance to nearest wind turbine, type of wind turbine, and flight height relative to the rotor plane, which was the height above ground from the lowest to highest reaches of the turbine blades. We classified flight behaviors as fly-through, gliding, soaring, high soaring, contouring, circling, kiting–hovering, diving, mobbing, being mobbed, column soaring, surfing, ground hopping, hawking insects, fleeing, interacting with conspecifics, flocking, and flushed. We classified 21 perch structures, including ground, rock–vegetation, tree, fence post, the top, cross-arm, or wire of electric distribution poles, anemometer tower, electric transmission tower, top inner framework or guy wire of vertical-axis wind turbines, top or inside of wind turbine motors, turbine blade, turbine propeller cone, catwalk of wind tower, side ladder of wind tower, and top, lower, or middle framework of diagonal lattice wind turbine towers.

Of particular interest were behaviors and distances of flights from the rotor zone, which was where we assumed birds were most vulnerable to collisions. The rotor zone was the reach of the rotating turbine blades or rotor-swept area within 50 m of the blades, which was a 50-m extension of the rotor plane (Fig. 1). To improve accuracy and consistency in recording the closest pass to the rotor zone, both field assistants calibrated height and depth measurements of known objects every 6 months. To minimize observer bias in distance estimates and behavior reporting, we made paired observations over 18 sessions in the study's first month. Observers recorded behavioral information simultaneously but independently on separate data sheets. At the end of each calibration session, we compared information to help ensure consistency of behavior interpretations. Once observers achieved similar distance estimates and behavior records, they began conducting separate 30-minute observation sessions. Four calibration sessions were repeated over 1–2 days every 6 months.

We recorded specific behaviors with alphanumeric codes onto a standardized data sheet, along with session start time, temperature, wind speed, wind direction (its origin), number of turbines operating, and cloud cover at the beginning of each session. For analysis, we lumped actual start times into representative times of the day, so 0800 hours represented 0700–0859 hours, 1000 hours was for 0900–1059 hours, 1200 hours for 1100–1259 hours, 1400 hours for 1300–1459 hours, 1600 hours for 1500–1659 hours, and 1800 hours for 1700–2059 hours. We measured temperature with a handheld thermometer, and we aggregated temperatures across spans of 2.8° C (5° F) for analysis. We measured wind force on the Beaufort scale, where 0 was <0.3 m/second, 1 was 0.3–1.5 m/second, 2 was 1.6–3.3 m/second, 3 was 3.4–5.4 m/second, 4 was 5.5–7.9 m/second, 5 was 8–10.7 m/second, 6 was 10.8–13.8 m/second, and 7 was >13.8 m/second. When wind speed exceeded 15 m/second (near gale winds), we left the field for safety reasons (i.e., parts of wind turbines can become dislodged).

On fatality searches, biologists searched out to 50 m from all rows of wind turbines that were made available to us by the wind companies in the APWRA (Smallwood and Thelander 2008). Search intervals varied from weekly to greater than monthly and spanned 1.5–4.5 years or longer than the behavior observation study at most turbine rows. Fatalities considered herein, along with resulting fatality rate estimates, corresponded with turbine rows and plots included in this behavior study.

Analytical Methods

We expressed utilization rates as number of birds seen per session or per hour when we compared them by month of the year. We expressed utilization rates as mean number of observations per session per hectare when we compared them among plots or turbine rows. Turbine rows were bounded by the line equidistant between adjacent turbine rows and extended to the 300-m plot boundary nearest the turbine row. We used a Geographic Information System to delineate plot and turbine row boundaries and to calculate areas.

We also compared number occurrences of specific behaviors per session, per hour, and per hectare in the same manner we compared utilization rates. We related behavior rates to session start time, temperature during the session, month and season of the year, wind speed, wind direction, and distance from wind turbines.

To estimate fatality rates, we used only fatalities estimated to have been caused $\leq$90 days before discovery, found within 125 m of wind turbines, and not determined to have died by causes other than wind turbines. Even though 50 m was the search radius, searchers recorded all carcasses, no matter how far from turbines. We included carcasses seen out to 125 m because the hills under turbine rows were steep, permitting carcasses thrown from turbines 50 m laterally to fall down the slope farther than 50 m away as measured by rangefinder. Also, many of these carcasses were visible from within the search radius due to short-stature vegetation, though we undoubtedly missed carcasses beyond 50 m more often than within 50 m of turbines. We established our inclusion threshold of 125 m after the study, using our experience in the study area to judge how far searchers could reasonably scan the ground for carcasses from the 50-m search radius.

Within each turbine row, we expressed the fatality rate as number of fatalities per MW per year, where MW was the sum of the MW of rated power outputs for all of the wind turbines in the row searched. Although individual turbines killed birds, we used wind turbine row as our study unit because we sometimes could not determine which turbine within the row killed a bird. To the number of years used in the fatality rate estimate, we added the number of days equal to the average search interval used at each turbine row to represent the time period when carcasses could have accumulated before our first search. We adjusted fatality rates for searcher detection error and scavenger removal rates using the approach of Smallwood (2007), and we used fatality rate estimates in Smallwood and Thelander (2008), but in this case we used estimates specific to each wind turbine row and to behavior plots instead of the entire wind farm.

We compared fatality rates to utilization rates and behavior rates among the 28 observation plots and to turbine rows within the plots using Pearson's correlation tests and least squares regression analysis. We also tested for correlations between fatality and utilization rates by month of the year. We estimated fatality rate by month of the year by multiplying the mean annual fatality rate estimate by the proportion of fatalities backdated to each month, where we based backdating on the field biologists' estimate of number of days since death.

RESULTS

Characteristics of Observation Sessions

During observation sessions, we recorded wind direction most often from the southwest (41%), followed by northeast (17%), west (13%), and northwest (13%). Winds measured on the Beaufort scale were 0 for 1.8% of sessions, 1 for 17.4%, 2–4 for 58.9%, 5 for 11.3%, 6 for 7.4%, and 7 for 3.2% of sessions. Wind speeds measured on the Beaufort scale averaged fastest from the southwest ($\bar{x}$ = 3.94, SD = 1.52), followed by the west ($\bar{x}$ = 3.45, SD = 1.68), northwest ($\bar{x}$ = 3.13, SD = 1.63), south ($\bar{x}$ = 2.76, SD = 1.58), north ($\bar{x}$ = 2.24, SD = 1.51), northeast ($\bar{x}$ = 2.14, SD = 1.08), southeast ($\bar{x}$ = 2.08, SD = 1.04), and east ($\bar{x}$ = 1.97, SD = 1.09). Average monthly proportion of turbines operating during the session correlated strongly with average monthly wind speed measured on the Beaufort scale (r_P = 0.98, n = 12, $P < 0.001$), and both variables peaked during summer.

We observed 36 bird species during 1,959 behavior observation sessions spanning 979.5 hours. We recorded 48,396 individuals, or 24.7 individuals per session and 49.4 per hour. Factoring in the number of minutes of observations of tracked individuals, recorded bird activity totaled 460,520 minutes, 67% of which were of gulls (*Larus* spp.) making daily flights to a landfill located west of the central aspect of the APWRA. We observed no birds in 184 (9.4%) of the sessions.

Utilization rates (birds/session) were highly seasonal (Figs. 2, 3). Whereas power output peaked over summer, bird activity peaked over winter (Fig. 2). Flights through turbine rows and flights within 50 m of turbines peaked during winter, when wind turbine operations were lowest (Fig. 2). By species, red-tailed hawk and American kestrel (*Falco sparverius*) utilization of the APWRA peaked in late fall, whereas golden eagle (*Aquila chrysaetos*) utilization peaked in summer (Fig. 3). Turkey vulture (*Cathartes aura*) activity peaked in late summer and late winter, and common raven (*Corvus corax*) and gull activity peaked over winter and early spring. Western meadowlark (*Sturnella neglecta*), horned lark (*Eremophila alpestris*), and house finch (*Carpodacus mexicanus*) activity peaked in winter, but mourning dove (*Zenaida macroura*) activity peaked in early spring. Loggerhead shrike (*Lanius ludovicianus*) utilization was even throughout the year. Burrowing owl (*Athene cunicularia*)

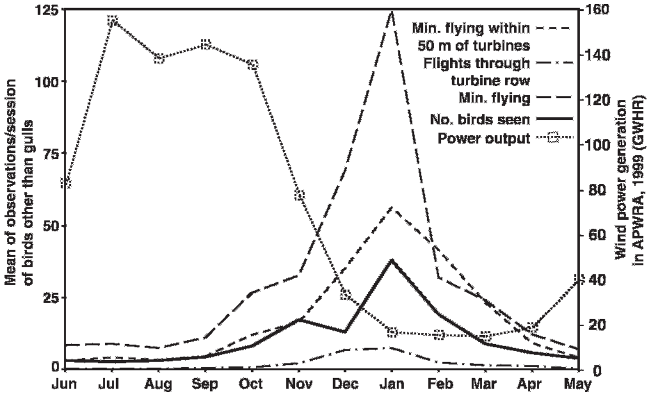

Figure 2. Middle of winter was when we observed avian species to peak in mean flying time, flight time within 50 m of wind turbines, number of passes through the turbine row, and number of birds seen in the plot, but winter was also the nadir of wind power generation in the Altamont Pass Wind Resource Area, California, USA, in 1999–2000.

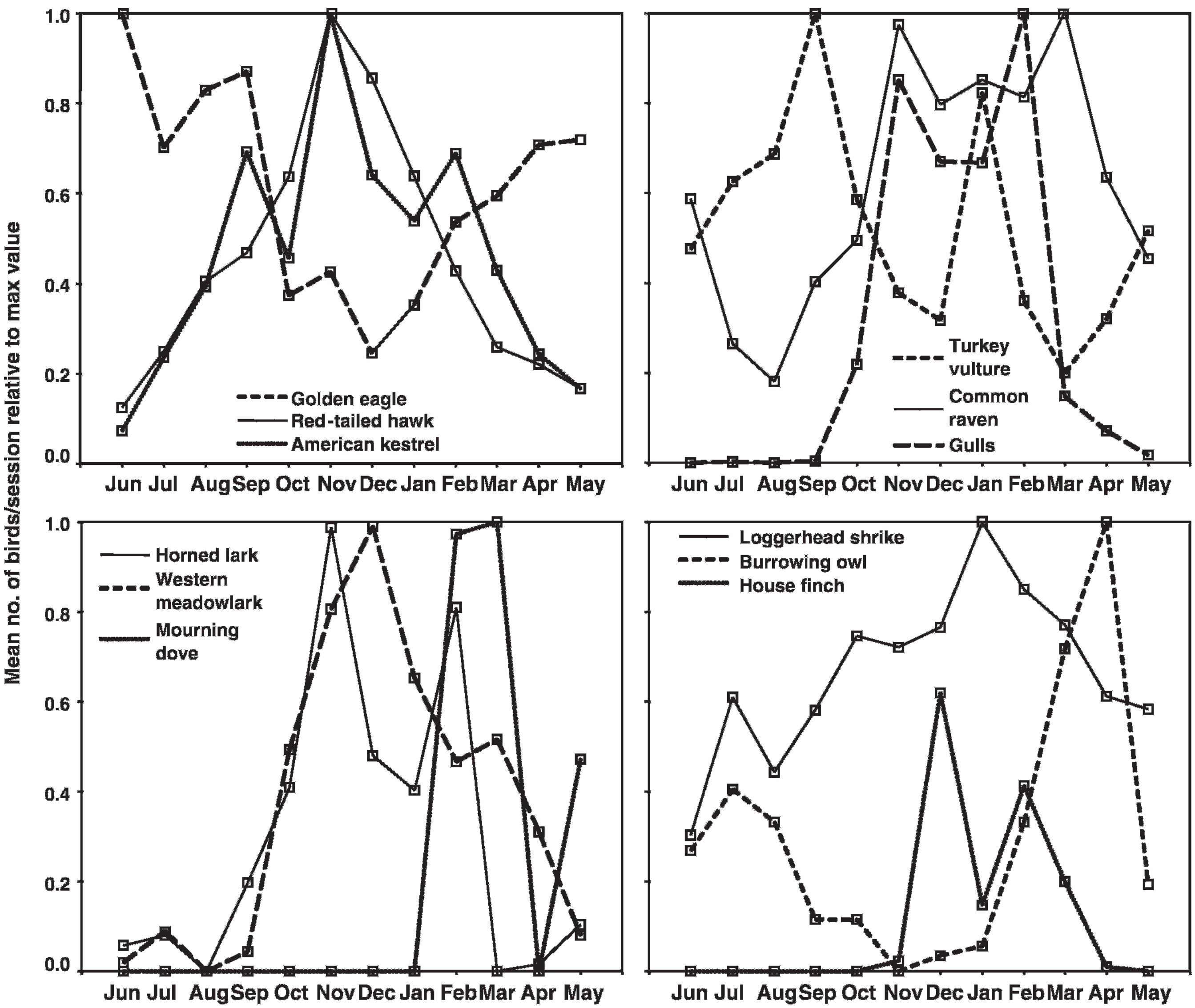

Figure 3. Relative seasonal abundance of various select avian species observed in the Altamont Pass Wind Resource Area, California, USA, during 1998–2000.

Table 1. Behavioral activities by species in the Altamont Pass Wind Resource Area, California, USA, 1998–2000.

Species	Scientific name	No. of birds seen	Total min	Min (%)		Distance (m) to closest turbine		No. of flights	
				Flying	Perching	$\bar{x}$	SD	Through rotor zone	<50 m to turbine
Mallard	*Anas platyrhynchos*	79	83	100	0	85	52	0	16
Common goldeneye	*Bucephala clangula*	1	1	100	0	10		0	2
Great blue heron	*Ardea herodias*	3	3	100	0	60	46	2	5
Turkey vulture	*Cathartes aura*	980	2,542	96	4	72	69	51	1,047
White-tailed kite	*Elanus leucurus*	1	2	100	0	100		0	0
Northern harrier	*Circus cyaneus*	126	389	76	24	76	82	21	162
Cooper's hawk	*Accipiter cooperii*	2	3	100	0	35	7	0	6
Red-tailed hawk	*Buteo jamaicensis*	2,005	15,680	43	57	65	81	270	2,682
Ferruginous hawk	*Buteo regalis*	12	74	59	41	53	41	0	38
Rough-legged hawk	*Buteo lagopus*	6	27	100	0	125	95	0	5
Golden eagle	*Aquila chrysaetos*	465	2,374	58	42	82	73	32	450
American kestrel	*Falco sparverius*	462	3,033	25	75	48	71	102	583
Prairie falcon	*Falco mexicanus*	66	199	58	42	62	60	4	84
Killdeer	*Charadrius vociferus*	2	2	100	0	20		0	1
Long-billed curlew	*Numenius americanus*	7	19	53	47	58	37	0	1
Ring-billed gull	*Larus delawerensis*	503	9,823	100	0	39	27	0	12
California gull	*Larus califfornicus*	36	36	100	0	50	42	0	5
Gull spp.		28,750	299,517	100	0	67	60	14	552
Rock pigeon	*Columba livia*	526	834	85	15	57	71	10	160
Band-tailed pigeon	*Columba fasciata*	30	30	100	0	5		1	1
Mourning dove	*Zenaida macroura*	7	88	8	92	45	38	0	5
Burrowing owl	*Athene cunicularia*	100	1,631	12	88	117	69	0	31
Say's phoebe	*Sayornis saya*	2	6	50	50	50	28	0	1
Loggerhead shrike	*Lanius ludovicianus*	139	846	16	84	49	56	11	98
American crow	*Corvus brachyrhynchos*	25	145	23	77	6	6	8	31
Common raven	*Corvus corax*	1,313	4,280	55	45	42	59	176	1,787
Horned lark	*Eremophila alpestris*	213	676	39	61	36	37	3	45
Cliff swallow	*Petrochelidon pyrrhonota*	23	52	100	0	22	10	0	14
Mountain bluebird	*Sialia currucoides*	118	291	79	21	52	37	0	6
European starling	*Sturnus vulgaris*	259	2,373	10	90	16	58	10	106
Red-winged blackbird	*Agelaius phoeniceus*	470	6,569	12	88	25	29	8	34
Tricolored blackbird	*Agelaius tricolor*	78	298	100	0	88	62	0	0
Western meadowlark	*Sturnella neglecta*	207	721	37	63	31	46	16	72
Brewer's blackbird	*Euphagus cyanocephalus*	337	1,744	40	60	35	66	7	41
Brown-headed cowbird	*Molothrus ater*	2	2	100	0	70		0	2
Blackbird spp.		7,924	67,425	39	61	38	56	45	329
House finch	*Carpodacus mexicanus*	1,024	15,620	13	87	25	48	6	61
Passerine spp.		1,974	23,076	33	67	38	68	25	141

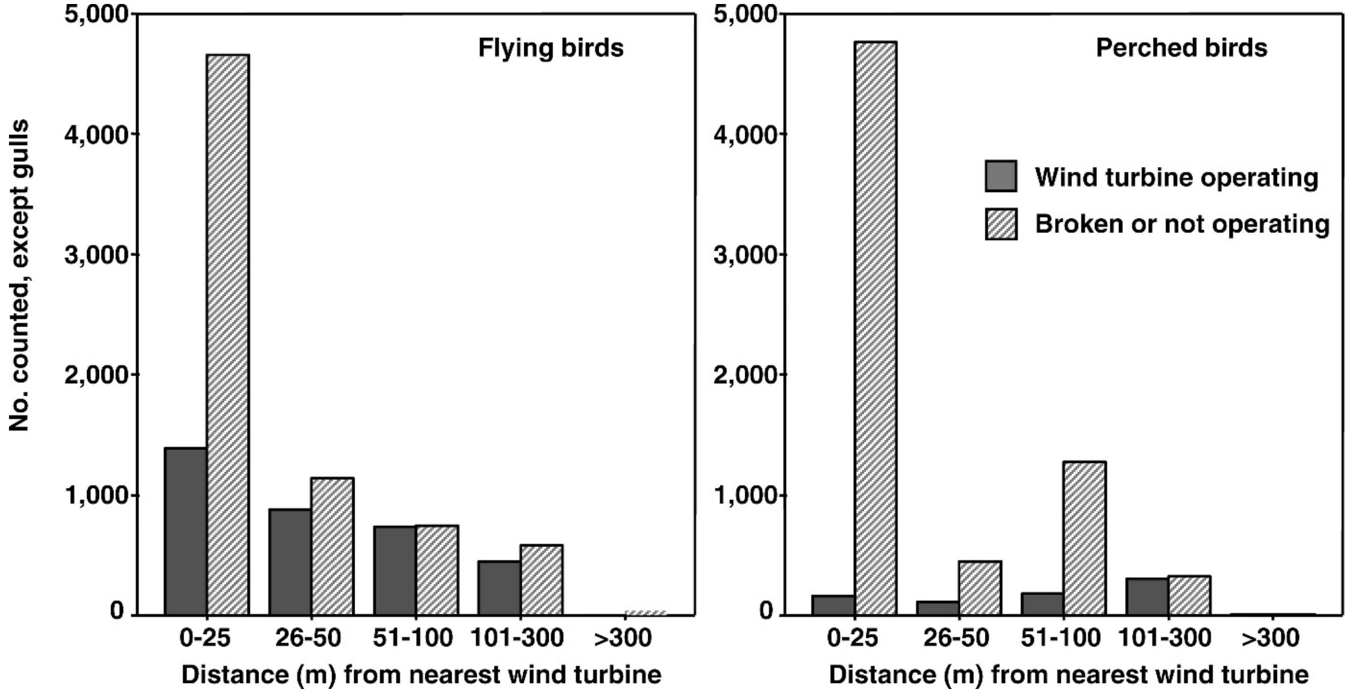

Figure 4. Counts of birds flying (left) and perched (right) by ranges of the distance to nearest turbine and whether the turbine operated at the time of the observation in the Altamont Pass Wind Resource Area, California, USA, 1998–2000.

activity peaked in spring, with a secondary peak in July and August (Fig. 3).

Behavior Patterns Around Wind Turbines

Of species observed $\geq$25 times, those observed usually flying included gulls, tricolored blackbird (*Agelaius tricolor*), turkey vulture, northern harrier (*Circus cyaneus*), rock pigeon (*Columba livia*), band-tailed pigeon (*Columba fasciata*), and mountain bluebird (*Sialia currucoides*; Table 1). Species observed usually perching included American kestrel, American crow (*Corvus brachyrhynchos*), European starling (*Sturnus vulgaris*), red-winged blackbird (*Agelaius phoeniceus*), and house finch. The species that averaged the closest distance to wind turbines included American crow, band-tailed pigeon, European starling, house finch, cliff swallow (*Petrochelidon pyrrhonota*), red-winged blackbird, and western meadowlark. We observed most (90%) birds other than gulls $\leq$100 m from wind turbines, and we observed 60% $\leq$25 m from turbines, but 82% of these close distances corresponded with times when the nearest turbine was either not operating or broken (Fig. 4). We recorded 8,618 flights that passed $\leq$50 m from turbines at blade height and 824 flights through the rotor zone; these 2 behaviors were highly correlated with each other while wind turbines were operating ($r_P = 0.96$, $n = 39$, $P < 0.001$).

Number of passes $\leq$50 m from turbines ($F_{<50}$) decreased with increasing proportion of turbines that operated during the observation session, T_{op} ($r^2 = 0.74$, SE $= 0.89$, $P < 0.001$):

$$F_{<50} = 7.98 - 6.41 \times T_{\text{op}}.$$

This same pattern was reflected in number of flights per bird within 50 m of turbines by month of the year (Fig. 5). As the proportion of turbines operating peaked during summer, number of flights per bird within 50 m of turbines was fewest, and when the proportion of turbines operating was smallest during winter, number of flights/bird within 50 m of turbines was greatest.

As the percentage of turbines that were operating increased with wind speed, mean number of birds observed during the session decreased, but mean number of flights per bird within 50 m of turbines increased (Fig. 6). In other words, birds were increasingly out of sight as wind increased

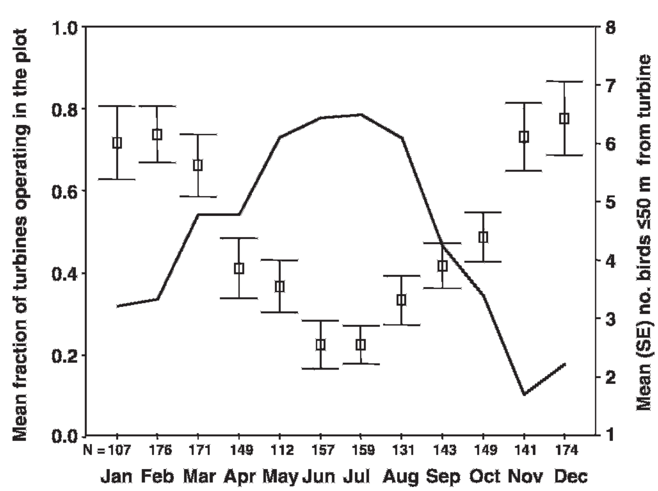

Figure 5. Mean fraction of turbines operating during behavior observation sessions (solid line) peaked over summer and was least during winter, whereas mean number of flights/bird within 50 m of turbines peaked in winter and was least during summer in the Altamont Pass Wind Resource Area, California, USA, 1998–2000.

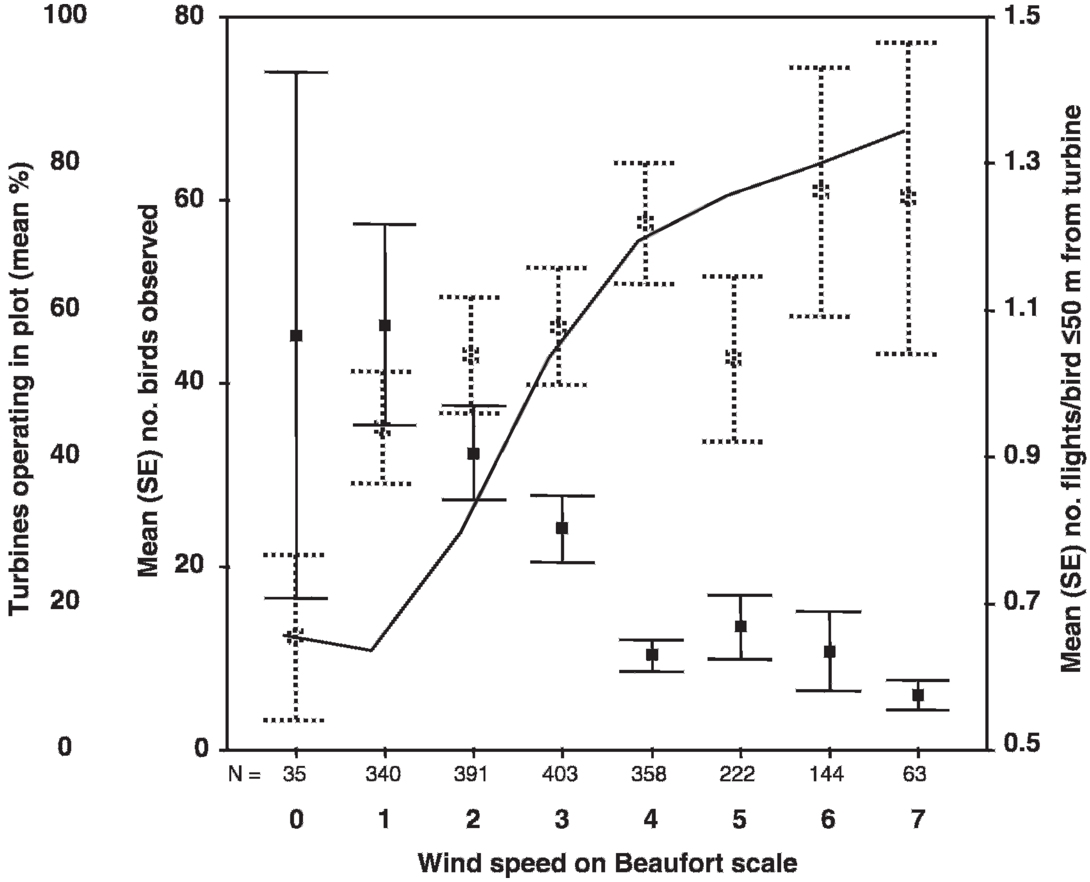

Figure 6. As wind increased in speed, the percentage of wind turbines operating within the behavior observation plot increased (solid line), mean number of birds observed decreased (solid squares and solid error bars), and mean number of flights per bird within 50 m of turbines increased (open squares and dashed error bars) in the Altamont Pass Wind Resource Area, California, USA, 1998–2000.

in strength, but flights by birds that remained observable were more frequently close to turbines. Each species responded to wind speeds in their own way, peaking in number and flights per session through the turbine row at particular wind speeds (Fig. 7).

Red-tailed hawk (*Buteo jamaicensis*) was among the most often observed species in the APWRA and the most often performing what we assumed to be more dangerous behaviors (Table 1). Gulls were by far the most commonly observed birds in the APWRA during our study, accounting for nearly 300,000 minutes of observations (we multiplied min/flock by no. of birds/flock). We did not identify most (98%) gulls to species, and of those we identified 93% were ring-billed gull (*Larus delawerensis*) and 7% were California gull (*Larus califfornicus*). Blackbirds were also common, accounting for >70,000 minutes of observation. We did not identify most (90%) blackbirds to species, but red-winged blackbird was 53% of blackbirds we identified. House finch was common and so were unidentified passerine species.

We assumed that dangerous behaviors included flights through turbine rows within the height domain of the blades, and we referred to these flights as through the rotor zone (rather than the rotor plane, which is specifically through the area swept by the blades). We also considered closer distances to turbines or number of flights ≤ 50 m from turbines to be more dangerous. Flights within 50 m were performed most often by red-tailed hawk (31.1%), common raven (20.7%), turkey vulture (12.2%), American kestrel (6.8%), gulls (6.6%), golden eagle (5.2%), and blackbirds (4.7%), followed by northern harrier (1.9%), rock pigeon (1.9%), and loggerhead shrike (1.1%) and most infrequently by burrowing owl (0.4%), swallows (0.2%), and rough-legged hawk (*Buteo lagopus*; 0.1%), among others (Table 1).

Among species we observed ≥ 10 times, the ratio of flights ≤ 50 m from turbines to number of birds observed per session was greatest for ferruginous hawk (*Buteo regalis*; 3.17), followed by common raven (1.36), red-tailed hawk (1.33), northern harrier (1.29), prairie falcon (*Falco mexicanus*; 1.27), American kestrel (1.26), turkey vulture (1.07), and golden eagle (0.97). Bird species with the smallest ratios included tricolored blackbird (0.00), gulls (0.02), band-tailed pigeon (0.03), blackbirds (0.04), mountain bluebird (0.05), and house finch (0.06).

The most commonly recorded flight behaviors included flying through the plot (61%), soaring (16%), and gliding (2%), followed by ground-hopping, flocking, and circling–searching (Table 2). Contouring, diving, fleeing while being mobbed, and being flushed were the rarest behaviors (<1% each). Considering total flight time per observation, the

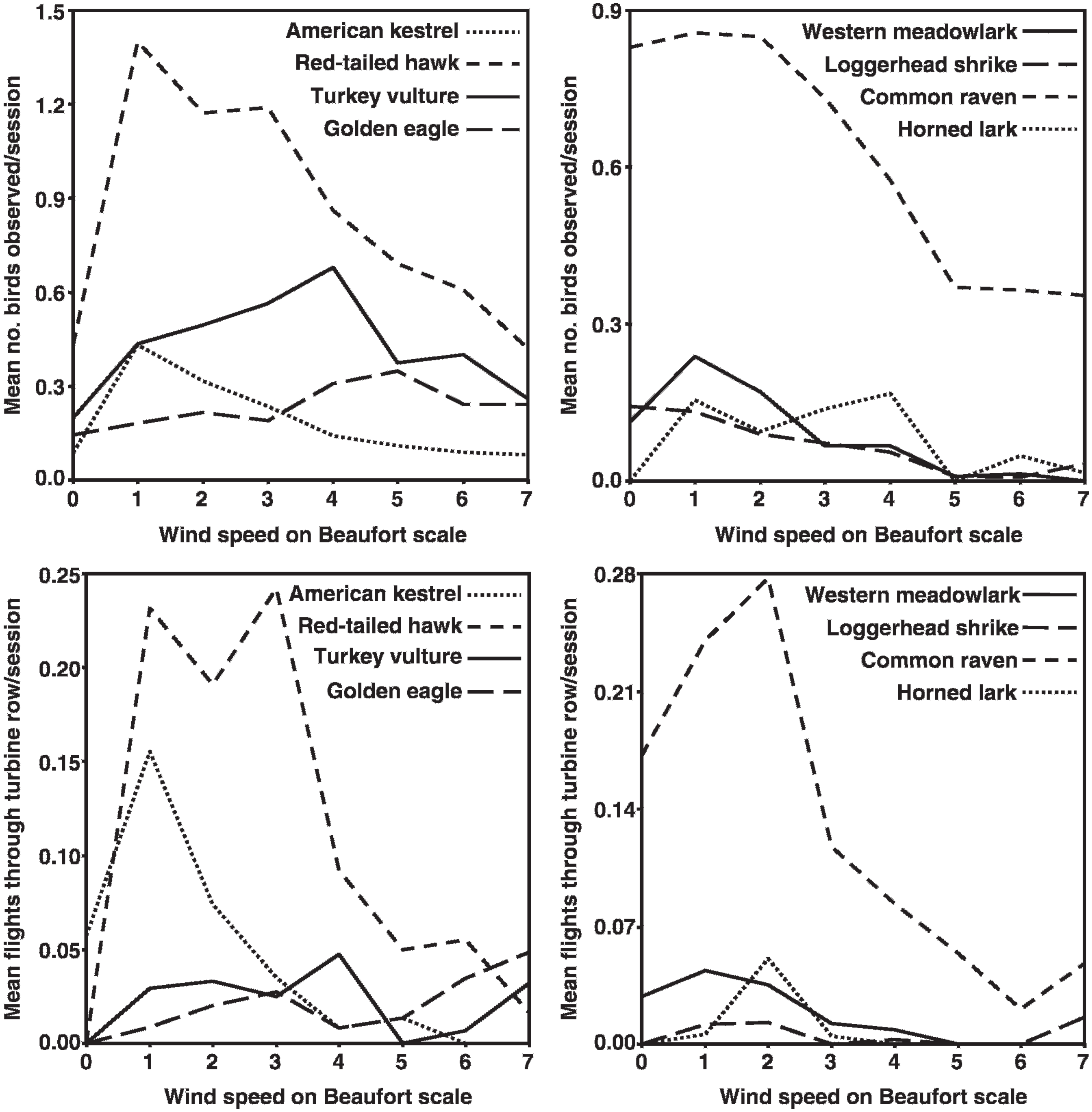

Figure 7. Mean number of birds observed and mean number of passes through the turbine row in relation to wind speed for various select species of birds in the Altamont Pass Wind Resource Area, California, USA, from 1998–2000.

most common behaviors were flying through (77%), column soaring (9%), flocking, and ground-hopping, and the rarest behaviors were diving, fleeing while being mobbed, and being flushed (Table 3).

For some species, operational status of the nearest turbine roughly corresponded with time spent flying to travel, forage, or interact with other birds while within the turbine rotor zone (Table 4). For example, golden eagles were traveling during almost 75% of total recorded time, but 9% of their time was shifted to foraging behaviors (i.e., hovering and contouring) while within the rotor zone, and we saw them interacting with other birds when the nearest turbine was operating. We observed substantial increases in time spent foraging (i.e., hovering, kiting, and diving) of red-tailed hawk (40%), prairie falcon (28%), and American kestrel (25%) while within the rotor zone of operating turbines (Table 4), likely because winds were stronger while turbines operated. Northern harriers spent 29% more of their flight time traveling (i.e., from low contour flights to straight fly-through) while moving through the rotor zone, no matter whether turbines were on.

Table 2. Flight behaviors recorded per bird observation during 1,958 sessions in the Altamont Pass Wind Resource Area, California, USA, 1998–2000.

	% of observations[a]													
Flight behaviors	**All birds**	**GOEA**	**RTHA**	**NOHA**	**PRFA**	**AMKE**	**BUOW**	**TUVU**	**CORA**	**MALL**	**LOSH**	**WEME**	**HOLA**	**ROPI**
Soar	4	38	28	24	9	3	3	27	7	0	0	0	0	<1
Column soar	12	<1	<1	0	2	0	0	0	0	0	0	0	0	0
Fly through	61	12	18	35	42	40	41	23	60	97	54	74	71	96
Glide	2	24	15	12	16	4	3	35	10	0	1	3	0	0
Surf	2	2	1	1	2	1	0	<1	3	0	3	0	11	0
Contour	<1	7	<1	17	0	0	0	<1	<1	0	0	0	0	0
Circle–search	3	10	13	8	13	6	0	14	10	0	0	0	0	2
Kite–hover	1	1	19	3	5	18	0	0	1	0	5	0	0	0
Fly-catch	<1	0	0	0	0	2	0	0	<1	0	1	0	0	0
Dive	<1	1	1	0	6	6	3	<1	<1	0	10	0	0	0
Ground hop	7	<1	1	0	2	1	19	<1	2	0	9	17	8	<1
Short flights	2	0	1	0	0	9	32	<1	5	1	11	6	5	2
Display	1	<1	1	0	2	2	0	0	1	0	4	0	5	0
Flocking	6	0	0	0	0	0	0	0	0	0	0	0	0	0
Mob	<1	<1	1	0	2	6	0	0	1	0	0	0	0	0
Mobbed–flee	<1	1	1	0	2	1	0	0	<1	0	1	0	0	0
Flushed	<1	3	1	0	0	1	0	0	<1	1	1	0	0	0
Total no.	46,568	426	1,642	124	64	358	37	971	1,240	79	80	178	205	514

[a] AMKE = American kestrel, BUOW = burrowing owl, CORA = common raven, GOEA = golden eagle, HOLA = horned lark, LOSH = loggerhead shrike, MALL = mallard, NOHA = northern harrier, PRFA = prairie falcon, ROPI = rock pigeon, RTHA = red-tailed hawk, TUVU = turkey vulture, and WEME = western meadowlark.

Table 3. Total minutes of flight behaviors recorded during 1,958 observation sessions in the Altamont Pass Wind Resource Area, California, USA, 1998–2000.

	% of flight activity[a]													
Flight behaviors	**All birds**	**GOEA**	**RTHA**	**NOHA**	**PRFA**	**AMKE**	**BUOW**	**TUVU**	**CORA**	**MALL**	**LOSH**	**WEME**	**HOLA**	**ROPI**
Soar	2	45	23	32	11	2	2	31	8	0	0	0	0	<1
Column soar	9	<1	0	0	2	0	0	0	0	0	0	0	0	0
Fly through	77	6	8	20	39	27	9	13	51	98	47	57	56	74
Glide	1	23	11	7	17	8	1	29	14	0	1	2	0	0
Surf	<1	2	<1	<1	3	1	0	<1	2	0	4	0	18	0
Contour	<1	9	<1	28	0	0	0	0	0	0	0	0	0	0
Circle–search	1	9	13	9	12	11	0	26	13	0	0	0	0	3
Kite–hover	1	1	37	3	4	28	0	0	1	0	4	0	0	0
Fly-catch	<1	0	0	0	0	5	0	0	0	0	1	0	0	0
Dive	0	1	1	0	6	5	1	0	<1	0	7	0	0	0
Ground hop	3	<1	4	0	2	1	4	<1	1	0	23	37	19	<1
Short flights	<1	0	1	0	0	5	83	<1	5	1	8	4	4	23
Display	1	1	1	0	1	1	0	0	1	0	3	0	4	0
Flocking	4	0	0	0	0	0	0	0	0	0	0	0	0	0
Mob	0	<1	1	0	2	5	0	0	2	0	0	0	0	0
Mobbed–flee	0	1	1	0	2	1	0	0	<1	0	1	0	0	0
Flushed	0	1	<1	0	0	1	0	0	0	1	1	0	0	0
Total no.	363,186	1,366	6,724	293	116	746	183	2,420	2,318	83	137	258	262	694

[a] AMKE = American kestrel, BUOW = burrowing owl, CORA = common raven, GOEA = golden eagle, HOLA = horned lark, LOSH = loggerhead shrike, MALL = mallard, NOHA = northern harrier, PRFA = prairie falcon, ROPI = rock pigeon, RTHA = red-tailed hawk, TUVU = turkey vulture, and WEME = western meadowlark.

Table 4. Distribution of percentage of time we observed species performing flights typical of traveling or foraging (i.e., soaring, column soaring, flying through, gliding), foraging (i.e., surfing, contouring, circling–searching, kiting, hovering, fly-catching, diving, ground hopping), and interacting with other birds in a non-predatory manner (i.e., short flights, display, flocking, mobbing, being mobbed, fleeing, flushed) in the Altamont Pass Wind Resource Area, California, USA, 1998–2000.

	Total flight min (%)			Flight time in rotor zone of nonmoving turbine (%)			Flight time in rotor zone of operating turbine (%)		
Species	Travel	Forage	Interact	Travel	Forage	Interact	Travel	Forage	Interact
Golden eagle	74.7	22.7	2.6	68.3	31.7	0.0	60.0	32.7	7.3
Red-tailed hawk	44.2	52.3	3.5	59.4	38.7	1.9	18.1	79.6	2.3
Northern harrier	59.7	40.3	0.0	88.2	11.8	0.0	88.9	10.1	0.0
Prairie falcon	69.0	26.7	4.3	70.6	17.6	11.8	54.5	45.5	0.0
American kestrel	38.2	49.9	11.9	36.1	51.0	13.0	15.2	75.8	9.1
Burrowing owl	12.0	4.9	83.1	0.0	0.0	100.0	0.0	0.0	0.0
Turkey vulture	72.9	27.0	0.1	79.3	20.7	0.0	71.7	28.3	0.0
Common raven	73.3	17.8	8.9	66.6	23.2	10.2	82.8	4.6	12.6
Mallard	97.6	0.0	2.4	100.0	0.0	0.0	0.0	0.0	0.0
Loggerhead shrike	47.4	40.1	12.4	16.7	41.7	41.7	0.0	0.0	0.0
Western meadowlark	58.9	37.2	3.9	100.0	0.0	0.0	100.0	0.0	0.0
Horned lark	55.7	36.6	7.6	100.0	0.0	0.0	0.0	0.0	0.0
Rock pigeon	74.2	2.9	22.9	72.2	5.6	22.2	86.4	6.8	6.8

We recorded most (83%) burrowing owl flights as interacting with other birds (Table 4), but probably included short foraging flights in addition to interactions with conspecifics. However, we recorded no burrowing owl flights within the rotor zone while the nearest turbine was operating. Both turkey vulture and common raven demonstrated no substantial shifts in flight behaviors within rotor zones (Table 4), but it was also difficult to discern when either of these species was foraging rather than traveling. Mallards (*Anas platyrhynchos*) traveled through study plots 98% of the time, but we did not see them flying through the rotor zone of operating turbines. Loggerhead shrike and horned lark also avoided the rotor zone of operating turbines, but loggerhead shrikes were much more interactive with other birds while within the rotor zone of nonoperating turbines. Western meadowlarks flew through rotor zones, but their flights typified traveling behavior. Rock pigeons were 15% less interactive with other birds while in the rotor zone of operating turbines (Table 4).

Eight species spent ≥25% of their perching time on wind turbines and their towers when turbines were broken or not operating (Table 5). Some birds, including golden eagle, prairie falcon, burrowing owl, and house finch, never perched on operating wind turbines, whereas they did perch on nonoperating turbines (Table 5). Red-tailed hawk, American kestrel, common raven, loggerhead shrike, and western meadowlark perched on operating turbines 1–3% of the time but perched on nonoperating turbines 26–52% of the time. Overall, observations of birds perched on turbines were 22 times more common while the turbines were not operating than when operating (Table 5), though this difference did not factor in the

Table 5. Distribution of perch time among select species observed in the Altamont Pass Wind Resource Area, California, USA, 1998–2000.

		Time perching (%)						
Species	Total min	Operating wind turbine[a]	Nonoperating wind turbine[b]	Power pole	Landscape element	Transmission tower	Electric distribution line	Ancillary structure
Golden eagle	1,003	0	3	26	41	23	4	4
Turkey vulture	96	0	0	0	89	0	11	0
Red-tailed hawk	8,799	1	47	15	18	4	12	3
Northern harrier	86	0	1	0	99	0	0	0
Prairie falcon	83	0	17	12	28	13	30	0
American kestrel	2,239	2	42	5	6	1	39	4
Burrowing owl	1,438	0	4	2	86	8	0	0
Common raven	1,904	3	52	9	20	1	12	2
European starling	2,140	11	76	0	0	0	9	3
House finch	13,525	0	54	0	0	0	45	1
Loggerhead shrike	698	1	26	8	9	0	50	6
Rock pigeon	128	20	65	1	0	0	1	13
Western meadowlark	450	2	50	1	15	0	28	4
Horned lark	409	0	0	0	100	0	0	0
Total	93,366	1	22	2	45	1	13	17

[a] Includes tower structure and all other components of turbine.
[b] Includes towers supporting turbines that are broken, missing, or functional but not operating.

Table 6. We fit models to average number of birds per session per 100 ha within 100-m intervals of distances between the observation point and turbine rows in the Altamont Pass Wind Resource Area, California, USA, 1998–2000.

Species or group	Regression model	*P*	r^2	SE	*a*	*b*	Distance from observer before detections at 100 m can be predicted to be fewer by 25%	75%
Turkey vulture	Inverse	<0.001	0.97	6.96	−3.373	13,200.123	132	372
Golden eagle	Inverse	<0.001	0.95	3.34	0.485	4,981.640	134	412
Red-tailed hawk	Linear	<0.001	0.93	10.63	122.970	−0.118	332	807
Northern harrier	Linear	<0.050	0.83	1.26	8.541	−0.009	316	738
Prairie falcon	Inverse	<0.001	0.95	1.08	−1.508	1,580.734	109	271
American kestrel	Logarithmic	<0.001	0.98	2.17	127.902	−18.509	178	563
Burrowing owl[a]	Power	<0.050	0.52	0.70	776.740	−0.927	136	446
Common raven	Linear	<0.001	0.85	14.19	103.251	−0.103	325	777
Gull spp.	Inverse	<0.001	0.98	377.92	−954.093	811,838.861	105	252
Mallard	Logarithmic	<0.050	0.70	2.28	29.740	−4.454	168	473
Medium-sized birds	Logarithmic	<0.001	0.96	4.51	194.431	−28.399	175	537
Non-gull spp.	Linear	<0.050	0.66	327.20	1,405.766	−1.421	322	767
Rock pigeon	Logarithmic	<0.001	0.90	5.85	153.008	−22.600	172	507
Mourning dove	Logarithmic	<0.050	0.58	0.60	6.048	−0.916	165	447
Loggerhead shrike	Inverse	<0.001	0.96	1.50	−2.266	2,549.385	130	316
Horned lark	Inverse	<0.001	0.90	2.82	−2.998	2,858.643	129	304
Western meadowlark	Inverse	<0.001	0.84	9.88	−10.973	7,648.279	127	280
Small-bodied birds[b]	logarithmic	<0.050	0.88	127.89	2,957.651	−427.548	178	567

[a] We added the value 1 to number of burrowing owls to prevent taking the log of 0.
[b] We held out record at 600 m as an outlier.

percentage of time during sessions when turbines were not operating.

Rates of Utilization and Fatalities Compared Spatially

Among all species, the largest correlation coefficient was 0.35 between fatality rates at turbine rows and utilization rates (i.e., no. of individuals observed/session/100 ha), so we did not report statistical test results. However, utilization rates among turbine rows declined with increasing distance between the observer and turbine row, indicating a substantial bias (Table 6; Fig. 8). Using models that best fit the data (i.e., homoscedastic pattern in the residuals, smallest root mean square error, and largest r^2 value), distances were much shorter at which predicted utilization rates declined to 25% and 75% of the observed rates at 0–100 m among small-bodied species, for the most part. Utilization rates declined rapidly with distance from observer for gulls, and steeply for golden eagles, turkey vultures, and prairie falcons, whereas rates for northern harriers and common ravens were less responsive to distance from the observer (Table 6).

We saved the unstandardized residuals from utilization rates regressed on distance of turbine row from observer (models in Table 6), and we related these residuals to fatality rates. However, the residuals did not explain variation in fatality rates among turbine rows for any bird species (all $r^2 < 0.1$, $P > 0.25$).

At the plot scale, utilization rate declined with increasing plot size (ha) for turkey vulture ($r = -0.70$, $P < 0.001$), red-tailed hawk ($r = -0.65$, $P < 0.001$), common raven ($r = -0.55$, $P < 0.001$), and American kestrel ($r = -0.44$, $P < 0.05$), but not for any other species. For these 4 species with significant correlations with plot size, we fit regression models and tested unstandardized residuals for a correlation with fatality rate among plots (Table 7). Fatality rate correlated with utilization rate only for all birds as a group ($r = 0.46$, $P < 0.05$), burrowing owl ($r = 0.54$, $P < 0.001$), and mallard ($r = 0.60$, $P < 0.001$). Fatality rate did not change with residuals from models fit for turkey vulture, red-tailed hawk, common raven, and American kestrel.

Behaviors and Fatality Rates

Mean monthly fatality rate of birds as a group increased with increasing flights/session through turbine rows (Fig. 9):

$$F_1 = 0.527 + 0.0876 \times U_T$$

and

$$F_2 = 0.911 + 0.631 \times U_T,$$

where F_1 represented October through April ($r^2 = 0.88$, root mean square error [RMSE] = 0.102, df = 1, 6, $P < 0.05$), F_2 represented May through September ($r^2 = 0.77$, RMSE = 0.041, df = 1, 4, $P < 0.05$), and U_T was utilization of turbine rows, or number of flights/session through the turbine row.

Mean monthly fatality rate of red-tailed hawks increased with increasing utilization rate, or the flights/session (Fig. 10):

$$F_3 = 0.033 + 0.029 \times \ln U,$$

where F_3 was mean monthly fatality rate of red-tailed hawks and U was utilization rate of the APWRA ($r^2 = 0.67$,

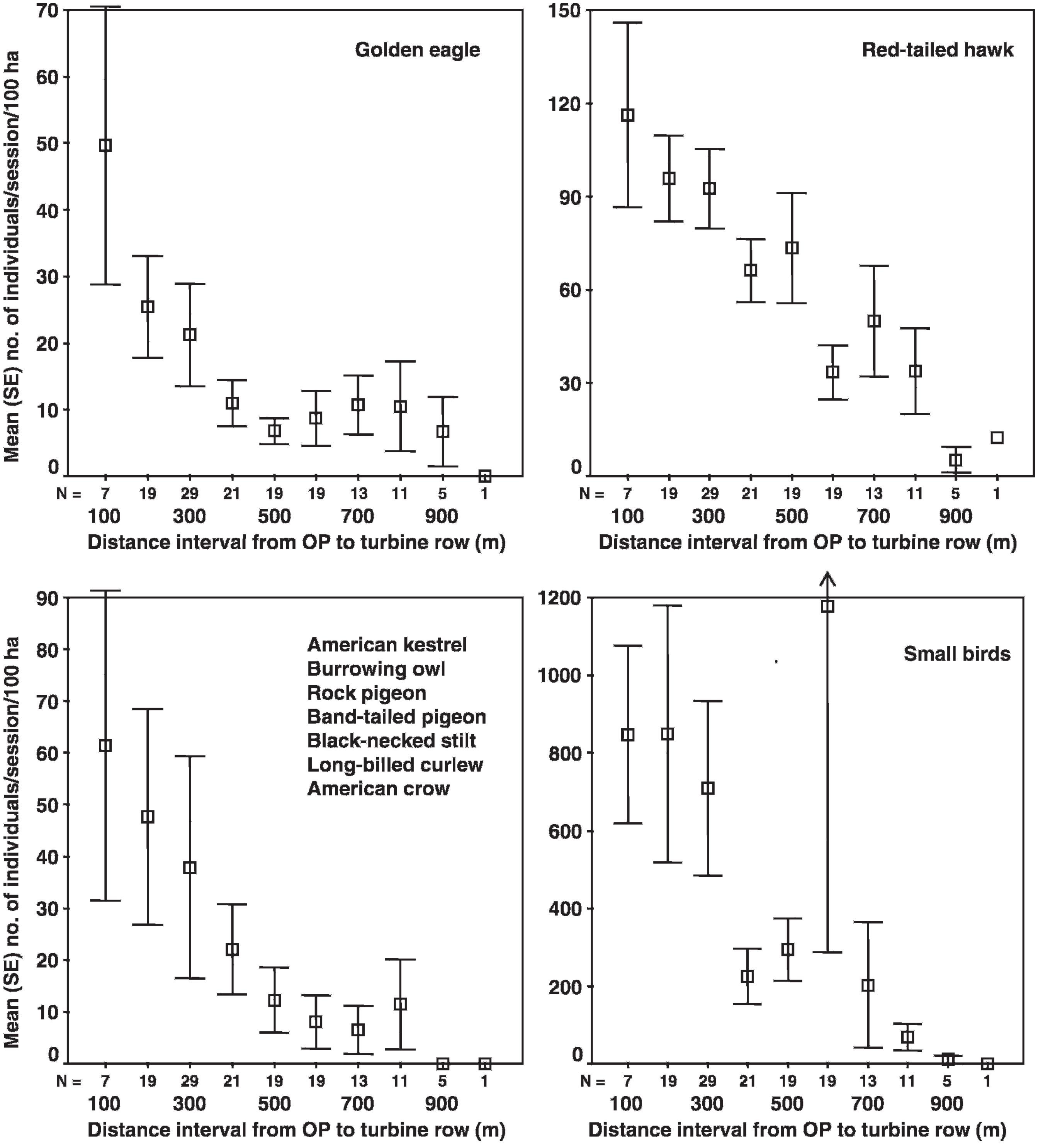

Figure 8. Utilization rates declined with increasing distance between wind turbine row and observer for golden eagles (top left), red-tailed hawks (top right), medium-sized birds (lower left), and small birds (bottom right), where distances were average distances to wind turbines in the row and aggregated to 100-m intervals in the Altamont Pass Wind Resource Area, California, USA, 1998–2000.

RMSE = 0.011, df = 1, 10, $P < 0.01$). Mean monthly fatality rate increased with number of flights per session through turbine rows (Fig. 10):

$$F_4 = 0.0512 - \frac{0.0017}{U_T}$$

and

$$F_5 = -0.0474 + 1.3010 \times U_T,$$

where F_4 represented October through April ($r^2 = 0.92$, RMSE = 0.006, df = 1, 6, $P < 0.001$), F_5 represented May through September ($r^2 = 0.92$, RMSE = 0.007, df = 1, 4, $P < 0.01$), and U_T was utilization of turbine rows, or number of flights/session through the turbine row.

Table 7. We fit models fit to average number of birds per session per 100 ha compared to plot size (ha) in the Altamont Pass Wind Resource Area, California, 1998–2000.

Species	Regression model	*P*	r^2	SE	*a*	*b*	Plot size (ha) before detections in 23 ha can be predicted to be fewer by 25%	75%
Turkey vulture	Logarithmic	<0.001	0.52	20.24	219.567	−40.970	40	122
Red-tailed hawk	Logarithmic	<0.001	0.45	32.34	323.057	−56.939	43	154
American kestrel	Logarithmic	<0.001	0.21	12.13	70.513	−12.018	46	178
Common raven	Linear	<0.001	0.23	29.09	93.943	−0.455	69	161

Mean monthly fatality rate of American kestrels correlated positively with rate of flights within 50 m of wind turbines ($r = 0.68$, $n = 12$, $P < 0.05$) and with number of flights/session through the turbine row ($r = 0.61$, $n = 12$, $P < 0.05$). Mean monthly fatality rates of golden eagles and burrowing owls did not correlate with rates of particular behaviors. Mean monthly fatality rate of western meadowlarks correlated with number of flights/session within 50 m of turbines while at rotor height ($r = 0.60$, $n = 12$, $P < 0.05$).

Fatality rate among plots correlated weakly with frequency of close flights per session per hectare for all birds as a group ($r = 0.38$, $P < 0.05$) but not for any individual species. Fatality rate did not correlate with frequency of hazardous flights made by any species or species group.

Fatality rate increased linearly with rates of utilization (i.e., birds/hr) and specific flight behaviors (i.e., flights/hr) of large raptors and small birds other than raptors within plots where we monitored behaviors (Fig. 11; Table 8). These increases in fatality rate were much faster among small birds than among large raptors, including 3.6 times faster for utilization, 5 times faster for flight time, 37 times faster for flights within 50 m of turbines, and 29 times faster for flights that cross the turbine row (Table 8). Relating fatality rate to rates of utilization and behaviors while birds were at blade height resulted in nonsignificant linear regression models for small birds but increased fatality rates among large raptors. Regressing fatality rate of large raptors on rates of behaviors performed at the heights of the turbine blades resulted in slope coefficients that were 3.5 times larger for utilization, 2.6 times larger for flight time, 7 times larger for flights within 50 m of turbines, and 0.7 times larger for flights through the turbine rows (Table 8).

Large-raptor fatality rate increased fastest with increasing number of flights/hour made by the species at blade height through turbine rows, followed by flights/hour at blade height within 50 m of turbines, and by number of birds/hour counted at blade height (Table 8). Small-bird fatality rate increased with increasing flights/hour made by species through turbine rows, followed by flights/hour within 50 m of turbines. Fatality rates of both large raptors and small birds were least responsive to amount of time species were observed perching/hour.

Whereas utilization (i.e., birds/hr) and recorded behaviors/hour explained nearly all variation in large-raptor fatality rate ($r^2 = 0.99$–1.00), they explained much less of the variation in small-bird fatality rate (Table 8). Number of flights close to turbines was the best predictor of small-bird fatality rate. Three species of small birds were consistent outliers in regressions of fatality rate on behaviors, and we therefore held them out of regression models. These consistent outliers were western meadowlark, mourning dove, and European starling and, compared with the other species of small birds, they died at wind turbines at rates much higher than we observed them during behavior monitoring. American kestrel and burrowing owl also fit none of the patterns observed for small birds and large raptors, and neither did medium- and large-sized species other than raptors, including mallard, gulls, and common raven.

Among species recorded diving toward the ground (i.e., foraging), fatality rate correlated with diving behavior in terms of number of minutes ($r = 0.85$, $n = 7$, $P < 0.05$) and number of individuals ($r = 0.98$, $n = 7$, $P < 0.001$) per hour. Among species observed fly-catching (i.e., foraging), fatality rate correlated with fly-catching in terms of number of minutes ($r = 0.93$, $n = 5$, $P < 0.05$) and number of individuals ($r = 0.88$, $n = 5$, $P < 0.05$) per hour. Among

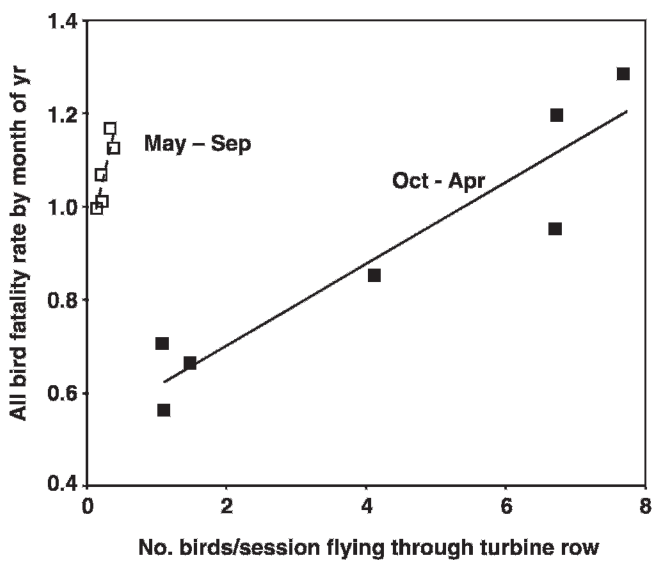

Figure 9. Adjusted fatality rate estimates of all birds increased with number of birds observed flying through turbine rows during observation sessions in the Altamont Pass Wind Resource Area, California, USA, 1998–2000.

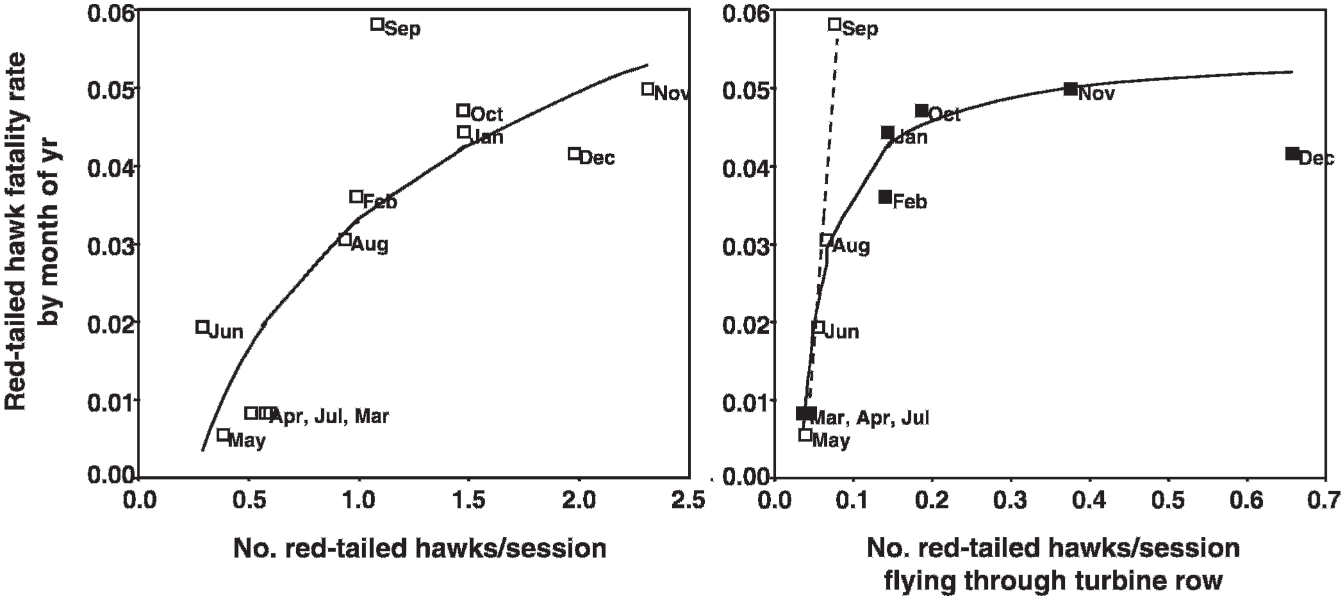

Figure 10. Mean monthly fatality rate estimates of red-tailed hawks increased with utilization rate (left) and rate of flights through turbine rows (right) during observation sessions in the Altamont Pass Wind Resource Area, California, USA, 1998–2000.

species observed hovering, fatality rate correlated with number of birds per hour that were hovering ($r = 0.71$, $n = 9$, $P < 0.05$).

DISCUSSION

Our results did not refute our hypothesis that birds lose track of wind turbines while focused on diving for prey items, fly-catching, and hovering. Those species more often expressing these directed foraging behaviors appeared to be more susceptible to wind turbine collisions. Periods of focused foraging comprised lapses in what otherwise appeared to be nearly constant caution of operating wind turbines by birds in the APWRA. Caution was demonstrated by birds rarely perching on towers of operating turbines and spending less time flying within 50 m of turbines as turbine operations increased through the observation session or seasonally. Northern harrier showed particular caution around wind turbines, switching to traveling flights only while flying within 50 m of turbines or crossing turbine rows, regardless of whether turbines were operating. However, the greater time golden eagle, red-tailed hawk, American kestrel, and prairie falcon spent foraging within the rotor zone of operating turbines probably countered the caution they exercised most of the time.

Another suite of behaviors that corresponded with higher fatality rates was interactions with other birds while in the rotor zone. Golden eagles often displayed territorial behaviors towards younger conspecifics and other raptors while in the rotor zone of operating turbines. Burrowing owls, loggerhead shrikes, rock pigeons, and American kestrels experienced high fatality rates, and we observed these species interacting with other birds while in the rotor zone nearest nonoperating turbines or vacant towers. Interaction behaviors are also distracting, and could lead to collisions with turbines operating adjacent to the nonoperating turbines or with the blades of nonoperating turbines that are allowed to move in the wind (termed feathering).

At wind speeds >1.5 m/sec, birds generally spent increasingly less time in the air with increasing wind speeds. However, of the birds that were flying in these winds, more flew within 50 m of turbines as wind speed increased. In strong winds, the proportion of birds flying within 50 m of wind turbines peaked, and this is when most wind turbines can be seen operating and when birds typically experience the most trouble controlling their flights. We hypothesize that collision risk increases for birds flying in high winds within the APWRA.

As previously hypothesized, collision rates corresponded with utilization rates, especially among small-bodied, non-raptor species and among large raptors flying at blade height. Outliers among interspecific comparisons between fatality rates and rates of utilization and specific flight behaviors included burrowing owl, American kestrel, western meadowlark, European starling, mourning dove, and medium- and large-sized birds other than raptors. For these species, we may have missed the rates of utilization and flight behaviors that matter most, such as nocturnal utilization and behaviors, which would matter if these species were killed mostly at night. This was certainly true of strictly nocturnal species, such as barn owl (*Tyto alba*) and great horned owl (*Bubo virginianus*), which we found dead, but that were unobserved during surveys.

We found that fatality rate precisely related to seasonal utilization of the APWRA by red-tailed hawk and that it related to frequency of flights through turbine rows by red-tailed hawks and all birds as a group. Flights through turbine rows during late spring and summer appeared especially deadly, resulting in steep slopes between fatality rate and flights through turbine rows. Also, mean monthly

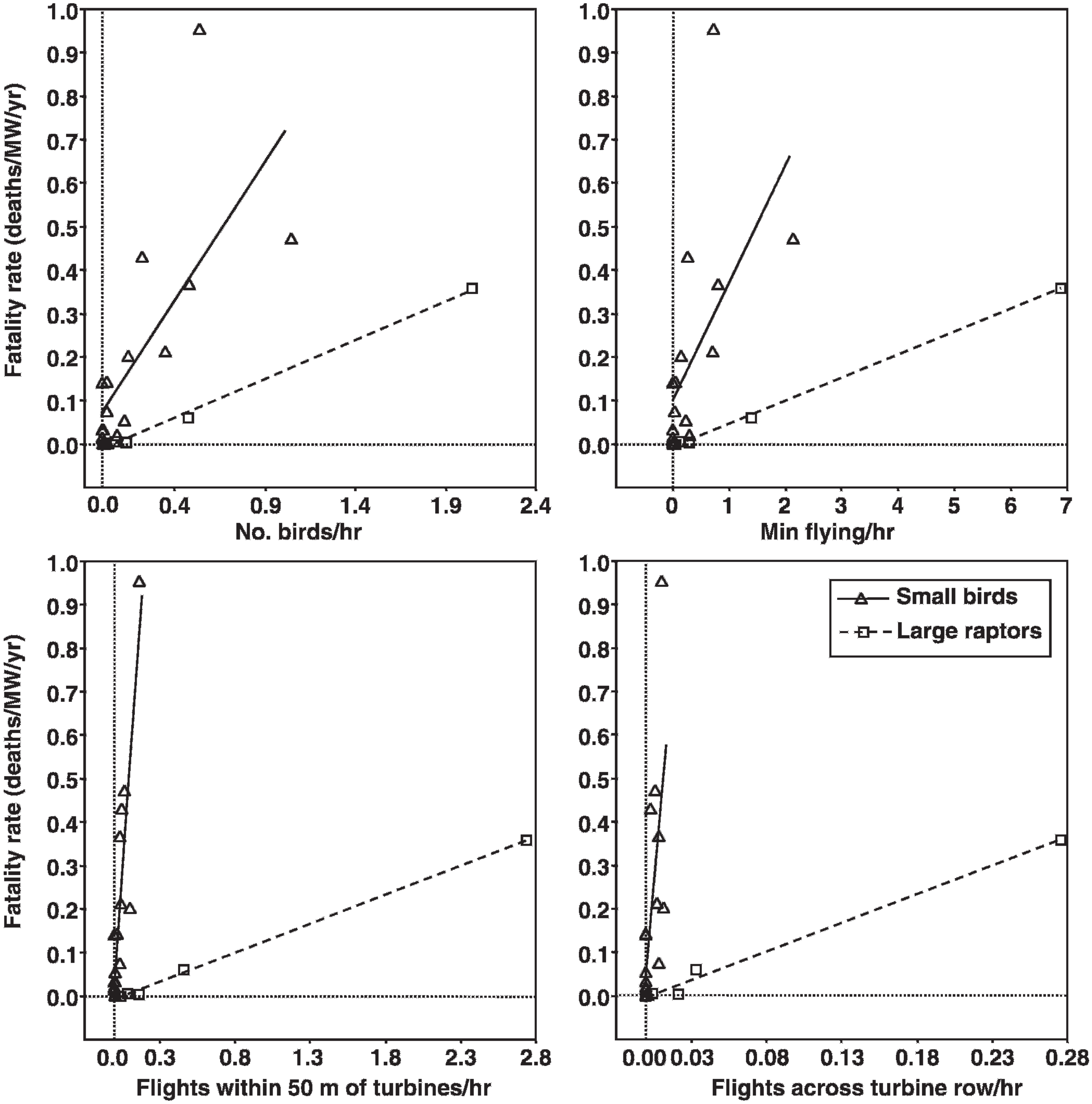

Figure 11. Response of mean adjusted fatality rate at wind turbines to rates of utilization and flight behaviors in the Altamont Pass Wind Resource Area, California, USA, 1998–2002 (fatality rate) and 1998–2000 (behavior).

fatality rates of American kestrels correlated with flights in the rotor zone, and those of western meadowlark did so while flights were at rotor height.

Contrary to correlations we observed between fatality and utilization rates both inter-specifically and seasonally, we failed to find strong correlations when we compared these rates spatially. Spatial comparisons of these rates were likely confounded by variable plot sizes and the strong decreases in utilization rates with increasing distance from the observer of the turbine rows. However, even after accounting for the effect of distance from the observer, fatality rates still did not correlate with utilization rates among turbine rows. Among observation plots, fatality and utilization rates correlated only for burrowing owl, mallard, and all birds as a group.

Orloff and Flannery (1992) found no relationship between fatality and utilization rates among their observation plots in the APWRA, which was consistent with our finding for most species examined. Perhaps these fatality and utilization rates do not correlate spatially, but we suspect the correlation eluded us and Orloff and Flannery (1992) due to the strong, species-specific effect of distance from the observer on estimating utilization rates. We failed to record small-bodied bird species beyond 400 m or 500 m, whereas

Table 8. Models of mean adjusted fatality rate (deaths/megawatt/yr) regressed on rates of utilization and bird flights and perching among observation plots in the Altamont Pass Wind Resource Area, California, USA, during 1998–2002 (fatality rate) and 1998–2000 (behavior).

Fatality rate	Observation records/hr	r^2	SE	*P*	*a*	*b*
Large raptors	No. birds	1.00	0.01	<0.001	−0.0081	0.1770
	Flight time	1.00	0.01	<0.001	−0.0046	0.0524
	Perch time	1.00	0.01	<0.001	0.0032	0.0390
	Close flights	1.00	0.01	<0.001	−0.0052	0.1330
	No. birds at blade ht	1.00	0.01	<0.001	−0.0006	0.6220
	Flight time at blade ht	0.99	0.01	<0.001	0.0044	0.1360
	Close flights at blade ht	0.99	0.01	<0.001	0.0025	0.9330
	Crossing turbines at blade ht	0.99	0.02	<0.001	0.0022	2.4270
Small birds	No. birds	0.52	0.18	<0.01	0.0734	0.6370
	Flight time	0.35	0.21	<0.05	0.1030	0.2680
	Perch time	0.13	0.25	>0.05	0.1600	0.0254
	Close flights	0.77	0.13	<0.001	0.0400	4.9120
	Crossing turbines	0.42	0.20	<0.01	0.0624	38.4240

we often recorded some conspicuous birds 800 m to 1,000 m distant. Due to this strong effect of distance from the observer, we also suggest that past comparisons of fatality and utilization rates among wind farms were of dubious value (Erickson et al. 2001, Young et al. 2003, Smallwood and Thelander 2004, Johnson et al. 2006, Whitfield and Madders 2006). Comparisons of fatality and utilization rates between sites will probably yield no useful patterns until methods are standardized to account for how the size of the area surveyed affects utilization rates.

On the other hand, temporal comparisons of fatality and utilization rates were often significant, likely because comparing utilization in the same plot through time cancels the effect of distance between birds and observer. High seasonal variation in flight activity among species suggested to us that pre- and postconstruction utilization monitoring needs to span all seasons and probably should do so for several years to account for interannual variation in relative abundance of species. Erickson et al. (W. Erickson, Western Ecosystems Technology, Inc., unpublished report) concluded that bird observations are not needed beyond one season of the year, but we disagree. Had we restricted our observations to summer, for example, we would have grossly mischaracterized utilization of the APWRA by red-tailed hawk, golden eagle, burrowing owl, etc. Utilization and behavior surveys also need to be extended into the night to detect nocturnal species and diurnal species that sometimes may be active at night.

MANAGEMENT IMPLICATIONS

Managers can now use the relationships we reported between fatality and utilization rates to forecast avian fatality rates at proposed wind farms, so long as adequate preconstruction utilization surveys are performed and adjustments made for differences in local conditions and wind turbine model and size. For example, if a large-bodied raptor species was seen flying at blade height within a proposed wind farm at the rate of 10 birds/hour, then the appropriate model (Table 8) would predict a fatality rate of 6.2 birds/MW/year, assuming no effect of differences in turbine size between the APWRA and the proposed wind farm.

A seasonal shutdown of wind turbines would reduce fatality rates of some but not all species due to considerable interspecific variation in seasonal activity patterns. However, a seasonal shutdown, such as a winter shutdown in the APWRA, can make sense as a tradeoff measure, balancing bird fatality reductions with minimizing loss of power generation in the wind farm. Shutting down wind turbines during high wind speeds also might reduce fatality rates, but unknown effects of this measure would warrant an experimental implementation.

Because birds almost never perch on operating turbines, perching on them did not relate to fatality rates. However, some species with high fatality rates often interacted among defunct turbines and vacant towers, so removing vacant towers, repairing broken turbines, and synchronizing turbine operations within a row might help reduce hazardous use of the rotor zone, thereby reducing collisions. Another measure to minimize or reduce fatality rates would be to leave sufficiently large gaps between groups of turbines to allow birds to travel and forage without having to necessarily fly close to wind turbines.

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Associate Editor: Brennan.

Rulemaking Petition to the U.S. Fish & Wildlife Service for Regulating the Impacts of Wind Energy Projects on Migratory Birds

Petitioner: AMERICAN BIRD CONSERVANCY

December 14, 2011

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GLOSSARY

ABC	American Bird Conservancy
ABPP	Avian and Bat Protection Plan
APA	Administrative Procedure Act, 5 U.S.C. § 500 et seq.
AWEA	American Wind Energy Association
AWWI	American Wind Wildlife Institute
BCC	Birds of Conservation Concern
BGEPA	Bald and Golden Eagle Protection Act, 16 U.S.C. §§ 668-668c
BMPs	Best Management Practices
BOEM	U.S. Bureau of Ocean Energy Management
BLM	U.S. Bureau of Land Management
DOE	U.S. Department of Energy
DOI	U.S. Department of Interior
ESA	Endangered Species Act, 16 U.S.C. § 1531 et seq.
FAA	Federal Aviation Administration
FACA	Federal Advisory Committee Act, 5 U.S.C. App. 2 §§1-16
FOIA	Freedom of Information Act, 5 U.S.C. § 552
FWS or Service	U.S. Fish and Wildlife Service
GAO	U.S. Government Accountability Office
GW	Gigawatt
HCP	Habitat Conservation Plan
ITP	Incidental Take Permit
MBTA	Migratory Bird Treaty Act, 16 U.S.C. § 703 et seq.
MOU	Memorandum of Understanding
MW	Megawatt
OCS	Outer Continental Shelf
Corps	U.S. Army Corps of Engineers

EXECUTIVE SUMMARY

Pursuant to the Administrative Procedure Act ("APA"), 5 U.S.C. § 553(e), and the implementing regulations of the U.S. Department of the Interior ("DOI"), 43 C.F.R. Pt. 14, American Bird Conservancy ("ABC"), hereby submits this Petition for Rulemaking to the U.S. Fish and Wildlife Service ("FWS" or "Service"), requesting the agency to promulgate regulations governing the impacts of wind energy projects on migratory birds. In particular, ABC petitions FWS to establish a permitting scheme that would regulate the impacts of wind power projects on migratory birds. As discussed in this Petition, such a scheme is clearly authorized by the Migratory Bird Treaty Act ("MBTA"), 16 U.S.C. § 703 et seq., would significantly improve the protection of birds covered by the MBTA, and would afford the wind power industry a degree of regulatory and legal certainty that cannot be provided in the absence of such a scheme.

ABC recognizes that properly sited and operated wind energy projects may be an important part of the solution to climate change, a phenomenon that indisputably poses an unprecedented threat to species and ecosystems. However, such projects also pose a serious threat to various species of birds, including large birds of prey and raptors such as the Bald Eagle, Golden Eagle, Ferruginous Hawk, Swainson's Hawk, American Peregrine Falcon, Short-eared Owl, and Flammulated Owl; endangered and threatened species such as the California Condor, Whooping Crane, Snail Kite, Marbled Murrelet, Hawaiian Goose, and Hawaiian Petrel; and other species of special conservation concern such as the Bicknell's Thrush, Sprague's Pipit, Cerulean Warbler, Oak Titmouse, Lewis's Woodpecker, Brewer's Sparrow, Long-billed Curlew, Bay-breasted Warbler, and Blue-winged Warbler. These species are impacted by existing wind energy projects and threatened by potential projects primarily through collision with wind turbines and associated power lines, and through loss or modification of essential habitat.

Based on the operation of approximately 22,000 turbines, FWS estimated in 2009 that at least 440,000 birds were killed each year by wind turbines. By 2020, there are expected to be more than 100,000 wind turbines in the United States and these are expected to kill at least one million birds each year, an estimate that ABC believes will be exceeded significantly. Further, wind energy projects are also expected to impact almost 20,000 square miles of terrestrial habitat, and another 4,000 square miles of marine habitat.

The MBTA, Endangered Species Act ("ESA"), 16 U.S.C. § 1531 et seq., and the Bald and Golden Eagle Protection Act ("BGEPA"), 16 U.S.C. §§ 668-668c, prohibit "take" of migratory birds, endangered and threatened species, and Bald and Golden Eagles. 50 C.F.R. § 10.12 (implementing regulations defining the term "take" to include to wound or kill, or to attempt to wound or kill). Bald and Golden Eagles are protected under both MBTA and BGEPA, and many species listed under the ESA are also protected under the MBTA, such as Whooping Cranes, California Condors, Least Terns, Kirtland's Warblers, Northern Aplomado Falcons, Roseate Terns, and Piping Plovers. While the ESA and BGEPA provide mechanisms for FWS to regulate, and in some instances authorize, take of endangered and threatened species and Bald and Golden Eagles respectively, at present no such comparable mechanism exists under the MBTA to authorize incidental take by wind power projects.

This reality is particularly significant for the wind industry because wind energy projects will inevitably take birds protected under the MBTA. In fact, because it is virtually impossible to operate a wind energy project without killing or injuring at least some migratory birds, most wind energy projects that are already in operation are in ongoing violation of the take prohibition of the MBTA. In addition, FWS itself is aware of other projects that are being planned that will also take migratory birds in violation of federal law.

FWS has prepared "voluntary" Guidelines in an attempt to address the impacts of wind energy projects on migratory birds instead of imposing mandatory regulatory obligations on wind energy projects to anticipate and avoid such impacts before they occur. By allowing the industry itself to make siting decisions in this manner, FWS has permitted widespread disregard for legal mandates the Service is entrusted to enforce. Further, while the Guidelines essentially treat the agency as a quasi-permitting authority requiring it to evaluate extensive information and provide advice to the developers, unlike a formal permitting system, FWS neither obtains appropriate permit fees (which typically provide some amount of resources and revenue to the agency), nor does the wind industry obtain unequivocal regulatory certainty for incidental take of migratory birds.

Thus, as explained in this Petition, ABC supports "bird-smart" wind energy that employs careful siting, operation, construction, mitigation, bird monitoring, and compensation criteria, designed to reduce and redress any unavoidable bird mortality and habitat loss. ABC recognizes the need for renewable energy development and will support the wind industry in its efforts to extend the federal tax grant and production tax credit for wind energy production, if FWS puts in place a system that ensures ongoing compliance with the MBTA along with other wildlife protection laws.

In this Petition, ABC urges FWS to promulgate regulations establishing a mandatory permitting system for siting, constructing, and operating wind energy projects and mitigating of their impacts on migratory birds. The Petition first sets forth the factual basis establishing the need for such a system, i.e., the proliferation of wind energy projects and the significant adverse effects this development is having and will increasingly have on migratory birds, particularly those of conservation concern. Then the Petition describes the legal framework under which FWS has more than sufficient authority to promulgate MBTA regulations specifically aimed at encouraging the development of wind power in a manner that ameliorates, to the extent practicable, the adverse effects on migratory birds. Further, the Petition examines in detail the several benefits of the proposed permitting system. Finally, ABC offers specific regulatory language that would accomplish the objectives identified in this Petition.

A. PETITIONER: AMERICAN BIRD CONSERVANCY

This Petition for Rulemaking is submitted on behalf of ABC by Meyer Glitzenstein & Crystal, a Washington D.C.-based public interest law firm specializing in environmental and wildlife laws.[1]

Petitioner ABC is a 501(c)(3) non-profit organization whose mission is to conserve native birds and their habitats throughout the Americas. It achieves this by safeguarding the rarest bird species, restoring habitats, and reducing threats to bird species. ABC is the only U.S.-based group with a major focus on bird habitat conservation throughout the entire Americas. ABC has more than 8,000 individual members and 30,000 constituents. ABC's members, supporters, and activists enjoy viewing, studying, and photographing migratory birds. Some of its members and activists routinely observe migratory birds in states such as California, New York, Texas, Pennsylvania, Washington and Oregon, where rapid wind energy development poses a serious threat to such birds.

ABC is a leading organization working to reduce threats to birds from habitat destruction; from collisions with buildings, towers, and wind turbines; and from toxins such as hazardous pesticides and lead. ABC uses a variety of mechanisms to achieve these objectives including scientific research and analysis; advocating for bird conservation at the local, state, regional, and federal levels; forming bird conservation partnerships; and pressing for meaningful regulatory changes to address such threats effectively through various means, including rulemaking petitions and litigation. See, e.g., ABC v Fed. Commc'ns Comm'n, 516 F.3d 1027 (D.C. Cir. 2008) (in response to ABC's review petition seeking protection of migratory birds from collisions with communications towers, the court vacated a part of the order for violation of the National Environmental Policy Act ("NEPA"), 42 U.S.C. § 4321 et seq.). ABC's staff includes more than 20 scientists with expertise in migratory birds, over a dozen of whom have doctoral degrees. ABC's scientists have published in many reputed journals.[2]

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[1] More information about Meyer Glitzenstein & Crystal is available at http://www.meyerglitz.com/.

[2] These journals include the Antarctic Journal of the United States, The Auk, Biodiversity Conservation, Biological Invasions, Biological Sciences, Bird Conservation International, Boletin SAO, Canadian Field Naturalist, Chelonion Research Monographs, Colonial Waterbirds, Condor, Cotinga, Ecological Applications, Ecology, Emu, Florida Field Naturalist, International Zoo Yearbook, Journal of Avian Medicine and Surgery, Journal of Field Ornithology, Journal of Raptor Research, Journal of Wildlife Diseases, Journal of Wildlife Management, Molecular Ecology, Neotropical Birding, North American Bird Bander, Oecologia, Ornitologiá Columbiana, Ornitologiá Neotropical, Oryx, Pacific Conservation Biology, Proceedings of the National Academy of Science, Proceedings of the Western Foundation of Vertebrate Zoology, Wilson Bulletin, Wilson Journal of Ornithology, and Zoo Biology.

ABC launched its "Bird-Smart Wind Program" to address the threats to birds and their habitats from wind energy development. ABC's Wind Program works to eliminate threats to birds and conserve habitat through the implementation of "Bird-Smart Wind Principles."[3] These Principles recognize that "bird-smart" wind energy is an important part of the solution to climate change. Bird-smart wind energy employs careful siting, operation, construction, mitigation, bird monitoring, and compensation criteria, designed to reduce and redress any unavoidable bird mortality and habitat loss. A key element of ABC's Bird-Smart Wind Principles is to work with FWS to establish appropriate mandatory federal standards for the siting, construction and operation of wind facilities. Thus, ABC believes that birds and wind power can co-exist, and that wind power can be "bird-smart," <u>if the wind industry is held to mandatory standards</u> that protect birds. More than 60 conservation groups, scientific societies, and businesses have endorsed ABC's Bird-Smart Wind Principles.[4]

ABC's experts have been extensively involved in studying and analyzing the impacts of wind energy, and its involvement in this issue predates the formation of the Wind Turbines Guidelines Federal Advisory Committee ("Wind FAC" or "Committee") established by DOI in 2007. For example, in 2005 ABC submitted comments on the Interim Guidance on Avoiding and Minimizing Impacts from Wind Energy prepared by FWS. In 2007, ABC's former Director of Conservation Advocacy, Dr. Michael Fry, testified before a Congressional subcommittee on the wildlife impacts of improperly sited wind energy projects.

Most recently, ABC has been actively involved in analyzing the ongoing preparation by FWS of voluntary guidelines for land-based wind energy projects. In this regard, ABC has attended every Wind FAC meeting, and has commented on each draft of the guidelines and the Wind FAC's recommendations.[5] ABC has also submitted comments during federal regulatory processes applicable to wind energy projects, including the FWS Draft Eagle Conservation Plan Guidance, the Great Plains Wind Energy Habitat Conservation Plan (scoping), the Desert Renewable Energy Conservation Plan (scoping), and the Mid-Atlantic Regional Environmental Assessment for Wind Leasing Areas (Delaware, Maryland, New Jersey, Virginia). ABC has also commented on

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[3] ABC's "Bird-smart Wind Principles" are available at http://www.abcbirds.org/abcprograms/policy/collisions/wind_policy.html

[4] A list of these organizations is available at http://www.abcbirds.org/abcprograms/policy/collisions/wind_letters.html

[5] ABC's comments on all iterations of the Wind Guidelines and the Eagle Guidance are available here: http://www.abcbirds.org/abcprograms/policy/collisions/wind_letters.html

individual wind projects, such as Kaheawa Wind II (Maui), Kawailoa Wind (Oahu), and Baryonyx (offshore Texas).[6]

ABC submits this Petition for Rulemaking to FWS pursuant to the APA, 5 U.S.C. § 553(e), and implementing regulations of the DOI, 43 C.F.R. Pt. 14, requesting the agency to expeditiously promulgate regulations establishing a permitting scheme for proper siting, construction, and operation of wind energy projects to reduce and redress bird mortality and habitat loss. Pursuant to 43 C.F.R. § 14.2, this Petition for Rulemaking provides the text of the proposed rule as well as detailed reasons in support of the Petition. ABC requests that the Petition be given prompt consideration as required by applicable regulations. 43 C.F.R. § 14.3. As an initial step, ABC requests that notice of this Petition be published in the Federal Register for public comment. 43 C.F.R. § 14.4.

B. SPECIES INFORMATION

Migratory birds protected under the MBTA, 16 U.S.C. § 703 et seq., are facing serious threats and many are in rapid decline. About 30% of the birds protected by the MBTA are officially recognized by FWS as being in need of particular protection, including approximately 75 endangered and threatened species, and more than 240 species that are listed by FWS as Birds of Conservation Concern ("BCC"). See FWS, Birds of Conservation Concern (2008);[7] see also FWS, Summary of Listed Species Listed Populations and Recovery Plans (Nov. 21, 2011).[8] FWS is statutorily required to designate and maintain the BCC list pursuant to a 1998 amendment to the Fish and Wildlife Conservation Act of 1980, 16 U.S.C. § 2901 et seq., which requires the agency to "identify species, subspecies, and populations of all migratory nongame birds that, without additional conservation actions, are likely to become candidates for listing under the Endangered Species Act of 1973." Id. § 2912(a)(3). Only a handful of birds designated as BCC are not protected by the MBTA. Thus, nearly 1/3 of the birds protected by the MBTA are either listed under the ESA, 16 U.S.C. § 1531 et seq., or designated as in danger of being listed if action to prevent listing is not taken.

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[6] ABC's comment letters are available here: http://www.abcbirds.org/abcprograms/policy/collisions/wind_letters.html

[7] Available at http://www.fws.gov/migratorybirds/NewReportsPublications/SpecialTopics/BCC2008/BCC2008.pdf. (last visited Nov. 20, 2011).

[8] Available at http://ecos.fws.gov/tess_public/pub/boxScore.jsp. (last visited Nov. 20, 2011).

Further, some common migratory birds that have not been officially designated as being of conservation concern are experiencing sharp population declines. According to the National Audubon Society, "[s]ince 1967 the average population of the common birds in steepest decline has fallen by 68 percent; some individual species nose-dived as much as 80 percent. All 20 birds on the national Common Birds in Decline list lost at least half their populations in just four decades." Nat'l Audubon Soc'y, Common Birds in Decline.[9] These declines indicate that birds in the United States are facing serious threats and potential extinction. For example, the fate of the Passenger Pigeon – once the most abundant bird in North America, with a population estimated in the billions, which was driven to extinction in fewer than 100 years – illustrates that even common birds can become extinct. T. D. Rich et al., Partners in Flight North American Landbird Conservation Plan: Part 1 The Continental Plan 4 (2004) ("N.A. Landbird Conservation Plan Part 1").[10]

Migratory birds face many threats including habitat loss, degradation and fragmentation; excessive logging and inappropriately managed forests; inappropriately or inadequately managed fires; hydrologic change to wetlands; exotic and invasive species; resource extraction and energy industry operations; overgrazing; climate change; contaminants and pesticides; prey resource depredation; human disturbance; long line and gill net fisheries; collisions with human-created structures; and intentional illegal killing. T. D. Rich et al., Partners in Flight North American Landbird Conservation Plan: Part 2 Conservation Issues 39 (2004) ("N.A. Landbird Conservation Plan Part 2");[11] see also Stephen Brown et al., United States Shorebird Conservation Plan 5 (2001) ("2001 U.S. Shorebird Conservation Plan");[12] Waterbird Conservation for the Americas, Waterbirds at Risk (Mar. 20, 2007).[13] Because there are serious threats to birds and such threats cumulatively pose even larger risks to their survival and conservation, it is important that action be taken to reduce each one.

ABC believes that threats to birds from wind energy development pose particular concern, especially because the industry is growing rapidly and projects are being frequently sited in important bird habitats. Wind energy is also recognized as a serious bird conservation issue in the North American Landbird Conservation Plan, which is an important conservation plan that has wide support throughout the bird conservation community. N.A. Landbird Conservation Plan Part 2 at 39,

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9 Available at http://web4.audubon.org/bird/stateofthebirds/cbid/ (last visited Nov. 20, 2011).

10 Available at http://www.pwrc.usgs.gov/pif/cont_plan/PIF2_Part1WEB.pdf (last visited Nov. 25, 2011).

11 Available at http://www.pwrc.usgs.gov/pif/cont_plan/PIF3_Part2WEB.pdf (last visited Nov. 20, 2011).

12 Available at http://www.fws.gov/shorebirdplan/USShorebird/PlanDocuments.htm (last visited Nov. 20, 2011).

13 Available at http://www.waterbirdconservation.org/atrisk.html (last visited Nov. 20, 2011).

62. The plan was created by Partners in Flight, an international coalition of government agencies (including FWS), conservation groups, and scientific researchers. It identifies two types of native birds that are of high conservation importance, "those that show some combination of population declines, small ranges, or distinct threats to habitat, and those that are restricted to distinct geographical areas, but otherwise not currently at risk." N.A. Landbird Conservation Plan Part 1 at 5. Inclusion of the impacts of wind energy as a conservation issue in the plan indicates that there is widespread recognition among major bird conservation groups, government agencies, and scientists of the grave threats posed by wind energy projects to migratory birds. In addition, wind energy is described as a form of energy development that can have significant negative impacts on birds in the 2009 State of the Birds report, which is a document collectively drafted by government agencies (including FWS), bird conservation coalitions, conservation groups, and scientific researchers. N. Am. Bird Conservation Initiative, U.S. Comm., The State of the Birds, United States of America (2009) 9, 30, 31 ("2009 State of the Birds Report").[14]

Set out below is a brief discussion of certain bird species that are facing risks from wind energy development. The list of birds discussed below is merely illustrative and not a complete or exhaustive listing of birds that ABC believes are at serious risk due to wind energy development.[15]

Hawaiian birds

Hawaiian birds face special risks from wind energy. Unfortunately, Hawaii is now cited as "the bird extinction capital of the world," where more bird species are vulnerable to extinction than anywhere else in the world. 2009 State of the Birds Report at 26. Almost any imaginable site for a wind energy project in Hawaii has the potential to impact federally listed threatened and endangered species, as well as other birds of conservation concern. The state has adopted an aggressive mandate to produce 40% of its electricity from renewable energy by 2030, and consequently several wind energy projects are being developed at sites that seriously impact species of conservation concern. See Am. Wind Energy Ass'n ("AWEA"), Wind Energy Facts: Hawaii (Aug. 2011).[16]

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[14] Available at http://www.stateofthebirds.org/2009/pdf_files/State_of_the_Birds_2009.pdf (last visited Nov. 25, 2011).

[15] It is pertinent to note that some of the birds discussed in this Section are also listed by the American Wind Wildlife Institute ("AWWI") (which includes wind industry members) as potentially being adversely impacted by wind energy development. AWWI, Wind and Wildlife Landscape Assessment Tool: Wind and Wildife Species List (2011), http://wind.tnc.org/awwi/#app=515d&7843-selectedIndex=0&fefa-selectedIndex=3 (last visited Dec. 7, 2011). This list includes many, but not all, of the birds ABC has identified as being at special risk from wind energy development (for example, the AWWI list is mainland focused and thus misses many Hawaiian birds. Another species not identified by AWWI's list is the Ferruginous Hawk, which has demonstrated mortality at U.S. wind projects.).

[16] Available at http://www.awea.org/learnabout/publications/upload/Hawaii.pdf (last visited Nov. 20, 2011).

Bird species of conservation concern that have already been killed at one Hawaiian wind project include the Hawaiian Goose (federally endangered, Red WatchList), Hawaiian Petrel (federally endangered, Red WatchList) and (Hawaiian) Short-eared Owl (BCC, Yellow WatchList).[17] See Kaheawa Wind Power II, LLC, Kaheawa Wind Power II Draft Habitat Conservation Plan 52 (2010).[18] Other imperiled birds present in Hawaii where wind energy development and its associated infrastructure currently exist, or are in the process of development, include the Newell's Shearwater (federally threatened, Red WatchList), Hawaiian Common Moorhen (federally endangered), Hawaiian Coot (federally endangered, Red WatchList), Hawaiian Duck (federally endangered, Red WatchList), Hawaiian Hawk (federally endangered, Red WatchList), Hawaiian Stilt (federally endangered), Band-rumped Storm-Petrel (BCC, Red WatchList), and Pacific Golden-Plover (U.S. Shorebird Conservation Plan, high concern).[19] See 2001 U.S. Shorebird Conservation Plan at 57.[20] Also of concern are MBTA-protected birds that have not yet been listed as endangered or threatened, such as frigatebirds, shearwaters, boobies, terns, noddies, and albatrosses.

Although in recent years certain wind energy developers have applied under the ESA for incidental take permits ("ITPs") for federally listed birds at proposed Hawaiian wind projects, see 16 U.S.C. § 1539 (authorizing FWS to issue ITPs allowing limited take of endangered and threatened species if prescribed criteria are satisfied), such applications have not been filed by all developers and some existing projects that may impact federally listed birds continue to operate without an ITP.

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[17] The United States WatchList, a joint project between ABC and the National Audubon Society, reflects a comprehensive scientific survey and study of all the bird species in the United States. It identifies those bird species in greatest need of immediate conservation attention. Red WatchList species are those of greatest conservation concern. Yellow WatchList species are still of concern but not to as extreme a degree as Red WatchList species.

[18] Available at http://www.fws.gov/pacificislands/Publications/DRAFT%20KWP%20II%20HCP.pdf (last visited Nov. 27, 2011).

[19] As of November 17, 2011, draft or final incidental take permits issued under the ESA have already been prepared for various federally listed species, including, Hawaiian Common Moorhen, Hawaiian Coot, Hawaiian Duck, Hawaiian Goose, Hawaiian Petrel, Hawaiian Stilt, and Newell's Shearwater.

[20] The U.S. Shorebird Conservation Plan is a partnership effort of state and federal agencies (including FWS), non-governmental conservation organizations, academic institutions, and individuals from across the country committed to restoring and maintaining stable and self-sustaining populations of shorebirds in the United States and throughout the Western Hemisphere. The plan provides a scientific framework to determine species, sites, and habitats that most urgently need conservation action. Available at http://www.fws.gov/shorebirdplan/USShorebird/downloads/USShorebirdPlan2Ed.pdf (last visited Nov. 27, 2011).

Further, such ITPs do not apply to BCC species (which by definition are not federally listed under the ESA), unless the developer agrees to include them in a Habitat Conservation Plan ("HCP").[21]

Grassland birds

The birds of America's grasslands are also in trouble, and unless properly regulated, wind energy development will add to the impacts that are already causing these birds' numbers to dwindle. "Grassland birds are among the fastest and most consistently declining birds in North America." 2009 State of the Birds Report at 4. Of the 46 grassland-breeding bird species, 48% are of particular conservation concern and 55% are declining significantly. Four are already federally listed as endangered. Id. at 8. MBTA-protected birds such as the Mountain Plover (BCC, Red WatchList), Sprague's Pipit (federal listing candidate, Yellow WatchList), Lark Bunting (BCC, Yellow WatchList), Baird's Sparrow (BCC, Red WatchList), Chestnut-collared Longspur (BCC, Yellow WatchList), and McCown's Longspur (BCC) show steep population declines of 68–91%. Id. at 8.

All the above-mentioned birds (except the Baird's Sparrow) engage in aerial displays – a behavior that makes them more vulnerable to turbine strikes. During aerial displays, males may not be paying attention fully to the structures around them. Grassland birds that engage in aerial displays during courtship, such as the Long-billed Curlew, Upland Sandpiper, Vesper Sparrow, Horned Lark, Chestnut-collared Longspur, and McCown's Longspur, have a greater risk of colliding with wind turbine rotor blades that occur within a male's territory. See Wyo. Game and Fish Dep't, Wildlife Protection Recommendations for Wind Energy Development in Wyoming 5 (Apr. 23, 2010).[22] Thus, birds that engage in aerial displays face a greater threat from wind energy turbines as they are particularly prone to collisions. Other grassland species of conservation concern that are especially vulnerable to harm from wind energy development include the Long-billed Curlew (BCC, Yellow WatchList), Grasshopper Sparrow, and Lesser Prairie-Chicken (federal listing candidate, BCC, Red WatchList).

Sprague's Pipit is protected under the MBTA and is an ESA candidate species. It is also a BCC species and on the Yellow WatchList. The species is typically found in open plains, especially shortgrass prairies. Sprague's Pipit is one of the few species endemic to the North American

[21] For example, the Hawaiian Short-eared Owl, which is not ESA-listed, will receive some protection under the proposed HCP for the Kaheawa Wind II facility. This happened because a conservation group worked to have protections for the species included in the HCP. Thus, it should not be assumed that all BCC species will be covered by HCPs for federally listed species at Hawaiian wind projects.

[22] Available at http://gf.state.wy.us/downloads/pdf/April%2023%202010%20Commission%20Approved%20Wind%20Recommendations.pdf (last visited Nov. 26, 2011).

grasslands. Like many grassland species, Sprague's Pipits are semi-nomadic, seeking suitable grassland conditions within their range for nesting in any particular year. They are associated with unbroken tracts of native grassland. In addition to the potential of losing additional habitat to wind energy development, Sprague's Pipit faces extra risk of being killed by collision with wind turbines because its behavior includes the longest periods of aerial display of any passerine species, and its display heights place the Pipit within the rotor-swept zone of modern wind turbines. Aerial displays lasting as long as three hours at display heights of 50 meters to over 100 meters above the ground have been documented. Mark B. Robbins, Display Behavior of Male Sprague's Pipits, 110 Wilson Bull. of Ornithology 435-438, 435 (1998).[23] The Government of Alberta identifies Sprague's Pipit as a species with potential for collisions with wind turbines due to its aerial display behavior. Gov't of Alta., Wildlife Guidelines for Wind Energy Projects 3 (Sept. 19, 2011) ("Alberta Wildlife Guidelines").[24] In addition, wind farms can cause Sprague's Pipits, like other grassland birds, to abandon otherwise suitable habitats. There is no reliable population estimate for Sprague's Pipit – according to the FWS Sprague's Pipit Conservation Plan, the global species population has been estimated at 870,000, but the plan also cautions that that number relies on standard assumptions and calculations that are "unverified with the existing data." FWS, Sprague's Pipit (Anthus spragueii) Conservation Plan 15 (2010).[25] The plan describes the estimate as a "rough" estimate with "unknown, but potentially large, error." Id.

Chestnut-collared Longspur is a shortgrass prairie species that is protected under the MBTA and has also been designated by FWS as a BCC species. It is on the Yellow WatchList. "The primary factor suspected to be limiting nesting populations of this species is the availability of native grasslands as they will not nest in croplands. Conversion of native grasslands to croplands and habitat loss to urbanization and industrialization have caused a contraction in this species' breeding range and range wide population declines." Wyo. Game and Fish Dep't, Chestnut-Collared Longspur 1 (2010).[26] In addition, "[w]ind power development in nesting areas can be problematic due to the courtship displays this species exhibits during the breeding season." Id. at 20. The 2004 N.A. Landbird Conservation Plan estimated the U.S and Canadian population of the Chestnut-collared Longspur at 5,600,000. N.A. Landbird Conservation Plan Part 1 at 21.

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[23] Available at http://elibrary.unm.edu/sora/Wilson/v110n03/p0435-p0438.pdf (last visited Nov. 20, 2011).

[24] Available at http://srd.alberta.ca/FishWildlife/WildlifeLandUseGuidelines/documents/WildlifeGuidelines-AlbertaWindEnergyProjects-Sep19-2011.pdf (last visited Nov. 20, 2011).

[25] Available at http://www.fws.gov/mountain-prairie/species/birds/spraguespipit/SpraguesJS2010r4.pdf. (last visited Nov. 20, 2011).

[26] Available at http://gf.state.wy.us/downloads/pdf/swap/birds/ChestnutcollarLongspur.pdf (last visited Nov. 20, 2011).

McCown's Longspur is a rare grassland bird which is protected under the MBTA and is also on the FWS BCC list. This species has suffered dramatic declines in the northern part of its range. Habitat loss and fragmentation due to loss of native prairie and conversion to agriculture are major threats to McCown's Longspur. If the ongoing population declines continue, McCown's Longspur could be petitioned for listing as a federally endangered species. The species engages in aerial display, putting the birds at heightened risk of collision with wind turbines. In addition, wind energy development in the plains will likely further decrease habitat availability for McCown's Longspur, potentially accelerating the population decline. The 2004 North American Landbird Conservation Plan estimated the U.S and Canadian population of the Chestnut-collared Longspur at 1,100,000. U.S. Landbird Conservation Plan Part 1 at 19.

The Long-billed Curlew is the largest North American shorebird. It is protected under the MBTA and is also listed as a FWS BCC species, a Species of Special Concern in Canada, and Highly Imperiled in both the U.S. and Canadian shorebird conservation plans. Additionally, it is listed on the Yellow WatchList. Its population has been estimated at only 20,000 birds. 2001 U.S. Shorebird Conservation Plan at 52. As the FWS Status Assessment and Conservation Action Plan for the Long-billed Curlew explains, "[t]he high levels of concern are due to the loss of the eastern third of their historical breeding range and apparent population declines, particularly in the shortgrass and mixed-grass prairies of the western Great Plains." FWS, Status Assessment and Conservation Action Plan for the Long-Billed Curlew (Numenius americanus) vii (2009).[27] The Conservation Plan further states that Long-billed Curlews are vulnerable to direct mortality due to strikes from wind power rotor blades, increased predation associated with additional wind farm structures and incursion into grasslands, disruption of aerial breeding displays, disturbance caused by increased human activity during both the development stage and during general maintenance of the wind farm, and habitat fragmentation. Id. at 12. The Long-billed Curlew relies primarily on native grasslands for nesting and overwintering. The conversion of these grasslands to agriculture is the primary ongoing threat to the species, and wind energy development will likely further decrease habitat availability. Long-billed Curlews also spend much time in flight defending their territories, thereby increasing their risk of colliding with wind turbines. The Government of Alberta identifies the Long-billed Curlew as a species with heightened potential for collisions with wind turbines due to its aerial display. Alberta Wildlife Guidelines at 3. A Long-billed Curlew fatality attributed to wind energy development has been recorded in the Pacific Northwest. See Gregory D. Johnson & Wallace P. Erickson, Avian, Bat And Habitat Cumulative Impacts Associated with Wind Energy Development in the Columbia Plateau Ecoregion of Eastern Washington and Oregon 12 (2010).[28]

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[27] Available at http://library.fws.gov/BTP/long-billedcurlew.pdf (last visited Nov. 20, 2011).

[28] The wind facility where the Long-billed Curlew was killed is not identified in the report. Nor did the report indicate whether the mortality searches took place during the times of Long-billed Curlew courtship, when the risk of turbine collision would be highest. Available at

Some grassland species may avoid areas with wind turbines, leading to reduced densities of birds in locations of highest quality habitat and with potentially adverse long-term impacts. Research to determine which grassland bird species are most susceptible to displacement from wind power development is still in its early stages. However, preliminary research by the U.S. Geological Survey has already demonstrated that displacement occurs with Grasshopper Sparrows and Clay-colored Sparrows, which are both listed as BCC species. See Partners in Flight, Landbird Population Estimates Database (2004) ("2004 PIF Population Estimates Database").[29] The North American Grasshopper Sparrow population is estimated at 14,000,000 and the North American Clay-colored Sparrow population is estimated at 23,000,000. Density of these birds decreased near wind turbines at study sites in Minnesota, North Dakota, and South Dakota. Jill A. Shaffer & Douglas H. Johnson, Displacement Effects of Wind Developments on Grassland Birds in the Northern Great Plains 51 (2010).[30] Some grassland birds have also been found to avoid important habitats near wind turbines and roads at other locations in Minnesota, Oregon, and Washington. Wallace Erickson et al., Protocol for Investigating Displacement Effects of Wind Facilities on Grassland Songbirds 2-3 (2007).[31]

Sagebrush-dependent songbirds

In addition to grassland songbirds, sagebrush-dependent songbirds also face threats from wind energy development in their habitat. One species known to have experienced mortality at U.S. wind energy facilities is the Brewer's Sparrow. Although no comprehensive study of Brewer's Sparrow mortality at wind energy facilities has been conducted, Brewer's Sparrow fatalities have been documented in Washington and Wyoming at the Tuolumne Wind and Foote Creek Rim facilities.[32] Brewer's Sparrow is a FWS BCC species and on the Yellow WatchList. Brewer's Sparrow breeds in sagebrush across the western United States and adjacent southern Canada, wintering from the southwestern United States to central Mexico. Threats it faces include

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http://www.whitmancounty.org/download/App%20F%20CPE%20Cumulative%20Impacts%20Report.pdf (last visited Nov. 26, 2011).

[29] Available at http://rmbo.org/pif_db/laped/ (last visited Nov. 20, 2011).

[30] Available at https://www.nationalwind.org/assets/research_meetings/Research_Meeting_VII_Shaffer.pdf. (last visited Nov. 20, 2011).

[31] Available at http://digitalcommons.unl.edu/usgsnpwrc/131/ (last visited Nov. 20, 2011).

[32] See, e.g., Tamara Enz & Kimberly Bay, Post-Construction Avian and Bat Fatality Monitoring Study, Tuolumne Wind Project, Klickitat County, Washington, Final Report, April 20, 2009 to April 7, 2010 19 (July 6, 2010), Attachment B; see also West, Inc., Avian and Bat Mortality Associated with the Initial Phase of the Foote Creek Rim Windpower Project, Carbon County, Wyoming November 1998 - June 2002 8 (Jan. 10, 2003), http://west-inc.com/reports/fcr_final_mortality.pdf (last visited Dec. 9, 2011).

destruction and fragmentation of sagebrush caused by agricultural expansion, over-grazing, altered fire regimes, invasive plants, and energy development. Daniel J. Lebbin et al., ABC, The North American Bird Conservancy Guide to Bird Conservation 108 (2010) ("ABC Guide to Bird Conservation "), Attachment A. Brewer's Sparrow population was estimated in 2004 at 16,000,000. The Landbird Conservation Plan recommends that the Brewer's Sparrow population be increased by 100% in order to protect the species. N.A. Landbird Conservation Plan Part 1 at 19.

Raptors

Many raptors are known to have been killed at U.S. wind energy facilities, with several on both the FWS BCC list and the U.S. WatchList. They include Swainson's Hawk (BCC, Yellow WatchList), American Peregrine Falcon (BCC), Ferruginous Hawk (BCC), Short-eared Owl (BCC, Yellow WatchList), Flammulated Owl (BCC, Yellow WatchList), Golden Eagle (BCC), and Bald Eagle (BCC).[33]

Swainson's Hawks breed in open grassland, shrub-land and agricultural land from Alaska through the Canadian prairies, then south through the western United States to northern Mexico. The California population has declined by 90%, and declines have been observed in Canada, but populations are believed to be stable elsewhere. See ABC Guide to Bird Conservation at 44, Attachment A. In 2004, the U.S. and Canadian population of the Swainson's Hawk was estimated at 460,000. N.A. Landbird Conservation Plan Part I at 18. Swainson's Hawks migrate in flocks through Central America to winter in the grasslands of Argentina, and this migration places the species at special additional risk of collision with wind turbines. More than 90% of the global population of Swainson's Hawk passes through the south of the Isthmus of Tehuantepec, where wind energy is being developed rapidly. According to Friends of the Swainson's Hawk, a California conservation group, 5,000 wind turbines are planned in the Isthmus of Tehuantepec. See Friends of the Swainson's Hawk, Energy Projects Challenge Wildlife and Habitat.[34] These proposed Mexican projects will add to the cumulative effects of wind energy development in the United States that Swainson's Hawks face.

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[33] Examples of wind energy facilities and regions where these raptors are known to have been killed include Shiloh I Wind, CA (Swainson's Hawk); Tehachapi Pass Wind Resource Area, CA (Flammulated Owl); Jersey-Atlantic Wind Farm, NJ (Peregrine Falcon); Stateline Wind Energy Center, OR-WA (Swainson's Hawk); Juniper Canyon Wind, WA (Ferruginous Hawk); Nine Canyon Wind, WA (Short-eared Owl); Big Horn Wind, WA (Short-eared Owl, Ferruginous Hawk); Harvest Wind, WA (Swainson's Hawk); and Foote Creek Rim Wind, WY (Short-Eared Owl). It should be noted that these examples are a fragmentary sampling of actual mortality, not a full accounting. Mortality data is not collected at all U.S. wind energy facilities, and even when data is collected, it is not collected during all operating hours, nor is it usually collected for all wind turbines in a facility. In addition, mortality data is very often not made publicly available.

[34] Available at http://www.swainsonshawk.org/story2.html (last visited Nov. 27, 2011).

The American Peregrine Falcon was removed from the federal endangered species list in 1999 but will continue to be monitored by FWS through 2015. See FWS, Proposed Information Collection; Monitoring Recovered Species After Delisting-American Peregrine Falcon, 76 Fed. Reg. 17147, 17148 (Mar. 28, 2011). Peregrine Falcons are most associated with mountain ranges, river valleys, and coastlines. FWS estimated their population in 2003 at 3,000 breeding pairs in Mexico, the United States, and Canada. Although the species has made a remarkable recovery, the pesticide best known for the falcon's decline, DDT, is still found in some parts of its environment within and outside the United States. See FWS, Peregrine Falcon (Falco peregrinus) Fact sheet (2006).[35] Wind energy development in Peregrine Falcon habitat adds to the cumulative impacts the species faces.

Another species potentially at risk from wind energy development is the Ferruginous Hawk, designated by FWS as a BCC species. The Ferruginous Hawk is the largest hawk in North America, inhabiting arid and open grassland, shrub steppe, and desert in the United States, Canada, and Mexico. It was petitioned for but denied endangered species status in the early 1990s. The 2004 estimate of the Ferruginous Hawk population was only 20,000. 2004 PIF Population Estimates Database. Ferruginous Hawks are known to have been killed at U.S. wind energy facilities in the West, for instance at the Big Horn Wind Energy Project in Washington. See, e.g., K. Shawn Smallwood, Avian and Bat Mortality at the Big Horn Wind Energy Project, Klickitat County, Washington 6 (Oct. 18, 2008).[36] Risk to Ferruginous Hawks from wind energy development has been acknowledged by FWS itself. See Patricia Y. Sweanor, FWS, Best Management Practices for Wind Energy in Areas with Golden Eagles (Aquila chrysaetos) in Wyoming 58 (abstract of paper submitted at the 2010 Raptor Research Foundation Conference).[37]

The Short-eared Owl nests in open habitats (tundra, grasslands, marshes, agricultural lands, and coastal dunes) throughout Eurasia and North America, with a Hawaiian subspecies that is also known to have been killed at a wind energy facility. In addition to the threat of collision with wind turbines and habitat loss and fragmentation posed by wind energy development, the Short-eared Owl also is threatened by loss and fragmentation of grassland, marsh, and coastal habitats due to agriculture, over-grazing and urban and coastal development, as well as invasive predators, potentially West Nile Virus, and pesticides. See ABC Guide to Bird Conservation at 74, Attachment A. In 2004, the U.S. and Canadian population of Short-eared Owls was estimated at 710,000. N.A. Landbird Conservation Plan Part 1 at 18.

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[35] Available at http://library.fws.gov/ES/peregrine06.pdf (last visited Nov. 27, 2011).

[36] Available at http://www.efsec.wa.gov/Whistling%20Ridge/Adjudication/Intervenor's%20pre-filed%20testimony/Ex%2022.03.pdf (last visited Dec. 12, 2011).

[37] Available at http://www.rmrp.info/pdf/2010_printed_program-9_091210_LAK.pdf (last visited Nov. 20, 2011).

The Flammulated Owl nests in cavities of dead and dying trees in open, montane ponderosa pine forest and is patchily distributed from southern British Columbia through the western United States to central Mexico. In addition to the threat of collision with wind turbines and habitat loss and degradation posed by wind energy development, the Flammulated Owl is threatened by degradation and loss of habitat, reduction of cavities available for nesting due to cutting of dead trees, declines in populations of woodpeckers that create the cavities in which the owls nest, and reductions in insect prey due to pesticide use in forests. Its global population is estimated at only 37,000. See ABC Guide to Bird Conservation at 73, Attachment A. In 2004, the Flammulated Owl population was estimated at only 29,000 in the United States and Canada. See N.A. Landbird Conservation Plan Part 1 at 19.

The American birds most emblematic of the need to properly regulate the wildlife impacts of wind energy are probably the Golden Eagle and Bald Eagle, both of which are protected under the MBTA. The Golden Eagle is a FWS BCC species; its population is difficult to state with certainty due to limited data. In 2011, FWS estimated the Golden Eagle population at perhaps only 30,000 in the United States. See FWS, Golden Eagles Status Fact Sheet (2011).[38] The 2004 Partners in Flight estimate of Golden Eagle population in North America was 80,000. 2004 PIF Population Estimates Database. Golden Eagles occur across much of the United States, utilizing habitats that include tundra, grasslands, forested habitat, woodlands, brush lands, and deserts. This broad range of habitats exposes Golden Eagles to a multitude of threats such as habitat loss, electrocution by and collision with energy infrastructure (including power lines and wind turbines), lead and rodenticide poisoning, human disturbance, climate change, disease, stock tank drowning, vehicle collisions, and illegal intentional killing. FWS, Minutes and Notes from the North American Golden Eagle Science Meeting (Sept. 21, 2010).[39] Scientific experts have ranked wind energy as the third greatest direct mortality threat to Golden Eagles (behind electric infrastructure, i.e., electrocutions from and collisions with power lines, which will also be expected from wind power expansion, and lead poisoning). Id. at 22.

The risk that wind power facilities pose to Golden Eagles has been known for some time due to the well-documented fatalities at Altamont Pass in California, where a 2010 study estimated that 55-94 Golden Eagles annually were killed by wind turbines since 1998. K. Shawn Smallwood, Fatality Rates in the Altamont Pass Wind Resource Area 1998-2009 (2010) at 25.[40] In fact,

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[38] Available at http://www.fws.gov/habitatconservation/Golden_Eagle_Status_Fact_Sheet.pdf (last visited Nov. 20, 2011).

[39] Available at http://www.dfg.ca.gov/wildlife/nongame/raptors/goldeneagle/docs/NAGoldenEagleScienceMeeting-2010-09-21.pdf (last visited Nov. 20, 2011).

[40] Available at http://altamontsrc.org/alt_doc/p145_smallwood_fatality_monitoring_results_12_31_09.pdf. (last visited Nov. 20, 2011).

Altamont Pass has not only been a death trap for the species, but has also been found to be a population sink, where turbine blade strikes kill more eagles than are produced within the area surveyed, thereby demanding a flow of recruits from outside the area to fill breeding vacancies as they occur. See Grainger Hunt & Teresa Hunt, The Trend of Golden Eagle Territory Occupancy in the Vicinity of the Altamont Pass Wind Resource Area: 2005 Survey 2 (2006).[41]

Further, FWS has been lax in providing information to the public regarding Golden Eagle deaths at wind energy projects through the Freedom of Information Act ("FOIA"), 5 U.S.C. § 552, or other mechanisms.[42] Indeed, the fragmentary picture of Golden Eagle mortality at wind farms that does emerge from the scattered bits of information made public is not encouraging.

For example, in 2011, the Los Angeles Times reported that at least six Golden Eagles had been killed at the Pine Tree wind project in California. Louis Sahagun, Federal Officials Investigate Eagle Deaths At DWP Wind Farm (L.A. Times, Aug. 3, 2011).[43] The Associated Press wrote about the death of a Golden Eagle at the Goodnoe Hills Wind Project in Washington in 2009. Associated Press, Golden Eagle killed by Wash. Wind turbines (Aug. 15, 2009).[44] In addition, Golden Eagle mortality at wind projects in Wyoming also appears serious. See Sophie Osborn, Wyo. Outdoor Council, Wind turbines killing more golden eagles in Wyoming than expected (June 21, 2011) (discussing Golden Eagle mortality at wind projects in Wyoming based on FWS data).[45] According to a FWS staff paper submitted at a 2010 conference of scientific experts specializing in raptor conservation, at one geographic region in Wyoming the mortality rate is one Golden Eagle death per 13 wind turbines per year; at another it is one Golden Eagle death per 39 wind turbines per year. Patricia Y. Sweanor, FWS, Best Management Practices for Wind Energy in Areas with Golden Eagles (Aquila chrysaetos) in Wyoming 58 (abstract of paper submitted at the 2010 Raptor Research Foundation Conference).

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[41] Available at http://www.energy.ca.gov/2006publications/CEC-500-2006-056/CEC-500-2006-056.PDF (last visited Dec. 11, 2011).

[42] It should be noted that information concerning wildlife fatalities, particularly Golden Eagle mortalities, at wind energy facilities is often known to FWS but such information is not easily accessible to the public, in part due to the increasingly long time that it takes the agency to respond to FOIA requests for wind project mortality data, typically extending well beyond the statutorily prescribed durations. For example, as of the beginning of December 2011, ABC is still waiting for FWS to send complete wind farm mortality data in response to a FOIA request that was made in April 2011.

[43] Available at http://articles.latimes.com/2011/aug/03/local/la-me-wind-eagles-20110803 (last visited Nov. 16, 2011).

[44] Available at http://www.nwcn.com/archive/62395757.html (last visited Nov. 16, 2011).

[45] Available at http://wyomingoutdoorcouncil.org/blog/2011/06/21/wind-turbines-killing-more-golden-eagles-in-wyoming-than-expected/ (last visited Nov. 16, 2011).

This means there are likely to be equivalents of the Pine Tree facility, or possibly worse, in Wyoming, where FWS staff has stated approximately 1,000 wind turbines were operating by September 2010 and another 1,000 are expected to be constructed in the following two years. Id. Unless steps are taken to better address these impacts – such as those proposed in this Petition – the number of Golden Eagles killed at wind power facilities will become even worse over time and will likely result in efforts to list the species as endangered or threatened under the ESA.

The Bald Eagle is another iconic American bird species that illustrates the need for effective regulation of wildlife impacts to wind energy. The FWS National Bald Eagle Management Guidelines state that there are breeding populations of Bald Eagles in each of the lower 48 states. The Guidelines also assert that, "[t]he largest North American breeding populations are in Alaska and Canada, but there are also significant bald eagle populations in Florida, the Pacific Northwest, the Greater Yellowstone area, the Great Lakes states, and the Chesapeake Bay region." FWS, National Bald Eagle Management Guidelines 3 (2007).[46] The Bald Eagle was removed from the endangered species list in 2007, but remains a FWS BCC species, and is undergoing post-delisting monitoring. The 2004 North American Landbird Conservation Plan estimated 330,000 Bald Eagles in the United States and Canada. N.A. Landbird Conservation Plan Part 1 at 20. At delisting, FWS estimated 9,789 Bald Eagle breeding pairs in the lower 48 states. FWS, Endangered and Threatened Wildlife and Plants; Removing the Bald Eagle in the Lower 48 States From the List of Endangered and Threatened Wildlife, 42 Fed. Reg. 37346, 37350 50 CFR Pt. 17 (July 9, 2007). Threats to the Bald Eagle include collisions with power lines, vehicles, and other obstacles; electrocution; disease; lead and pesticide poisoning; and shooting. See FWS, Post-delisting Monitoring Plan for the Bald Eagle (Haliaeetus leucocephalus) in the Contiguous 48 States 18 (2010).[47]

Wind energy development in Bald Eagle habitat is expanding and therefore Bald Eagles will over time have greater potential for collisions with wind turbines. A 2004 Bald Eagle species assessment prepared for the U.S. Bureau of Land Management ("BLM") states, "[i]t is assumed that an increase in the number and type of wind-power turbines will generally increase the number of bald eagle deaths by aerial collisions, especially if such turbines are positioned with little consideration of bald eagle habitat." Amber Travsky & Gary P. Beauvais, Species Assessment for Bald Eagle (Haliaeetus Leucocephalus) in Wyoming (prepared for BLM, 2004) at 25.[48] In fact, Bald Eagle deaths at wind facilities in Wyoming and Ontario, Canada have been reported in scattered

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[46] Available at http://www.fws.gov/pacific/eagle/NationalBaldEagleManagementGuidelines.pdf (last visited Nov. 20, 2011).

[47] Available at http://www.fws.gov/midwest/eagle/protect/FINAL_BEPDM11May2010.pdf (last visited Nov. 20, 2011).

[48] Available at http://www.blm.gov/pgdata/etc/medialib/blm/wy/wildlife/animal-assessmnts.Par.41209.File.dat/BaldEagle.pdf (last visited Dec. 6, 2011).

outlets. DecorahNews.com, Ask Mr. Answer Person about the Luther Wind Turbine (Nov. 16, 2011);[49] see also U.S. Dep't of Energy ("DOE"), South Dakota PrairieWinds Project, Final Environmental Impact Statement 180 (2010).[50]

While publicly reported Bald Eagle mortality at wind projects so far appears low, Bald Eagle mortality is also likely to increase as more wind facilities are built in Bald Eagle habitat, especially if those projects are inappropriately sited. There has been some speculation that Bald Eagles might be more likely than Golden Eagles to avoid wind turbines. Lynn Sharp, Comparison of Pre- and Post-construction Bald Eagle Use at the Pillar Mountain Wind Project, Kodiak, Alaska, Spring 2007 & 2010 66-68 (2010).[51]

Eastern forest and woodland birds

Although raptors such as eagles have been known for some time to be at risk from wind energy development on western ridgelines, as the industry spreads into new habitats the impacts of wind power on new groups of birds, such as Eastern forest and woodland birds, need to be addressed. These include the Bicknell's Thrush, Cerulean Warbler, Bay-breasted Warbler, and Blue-winged Warbler.

The Bicknell's Thrush is a rare forest bird with a fragmented and limited breeding range in montane and maritime forest habitats in the Catskills and Adirondacks of New York and the higher peaks of northern New England and Quebec, New Brunswick, and Nova Scotia. Wind energy has already been developed in Bicknell's Thrush habitat in New Hampshire, was proposed in Bicknell's Thrush habitat in Maine, and more projects are likely in its U.S. range, which could lead to further habitat loss and fragmentation. Bicknell's Thrush is an ESA candidate species, FWS BCC species and on the Red WatchList. The 2004 estimate of the Bicknell's Thrush population was only 40,000 in the United States and Canada; the International Bicknell's Thrush Conservation Group estimated 95,000 to 126,000 globally. U.S. Landbird Conservation Plan Part 1 at 18.

Another eastern forest bird of great concern is the Cerulean Warbler. It is protected under the MBTA, listed as a FWS BCC species and has been petitioned for ESA listing. (The listing petition was rejected in 2006). It is also on the Yellow WatchList, and is a Species of Continental

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[49] Available at http://www.decorahnews.com/news-stories/2011/11/1237.html (last visited Nov. 20, 2011).

[50] Available at http://www.rurdev.usda.gov/SupportDocuments/DOE-EIS-0418_Ch8_Use-Productivity.pdf (last visited Nov. 20, 2011).

[51] Available at http://www.nationalwind.org/assets/research_meetings/Research_Meeting_VIII_Proceedings1.pdf. (last visited Nov. 20, 2011).

Importance in the North American Landbird Conservation Plan. It has had the steepest rate of decline of any North American warbler that is monitored by North American Breeding Bird Surveys; Cerulean Warbler populations have been declining at more than 3% annually for the last 40 years. FWS, A Conservation Action Plan for the Cerulean Warbler (Dendroica cerulea) 3-4 (2007).[52] According to FWS, factors that limit the bird's population are not well understood, "[h]owever, it is widely assumed that loss of habitat quantity and degradation of habitat quality on the non-breeding and breeding habitats are critical factors that have contributed to the observed declines." Id. at 4. The Cerulean Warbler's U.S. breeding habitat is located in mature deciduous forests in the East, much of it in the Appalachian region, where wind power is developing rapidly. Id. at 3. Threats to the species' habitat include mountaintop removal coal mining and unregulated wind energy development. No comprehensive study of Cerulean Warbler mortality at wind facilities has been conducted, but a Cerulean Warbler mortality was reported in a one-year mortality study at a wind project in Tennessee. See J. K. Fiedler et al., Results of Bat and Bird Mortality Monitoring at the Expanded Buffalo Mountain Windfarm, 2005 21 (June 28, 2007), Attachment C.

The Bay-breasted Warbler migrates through the eastern United States and winters in forested habitats and shade coffee plantations in Central and South America; 90% of the population breeds in mature boreal forest in Canada. ABC Guide to Bird Conservation at 102, Attachment A. The Bay-breasted Warbler is a FWS BCC species and on the Yellow WatchList. Its population was estimated at 3,100,000 in 2004. N.A. Landbird Conservation Plan Part 1 at 18. It is threatened by forestry practices that favor young even-aged forests or trees resistant to budworm over older forests, as well as pesticide spraying for budworms, winter habitat loss and collisions during migration. ABC Guide to Bird Conservation supra at 102. No comprehensive study of Bay-breasted Warbler mortality at wind facilities has been conducted, but Bay-breasted Warbler fatalities were reported in 2011 at the NedPower Mt. Storm wind power project in West Virginia. David P. Young, Jr. & Zapata Courage, Avian/Bat Monitoring September 25, 2011 Memo 2 (Sept. 30, 2011), Attachment D.

The Blue-winged Warbler breeds in early successional habitats, ranging from the Midwest, east to New England and the Appalachians, and north to Ontario, Canada. It winters in tropical forests from Mexico to Panama. It is threatened by loss of breeding and wintering habitat; hybridization with Golden-winged Warblers; predation by feral cats; nest parasitism; and collisions with manmade structures. ABC Guide to Bird Conservation supra at 97. The Blue-winged Warbler is a FWS BCC species and on the Yellow WatchList. Its population was estimated in 2004 at 390,000 in the United States and Canada. N.A. Landbird Conservation Plan Part 1 at 19. No comprehensive study of Blue-winged Warbler mortality at wind facilities has been conducted, but Blue-winged Warbler fatality was reported between 2007 and 2009 at an unidentified Pennsylvania

[52] Available at http://www.fws.gov/migratorybirds/CurrentBirdIssues/Management/FocalSpecies/Plans/CeruleanWarbler.pdf (last visited Nov. 20, 2011).

wind energy facility or facilities. Tracey Librandi Mumma & William Capouillez, Pa. Game Comm'n, Wind Energy Voluntary Cooperation Agreement: Second Summary Report 31 (rev. Mar. 16, 2011).[53]

Western forest and woodland birds

The Oak Titmouse nests in oak and pine-oak woodlands from southern Oregon south through California to Baja California, Mexico. It is threatened by loss and degradation of habitat for urban development, pasture, and agriculture, as well as fire suppression, over-grazing, fuel-wood harvesting, and West Nile virus. ABC Guide to Bird Conservation at 89, Attachment A. It is a FWS BCC species and on the Yellow WatchList. Its population was estimated in 2004 at 900,000 in the United States and Canada. N.A. Landbird Conservation Plan Part 1 at 18. No comprehensive study of Oak Titmouse mortality at wind facilities has been conducted, but an Oak Titmouse mortality was reported in 2010 at the Pine Tree wind project in California. BioResource Consultants Inc., 2009/2010 Annual Report Bird and Bat Mortality Monitoring, Pine Tree Wind Farm, Kern County, California 8 (Oct. 14, 2010), Attachment E.

Lewis's Woodpeckers occur locally in the western United States and southern British Columbia, Canada, breeding mainly in open ponderosa pine forests in mountains (especially burned forests), but also using open cottonwoods, aspen and oak woodlands, and pinyon-juniper forest. Northern populations migrate south during winter, sometimes as far as northern Baja California, Mexico. Lewis's Woodpecker is threatened by habitat loss and degradation, over-grazing, and pesticides. ABC Guide to Bird Conservation supra at 78. It is a FWS BCC species and on the Red WatchList (highest concern). Its population was estimated in 2004 at 130,000 in the United States and Canada. No comprehensive study of Lewis's Woodpecker mortality at wind facilities has been conducted, but Lewis's Woodpecker fatality was reported as early as 1999 at the Vansycle Wind, Oregon wind facility. Wallace P. Erickson et al., Avian and Bat Mortality Associated with the Vansycle Wind Project, Umatilla County, Oregon 1999 Study Year 9 (Feb. 7, 2000).[54]

Birds at risk from offshore wind development

With the development of the U.S. offshore wind industry in the oceans and the Great Lakes, additional birds of conservation concern protected under the MBTA are at risk of collision with turbines or displacement from important habitat, such as traditional feeding areas. Because offshore

[53] The Pennsylvania Game Commission publishes wind energy mortality data in summary form, without the exact date or name of facility where it occurred. Available at http://www.scribd.com/doc/52395539/Wind-Energy-Voluntary-Cooperation-Agreement-Second-Summary-Report (last visited Nov. 27, 2011).

[54] Available at http://www.west-inc.com/reports/vansyclereportnet.pdf (last visited Nov. 27, 2011).

wind power is not currently installed in the United States, there is no existing U.S. track record to indicate which species will likely be killed. In addition, knowledge of offshore bird presence and migration routes is not as well developed as for birds onshore, so there may be species at risk from offshore wind development that have not yet been flagged as such.

Government agencies, academics, and conservation groups have already identified a number of birds of conservation concern believed to be at risk from offshore wind development in the United States. A sampling of these species includes federally threatened and endangered species such as the Piping Plover (also Red WatchList), Roseate Tern (also Yellow WatchList), Whooping Crane (also Red WatchList), and Kirtland's Warbler (also Red WatchList); candidate species for ESA listing such as the Red Knot (BCC, Yellow WatchList); and others such as the Black-Capped Petrel (BCC, Yellow WatchList), Wilson's Plover (BCC, Yellow WatchList), Gull-billed Tern (BCC, Yellow WatchList) and Audubon's Shearwater (BCC, Yellow WatchList), and landbirds that can fly through nearshore areas such as Bald and Golden Eagles (both BCC) and Peregrine Falcons (BCC). See, e.g., Doug Forsell, FWS, Waterbirds and Offshore Wind Energy Development, A Biologists [sic] Perspective On Regulation 2 (2010);[55] see also Sarah M. Karpanty, Virginia Tech, Virginia Coastal Energy Research Consortium: Potential Effects of Virginia Offshore Wind Power on Birds 4 (2011) ("Virginia Coastal Energy Research");[56] David N. Ewert et al., The Nature Conservancy, Wind Energy: Great Lakes Regional Guidelines 11 (2011).[57]

Other birds potentially at risk from U.S. offshore wind development include sea ducks (such as Long-tailed Ducks, mergansers, scoters, eiders), Redheads, loons, gannets, shorebirds, terns, and migratory songbirds. See Virginia Coastal Energy Research at 4; see also Albert Manville, FWS, Presentation on Shoreline, Near-shore, and Offshore Wind Energy Development in Texas State Waters: Tools to Help Avoid or Minimize "Take" of Waterbirds and Other Avifauna 14 (2011), Attachment F.

In sum, more than one-third of the migratory birds protected under the MBTA are facing several serious threats that are leading to declines in or uncertainty about their population numbers. In the absence of any regulations for avoiding and minimizing the impacts of wind energy projects through an appropriate permitting scheme – such as those proposed in this Petition – rapid wind energy development poses a grave threat to many migratory birds protected under the MBTA. As

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[55] Available at http://web2.uconn.edu/seagrantnybight/documents/Energy%20Docs/Forsell_NY%20Bight%20Energy%20Oct%207%202010_Seabirds.pdf (last visited Nov. 27, 2011).

[56] Available at http://vasierraclub.org/Karpanty.pdf (last visited Nov. 27, 2011).

[57] Available at http://www.glc.org/energy/wind/pdf/TNC-Great-Lakes-Regional-Guidelines.pdf (last visited Nov. 27, 2011).

described infra, see Section C.3, FWS's approach to these impacts, i.e., through voluntary inadequate guidelines in lieu of mandatory regulations, will likely exacerbate the decline of many species protected under the MBTA, potentially leading to the need to list such species as endangered or threatened under the ESA.[58]

C. FACTUAL BACKGROUND

C.1. Thousands of wind turbines are already in operation and thousands more are being planned.

Growth in the wind industry

"[T]he U.S. wind industry is growing rapidly," driven by several policy incentives such as federal production tax credits, and renewable portfolio standards in roughly 50% of the states. See DOE, 20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply 1 (July 2008) ("DOE 20% Wind Report").[59] The DOE has announced a collaborative effort in which wind power is expected to provide 20% of U.S. electricity by 2030. Id. The 20% wind U.S. scenario would require an installation rate of 16 GW per year after 2018. See Figure 1: Cumulative and Annual Wind Installations By 2030.

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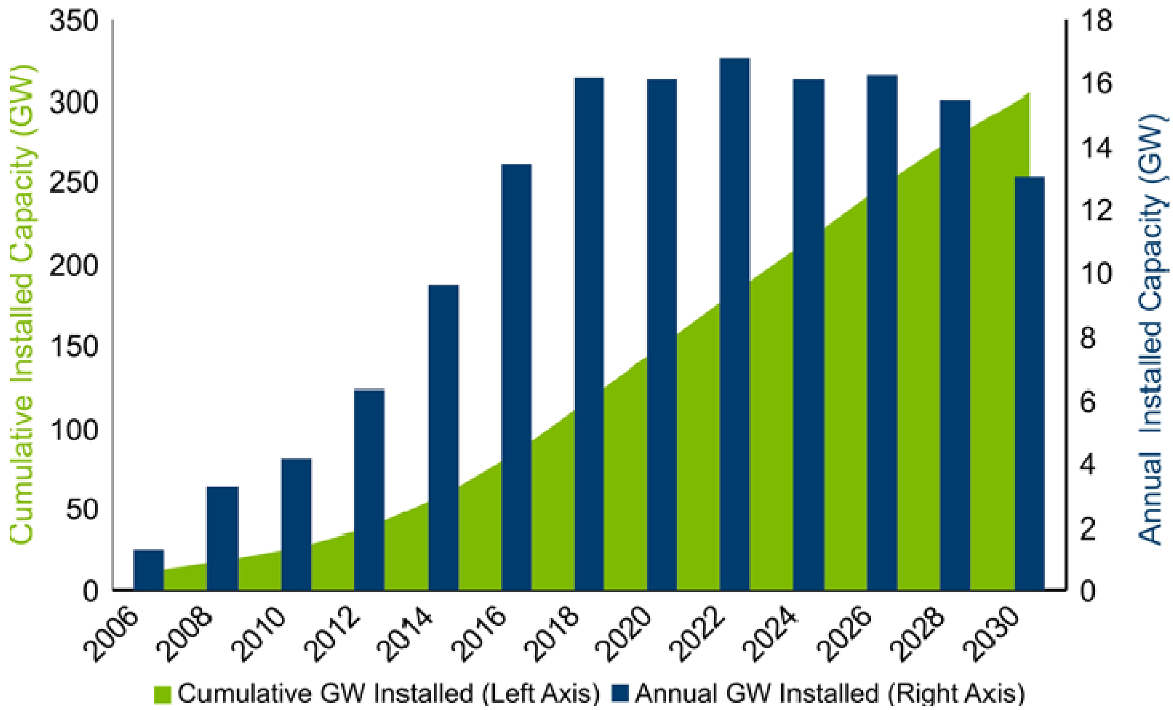
[58] An upsurge in ESA listings will have serious consequences particularly for the industry, which will then be required to comply with comprehensive ESA requirements and may also be required to shut down projects due to potential ESA violations. For example, in response to a citizen suit, a federal court recently issued an injunction against the Beech Ridge wind energy project in West Virginia for potential take of the endangered Indiana bat without an incidental take permit. See Animal Welfare Inst. v. Beech Ridge Energy LLC, 675 F. Supp. 2d 540, 545 (D. Md. 2009). Accordingly, the industry has an enormous incentive to avoid additional ESA listings of species affected by wind power projects.

[59] Available at http://www.nrel.gov/docs/fy08osti/41869.pdf (last visited Dec. 11, 2011).

Figure 1: Cumulative and Annual Wind Installations By 2030[60]



The number of operating wind turbines is estimated at 30,000 in 2009 and will likely increase to over 70,000 turbines by end of 2011.[61] See Figure 2: Wind Turbines in the United States (2003-2011); Table: 1: Increase in Proposed and Existing Wind Turbines in the United States (2003-2011).

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[60] Source: DOE 20% Wind Report at 7.

[61] These figures are estimates based on the data submitted to the FAA for proposed wind projects.

Figure 2: Estimate of Wind Turbines in the United States (2003-2011)

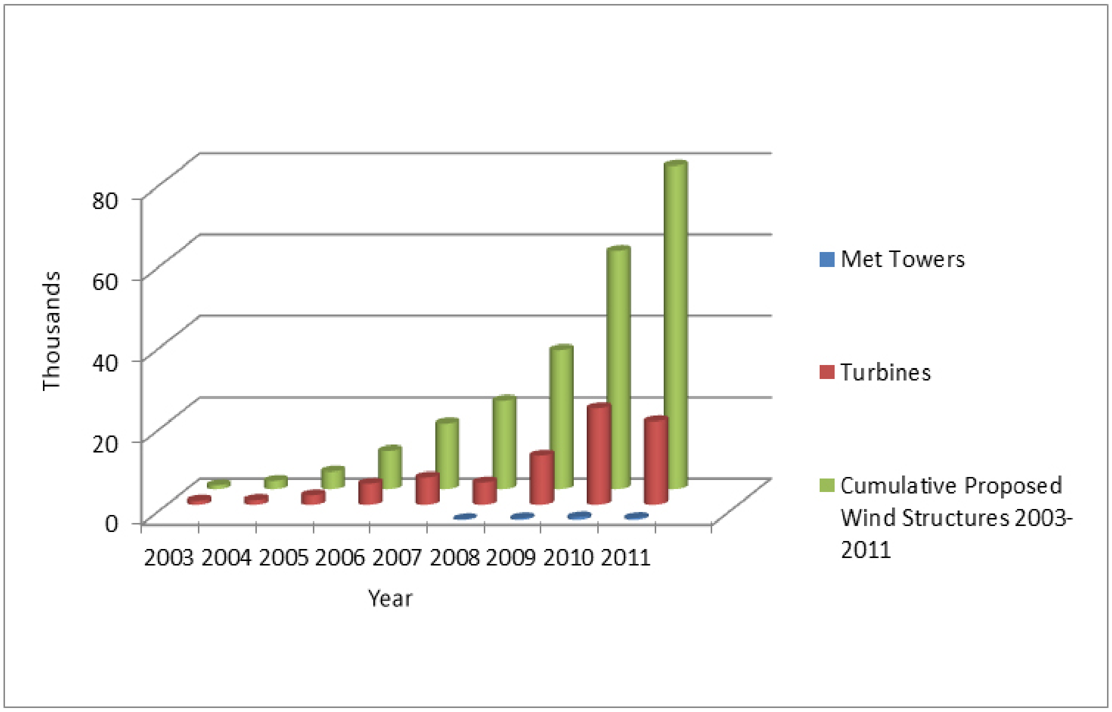

Figure 2 (above) is based on all unique wind turbines and associated meteorological tower proposals submitted to the Federal Aviation Administration/Obstruction Evaluation/Airport Airspace Analysis offices ("FAA - OE/AAA"). Wind turbines that were already proposed or existing prior to 2003 are not included in this analysis. Although meteorological towers were proposed during 2003-2007, they are not included in this data set due to data compilation and processing issues.

Table 1: Estimated Increase in Wind Turbines in the United States (2003-2011)

Year	# Wind Turbines	# Meteorological Towers[62]	Total Wind Related Structures	# Cumulative Proposed Wind Structures 2003-2011
2003	950	n/a	950	**950**
2004	1114	n/a	1114	**2064**
2005	2253	n/a	2253	**4317**
2006	5124	n/a	5124	**9441**
2007	6700	n/a	6700	**16141**
2008	5446	179	5625	**21766**
2009	12063	398	12461	**34227**

[62] Although meteorological towers were proposed during 2003-2007, they are not included in this data set due to data compilation and processing issues.

Year	# Wind Turbines	# Meteorological Towers[62]	Total Wind Related Structures	# Cumulative Proposed Wind Structures 2003-2011
2010	23714	661	24375	**58602**
2011 (through 11-1-11)	20460	451	20911	**79513**

The cumulative wind power capacity in the United States grew by a healthy 15% in 2010. DOE, 2010 Wind Technologies Market Report 1 (June 2011) ("2010 DOE Wind Market Report").[63] In fact, according to AWEA's most recent third quarter report published in October 2011, the wind industry had more than 1,200 MW installed in the third quarter, and more than 8,400 MW under construction – the most in any quarter since 2008. AWEA, U.S. Wind Industry Third Quarter Market Report (Oct. 2011) ("AWEA Third Quarter Report");[64] see also Meg Cichon, Meanwhile, Wind Industry Sees Big Gains – Will it Last? (RenewableEnergyWorld.com Nov. 17, 2011).[65]

Further, around 50% of U.S. states have adopted binding "renewable portfolio standards," i.e., state policies that require electricity providers to obtain a minimum percentage of their power from renewable energy resources by a certain date. See Table 2: State Renewable Portfolio Standards.

[63] Available at http://eetd.lbl.gov/ea/ems/reports/lbnl-4820e.pdf (last visited Nov. 17, 2011).

[64] Available at http://www.awea.org/learnabout/publications/reports/upload/3Q-2011-AWEA-Market-Report-for-Public-2.pdf (last visited Nov. 14, 2011).

[65] Available at http://www.renewableenergyworld.com/rea/news/article/2011/11/meanwhile-wind-industry-sees-big-gains-will-it-last (last visited Nov. 17, 2011).

Table 2: State Renewable Portfolio Standards[66]

	State	Renewable Energy Amount	Year
1.	Arizona	15%	2025
2.	California	33%	2030
3.	Colorado	20%	2020
4.	Connecticut	23%	2020
5.	District of Columbia	20%	2020
6.	Delaware	20%	2019
7.	Hawaii	20%	2020
8.	Iowa	105 MW	-
9.	Illinois	25%	2025
10.	Massachusetts	15%	2020
11.	Maryland	20%	2022
12.	Maine	40%	2017
13.	Michigan	10%	2015
14.	Minnesota	25%	2025
15.	Missouri	15%	2021
16.	Montana	15%	2015
17.	New Hampshire	23.8%	2025
18.	New Jersey	22.5%	2021
19.	New Mexico	20%	2020
20.	Nevada	20%	2015
21.	New York	24%	2013
22.	North Carolina	12.5%	2021
23.	North Dakota*	10%	2015
24.	Oregon	25%	2025
25.	Pennsylvania	8%	2020
26.	Rhode Island	16%	2019
27.	South Dakota*	10%	2015
28.	Texas	5,880 MW	2015
29.	Utah*	20%	2025
30.	Vermont*	10%	2013
31.	Virginia*	12%	2022
32.	Washington	15%	2020
33.	Wisconsin	10%	2015

Thirty-eight states have utility-scale wind installations. See Figure 3: 2010 State Wind Installed Capacity. Texas has the largest installed wind capacity followed by Iowa and California.

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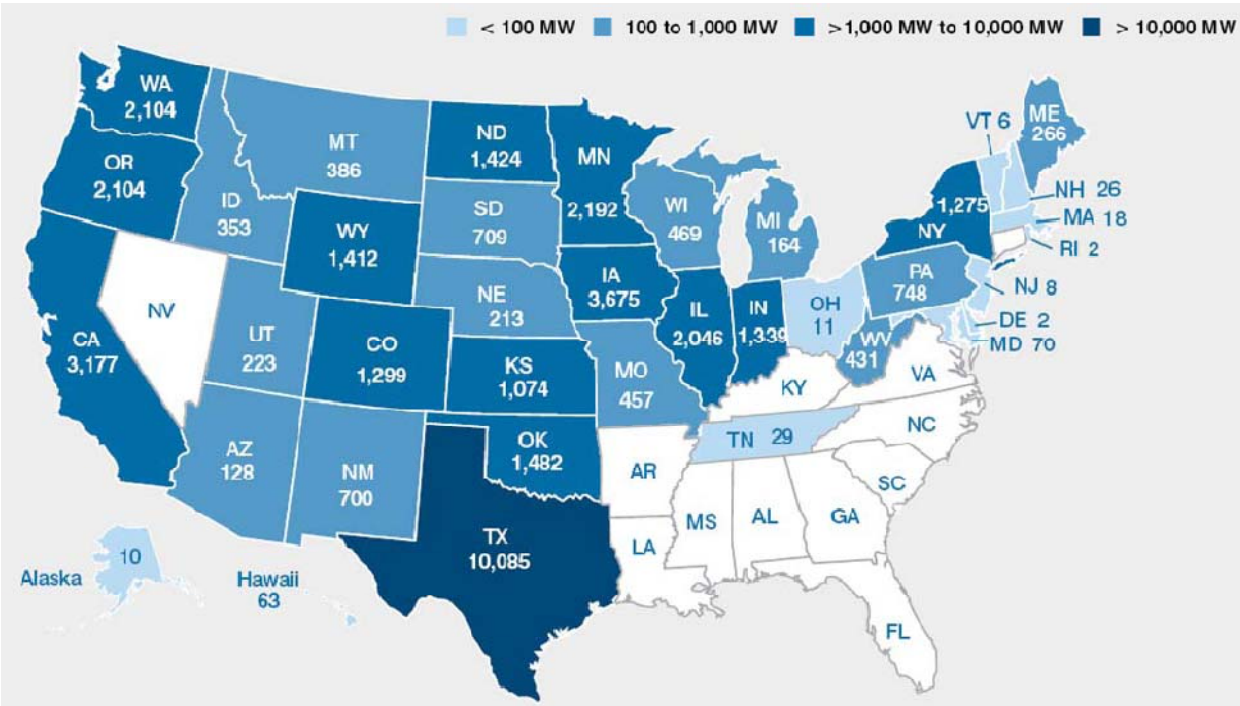
[66] Source: DOE, State Renewable Portfolio Standards, http://apps1.eere.energy.gov/states/maps/renewable_portfolio_states.cfm (last visited Nov. 17, 2011). Percentages refer to a portion of electricity sales and megawatts (MW) to absolute capacity requirements. *Five states, North Dakota, South Dakota, Utah, Virginia, and Vermont, have set voluntary goals for adopting renewable energy instead of portfolio standards with binding targets.

AWEA, Wind Energy Facts: California (Aug. 2011).[67] Seven of the nation's ten largest wind farms are in Texas, including all of the top five. AWEA, Wind Energy Facts: Texas (Aug. 2011).[68]

Figure 3: 2010 State Wind Installed Capacity[69]



Further, the maps provided below (Maps 1.1 – 2.3) illustrate the actual locations of many of the wind projects in the United States – showing that this is an industry that is growing rapidly across the nation. The point maps and heat maps provided below are based on all unique wind turbine and associated meteorological tower proposals submitted to the FAA - OE/AAA between 2003 (the year when voluntary guidelines were established for wind energy projects by FWS) to 2011. Wind turbines that were already proposed or existing prior to 2003 are not shown. Meteorological towers represent 2.12% of the structures on the map.

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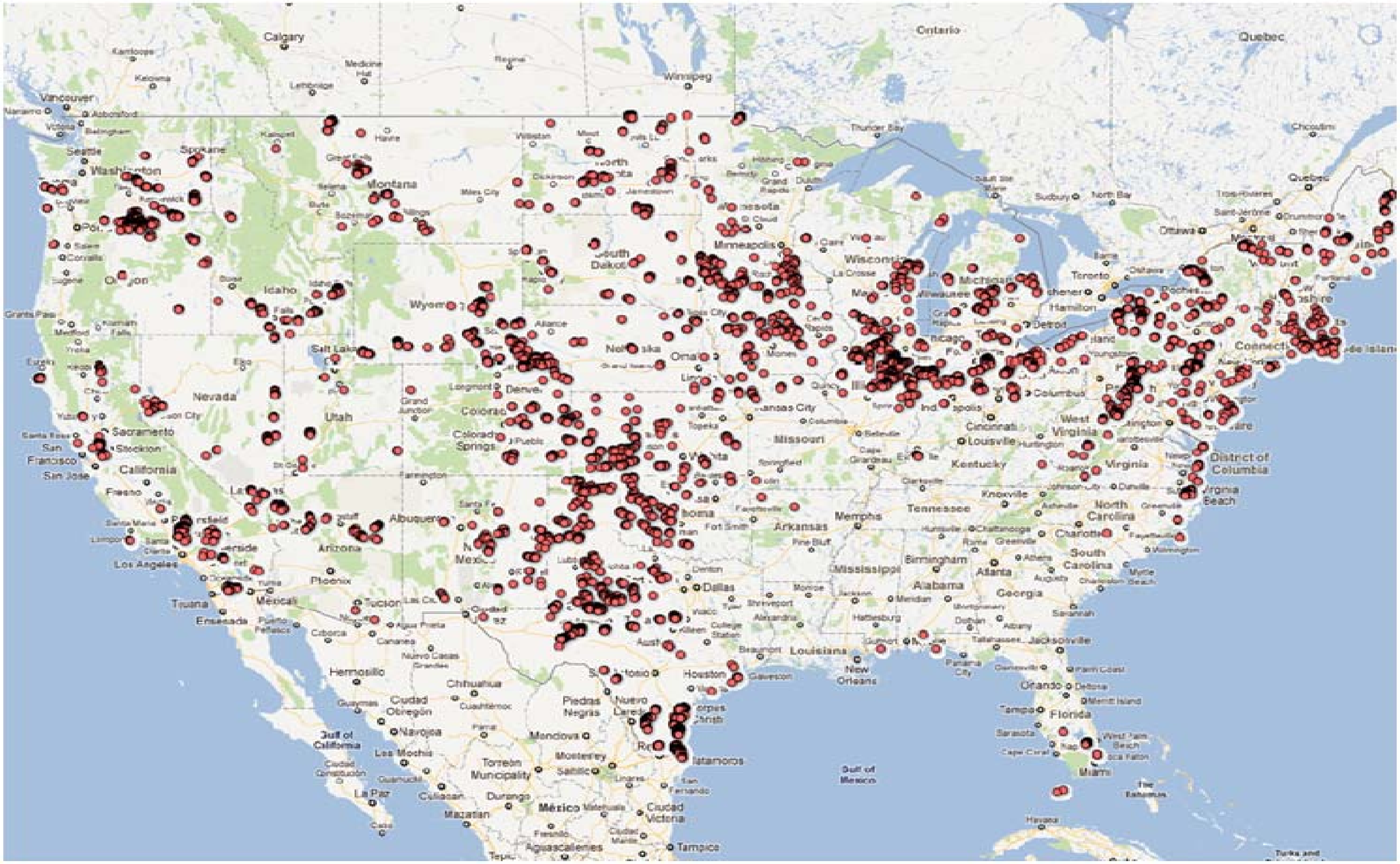
[67] Available at http://www.awea.org/learnabout/publications/upload/California.pdf (last visited Nov. 14, 2011).

[68] Available at http://www.awea.org/learnabout/publications/upload/Texas.pdf (last visited Nov. 14, 2011).

[69] Source: AWEA, 2010 U.S. Wind Industry Market Update, available at http://www.awea.org/learnabout/publications/factsheets/upload/Market-Update-Factsheet-Final_April-2011.pdf (last visited Nov. 14, 2011).

MAP 1.1: Estimated Wind Turbines in the Lower 48 States (2003 – 2011)[70]

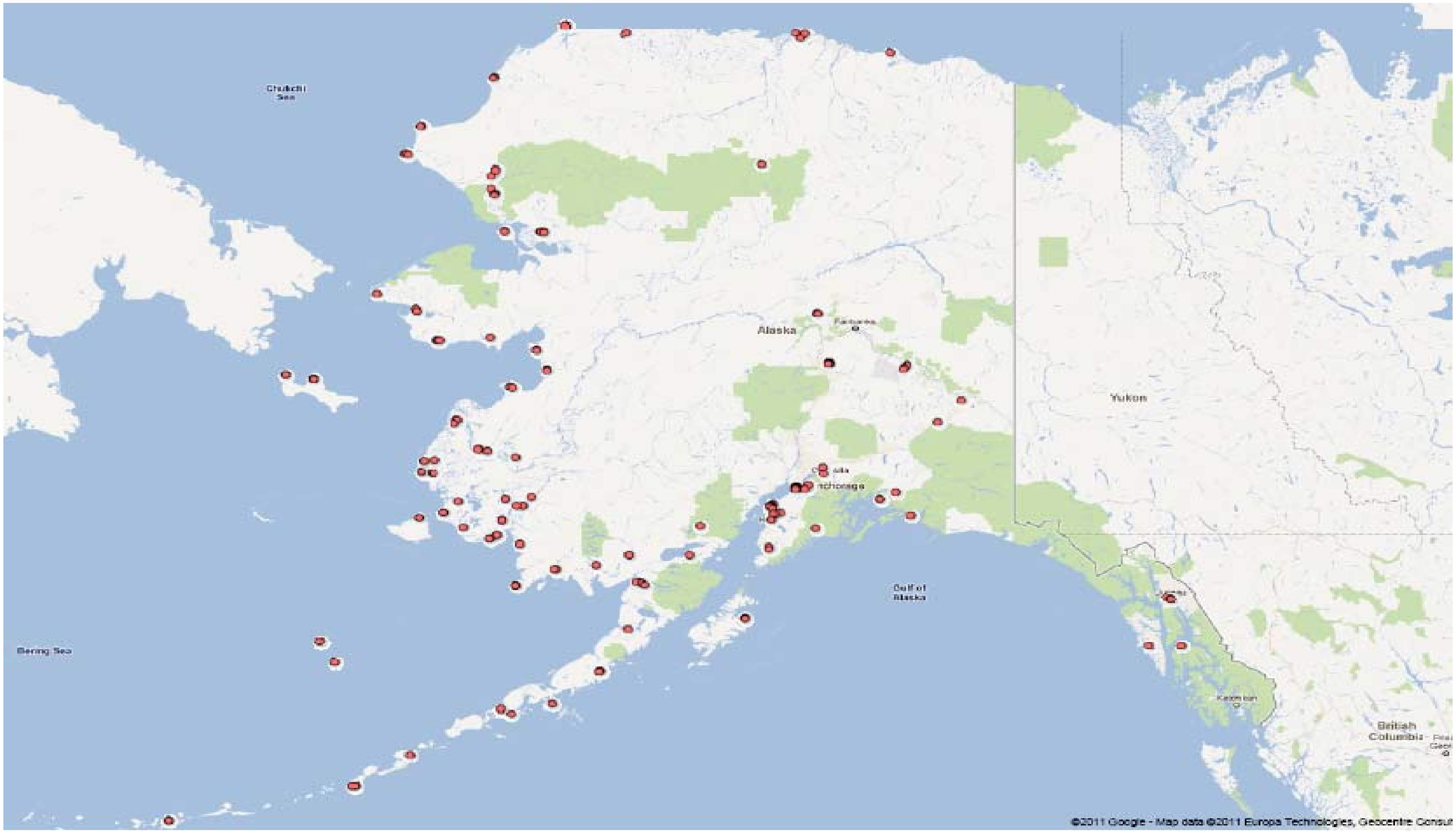


[70] Point map illustrating the location of wind turbines in 48 states in the United States that were logged with the FAA between 2003 and 2011. These are a mix of both existing and proposed wind turbines, as well as meteorological towers. Meteorological towers make up 2.12% of the logged structures on the overall U.S. map. All maps provided in this Petition are based on data available on the FAA website.

MAP 1.2: Estimated Wind Turbines in Hawaii (2003 – 2011)[71]

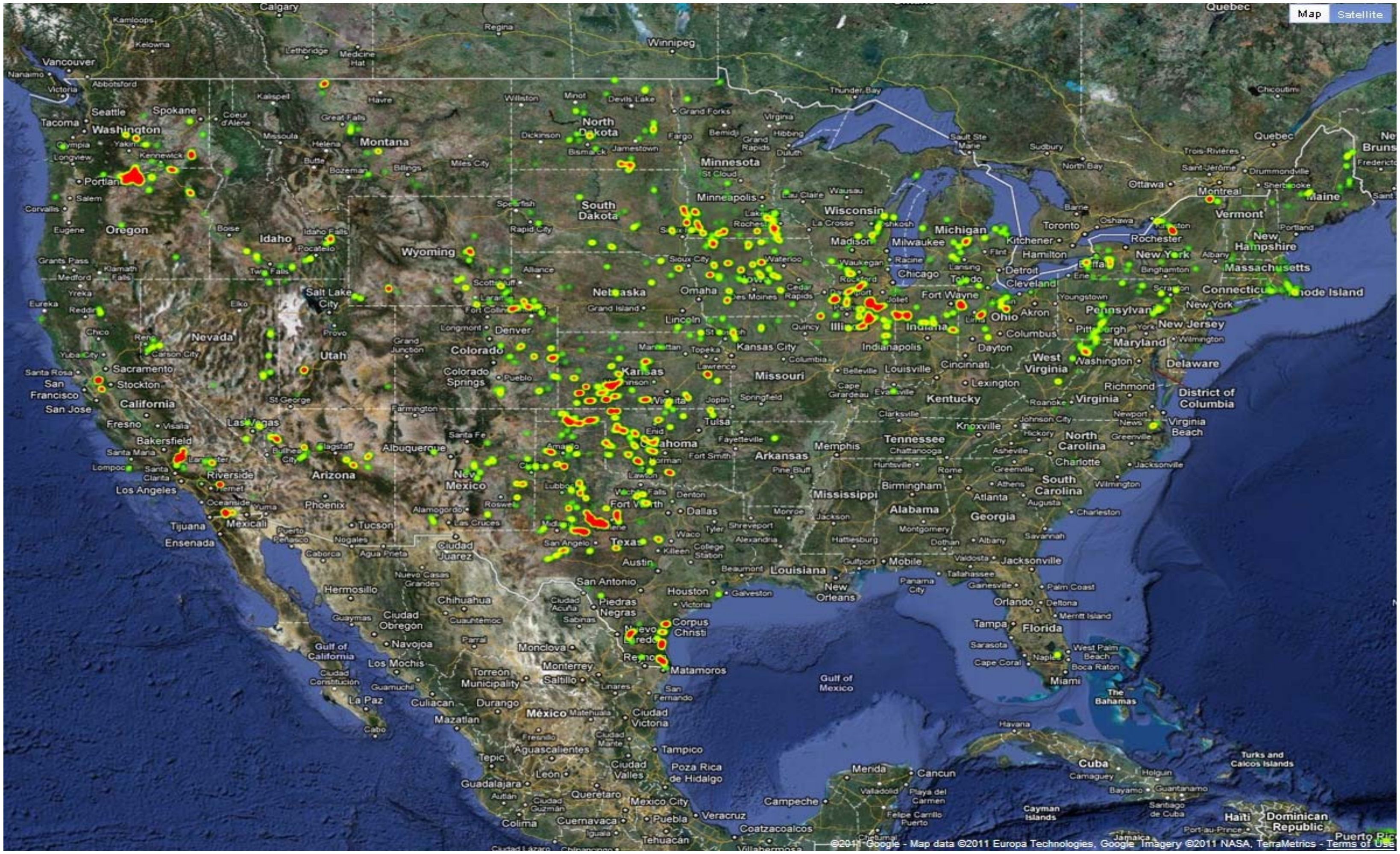
[71] Point map illustrating the location of wind turbines in Hawaii that were logged with the FAA between 2003 and 2011. These are a mix of both existing and proposed wind turbines, as well as meteorological towers. Meteorological towers make up 2.12% of the logged structures on the overall U.S. map. All maps provided in this Petition are based on data available on the FAA website.

MAP 1.3: Estimated Wind Turbines in Alaska (2003 – 2011)[72]



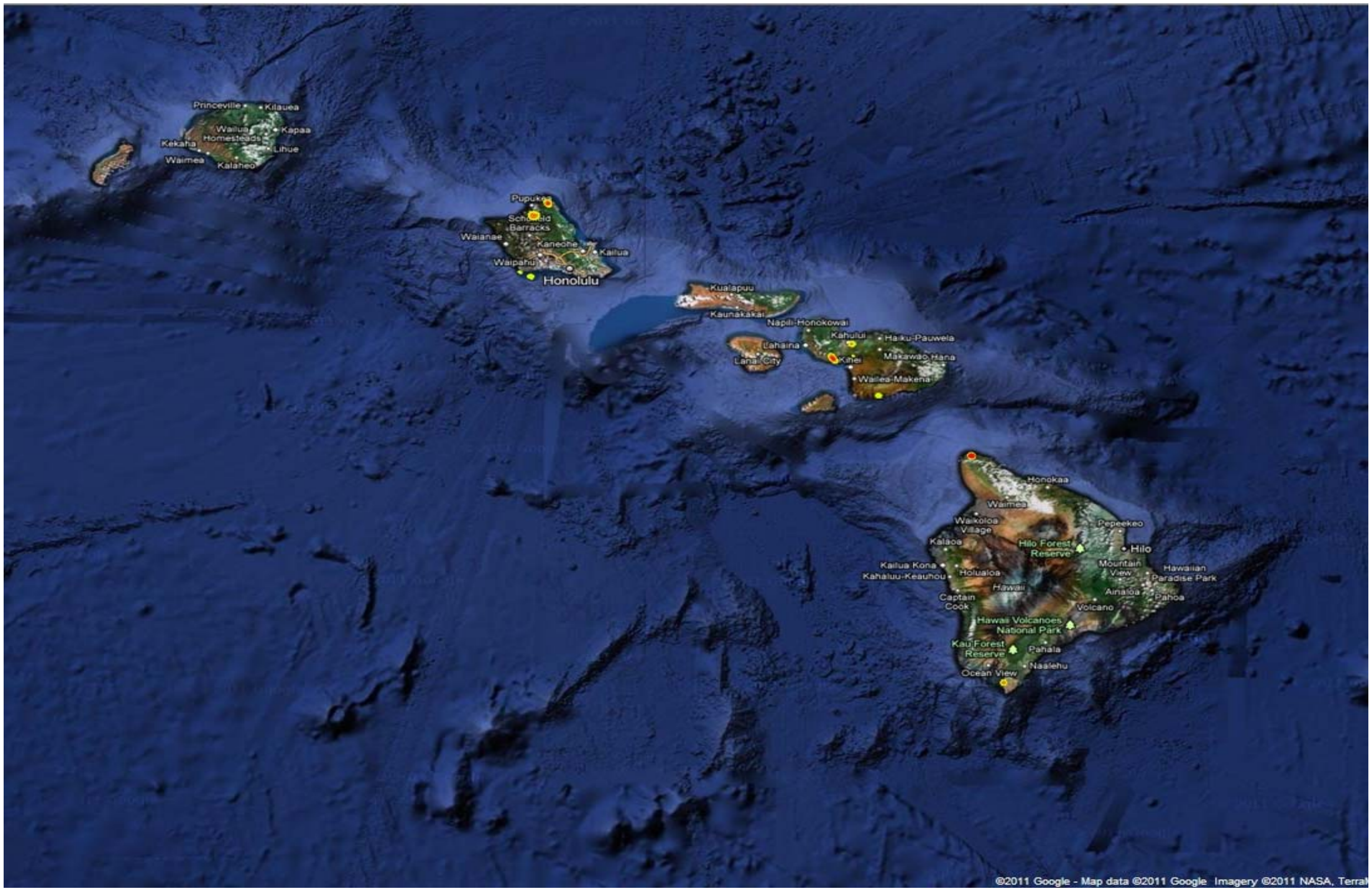
[72] Point map illustrating the location of wind turbines in Alaska that were logged with the FAA between 2003 and 2011. These are a mix of both existing and proposed wind turbines, as well as meteorological towers. Meteorological towers make up 2.12% of the logged structures on the overall U.S. map. All maps provided in this Petition are based on data available on the FAA website.

MAP 2.1: Estimated Wind Turbines in the Lower 48 States (2003 – 2011)[73]



[73] Heat map indicating location of wind turbines in 48 states in the United States that were logged with the FAA between 2003 and 2011. These are a mix of both existing and proposed wind turbines, as well as meteorological towers. Meteorological towers make up 2.12% of the logged structures on the overall U.S. map. The darker orange and red dots represent areas with a relatively higher density of proposed wind structures than areas with green, yellow or no color dots. All maps provided in this Petition are based on data available on the FAA website.

MAP 2.2: Estimated Wind Turbines in Hawaii (2003 – 2011)[74]



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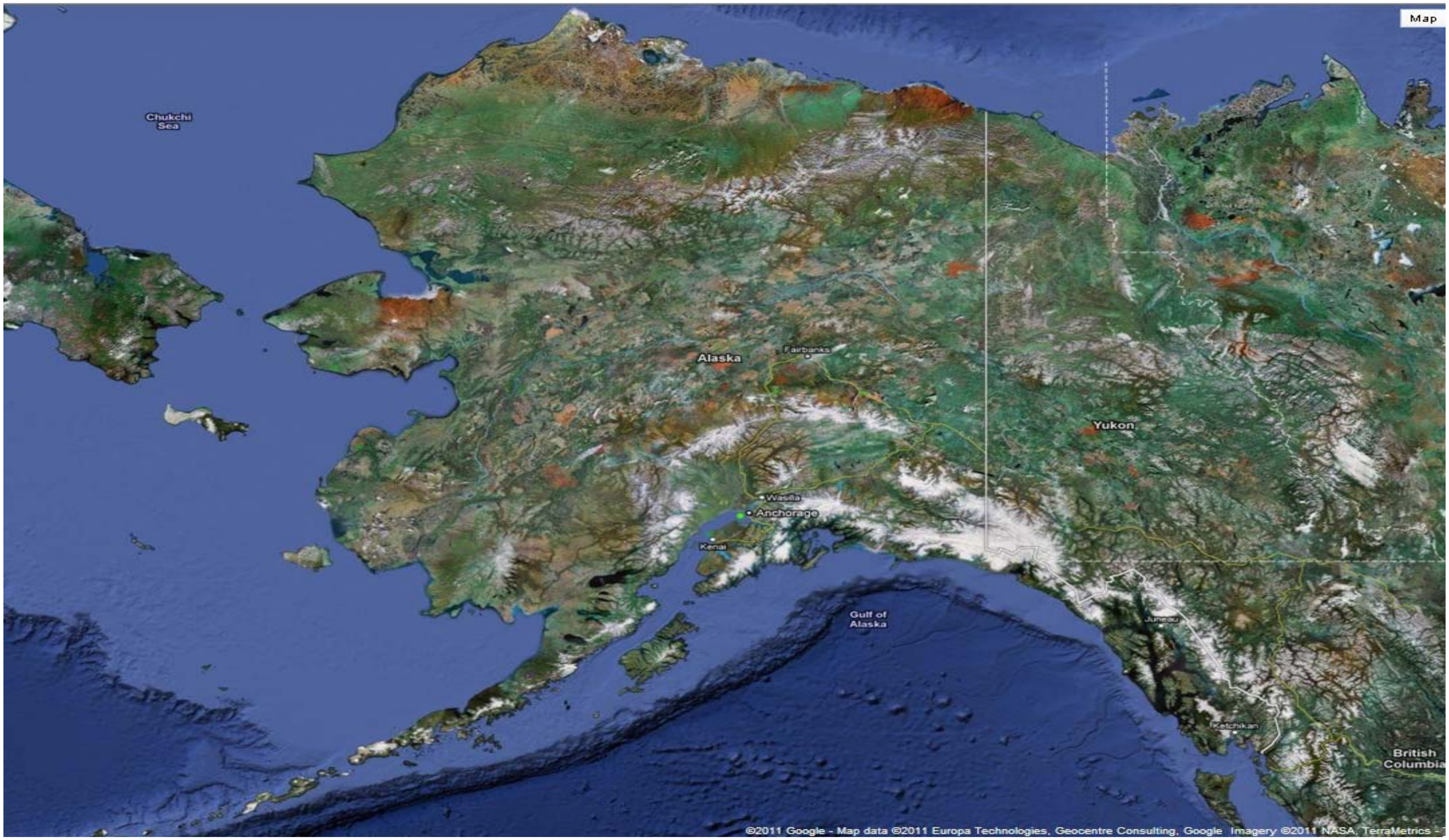
[74] Heat map indicating location of wind turbines in Hawaii that were logged with the FAA between 2003 and 2011. These are a mix of both existing and proposed wind turbines, as well as meteorological towers. Meteorological towers make up 2.12% of the logged structures on the overall U.S. map. The darker orange and red dots represent areas with a relatively higher density of proposed wind structures than areas with green, yellow or no color dots. All maps provided in this Petition are based on data available on the FAA website.

MAP 2.3: Estimated Wind Turbines in Alaska (2003 – 2011)[75]



[75] Heat map indicating location of wind turbines in Alaska that were logged with the FAA between 2003 and 2011. These are a mix of both existing and proposed wind turbines, as well as meteorological towers. Meteorological towers make up 2.12% of the logged structures on the overall U.S. map. Because there are relatively few wind turbines in Alaska, they appear as small, light green dots on the map and might not be visible to some readers without magnification. All maps provided in this Petition are based on data available on the FAA website.

In addition to projects that have completed construction, there are over 90 separate projects totaling 8,400 MW of capacity currently under construction in 29 states. AWEA Third Quarter Report.

Along with land-based wind development, offshore wind energy is also poised to develop rapidly. See, e.g., DOI Press Release, Salazar, Chu Announce Major Offshore Wind Initiatives (Feb. 7, 2011)[76] (unveiling a coordinated strategic plan which pursues the deployment of 10 GW of offshore wind capacity by 2020 and 54 GW by 2030 and announcing $50.5 million in funding for offshore wind energy deployment). The Energy Policy Act of 2005 authorized the Secretary of the Interior to grant leases on the Outer Continental Shelf ("OCS") for alternative energy projects, including offshore wind energy projects. Pub. L. No. 109-58, 119 Stat. 594, § 388. The Secretary delegated this authority to the Director of the U.S. Bureau of Ocean Energy Management ("BOEM"), which subsequently approved the nation's first commercial offshore wind energy project with around 130 turbines – the Cape Wind project – in federal waters off the coast of Massachusetts. Many other projects are being planned for construction in federal waters off the coast of Delaware, New Jersey, Florida and Georgia. See BOEM, Offshore Renewable Energy: Interim Policy Projects.[77] In addition, several projects are also being planned for state waters, such as Baryonyx Corporation's proposal to construct 500 wind turbines off the Texas Gulf Coast. DOI has also announced a 'Smart from the Start Initiative' to facilitate siting, leasing and construction of new projects in the Atlantic Outer Continental Shelf. See DOI Press Release, Salazar Launches 'Smart from the Start' Initiative to Speed Offshore Wind Energy Development off the Atlantic Coast (Nov. 23, 2010).[78]

The leading wind energy developers in the United States include developers that have extensive past experience with renewable energy sources, such as Iberdrola Renewables and Horizon Wind Energy, as well as subsidiaries of large oil companies such as BP and Shell. See, e.g., BP Alternative Energy, Our Business: Wind Power;[79] Shell, Wind Energy Operations.[80]

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[76] Available at http://www.doi.gov/news/pressreleases/Salazar-Chu-Announce-Major-Offshore-Wind-Initiatives.cfm (last visited Nov. 15, 2011)

[77] Available at http://www.boemre.gov/offshore/RenewableEnergy/Projects.htm (last visited Nov. 15, 2010).

[78] Available at http://www.doi.gov/news/pressreleases/Salazar-Launches-Smart-from-the-Start-Initiative-to-Speed-Offshore-Wind-Energy-Development-off-the-Atlantic-Coast.cfm (last visited Nov. 15, 2010).

[79] Available at http://www.bp.com/sectiongenericarticle.do?categoryId=9024940&contentId=7046497 (last visited Nov. 11, 2011)

[80] Available at http://www.shell.us/home/content/usa/innovation/wind/projects/ (last visited Nov. 17, 2011).

Increase in size of wind turbines in order to produce more energy

The growth in the industry has been paralleled by an expansion in the size of the turbines. "Modern wind turbines are giant structures" and may vary from 200 to 400 short tons in weight. AWEA et al., Winds of Change: A Manufacturing Blueprint for the Wind Industry (June 2010) at 6, 20. The blade tip speed of the turbines is typically around 180 mph. See Albert Manville, FWS, Presentation on Framing the Issues Dealing with Migratory Birds, Commercial Land-based Wind Energy Development, USFWS, and the MBTA (Oct. 21, 2011) 5 ("FWS 2011 MBTA Conference Presentation") (explaining that the combination of large turbine blades and high speed increases the potential for bird collisions), Attachment G. Further, offshore wind energy projects use turbines much larger than those typically installed onshore. Id. at 16.

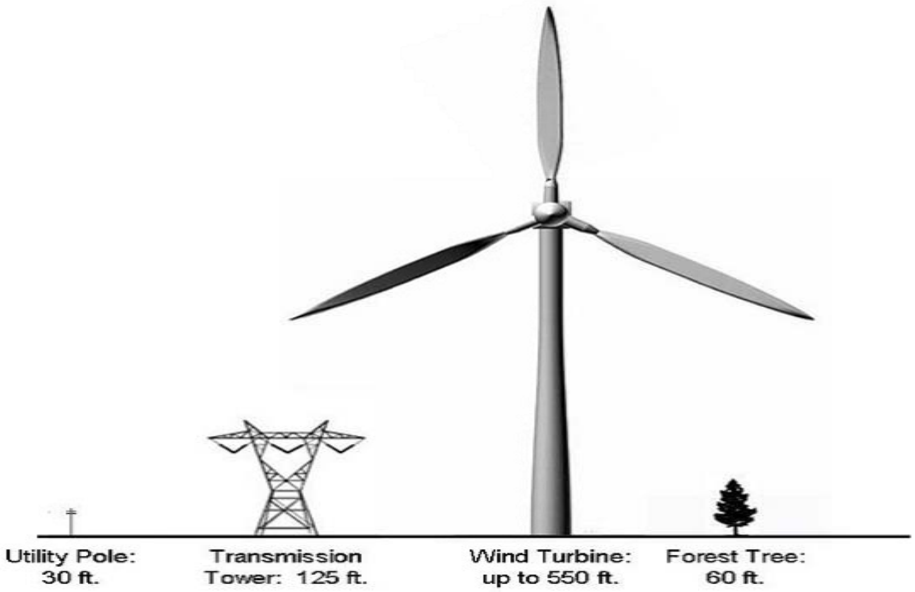
Larger turbines produce more energy. See DOE, Wind Power Today (May 2007) ("DOE Wind Power Today")[81] (explaining that DOE has been working with the wind industry to develop larger machines that are more efficient and that capture more energy from the wind). To meet the growing demand, in 2006 alone, average turbine size increased by more than 11% over the 2005 level. See DOE 20% Wind Report at 5; see also Global Energy Concepts, Wind Turbine Technology: Overview (Oct. 2005)[82] ("The rotor diameters and rated capacities of wind turbines have continually increased in the past 10 years"). The average turbine installed in 2006 (at 1.5 MW) was almost as tall as the Statue of Liberty and had a rotor large enough to sweep a football field. DOE Wind Power Today at 2. By 2010, the size of wind turbines had increased with the rotor diameter of the blades exceeding 364 feet (111 meters) (a space that could provide parking for 24 average-sized cars end to end across the diameter of its rotor). Id. at 3.

Significant increase in the size of wind turbines is expected in the near term. By 2015, the average turbine size is expected to exceed 700 feet (213 meters) in height. DOE Wind Power Today at 3; see also Figure 4: Comparison Of The Height Of A Large Wind Turbine With Other Tall Structures. A recent DOE study on trends in the wind industry found that: "[a]verage hub heights and rotor diameters have also scaled with time, to 79.8 and 84.3 meters, respectively, in 2010. Since 1998-99, the average turbine hub height has increased by 43%, while the average rotor diameter has increased by 76%. Industry expectations as well new turbine announcements (especially to serve lower-wind-speed sites) suggest that significant further scaling, especially in rotor diameter, is anticipated in the near term." 2010 DOE Wind Market Report at v; DOE Wind Power Today at 29-31.

[81] Available at http://www.nrel.gov/docs/fy07osti/41330.pdf (last visited Nov. 16, 2011).

[82] Available at http://www.powernaturally.org/programs/wind/toolkit/9_windturbinetech.pdf (last visited Nov. 16, 2011).

Figure 4: Comparison Of The Height Of A Large Wind Turbine With Other Tall Structures[83]



In sum, the wind industry has developed rapidly over this decade and has great potential to continue to grow. Further, larger and more efficient turbines are generating greater amounts of wind power at lower costs. However, the industry has been concerned about the expiration of a federal production tax credit by the end of 2012. ABC recognizes the need for renewable energy development and will support the industry in its efforts to extend the tax credit for wind energy production, if FWS puts in place a system that ensures ongoing compliance with the MBTA along with other wildlife protection laws.

C.2. Unregulated wind energy projects pose a serious threat to migratory birds protected under federal wildlife laws.

Rapid development of the wind industry and proliferation of massive wind turbines pose a serious threat to migratory bird species if they take place without meaningful regulation and appropriate mandatory federal standards. Indeed, the wind power industry has two essential attributes that render it particularly suitable to development of a permitting system for regulating take of migratory birds.

First, it is an industry that is inherently risky to birds because it entails placing huge turbines and associated power lines and other infrastructure in areas where killing of migratory birds (and hence violations of the MBTA) are virtually inevitable. See Letter from Laury Zicari, FWS to Jennifer McCarthy, U.S. Army Corps of Engineers ("Corps") (May 11, 2011), Attachment H (in providing recommendations in relation to the wildlife impacts of the Saddleback Ridge wind project,

[83] Source: Virginia Wind, Turbine Size, http://www.vawind.org/#javascript (last visited Nov. 17, 2011).

FWS observed that, "[a]ll wind power projects will take birds and bats."); Nat'l Wind Coordinating Collaborative, Wind Wildlife Research Meeting VIII: Presentation and Poster Abstracts 45-46 (Oct. 2010)[84] ("The rapid development of the wind industry in the US has resulted in situations in which wind sites without environmental constraints are becoming increasingly rare. Therefore, more sites with potential conflicts with endangered species and their habitats are under consideration for development… Locations with threatened or endangered species issues are becoming more common as the industry becomes more competitive. Although the species may differ, consistent problems with special status species exist nationwide.").

Indeed, most birds impacted by wind energy projects are protected under the MBTA. See, e.g., Thomas Kunz et al., Assessing Impacts of Wind-Energy Development on Nocturnally Active Birds and Bats: A Guidance Document, 71(8) J. Wildlife Mgmt. 2449, 2450 (2007)[85] ("In a review of bird collisions reported from 31 studies at utility-scale wind energy facilities in the United States, Erickson et al. (2001) showed that 78% of carcasses found at wind-energy facilities outside of California were songbirds protected by the Migratory Bird Treaty Act.").[86]

Second, the environmentally responsible development of wind power is generally recognized to be of benefit to society, particularly because it may be able to play a long-term role in alleviating the effects of climate change on ecosystems. A permitting system – such as that proposed in this Petition – is essential to such development.

Collision with wind turbines and related infrastructure

Wind energy projects adversely impact migratory birds in multiple ways. First, migratory birds are routinely killed by collisions with wind turbines or the infrastructure needed to support wind energy facilities. FWS estimated in 2009 that 440,000 birds were being killed annually by wind turbines in the United States. This mortality estimate is likely an underestimate based on the operation of approximately 22,000 turbines in 2009. See Albert Manville, FWS, Towers, Turbines, Power Lines, and Buildings – Steps Being Taken By the U.S. Fish and Wildlife Service to Avoid or Minimize Take of Migratory Birds at These Structures 6 (July 17 2009) ("Manville 2009 Paper"), Attachment I. By 2020, more than 100,000 turbines are projected to be operating, and it is expected that such an exponential increase of wind turbines will kill at least one million birds each year, and it

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[84] Available at http://www.nationalwind.org/assets/research_meetings/Research_ Meeting_ VIII_ Abstracts.pdf (last visited Nov. 16, 2011).

[85] Available at http://www.batsandwind.org/pdf/jwm_m&m.pdf (last visited Nov. 16, 2011).

[86] Poorly sited and operated wind power projects may also have very detrimental effects on other wildlife, particularly bats. As discussed infra, see Section E.4, although this Petition is directed at migratory bird impacts, the permitting scheme that it advocates would have collateral benefits for other wildlife as well.

is likely that the actual mortality will significantly exceed this estimate. See ABC Bird-Smart Wind Principles.

Further, while there are no well-established estimates for the numbers of birds killed by wind energy infrastructure (other than turbines) such as power lines, substations, and meteorological towers, three examples demonstrate why this infrastructure is also of serious concern. See Manville 2009 Paper at 7.

First, power lines are known to be the greatest source of anthropogenic mortality for fledged Whooping Cranes, whose Aransas-Wood Buffalo migration corridor traverses the Great Plains, where a large build out of wind power is expected. See FWS Regions 2 and 6, Whooping Cranes and Wind Development – an Issue Paper 2-3 (2009).[87] Golden Eagle and hawk mortality at power lines are also well documented.

Second, substations associated with wind energy facilities can be another source of mortality, especially when steady-burning lights are left on in low-visibility conditions during migration, as happened during October 1-2, 2011 at the Laurel Mountain wind project and around May 23, 2003 at the Mountaineer wind facility, both in West Virginia. See Memo from Stantec Consulting (consultants for developer) to Laura Hill, FWS, Bird Mortality at Laurel Mountain Substation Memo (Oct. 25, 2011) at 1, Attachment J; Curry & Kerlinger, LLC, A Study of Bird and Bat Collision Fatalities at the Mountaineer Wind Energy Center, Tucker County, West Virginia: Annual Report for 2003 (Feb. 14, 2004) at 5.[88] 484 birds killed by the Laurel Mountain wind energy project, mostly MBTA-protected songbirds, were found at a substation and battery energy storage station on the site; at Mountaineer, 33 birds were found dead at a substation and three wind turbines.

Third, meteorological towers are documented to kill birds. For example, at the Shiloh II Wind Power Project in California, more than 52 birds were found dead at ten meteorological towers over a two-year period (these are unadjusted mortality numbers and actual mortality at the sites would have been higher). See Curry & Kerlinger LLC, Meteorological Tower Fatality Study at the

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[87] Available at ftp://wiley.kars.ku.edu/windresource/Whooping_Crane_and_Wind_Development_FWS_%20April%202009.pdf (last visited Nov. 17, 2011).

[88] Available at http://www.wvhighlands.org/Birds/MountaineerFinalAvianRpt-%203-15-04PKJK.pdf (last visited Nov. 17, 2011).

Shiloh II Wind Project, Solano County, California (Apr. 2008) at 6.[89] According to the Shiloh II study, 85% of the dead birds were legally protected.[90] Id. at 14.

Habitat loss and degradation

Development of wind energy projects can harm birds through long-term habitat loss, alteration, degradation, and fragmentation. Wind energy projects are expected to impact almost 20,000 square miles of terrestrial habitat, and another 4,000 square miles of marine habitat. See DOE 20% Wind Report at 110-11. A U.S. Government Accountability Office ("GAO") report on wind energy found that, "[a]ccording to FWS, the loss of habitat quantity and quality is the primary cause of declines in most assessed bird populations and many other wildlife species." GAO, Wind Power: Impacts on Wildlife and Government Responsibilities for Regulating Development and Protecting Wildlife 15 (2005) ("GAO Wind Power Report");[91] see also Ill. Dep't of Natural Res., The Possible Effects of Wind Energy on Illinois Birds and Bats 2 (2007).[92]

FWS itself has raised concerns about both direct and indirect effects of various wind energy projects. See, e.g., Letter from FWS to Amber Zuhlke, Wind Capital Group, Big Lake Wind Facility in Palm Beach, Florida (July 1, 2011), Attachment K (regarding construction of a project in the Everglades Agricultural Area, FWS stated that the site "supports a host of sensitive trust resources including federally protected migratory birds… The Service has significant concerns on the effects of the proposed project on our trust resources and their habitats. These include both the direct effects of "take" (i.e., mortality and injury through collision) and the indirect effects of habitat fragmentation, site avoidance, disturbance, habitat degradation, barriers, and creation of marginal/suboptimal adjacent wetlands habitats, among others.").

Wind energy facilities require not only wind turbines but also access roads and other infrastructure such as power lines, substations, and outbuildings, resulting in habitat impacts. Furthermore, another form of habitat that is lost due to wind energy development is the airspace that birds formerly used in flight, which can disrupt migrations and other essential behavioral patterns. See FWS 2011 MBTA Conference Presentation at 2.

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[89] Available at http://www.co.solano.ca.us/civicax/filebank/blobdload.aspx?blobid=8916 (last visited Nov. 17, 2011).

[90] The study states that 15% of the dead birds found at the met towers were legally unprotected. It is likely that the remaining 85% of the birds killed by the project were protected under the MBTA because almost all of the species that were listed as fatalities found during the study were those protected under the MBTA.

[91] Available at http://www.gao.gov/new.items/d05906.pdf (last visited Dec. 11, 2011).

[92] Available at http://dnr.state.il.us/publications/pdf/00000544.pdf (last visited Dec. 11, 2011).

In addition to the habitat lost to the cumulative footprint of wind facilities, habitat that remains but is fragmented by the facility can lose its value for some bird species. Examples of species sensitive to habitat fragmentation include the Lesser Prairie-Chicken and Grasshopper Sparrow. See Lesser Prairie-Chicken Interstate Working Group, Assessment and Conservation Strategy for the Lesser Prairie-Chicken (Tympanuchus pallidicinictus) 10 (1999).[93] For instance, the Grasshopper Sparrow has been found by the U.S. Geological Survey to avoid habitat near wind turbines. See Jill A. Shaffer & Douglas H. Johnson, U.S. Geological Survey, Displacement Effects of Wind Developments on Grassland Birds in the Northern Great Plains 51 (2010).[94]

Habitat fragmentation results in an increase of "edges" – areas where habitat is interrupted by human-created features such as access roads and substations. According to FWS, "an increase in edge may result in greater nest parasitism and nest predation." FWS, Revised Draft Land-Based Wind Energy Guidelines 86 (Sept. 13, 2011) ("Wind Guidelines Third Draft").[95] Moreover, some bird species are sensitive to tall structures and will abandon important habitat when tall structures are added. For example, Greater Sage-Grouse abandoned key habitat at an Idaho site after meteorological towers for wind testing were installed. See Biodiversity Conservation Alliance, Wind Power in Wyoming: Doing It Smart from the Start 21 (2008).

Barrier effects

In addition to collision with wind turbines and displacement from habitat, there are other serious threats posed by wind energy development to migratory birds. "Barrier effects," i.e., the energetic impacts to birds of avoiding wind energy facilities rather than flying through them, will become of increasing importance as the size of wind facilities increases and as migration pathways or regional use areas fill with wind turbines. See FWS, Barrier Effect (2011) (providing an overview of barrier effects).[96]

For example, more than 2,000 wind turbines have been proposed at a project in the Whooping Crane's Aransas-Wood Buffalo migration corridor in South Dakota (Titan Wind project). Clipper Wind Power, Clipper Windpower And BP Alternative Energy Form Joint Venture To Develop Up To 5,050 MW: Project to be World's Largest (2008).[97] Further, 1,000 wind turbines

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[93] Available at http://bsi.montana.edu/prairiemap/files/LesserChicken.pdf (last visited Dec. 11, 2011).

[94] Available at https://www.nationalwind.org/assets/research_meetings/Research_Meeting_VII_Shaffer.pdf (last visited Dec. 12, 2011).

[95] Available at http://www.fws.gov/windenergy/ (last visited Dec. 11, 2011).

[96] Available at http://www.fws.gov/windenergy/docs/Barrier_Effect.pdf. (last visited Nov. 15, 2011).

[97] Available at http://www.clipperwind.com/pr_073008.html (last visited Nov. 15, 2011).

have been proposed for a project in Golden Eagle use areas in Wyoming (Chokecherry-Sierra Madre project). See BLM, Chokecherry and Sierra Madre Draft Environmental Impact Statement (2011).[98]

According to FWS, barrier effects have been observed at both land-based and offshore wind projects. In addition, FWS has said that energetic impacts caused by birds avoiding wind turbines may lead to population impacts over time. Barrier Effect supra (2011).

Noise effects

The effects of noise produced by wind turbines can also have adverse impacts on bird species. For instance, utility-scale wind turbines have been demonstrated to produce noise within the range that can reduce densities in some grassland and woodland birds. Noise can also mask the calls birds use to communicate. See FWS, The Effects of Noise on Wildlife (2011) (providing an overview of noise impacts).[99]

Mapping of Estimated Wind Turbines in Key Bird Use Areas

The maps provided below, see Maps 3.1 – 3.3, demonstrate that many wind energy projects have already likely been constructed in areas that are extremely important for birds. These maps have been created by ABC based on data submitted to the FAA - OE/AAA between 2003 (the year when voluntary guidelines were established for wind energy projects by FWS) to 2011. They include all unique wind turbine and associated meteorological tower proposals submitted to the FAA during that time. Wind turbines that were already proposed or existing prior to 2003 are not shown. Meteorological towers represent 2.12% of the structures on the map. These FAA-documented proposed wind turbines and metrological towers are overlaid on the ABC Wind Development Bird Risk Map.[100]

On the maps provided below, red indicates critically important areas for birds where wind energy should not be developed. These areas include important habitat for endangered birds, for concentrations of 500,000 or more migratory birds, for concentrations of the rarest WatchList bird, or those that have special habitat requirements and/or are especially likely to be vulnerable to wind-

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[98] Available at http://www.blm.gov/wy/st/en/info/NEPA/documents/rfo/Chokecherry.html (last visited Nov. 15, 2011).

[99] Available at http://www.fws.gov/windenergy/docs/Noise.pdf (last visited Nov. 15, 2011).

[100] The data presented on the maps provided below are derived from a variety of sources. Examples of primary sources include ABC's list of the 500 most Important Bird Areas in the United States, data on Sage-Grouse core areas from the BLM, and data on the migration corridor of the Whooping Crane from The Nature Conservancy/AWWI. Boundaries of sites are either provided by existing federal or other Geographic Information System layers, or produced by ABC using the best available maps and expert staff opinion. The boundaries of these areas are set on the map based on ABC's best expert judgment as to where the greatest concentration of birds will be present during most migration periods.

related mortality or habitat impacts and the very highest importance bottleneck areas for migrant birds.

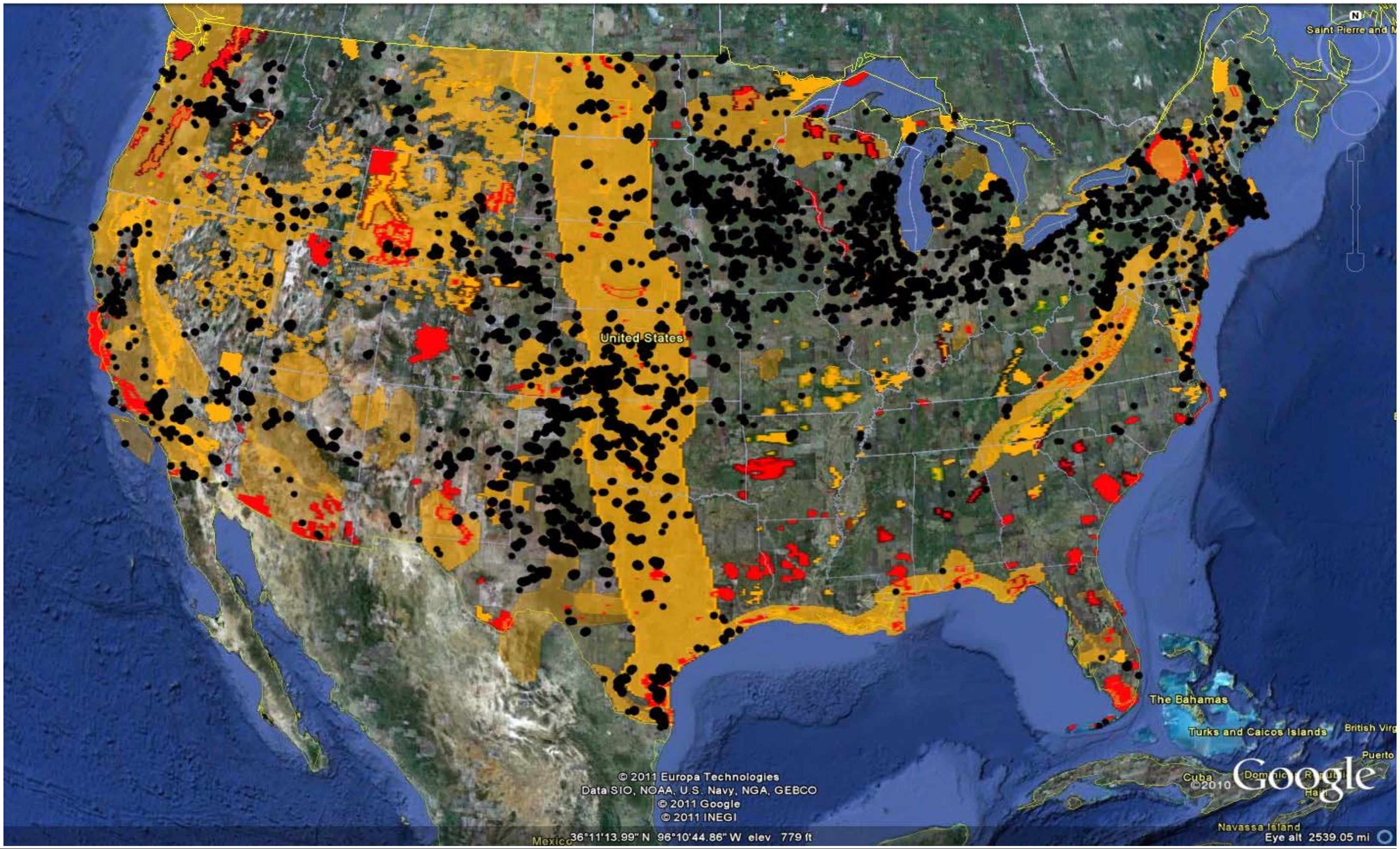
Orange indicates areas that are highly important to birds. Wind development might sometimes be possible in orange locations but will require especially careful siting and operation. Wind power should also only be developed after thorough pre-construction assessments can prove there is not a significant bird problem for a particular planned turbine configuration, or can identify ways that micro-siting or operational mitigation can effectively address any identified problem. Such areas include: Globally Important Bird Areas, important habitat for high-priority WatchList birds, and areas where migratory birds can be expected to be significantly affected. Monitoring and compensatory mitigation will be needed to redress the loss of any birds or habitat unavoidably harmed.

Areas shown in a tint of orange are either (a) Key Migration Corridors where risk to birds will differ from season to season, and may also differ from year to year between specific locations within the corridor, or (b) Key Habitat Areas for specific at-risk species where the species may not be present all year round, and birds are likely to be most at risk from wind development where their optimal habitat is found within the tinted area.

Areas that are not colored orange or red can generally be developed for wind energy if well-conducted pre-construction assessments do not indicate an unexpected or previously unknown bird impact or habitat problem, and so long as appropriate construction and operational mitigation, monitoring, and compensatory mitigation are implemented.

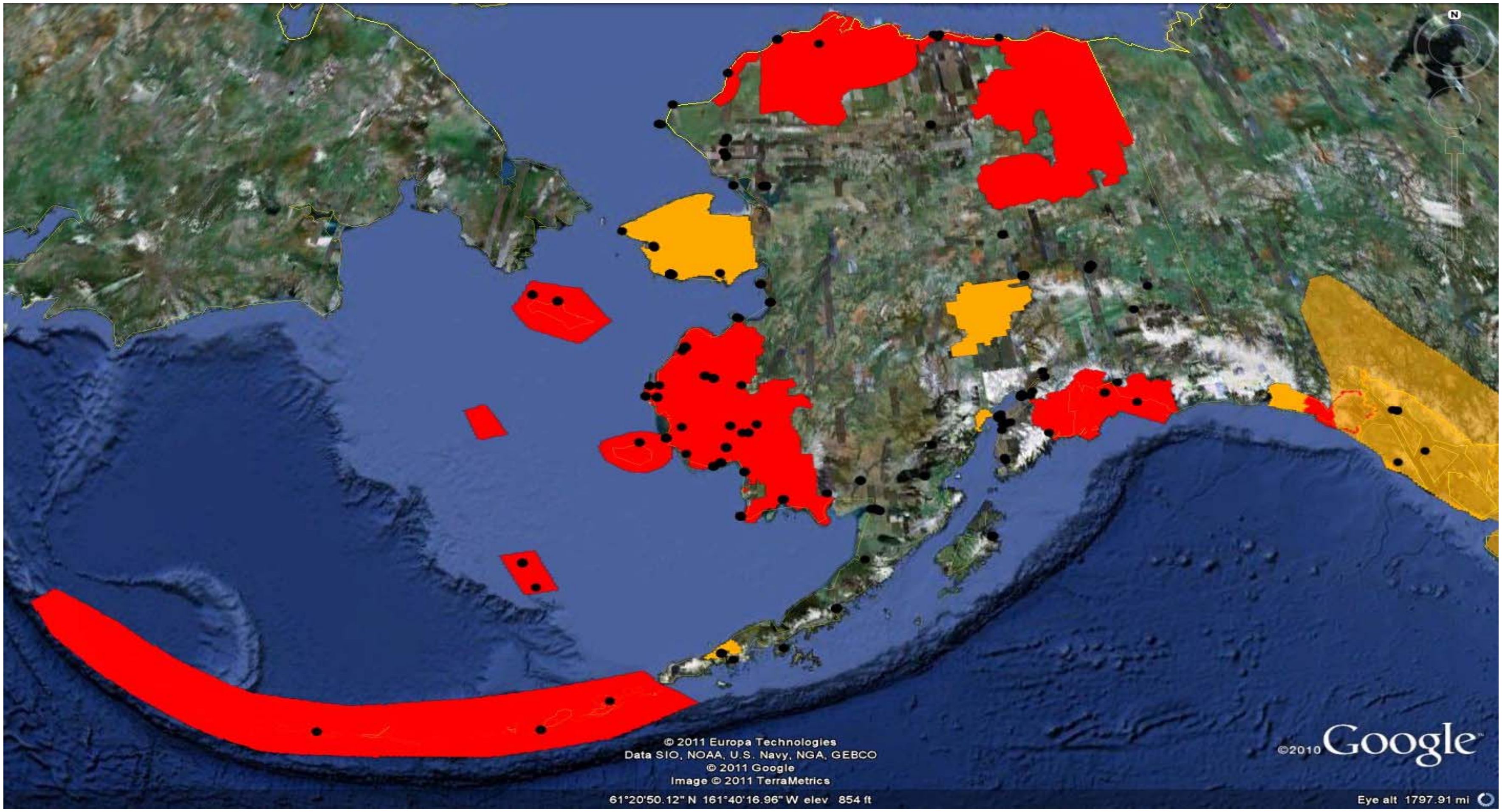
The maps are based on the best data available to ABC as of early December 2011 and ABC will update the maps over time.

MAP 3.1: Key Bird Use Areas and Estimated Wind Turbines in the Lower 48 States (2003-2011)[101]



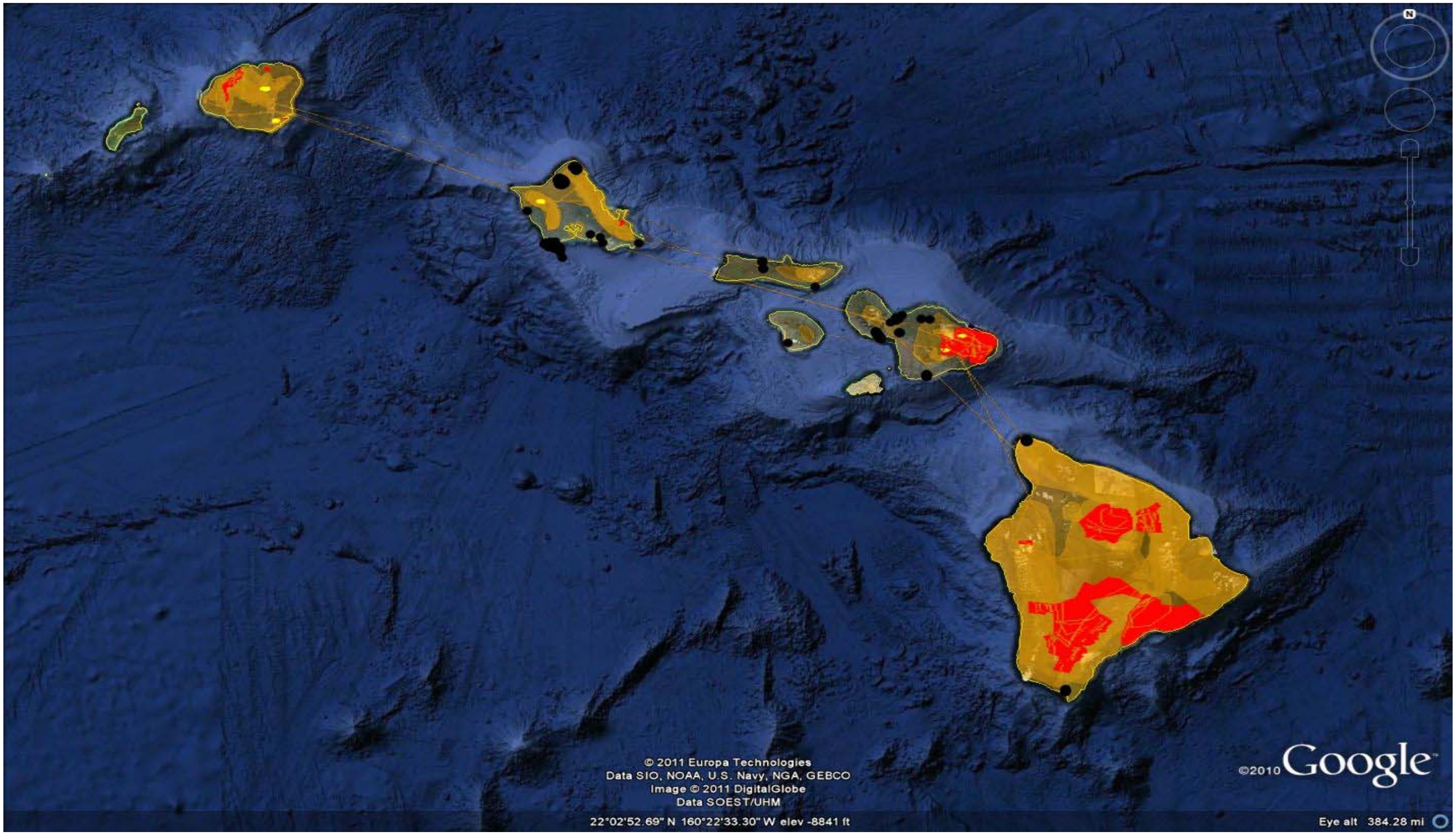
[101] Black represents proposed wind turbines and meteorological towers logged with the FAA between 2003 and 2011 in 48 states in the United States. Red indicates critically important areas for birds where wind energy should not be developed. Wind development might sometimes be possible in orange locations but will require especially careful siting and operation. All maps provided in this Petition are based on data available on the FAA website.

MAP 3.2: Key Bird Use Areas and Estimated Wind Turbines in Alaska (2003-2011)[102]



[102] Black represents proposed wind turbines and meteorological towers logged with the FAA between 2003 and 2011 in Alaska. Red indicates critically important areas for birds where wind energy should not be developed. Wind development might sometimes be possible in orange locations but will require especially careful siting and operation. All maps provided in this Petition are based on data available on the FAA website.

MAP 3.3: Key Bird Use Areas and Estimated Wind Turbines in Hawaii (2003-2011)[103]



[103] Black represents proposed wind turbines and meteorological towers logged with the FAA between 2003 and 2011 in Hawaii. Red indicates critically important areas for birds where wind energy should not be developed. Wind development might sometimes be possible in orange locations but will require especially careful siting and operation. All maps provided in this Petition are based on data available on the FAA website.

Cumulative impacts

Finally, wind energy development can harm birds through its addition to the cumulative impacts of all the threats that birds face. According to the GAO:

> Scientists, in particular, are concerned about the potential cumulative impacts of wind power on species populations if the industry expands as expected. Such concerns may be well-founded because significant development is proposed in areas that contain large numbers of species or are believed to be migratory flyways. Concerns are compounded by the fact that the regulation of wind power varies from location-to-location and some state and local regulatory agencies we reviewed generally had little experience or expertise in addressing the environmental and wildlife impacts from wind power. In addition, given the relatively narrow regulatory scope of state and local agencies, it appears that when new wind power facilities are permitted, no one is considering the impacts of wind power on a regional or "ecosystem" scale—a scale that often spans governmental jurisdictions. FWS, in its responsibility for protecting wildlife, is the appropriate agency for such a task and in fact does monitor the status of species populations, to the extent possible.

GAO Wind Power Report at 43 (emphases added). FWS has also stated that cumulative impacts are important: "Declining bird populations are probably most often the result of combined or cumulative impacts of all mortality, thus addressing each of the contributing factors is a priority." FWS, Migratory Bird Mortality: Many Human-Caused Threats Afflict our Bird Populations 2 (2002).[104]

All of the impacts of wind energy projects, described above, pose a serious threat to migratory birds. This is particularly so because at present FWS does not have any mandatory standards and regulations in place for development of wind energy projects in a manner that is protective of migratory birds.

C.3. At present, for land-based wind energy projects, FWS is relying on a system of voluntary compliance with the MBTA that is empirically ineffective in protecting migratory birds and will lead to rampant violations of federal law.

The MBTA, ESA, and BGEPA, prohibit "take" of migratory birds, endangered and threatened species, and Bald and Golden Eagles. Both the ESA and the implementing regulations of BGEPA provide mechanisms for FWS to regulate take of endangered and threatened species and Bald and Golden Eagles by individual wind energy projects (typically by issuing incidental take

[104] Available at http://www.fws.gov/birds/mortality-fact-sheet.pdf (last visited Nov. 15, 2011).

permits subject to various terms and conditions). However, at present no such comparable mechanism exists under the MBTA.

In lieu of mandatory standards and obligations for avoiding and minimizing the wildlife impacts of wind energy projects, FWS has long elected to merely provide non-binding "recommendations" to the wind industry that developers may "voluntarily" choose to follow or reject.

While such recommendations are wholly inadequate, as described further below, it should be noted that such recommendations recognize the need for a federal (and not a state) system to protect migratory birds from the threats posed by wind energy projects. For instance, state public service commissions, which are typically the state authorities that are involved in the approval of wind energy projects on non-federal lands, unlike FWS, are not equipped to address the cumulative migratory bird impacts of wind energy projects. Indeed, the MBTA itself is premised on the recognition that migratory birds constitute a unique federal trust resource that ought to be protected under a federalized system rather than in an ad hoc manner by individual states.[105] In State of Missouri v. Holland, 252 U.S. 416 (1920), the U.S. Supreme Court upheld the constitutionality and validity of the MBTA and particularly recognized the need for "national action" in lieu of potentially inconsistent state actions to protect and regulate take of migratory birds. The Court observed as follows:

> No doubt it is true that as between a State and its inhabitants the State may regulate the killing and sale of such birds, but it does not follow that its authority is exclusive of paramount powers…. The whole foundation of the State's rights is the presence within their jurisdiction of birds that yesterday had not arrived, tomorrow may be in another State and in a week a thousand miles away…. Here a national interest of very nearly the first magnitude is involved. It can be protected only by national action in concert with that of another power. The subject matter is only transitorily within the State and has no permanent habitat therein. But for the treaty and the statute there soon might be no birds for any powers to deal with. We see nothing in the Constitution that compels the Government to sit by while a food supply is cut off and the protectors of our forests and our crops are destroyed. It is not

[105] Further, under international law, migratory species that migrate between two or more nations constitute "shared natural resources" over which a single nation cannot assume unilateral control such that it deprives the other concerned nations of their right to an equitable and reasonable share of the resource. See, e.g., U.S.-Import Prohibition of Certain Shrimp and Shrimp Products, 12 October 1998, 38 ILM 118 ¶133 (observing that sea turtles are highly migratory animals, passing in and out of the waters of various coastal states and that each of such states can claim an interest in the species conservation); see also Philippe Sands, Principles of International Environmental Law 238 (2d ed. 2003); U. N. Env't Prog., Principles of Conduct in the field of the Environment for the Guidance of States in the Conservation and Harmonious Utilization of Natural Resources Shared by Two or More States, 17 ILM 1097 (1978), Principle 3(3).

> sufficient to rely upon the States. The reliance is vain, and were it otherwise, the question is whether the United States is forbidden to act. We are of opinion that the treaty and statute must be upheld.

252 U.S. at 434-435.

In recognition of its federal trust responsibility to protect migratory birds, in 2003, FWS issued "Interim Guidance" designed to address impacts of wind energy projects on migratory birds and other wildlife. See FWS, Interim Guidance on Avoiding and Minimizing Wildlife Impacts From Wind Turbines (May 13, 2003) ("2003 Interim Guidance").[106] FWS indicated its intent to evaluate the guidance over a two-year period. The guidance contained "voluntary" guidelines for the wind industry and did not impose any mandatory requirements to avoid or minimize wildlife impacts. In fact, in 2004, FWS issued a memo which reiterated "the voluntary and flexible nature" of the 2003 Interim Guidance and went so far as to state that, "[t]he Interim Guidelines are not to be construed as rigid requirements, which are applicable to every situation, nor should they be read literally." Memo from Steven Williams, FWS Director to FWS Regional Directors, Implementation of Service Voluntary Interim Guidelines to Avoid and Minimize Wildlife Impacts from Wind Turbines (Apr. 26, 2004).[107]

Subsequently, DOI announced the formation of a Wind Turbine Guidelines Federal Advisory Committee ("Wind FAC") to provide recommendations and advice to DOI and FWS "on developing effective measures to protect wildlife resources and enhance potential benefits to wildlife that may be identified." DOI, Establishment of Wind Turbine Guidelines Advisory Committee, 72 Fed. Reg. 11373 (Mar. 13, 2007). On October 26, 2007, the Secretary of the Interior announced in a press release that 22 individuals had been named to serve on the Wind FAC. Thereafter, several wildlife conservation groups raised objections about the skewed composition of the Wind FAC which was dominated by representatives of the wind power industry. Many members of the wildlife conservation community argued that the Committee violated the requirements of the Federal Advisory Committee Act ("FACA"), 5 U.S.C. App. 2 §§1-16, that all chartered advisory committees must be "fairly balanced in terms of the points of view represented and the functions to be performed by the advisory committee," and "will not be inappropriately influenced by … any special interest." Id. §§ 5(b)(2)-(3). In response to these objections, although DOI made some limited changes to the composition of the Committee, the members representing the wildlife protection interests continue to be clearly outweighed by industry advocates and do not represent the full spectrum of viewpoints on the issue that exist within the wildlife protection community.[108]

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[106] Available at http://www.fws.gov/midwest/wind/guidance/Serviceinterimguide.pdf (last visited Nov. 17, 2011).

[107] Available at http://www.fws.gov/habitatconservation/wind_guidelines.pdf (last visited Nov. 17, 2011).

[108] Indeed, by far the largest single voting bloc on the Committee is constituted by the wind industry representatives. Excluding the FWS official who works for the agency receiving the recommendations, there

On April 13, 2010, the Wind FAC submitted its final recommendations to FWS and DOI. See Wind Turbine Guidelines Advisory Committee Recommendations (2010) ("Committee Recommendations").[109] Instead of merely rubber-stamping the Committee Recommendations, FWS's wildlife biologists recognized that those Recommendations suffered from certain shortcomings and would not accomplish their stated conservation objectives, at least without substantial revision. See FWS, Comparison of FAC Recommendations to FWS Draft Voluntary Guidelines (Feb. 2011).[110] Thus, FWS convened a team of its wind-wildlife experts during late spring 2010 to prepare new guidelines for wind energy projects, which were finally published for public comment by FWS on February 8, 2011, i.e., the Draft Voluntary Land-Based Wind Energy Guidelines ("Wind Guidelines First Draft") and the Draft Eagle Conservation Plan Guidance ("Eagle Guidance"). See FWS 2011 MBTA Conference Presentation at 13. Both documents provided agency recommendations for industry to avoid and minimize wildlife impacts.

The Wind Guidelines First Draft was commended by many in the conservation community as an important first step, and there was strong support for further strengthening the guidelines and making their provisions mandatory for wind energy developers. See, e.g., ABC et al., Wind Energy Guidelines Comments (May 19, 2011) ("The guidelines must be strengthened and made mandatory"); Black Swamp Bird Observatory, Wind Energy Guidelines Comments (May 18, 2011) ("If the Guidelines are to truly avoid and minimize negative effects to fish, wildlife and their habitats resulting from construction, operation and maintenance of land-based, wind energy facilities, then the Guidelines, once finalized, must be regulatory and not voluntary on all lands, public and private."); Cornell Lab of Ornithology, Comments to the U.S. Fish and Wildlife Service: Draft Land-based Wind Energy Guidelines (May 2011) ("We respectfully suggest that at least some components of the Guidelines move forward as mandatory."); Friends of Blackwater et al., Wind Energy Guidelines Comments and Eagle Conservation Plan Guidance Comments (May 19, 2011) at 2 ("Unfortunately, as presently written, the Guidelines cannot satisfy this fundamental objective for a national policy on land-based wind power projects because the Guidelines' provisions addressing siting, construction, operation, and monitoring are merely voluntary, i.e., wind energy developers can choose not to adhere to the requirements in the Guidelines."); Conservation Biology Inst., Comments on Wind Energy Guidelines (May 19, 2011) ("the proposed wind energy guidelines, as drafted, are unlikely to lead to the types of rigorous regional analyses that are necessary to adequately assess potential ecological and cumulative impacts…. The guidelines should be

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are 21 current members in the Committee – 43% are wind industry representatives where 7 members work in wind energy companies and 2 members are lawyers who represent wind energy companies. See DOI Press Release, Interior Secretary Kempthorne Names Members for Committee to Address Wildlife Impacts of Wind Turbines (Oct. 26, 2007); see also FWS, Committee Background, http://www.fws.gov/habitatconservation/windpower/wind_turbine_advisory_committee_information.html (providing a list of the current members of the Committee).

[109] Available at http://www.fws.gov/habitatconservation/windpower/wind_turbine_advisory_committee.html (last visited Dec. 12, 2011).

[110] Available at http://www.fws.gov/windenergy/index.html (last visited Nov. 17, 2011).

regulatory, not voluntary, on both public and private lands, and should be enforced."); Pa. Game Comm'n, FWS Draft Land-based Wind Energy Guidelines (May 2011) ("the Guidelines would be more effective if they are regulatory rather than voluntary."); San Diego Audubon Soc'y, Wind Energy Guidelines Comments (May 19, 2011) ("Given the strong federal emphasis on expanding wind power throughout the country, mandatory guidelines are absolutely essential to preserve our avian heritage. They need to be mandatory now, before thousands of new wind turbines, transmissions lines, and access roads are installed in inappropriate locations, not later when it is too late."); Email Comment from Roger Shamley, President Chicago Audubon Soc'y (Mar. 5, 2011) ("I suggest that if you are serious about this issue that you make compliance mandatory, rather than optional."); Pub. Employees for Envtl. Responsibility (PEER), Wind Energy Guidelines Comments (May 19, 2011) ("Making the Guidelines voluntary rather than mandatory renders them meaningless…. PEER urges USFWS to make mandatory Guidelines for the siting of these facilities.").[111]

Nonetheless, the Committee itself – which in any event under FACA may only play a purely "advisory" role in the decision-making process, 5 U.S.C. App. II § 2(b)(6) ("the function of advisory committees should be advisory only") – expressed its "disappoint[ment]" with the agency's strengthened guidelines, and urged the agency to modify its recommendations in order "to mirror the FAC Recommendations." FWS, April 27, 2011 Wind Federal Advisory Committee Meeting Summary 2, 18 (2011).[112] Indeed, although FWS initially requested the public to specifically comment on whether the Wind Guidelines First Draft should be made mandatory, in response to pressure from the Wind FAC, FWS did not again raise or address this issue, despite extensive public comments (cited above) urging FWS to make the guidelines mandatory. See id. at 14 (summarizing FWS's position that, "FWS did not intend to write language that gave it control over the project or the process."); see also id. at 15 (summarizing the FAC's concern that "[t]he Draft Guidelines shift from trust and communication with the FWS to command and control by the FWS.").

Further, in response to extensive pressure (particularly from the industry representatives of the Committee), FWS substantially weakened the wildlife protections in its initial guidelines – so much so that on many issues the subsequent two drafts published by the agency presented a complete departure from the agency's previous position. See FWS, Revised Draft Land-Based Wind Energy Guidelines (July 12, 2011); ("Wind Guidelines Second Draft") and Wind Guidelines Third

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[111] Public comments on the Guidelines are available here: http://www.fws.gov/windenergy/index.html (last visited Nov. 17, 2011).

[112] Available at http://www.fws.gov/habitatconservation/windpower/wind_turbine_advisory_committee_past_mtgs.html (last visited Nov. 14, 2011).

Draft (jointly, the "Revised Wind Guidelines"); see also FWS, Comparison of Wind Federal Advisory Committee Recommendations and Guidelines.[113]

For instance, the Wind Guidelines First Draft recommended pre-construction monitoring for a minimum duration of three years. However, that position of the expert agency on what was necessary to gather adequate pre-construction data for decision-making was modified substantially by draft Revised Guidelines (in accordance with the Committee Recommendations). Accordingly the Revised Guidelines eliminated the specific duration requirement for pre-construction studies. Another example of substantial watering down of FWS's own recommendations and language in the Guidelines concerns the agency's position on adaptive management. In the Wind Guidelines First Draft, FWS extensively premised its recommendations on the need for wind energy developers to carry out comprehensive adaptive management. See Wind Guidelines First Draft at 12 ("Monitoring should be designed to support the adaptive management decision-making/assessment process."); see also id. at 21 (discussing the applicability of adaptive management).

However, in the Revised Guidelines, FWS substantially weakened what were initially strong recommendations for adaptive management and went on to expressly state that: "[a]daptive management should not typically need to be applied to land-based wind energy projects because, in the majority of instances, when a developer follows the Guidelines, the impacts and the level of uncertainty should be low. Nevertheless, the tiered approach is designed to accommodate [adaptive management], when warranted." Wind Guidelines Third Draft at 22 (emphases added). The Service, however, proffered no new data to support the proposition that the impacts and level of uncertainty will be "low" in the absence of meaningful adaptive management.

Further, the changes made to the Guidelines based on the Committee's recommendations are designed to allow project developers to obtain assurances for non-prosecution in exchange for merely documenting FWS recommendations and developers' reasons for "disagreeing" with the Service to show "adherence" to the Guidelines. See Wind Guidelines Third Draft at 13 ("While the advice of the Service is not binding, neither can it simply be reviewed and rejected without a contemporaneously documented reasoned justification, at least if the developer seeks to have the benefit of the enforcement discretion provisions of these guidelines. Instead, proper consideration of the advice of the Service entails contemporaneous documentation of how the developer evaluated that advice and the reasons for any departures from it." (emphasis added)). Further, with respect to take of eagles by wind energy projects, in the Wind Guidelines Third Draft, FWS not only purported to provide non-enforcement assurances without regard to the applicable take permit regulations under BGEPA but, remarkably, did so based on the developers' own determination as to whether such take will occur. See id. ("If taking of eagles is not anticipated, adherence to the Guidelines would give rise to assurances regarding enforcement discretion if an unexpected taking occurs.").

[113] All drafts of the Guidelines and related documents are available here: http://www.fws.gov/windenergy/index.html (last visited Nov. 17, 2011).

Thus, the Revised Guidelines eliminated important recommendations that FWS's own staff had initially adopted in the February 2011 Wind Guidelines First Draft – capitulating to the views of an industry-dominated advisory committee in lieu of the expert agency's own assessment of what is needed to conserve migratory birds and other wildlife resources held in trust for the American people. This is an apparent violation of FACA's directive that the "function of advisory committees should be advisory only," and in any event represents a failure to adopt a system even remotely approximating what the Service's own staff recognized as minimally acceptable to effectuate the MBTA.

Further, while the Revised Wind Guidelines are entirely "voluntary" in nature, the only measure that is "mandatory" as such is one imposed on FWS itself, and not the wind energy developer. The Revised Wind Guidelines impose no mandatory obligations on wind energy developers, but they require FWS to respond to industry proposals for site location within a truncated time frame, i.e., 60 days from receipt of the proposal. See Wind Guidelines Third Draft at 17 ("The Service has determined that Field Offices have 60 calendar days to respond to a request by a wind energy developer to review and comment on proposed site locations, pre- and post-construction study designs, and proposed mitigation."). If the agency fails to provide a response within 60 days, then the developer can proceed with construction of the project without waiting for Service input. Moreover, if the Service takes more than 60 days to respond to the industry proposal, the developer need only consider the Service's recommendations "if feasible" and no comparable flexibility is given to the Service, regardless of the size or complexity of the project, or its risk to wildlife. Id. ("If the Service does not respond within 60 days of receipt of the document, then the developer can proceed through Tier 3 without waiting for Service input. If the Service provides comments at a later time, the developer should incorporate the comments if feasible." (emphases added)).

Thus, despite being well-aware that wind energy projects will invariably take migratory birds protected under the MBTA, FWS has embarked on an approach that merely provides voluntary guidelines in lieu of mandatory obligations for wind energy developers, and that affords developers little incentive to abide by the determinations of FWS biologists as to which sites pose unacceptable risks to migratory birds. See infra Section E.3.ii (discussing various letters sent by FWS to wind energy developers and/or their consultants cautioning them about their project's wildlife impacts). There is no empirical, or even rational, basis for concluding that these guidelines, especially as so watered-down and weakened in response to industry pressure, will be sufficient to ameliorate the serious and growing impacts of poorly sited wind power projects on migratory birds. To the contrary, it is predictable that the Guidelines will have the opposite effect by, in essence, encouraging wind power companies to believe that they may avoid prosecution for violations of the MBTA by self-certifying that they have "complied" with the Guidelines simply by documenting their reasons for declining to abide by the Service's recommendations.

C.4. At present, FWS does not have any standards – not even voluntary guidelines – for addressing the impacts of offshore wind energy projects on migratory birds.

The "voluntary" Guidelines described supra, Section C.3, only apply to land-based wind energy projects and no such comparable document exists for avoiding and mitigating the serious wildlife impacts of offshore wind energy projects. The current draft of the Guidelines further states that "[o]ffshore wind energy projects may involve another suite of effects and analyses not addressed here." Wind Guidelines Third Draft at 16. In discussions in July and September 2011, FWS staff has told ABC personnel that while FWS might decide to prepare voluntary guidelines for offshore wind at some time in the future, the agency does not currently have a timeline for the preparation of such a document, and in fact has not made a decision to do so. Communication between Kelly Fuller, ABC and Albert Manville, FWS (July 12, 2011), and Jerome Ford, FWS (Sept. 20, 2011). Instead, FWS plans to provide case-by-case input to BOEM in regard to wildlife at proposed offshore wind facilities in federal waters. In addition, FWS plans to provide comments regarding Army Corps of Engineers' permits for offshore wind facilities.

FWS's approach to exercising oversight over offshore wind energy projects is extremely inadequate. At present, there are no mandatory standards or rules implementing the MBTA for offshore wind energy project developers. Indeed, there are not even inadequate "voluntary" guidelines such as those that exist for land-based projects. As a result, different FWS regional offices may propose varying methods and measures, resulting in no consistent standard for offshore wildlife protection. Furthermore, the lack of standardized regulatory guidance makes it impossible for offshore wind developers to plan ahead of time for what they will be asked to do. This uncertainty may complicate private-sector project financing, thus discouraging the development of offshore wind energy. In addition, in the absence of standardized regulatory guidance from FWS, other federal agencies that lack FWS's avian expertise may move into the void and issue what may become de facto offshore wind guidelines. In fact, BOEM has already taken a step down this road by including Best Management Practices ("BMPs") for reducing avian impacts of offshore wind projects in its Alternative Energy Programmatic Environmental Impact Statement. However, these BMPs set the bar very low and are entirely inadequate to reduce wildlife impacts. U.S. Minerals Mgm't Serv., OCS Alternative Energy and Alternate Use Programmatic Environmental Impact Statement at 2-25 to 2-26.[114]

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[114] The document lists merely five minimal BMPs: "The Lessee shall evaluate avian use of the project area and design the project to minimize or mitigate the potential for bird strikes and habitat loss. The amount and extent of ecological baseline data required will be determined on a project-by-project basis; Lessees shall take measures to reduce perching opportunities; Lessees shall locate cable landfalls and onshore facilities so as to avoid impacts to known nesting beaches; Wind turbine rotors should not come within 30 m (100 ft) of the ocean surface to minimize impacts to water birds; Lessees shall comply with the FAA and Corps requirements for lighting while using lighting technology (e.g., low-intensity strobe lights) that minimizes impacts to avian species." Needless to say, these five BMPs are not sufficient to avoid, minimize, and mitigate the impacts of offshore wind facilities on birds protected by the MBTA. Available at http://ocsenergy.anl.gov/documents/fpeis/Alt_Energy_FPEIS_Chapter2.pdf. (last visited Nov. 20, 2011).

It is also necessary for FWS to expeditiously take appropriate action to regulate the impacts of offshore wind energy projects on migratory birds because the regulatory processes of BOEM and the Corps will not ensure that all offshore wind energy projects adequately avoid, minimize and mitigate impacts to birds covered by the MBTA.

First, BOEM's regulatory authority over offshore wind projects is limited to those in waters over which BOEM has jurisdiction, which is currently limited to federal offshore waters and would not apply to state waters. In general, state waters extend three nautical miles from shore, however the state water limits in Texas and Florida (off the Gulf Coast) extend to about nine nautical miles. In addition, the Great Lakes are considered state waters. Office of Ocean and Coastal Res. Mgm't and Nat'l Oceanic and Atmospheric Admin., State Jurisdiction and Federal Waters 1 (2011).[115] The relative lack of federal regulatory processes in state waters has been marketed by some states, such as Texas, as a reason for offshore wind developers to develop projects in their state waters. Tex. Gen. Land Office, Texas Offshore Wind Energy ("Developers partnering with the Land Office find the state easy to do business in. Texas' unique coastal sovereignty - out to 10.3 miles - means less federal entanglement.").[116]

Second, while FWS can provide comments during BOEM and Corps processes, unless FWS has its own binding determination to issue under the MBTA, the agency's comments need not be followed, which will leave the agency without a clear path for fulfilling its mandate to protect migratory birds. Wind energy development in state water locations will present significant challenges if it is sited and operated without a concrete framework for avoiding, minimizing and mitigating wildlife impacts. As a general rule of thumb, more birds use near shore areas than locations farther out to sea. In the eastern United States, for example, large numbers of birds migrate along the Atlantic Coast. Likewise, the Texas Gulf Coast is heavily used by birds migrating to and from Globally Important Bird Areas. The Great Lakes are also potentially a difficult location because of the large amount of bird migration that takes place across them. Thus, offshore wind facilities in state jurisdictional waters are where some of the most serious impacts to birds protected by the MBTA could take place, but where FWS may have the least ability to fulfill its wildlife protection mandate, unless a permitting scheme such as that proposed in this Petition is adopted.

Wind energy development in waters outside of federal jurisdiction is already underway and several wind energy projects are being constructed in state waters – areas which, although covered by the MBTA's general prohibition on unauthorized take, may lack any other federal mechanism to the project affording an adequate review of wildlife impacts. The proposed Baryonyx offshore wind facility would entail 500 6-MW wind turbines between five and ten miles off the Texas shore, with

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[115] Available at http://seagrant.gso.uri.edu/coast/cmsp_material/state_fed-waters.pdf (last visited Nov. 20, 2011).

[116] Available at http://www.glo.texas.gov/glo_news/hot_topics/articles/offshore-wind-energy.html (last visited Nov. 20, 2011).

transmission cables potentially crossing Padre Island, Padre Island National Seashore, Corpus Christi Bay, and Laguna Madre. The project has already completed a public comment period related to scoping for an environmental review document (EA or EIS) from the Corps. The Baryonyx project could be disastrous for wildlife, as the FWS comment letter made clear. See Letter from Allan M. Strand, FWS to Jayson Hudson, Corps (Aug. 15, 2011), Attachment L; see also Kelly Fuller, ABC, Comments on Permit Application SWG-2011-00511 (Baryonyx Corporation Offshore Wind Project (Aug. 17, 2011) (ABC comments submitted to the Corps).

In addition, it is unclear whether the Corps' environmental review will be rigorous, given that it is taking place in the context of permit requirements under the Clean Water Act, and that the Corps has a long track record of failing to address all of the adverse wildlife impacts flowing from its permitting decisions. The proposed Baryonyx offshore wind facility is not the only one being considered for Texas state waters. ABC has been informed that as of August, 2011, Coastal Point had an offshore lease with the Texas State Land Commission and Offshore Wind Systems had a permit from the Corps for an offshore wind testing structure. Personal communication between Kelly Fuller, ABC and Bob Blumberg, Texas General Land Office (Aug. 29, 2011). Coastal Point has since announced plans to install one offshore wind turbine by the end of 2011. See Nathanial Gronewold, Texas is Bullish on Offshore Wind (E & E News, Nov. 21, 2011), Attachment M. Offshore wind projects in Texas are of tremendous concern because the Texas Gulf Coast is the most sensitive coastal area for birds in the United States, and the State of Texas does not have its own wind energy permitting process with environmental review.

Wind turbine projects in the jurisdictional waters of other states have also been proposed. Although these are currently small proposals, the scale of offshore projects is expected to increase. In addition, in the wrong location, even a single offshore wind turbine could have serious impacts. Some examples of offshore wind energy project proposals in state waters are listed below:

- Gamesa Energy USA and Northrup Grumman International have proposed building a 5-MW wind turbine in lower Chesapeake Bay and the state's Marine Resources Commission has given approval for preliminary studies of the site to take place. FWS staff have raised concerns about potential bird impacts at the Chesapeake Bay location, but the agency was informed that the site could not be changed. See Email from Tylan Dean, FWS to Keith Hastie, FWS (Mar. 30, 2011), Attachment N.
- Fishermen's Energy, LLC has proposed a five-turbine, 20 MW wind facility approximately three miles off Atlantic City in New Jersey state waters. See Fishermen's Energy, LLC, FAQ.[117] In spring 2011, the project received all the necessary state permits and is currently awaiting a permit from the Corps. The company has also expressed interest in developing

[117] Available at http://www.fishermensenergy.com/faq.html (last visited Nov. 20, 2011).

offshore wind in the Great Lakes. Fishermen's Energy, LLC, VA Offshore Wind 2011 Presentation (June 22, 2011).[118]

- The University of Delaware has proposed a six-turbine offshore wind facility approximately 2.8 miles off the coast in Delaware state waters and has met with the Corps to discuss it. Corps, Wind Turbine Proposals within Philadelphia District (2011).[119]
- Deepwater Wind has proposed a five turbine offshore wind facility approximately three miles off Block Island, in Rhode Island state waters. Deepwater Wind, Block Island Wind Farm.[120] In September, 2011, Deepwater announced that a marine survey at the site had begun. See Deepwater Wind, Block Island Wind Farm Project Advances with Cutting-Edge Marine Surveys, Expanded Team (Sept. 22, 2011).[121]
- West Wind Works, LCC has expressed interest in building a 400 MW offshore wind facility three nautical miles south of Oahu. This location may be in the state waters of Hawaii. Email from Kyle Avery, West Wind Works to Hawaii Inter-island Renewable Energy Program, Public Scoping Comment on Hawaii Interisland Renewable Energy Program: Wind (Mar. 9, 2011).[122]
- The Lake Erie Energy Development Corporation (LEEDCO) and Freshwater Wind, LLC announced in January 2011 that they have a signed option with the state of Ohio to lease lake bottom land in Lake Erie for a 20 MW offshore wind facility of five turbines, approximately seven miles offshore NW of Cleveland. LEEDCo's reported goal is 1,000 MW of offshore wind development in Lake Erie by 2020. See Offshorewindbiz.com, LEEDCo and Freshwater Wind Sign Option With State Ohio to Lease Lake Erie to Build Offshore Wind Farm (Jan. 11, 2011).[123] According to an October 2011 Corps fact sheet, LEEDCo's project would be five to eight turbines, and the Corps is encouraging its construction in Lake Erie in order to judge impacts. Larger projects would be built later, up to 1,520 offshore wind

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[118] Available at http://vasierraclub.org/Goldsmith.pdf (last visited Nov. 20, 2011).

[119] Available at http://www.nap.usace.army.mil/cenap-op/regulatory/wind_turbine.html (last visited Nov. 20, 2011).

[120] Available at http://dwwind.com/block-island/block-island-project-overview (last visited Nov. 20, 2011).

[121] Available at http://dwwind.com/news/block-island-wind-farm-project-advances-with-cutting-edge-marine-surveys-expanded-team/?a=news&p=news (last visited Nov. 20, 2011).

[122] Available at http://www.hirepeis.com/documents/scopingcomments/ngos_private_entities/WestWindWords.pdf (last visited Nov. 20, 2011).

[123] Available at http://www.offshorewind.biz/2011/01/09/leedco-and-freshwater-wind-sign-option-with-state-ohio-to-lease-lake-erie-to-build-offshore-wind-farm-usa/ (last visited Nov. 20, 2011).

turbines in the Great Lakes state waters of New York, Ohio, and Pennsylvania. See Corps, Offshore Wind Farm Sitings on the Lower Great Lakes Fact Sheet (Oct. 2011).[124]

Further, the first offshore wind energy project in federal waters approved by the federal government – the Cape Wind project – has raised several concerns about its wildlife impacts, particularly to migratory birds. Several environmental organizations including Public Employees for Environmental Responsibility have challenged that decision on the grounds that the project, as designed, will kill thousands of federally protected birds, without the level of pre-construction surveying that had been recommended by FWS and without any coherent post-construction monitoring or mitigation plan in place for the project. See Second Amended Complaint at 27, 31, Public Employees for Environmental Responsibility v. Bromwich, Case No. 1:10-cv-01067-RMU (D.D.C. 2010).

Thus, as things presently stand, there are patently inadequate, if not counterproductive, voluntary "Guidelines" for land-based wind power projects and not even a guidance document for offshore projects. On the other hand, as described in detail infra, Section D.2 and Section E.1, FWS has more than sufficient legal authority to establish meaningful, effective measures for protecting migratory birds.

D. STATUTORY BACKGROUND: THE BROAD SCOPE OF THE MBTA'S TAKE PROHIBITION

D.1. The MBTA is a broad wildlife conservation statute that prohibits both intentional and incidental take, unless expressly permitted by FWS.

The MBTA is a conservation statute "designed to prevent the destruction of certain species of birds." Andrus v. Allard, 444 U.S. 51, 52-53 (1979) (noting that the statute was originally enacted to give effect to the 1916 convention between the United States and Great Britain (then for Canada) for the protection of migratory birds, "and for other purposes.").[125] Subsequent MBTA amendments ratified similar bilateral conventions with Mexico in 1936, Japan in 1972, and Russia in 1976.

At present, approximately 1,007 bird species are protected under the Act, ranging from a wide variety of songbirds, waterfowl, and shorebirds to hawks, owls, vultures, and falcons, including

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[124] Available at http://www.lrb.usace.army.mil/Factsheets/NYS/NY-22/Offshore%20 WindFarms% 20Oct%202011.pdf (last visited Nov. 20, 2011).

[125] The phrase "other purposes" has been interpreted to mean purposes other than giving effect to the treaty wherein "Congress intended to invoke its own powers to accomplish other purposes than those enabled by the treaty." Cerritos Gun Club v. Hall, 96 F.2d 620, 627-628 (9th Cir. 1938).

Golden Eagles and Bald Eagles.[126] See FWS, Revised List of Migratory Birds and Your Permit: Questions and Answers (Nov. 1, 2010).[127] These species are shared natural resources subject to FWS's "federal trust responsibility," i.e., FWS, as a trustee of these resources, has the duty to conserve, protect and enhance migratory birds. See FWS, Recommendations to Avoid Adverse Impacts to Migratory Birds, Federally Listed Species, and Other Wildlife form Communication Towers & Antennae (2000) ("Migratory birds are a federal trust resource responsibility, and the Service considers migratory bird concentration areas environmentally significant."); see also Wind Guidelines Second Draft at 3, 12.

The MBTA prohibits the taking or killing of migratory birds, as well as any attempt to take or kill migratory birds or any part, nest, or eggs of any such bird, "at any times, by any means, or in any manner." 16 U.S.C. § 703; see also Andrus, 444 U.S. at 56, 57, 59–60 (describing the statutory prohibitions of the MBTA as "comprehensive," "exhaustive," "carefully enumerated," "expansive," and "sweepingly framed"). Regulations implementing the statute explain that the term "take" means to "pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to pursue, hunt, shoot, wound, kill, trap, capture, or collect." 50 C.F.R. § 10.12. Significantly, the statute does not have a mens rea requirement, i.e., entities that violate the Act can be prosecuted on a strict liability basis regardless of intent or motive to take or kill migratory birds. Further, it is pertinent to note that unlike BGEPA's take prohibition, the MBTA also prohibits "attempt" to take. Compare BGEPA, 16 U.S.C. § 668c and 50 C.F.R. § 22.3 with MBTA, 16 U.S.C. § 703 and 50 C.F.R. § 10.12.

Plainly, as courts have agreed, the take prohibition in the MBTA is broad and prohibits both intentional take, such as hunting, and incidental or unintentional take, such as bird mortality due to collision with wind turbines. See, e.g., Ctr. for Biological Diversity v. Pirie, 201 F. Supp. 2d 113 (D.D.C. 2002) (military training exercises of the Department of the Navy resulting in incidental take of migratory birds without a permit violated the MBTA); United States v. Apollo Energies, Inc., 611 F.3d 679, 684 (10th Cir. 2010) (failure to bird-proof oil drilling equipment resulting in incidental take of migratory birds is a violation of the MBTA); United States v. Moon Lake Elec. Ass'n, 45 F. Supp. 2d 1070 (D. Colo. 1999) (failure to install protective equipment on power poles by electrical association resulting in incidental take of migratory birds is a violation of the MBTA); United States v. FMC Corp., 572 F.2d 902 (2d Cir. 1978); United States v. Corbin Farm Serv., 444 F. Supp. 510

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[126] Bald and Golden Eagles are protected under both the MBTA and BGEPA. BGEPA makes it illegal to take any bald or golden eagle, or any part, nest or egg thereof. 16 U.S.C. § 668a. BGEPA provides broad authority to FWS to issue permits for the take of Bald or Golden Eagles in certain circumstances, provided that such permits are compatible with the preservation of the species. Id. § 668a. FWS has recently promulgated regulations establishing a general permit process for incidental takes, under which permits may be granted for unavoidable incidental takes, subject to compliance with appropriate avoidance, minimization and mitigation measures. 50 C.F.R. § 22.6(c).

[127] Available at http://www.fws.gov/migratorybirds/RegulationsPolicies/mbta/Part%2010.muscovy%20Fact%20Sheet.11-1-2010.pdf (last visited Nov. 8, 2011).

(E.D. Cal. 1978) (both cases holding that bird deaths related to pesticide use resulting in incidental take is a violation of the MBTA).

In brief, the MBTA is a national conservation statute which is premised on the "important public policy behind protecting migratory birds," FMC Corp., 572 F.2d at 908, and prohibits both intentional and incidental take.

D.2. **FWS can authorize limited take of protected birds *only* by exercising its broad authority to promulgate regulations and issue take permits under the MBTA.**

Despite the broad take prohibitions embodied in Section 703 of the Act, the scope for FWS to promulgate regulations permitting take and implementing the treaties, "render[s] the initial flat [take] prohibition eminently workable." Larry Martin Corcoran & Elinor Colbourn, Shocked, Crushed and Poisoned: Criminal Enforcement in Non-hunting Cases Under the Migratory Bird Treaties, 77 Denv. U. L. Rev. 359, 371 (1999). Under Section 704 of the MBTA, FWS is "authorized and directed" to determine the exceptions to the MBTA's take prohibition, i.e., FWS has the sole authority and responsibility "to determine when, to what extent, if at all, and by what means" taking of migratory birds is permissible, and to "adopt suitable regulations permitting and governing the same." 16 U.S.C. § 704(a);[128] see also infra Section E.1 (discussing in detail the broad rulemaking authority of FWS over incidental takes).

Such regulations are crucial because in the absence of authorization by FWS regulations for take of migratory birds, activities that kill or have the potential to kill migratory birds are "otherwise *wholly* unlawful." United States v. Catlett, 747 F.2d 1102, 1105 (6th Cir. 1984); see also, e.g., Ctr. for Biological Diversity v. Pirie, 201 F.Supp.2d 113 (D.D.C. 2002) (enjoining military training exercises of the Department of the Navy in the absence of appropriate permit from FWS for incidental take of migratory birds). In addition, under Section 712 of the MBTA, FWS is also expressly authorized to issue implementing regulations related to the international migratory bird treaties. See MBTA § 712(2).

Further, it is well-established that the delegation of authority to the agency was a valid exercise by Congress of its treaty and commerce powers. Bailey v. Holland, 126 F.2d 317, 321 (4th Cir. 1942) (holding that regulations promulgated by the Secretary of Interior prohibiting the hunting of migratory wildfowl on land and water adjacent to certain federally owned lands are valid).

FWS has recognized that its authority to issue take permits under the MBTA stems from the MBTA, 16 U.S.C. §§ 703-712, and its implementing regulations, 50 C.F.R. Pts. 10, 13, 21, 22. See

[128] The authority vested in the President in Section 704(a) has been delegated to the Secretary of the Interior. See Executive Order 10250: Providing for the Performance of Certain Functions of the President by the Secretary of the Interior § 2(b) (June 5, 1951).

FWS, Manual, Authorities, Objectives, and Responsibilities for Migratory Bird Permits, 724 FW 1 (Aug. 6, 2003);[129] see also Meredith Blaydes Lilley & Jeremy Firestone, Wind Power, Wildlife, and The Migratory Bird Treaty Act: A Way Forward, 38 Envtl. L. 1167, 1180 (2008) ("Section 704 of the MBTA confers permitting authority to the Secretary of the Interior, who has, in turn, delegated that authority to U.S. Fish and Wildlife Service."). Further, FWS has stated that the objective of the migratory bird permit program is "[t]o promote the long-term conservation of migratory bird populations while providing opportunities for the public to study, use, and enjoy migratory birds consistent with the [MBTA] and [BGEPA]." Id.

At present, FWS issues MBTA take permits for a range of activities such as import/export, scientific collecting, taxidermy, waterfowl sale and disposal, educational use, game bird propagation, salvage, falconry, raptor propagation, rehabilitation, control of depredating migratory birds, and special purpose activities. See FWS, Manual: Migratory Bird Permits, 724 FW 2 (Aug. 6, 2003).[130] Permittees must maintain accurate records of their permitted activities and may be required to submit reports covering those activities to the Regional Migratory Bird Permit Office. Id. FWS may suspend or revoke a migratory bird permit for a violation of the terms and conditions of the permit or the regulations under which the permit was issued, or for any reason set forth in 50 C.F.R. § 13.27 (permit suspension) and 50 C.F.R. § 13.28 (permit revocation). Id. The validity of any permit is conditioned on observance of all applicable foreign, state, local, or other federal laws. Id. Further, regardless of issuance of a permit, FWS has expressly cautioned that "[t]he migratory birds, nests, eggs, and any portions thereof remain in the stewardship of the Fish and Wildlife Service and may be recalled at any time." Id.

Accordingly, FWS has the statutory mandate to protect "public trust resources" protected under the MBTA and may only authorize take of such resources in accordance with Section 704(a) of the Act, i.e., through "suitable regulations." In the absence of such authorization, any activities that take or have the potential to take protected birds are flatly unlawful.

D.3. FWS has the primary responsibility to enforce the MBTA and its implementing regulations.

The MBTA provides for both misdemeanor, 16 U.S.C. § 707(a), as well as felony offenses. Id. § 707(b). "Any person, association, partnership, or corporation" that "violate[s] any provisions" of the Act or its implementing regulations is guilty of a misdemeanor. Id. § 707(a). On the other hand, felony offenses are more limited in nature and involve "knowingly" taking birds for sale or barter. Id. § 707(b). Thus, taking of migratory birds without an appropriate permit can result in a criminal conviction – either a misdemeanor or, in some circumstances, a felony conviction.

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[129] Available at http://www.fws.gov/policy/724fw1.html (last visited Nov. 17, 2011).

[130] Available at http://www.fws.gov/policy/724fw2.html (last visited Nov. 17, 2011).

Unlike the ESA, the MBTA contains no citizen suit provision, meaning that entities other than the federal government may not initiate legal action against private parties for violating the Act. However, as a number of cases have recognized, private parties may use the APA to pursue civil claims against federal agencies for taking actions that authorize or lead to violations of the MBTA. See, e.g., City of Sausalito v. O'Neill, 386 F.3d 1186 (9th Cir. 2004); Humane Soc'y of the U.S. v. Glickman, 217 F.3d 882 (D.C. Cir. 2000). In any event, because the MBTA does not contain a citizen suit provision, FWS has the primary responsibility to administer and enforce the Act.

Further, in 2001, President Clinton executed Executive Order 13186, 66 Fed. Reg. 3853 (Jan. 17, 2001) ("Migratory Bird Executive Order"),[131] which identified the responsibilities of federal agencies to protect migratory birds under the Act. The Executive Order directs federal agencies to take actions to protect and conserve migratory birds. The Order resulted in memorandums of understanding ("MOUs") between certain federal agencies and FWS, which memorialize actions that each party will take to fulfill their respective responsibilities under the Act. See, e.g., MOU Between BLM and FWS to Promote the Conservation of Migratory Birds (Apr. 2010).[132]

E. DISCUSSION: FWS HAS BOTH THE LEGAL AUTHORITY AND COMPELLING CONSERVATION REASONS TO ESTABLISH AN MBTA PERMITTING REGIME FOR WIND POWER PROJECTS.

E.1. FWS has broad regulatory and permitting authority under the MBTA to regulate incidental take by wind energy projects.

Section 703 of the MBTA establishes a strict liability prohibition against take of listed migratory birds "at any time, by any means or in any manner" "[u]nless and except as permitted by regulations[.]" See 16 U.S.C. § 703 (emphasis added). Pursuant to Section 704, FWS is authorized to permit "take" through "suitable regulations" so long as such taking is compatible with the terms of the migratory bird conventions. Id. § 704(a); see also Fund for Animals v. Kempthorne, 538 F.3d 124 (2d Cir. 2008).

In establishing such regulations, FWS may consider factors such as the zones of temperature and the distribution, abundance, economic value, breeding habits, and times and lines of migratory flight of birds. 16 U.S.C. § 704(a). The regulations may stipulate "when" take is permissible, "to what extent," and "by what means." Id. In addition, under Section 712, FWS is authorized to issue

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[131] Available at http://frwebgate.access.gpo.gov/cgibin/getdoc.cgi?dbname=2001_register&docid=fr17ja01-142.pdf (last visited Nov. 8, 2011).

[132] Available at http://www.blm.gov/wo/st/en/info/regulations/Instruction_Memos_and_Bulletins/national_information/2010/IB_2010-110.html (last visited Nov. 8, 2011).

"such regulations as may be necessary to implement" the migratory bird treaties with Canada, Russia, Japan, and Mexico. Id. § 712(2).

The rulemaking authority conferred upon the Secretary has been "liberally construed," Bailey v. Holland, 126 F.2d 317, 322 (4th Cir. 1942), and is "greatly flexible." Fund for Animals v. Norton, 365 F. Supp. 2d at 419. FWS has "broad permitting authority," Kempthorne, 538 F.3d at 124, and "plenary power" to establish permitting regulations controlling the "taking of migratory birds, which is otherwise *wholly unlawful*." Catlett, 747 F.2d at 1105.

FWS's "broad permitting authority" has been recognized to encompass authority to regulate both intentional and non-intentional or incidental take. Indeed, as described below, FWS's regulatory authority over incidental take has been recognized not only by FWS and federal courts, but by Congress itself.

i. *Congress has recognized FWS's broad rulemaking authority over incidental take under the MBTA.*

The MBTA authorizes FWS to regulate both intentional and incidental take. Congress recognized FWS's authority to regulate incidental take when it enacted the National Defense Authorization Act for FY 2003 ("National Defense Act"). Pub. L. No. 107–314, § 315, 116 Stat 2458 (Dec. 2, 2002). Section 315 of the Act provides that "the Secretary of the Interior shall exercise the authority of that Secretary under [Section 704(a) of the MBTA] to prescribe regulations to exempt the Armed Forces for the incidental taking of migratory birds during military readiness activities[.]" Id. (emphasis added). The Act clearly indicates that Congress did not bestow new authority on FWS to regulate incidental take, but directed it to exercise its existing authority under the MBTA to allow incidental take by the Armed Forces. Accordingly, there can be no legitimate dispute that FWS has the authority to establish permitting regulations for particular activities that are otherwise legitimate but that have adverse impacts on migratory birds.

Further, the legislative history of the National Defense Act shows that Congress deliberately rejected the original proposal to provide a blanket legislative exemption for military activities from the take prohibitions of the MBTA, and instead chose a course of action that would involve FWS exercising its regulatory authority and oversight over the Armed Forces. 148 Cong. Rec. S10858-01, 2002 WL 31520009 at S10861 (Nov. 13 2002) ("We were able to modify a House provision which authorized the exemption of certain Department of Defense activities from the provisions of the Migratory Bird Treaty Act. That was a highly controversial action on the part of the House. We were able to obtain some important concessions in the conference relative to that provision, including an agreement to structure the provisions so that the Department of Interior will be required to exercise its regulatory powers over the Department of Defense activities impacting migratory birds and to require appropriate actions to mitigate the impact of Department of Defense actions on migratory birds." (emphasis added)); see also id. at S10868 ("it is clear in Subsection (d) [of Section 315 of the National Defense Act] that the authority of the Secretary of the Interior to prescribe regulations for the incidental taking of migratory birds during military readiness activities is limited to the Secretary's authority under section 3(a) of the Migratory Bird Treaty Act").

The experience with the National Defense Act further demonstrates that, even with activities as crucial as those necessary for national defense preparedness, Congress did not endorse a wholesale exemption from the MBTA (which, as discussed further below, is tantamount to what the wind power industry is now receiving in view of the Service's systemic failure to enforce the Act's take prohibition against wind power projects), nor did Congress authorize the military to take a purely voluntary approach to MBTA compliance.

Thus, FWS does not require any additional authorization from Congress to regulate incidental take and can do so by exercising its existing authority under the MBTA.

ii. *FWS has already established regulations for permitting certain incidental takes.*

As a result of the National Defense Act, FWS promulgated regulations governing take of migratory birds by the Armed Forces incidental to military readiness activities. See 50 C.F.R. § 21.15 (2007). The regulations require the Armed Forces to "confer and cooperate with the Service to develop and implement appropriate conservation measures" for "those ongoing or proposed activities" that may result in a significant adverse effect on a population of migratory bird species.[133] Id. § 21.15(a)(1) (emphasis added). However, the incidental take authorization provided therein can be suspended or withdrawn by the Secretary. The Secretary can "suspend" take authorization if he determines, after seeking the views of the Secretary of Defense and consulting with the Secretary of State, that the take authorization is no longer compatible with the migratory bird treaties. Id. § 21.15(b)(1). The Secretary can also "withdraw" take authorization in certain circumstances when a proposed military readiness activity is likely to result in significant adverse effects on the population of a migratory bird species. Id. § 21.15(b)(2).

In establishing the incidental take regulations for military incidental take, FWS reiterated that the agency had authority to regulate incidental take under the MBTA, independent of the National Defense Act's directive:

[133] "Significant adverse effect on a population" has been defined by FWS to mean "an effect that could, within a reasonable period of time, diminish the capacity of a population of migratory bird species to sustain itself at a biologically viable level. A population is 'biologically viable' when its ability to maintain its genetic diversity, to reproduce, and to function effectively in its native ecosystem is not significantly harmed. This effect may be characterized by increased risk to the population from actions that cause direct mortality or a reduction in fecundity. Assessment of impacts should take into account yearly variations and migratory movements of the impacted species. Due to the significant variability in potential military readiness activities and the species that may be impacted, determinations of significant measurable decline will be made on a case-by-case basis." 50 C.F.R. § 21.3.

> [T]he authorization that this rule provides is essential to preserving the Service's role in determining what military readiness activities, if any, create an unacceptable risk to migratory bird resources and therefore must be modified or curtailed…. In the Authorization Act, Congress directed the Secretary to utilize his/her authority to permit incidental take for military readiness activities. Furthermore, Congress itself by passing the Authorization Act determined that allowing incidental take of migratory birds as a result of military readiness activities is consistent with the MBTA and the treaties. Thus, this rule does not abrogate the MBTA… The Defense Authorization Act does not limit that authority [of FWS under Section 704 of the MBTA]… the Defense Authorization Act does not restrict or limit our authority in 16 U.S.C. 704 and 712 relative to administering and enforcing the MBTA and complying with the four migratory bird treaties…. Even in the absence of the Authorization Act, regulations authorizing take incidental to military readiness activities are compatible with the terms of the treaties, and therefore authorized by the MBTA.

FWS, Final Rule: Migratory Bird Permits - Take of Migratory Birds by the Armed Forces (Feb. 28, 2007) ("Military Take Final Rule") (emphases added).

In addition to the incidental take regulations for military take, other existing regulations promulgated under the MBTA enable FWS to regulate and authorize certain incidental takes. For example, under 50 C.F.R. § 21.27, FWS has the authority to issue special purpose permits for take that is otherwise outside the scope of the standard form permits of Part 21. See United States v. Winddancer, 435 F.Supp.2d 687, 690 (M.D. Tenn. 2006) ("50 C.F.R. § 21.27 provides for special purpose permits available to all citizens 'for special purpose activities related to migratory birds, their parts, nests, or eggs' that are not otherwise provided for by the other permit provisions."); see also Military Take Final Rule at 8947 ("Special purpose permits may be issued for actions whereby take of migratory birds could result as an unintended consequence."); Wind FAC Legal Subcommittee White Paper at 13 (Oct. 22, 2008) ("FAC Legal White Paper").[134] The relevant portion of the regulation provides that:

> **§ 21.27 Special purpose permits.**
> Permits may be issued for special purpose activities related to migratory birds, their parts, nests, or eggs, which are otherwise outside the scope of the standard form permits of this part. A special purpose permit for migratory bird related activities not otherwise provided for in this part may be issued to

[134] Available at http://www.fws.gov/habitatconservation/windpower/Subcommittee/Legal/Reports/Wind_Turbine_Advisory_Committee_Legal_Subcommittee_White_Paper_(Final_As_Posted).pdf (last visited Nov. 17, 2011).

> an applicant who submits a written application containing the general information and certification required by Part 13 and makes a sufficient showing of benefit to the migratory bird resource, important research reasons, reasons of human concern for individual birds, or other compelling justification.

50 C.F.R. § 21.27 (emphases added).

FWS has issued special purpose permits to authorize certain incidental takes and to exercise ongoing federal oversight over such activities. For example, FWS has issued a special purpose permit to the Channel Islands National Park permitting incidental take of migratory birds resulting from spraying rat poison in order to eradicate black rats on Anacapa Island. See Anacapa Island Restoration Project, Channel Islands National Park, Phase I MBTA Summary Report (2002) (explaining that on Nov. 16, 2001, FWS issued a Special Purpose Permit (MB050154-0) providing incidental take authorization to Channel Islands National Park), Attachment O; see also FWS Memo from Acting Director to Regional Directors, Migratory Bird Permits for Controlling Invasive Species (Jan. 20 2010) ("FWS Invasive Species Memo") (advising that FWS may process applications for special purpose permits under 50 C.F.R. § 21.27 for take of migratory birds incidental to eradication or control of invasive species);[135] FAC Legal White Paper at 13-14 ("[Special purpose permits] potentially could be used to authorize incidental take caused by wind energy projects. For example, a wind energy project theoretically could apply to FWS for a special use permit for an incidental take of birds based on a showing that the wind facility was providing an overall positive benefit to the migratory bird resource, perhaps through accompanying mitigation measures, or constitutes a situation of compelling justification due to the benefits of renewable energy generation.").

Indeed, it appears that FWS has previously undertaken the process of developing general incidental take regulations. See FWS Invasive Species Memo ("The [FWS] Division of Migratory Bird Management is continuing work towards developing regulations to address the larger issue of incidental take of migratory birds. In the meantime, staff should continue to work with our agency counterparts to consider migratory bird impacts during project planning and to incorporate conservation measures where appropriate[.]"). In fact, during the course of litigation concerning take of migratory birds incidental to military readiness activities – a case that was eventually dismissed on mootness grounds upon the enactment of the National Defense Act – the federal government went on record to state that FWS had already drafted a proposed rule that would authorize incidental take of migratory birds by federal agencies. See Brief of Fed. Defendants-Appellants, Ctr. for Biological Diversity v. England, 2002 WL 34248159 (D.C. Cir. Sept. 17, 2002). In that case, the government argued as follows:

[135] Available at http://nctc.fws.gov/CSP/Resources/mig_birds/CD/MBTA%20Resources/invasive_species_memo.pdf (last visited Dec. 11, 2011).

> There are several conceivable avenues by which the Navy could come into compliance with the district court's holding that its exercises on FDM violate the MBTA. First, the Navy may obtain a permit from the FWS. Indeed the Navy is actively pursuing an MBTA permit [under 50 C.F.R. s 21.27], in compliance with the court's order… Second, the Navy may petition the FWS to amend the regulations to authorize its taking of migratory birds. The MBTA grants the FWS this authority. 16 U.S.C. ss 704, 712(2). Although the FWS has in the past relied upon its enforcement discretion in cases of unintentional takes, it has already drafted a proposed rule that would authorize the unintentional taking of migratory birds by federal agencies incident to other lawful activities.

Id. (emphasis added).

Thus, FWS itself has been on record for many years that it has the authority to issue regulations circumscribing the conditions under which particular entities or activities may incidentally take migratory birds.

iii. *Federal courts and other sources have also recognized that FWS has the authority to regulate incidental take under the MBTA.*

As explained supra, Section D.2, federal courts have also recognized the "broad" "plenary power" of FWS to regulate take under Section 704(a) of the MBTA. In fact, regulations promulgated by FWS to avoid and minimize incidental take under the MBTA have been upheld at least in one instance. Nat'l Rifle Ass'n of Am. v. Kleppe, 425 F. Supp. 1101 (D.D.C. 1976). In that case plaintiffs challenged the adoption of regulations which required the use of steel shot in 12-gauge or larger shotguns for hunting. Although the regulations were related to intentional taking, the stated purpose for establishing these regulations was to avoid and minimize incidental take, i.e., "to limit further deposition of lead pellets in areas used by aquatic birds. . . . (which cause) lead intoxication and death…" Id. at 1103-04. The court upheld the regulations as being grounded in Section 704 of the MBTA. Id. at 1110. This decision was affirmed by the U.S. Court of Appeals for the D. C. Circuit, Nat'l Rifle Ass'n of Am. v. Andrus, 571 F.2d 674 (Table) (D.C. Cir. 1978), and has also been relied on in cases concerning other environmental statutes. See, e.g., Conn. Coastal Fishermen's Ass'n v. Remington Arms Co., 989 F.2d 1305, 1317 (2d Cir. 1993) (holding that lead shot was subject to regulation as hazardous waste under the Resource Conservation and Recovery Act of 1976).

Further, other sources have also recognized the authority of FWS to regulate incidental take. For example, the committee established by DOI under FACA to advise FWS on developing effective measures to avoid or minimize wildlife impacts related to land-based wind energy facilities, has also concluded that FWS has the authority to regulate incidental take, specifically in the wind energy context:

> The language of the MBTA gives the FWS authority and discretion to adopt regulations to permit reasonable activities that result in the taking of birds. Congress, in Section 704 of the MBTA, expressly authorizes the promulgation of regulations that permit the taking of migratory birds in a broad grant of authority to the FWS… From this broad Congressional grant of authority in Section 704(a), the FWS may have the authority to promulgate regulations establishing a new permit that would allow for the taking of birds at wind energy developments under certain conditions. Although the FWS does not have express authorization in the MBTA to issue "incidental take permits" as provided in the ESA, the broad grant of authority in Section 704 seems to allow issuance of such permits should the FWS choose to exercise this authority in the wind energy and other contexts. This would require the promulgation of a new regulation by the FWS.

FAC Legal White Paper at 13-14 (emphases added).[136]

In addition, FWS has been advised by its legal department that regulations specifically tailored for permitting incidental take may be more appropriate than using the mechanism provided for allowing incidental take through issuance of special purpose permits under 50 C.F.R. § 21.27. See Memorandum from Pete Raynor, Assistant Solicitor, Fish and Wildlife Branch, to John Rogers, Deputy Director, FWS, Permitted Incidental Take of Migratory Birds Listing Under the Endangered Species Act 3 (Feb. 5, 1996) ("although [50 C.F.R.] § 21.27 appears to be broad enough to encompass the permitting of unintentional take for the purposes of the MBTA, that section is not narrowly focused on incidental take. A regulatory permitting program specifically geared to the problems of incidental take may be advisable." (emphasis added)), Attachment P.

In sum, Sections 704(a) and 712(2) of the MBTA provide broad authority to FWS to promulgate regulations regulating, and authorizing certain incidental takes, subject to appropriate conditions and ongoing federal oversight. Accordingly, FWS clearly has the requisite rulemaking authority to establish a permitting scheme to regulate the incidental take of migratory birds by wind energy projects.

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[136] The White Paper prepared by the Legal Subcommittee was adopted by the full Wind Turbine Guidelines Federal Advisory Committee. See Appendix B (FAC Legal Subcommittee White Paper), Committee Recommendations.

E.2. Wind energy projects have been taking and are likely to continue to take migratory birds in violation of the MBTA's take prohibition.

As noted supra, see Section C.2, FWS is well aware that many wind energy projects are either already in operation or are being planned that will take migratory birds in violation of the MBTA. See Wind Guidelines Third Draft at 15 ("The Service recognizes that hundreds of wind energy projects exist and are being planned."). By 2020, it is expected that an exponential increase of wind turbines will kill at least one million birds each year, and impact almost 20,000 square miles of terrestrial bird habitat, and another 4,000 square miles of marine habitat. See ABC's Bird-smart Wind Principles.

Further, as explained supra, Section C.1, present-day utility scale wind turbines are massive machines and their size continues to increase on a regular basis. However, such an increase in turbine size also expands the rotor-swept area of the blades (at present exceeding 400 acres), which in turn further increases the potential for bird collisions. See FWS 2011 MBTA Conference Presentation at 5-6 (the rotor swept area of wind turbines has increased from 3,700 square meters (about 1 acre) in 2000 to 15,000 square meters (3.8 acres) in 2010). Like other for-profit industries that are made to internalize the environmental costs of their operations, the wind industry should be required to internalize the costs related to the impacts of its projects on migratory birds and other wildlife that have concrete societal benefits in terms of ecosystem functioning, ecotourism, and the like. See Cornell Lab of Ornithology, Comments to the U.S. Fish and Wildlife Service: Draft Land-based Wind Energy Guidelines (May 2011) ("we strongly encourage the Guidelines to require research protocols and open access to wildlife research data as a mandatory "cost of doing business." (emphasis added)).

Indeed, especially since the wind power industry seeks to present itself as a "green" energy source that is part of the solution to climate change – and hence beneficial to wildlife – the industry should not be permitted to simultaneously undermine the conservation of migratory bird populations in violation of the MBTA, especially with regard to species already at risk or otherwise of conservation concern. Yet FWS already possesses definitive evidence, much of which is discussed in and attached to this Petition, that wind energy projects in the United States will inevitably kill, injure, or otherwise harm many of the 1007 migratory bird species listed under the MBTA, such as a wide variety of songbirds, raptors, and waterfowl including but not limited to, the Bald Eagle, Golden Eagle, Ferruginous Hawk, Swainson's Hawk, American Peregrine Falcon, Short-eared Owl, Flammulated Owl, California Condor, Whooping Crane, Snail Kite, Marbled Murrelet, Hawaiian Goose, Hawaiian Petrel, Bicknell's Thrush, Sprague's Pipit, Cerulean Warbler, Oak Titmouse, Lewis's Woodpecker, Brewer's Sparrow, Long-billed Curlew, Bay-breasted Warbler, and Blue-winged Warbler. See supra Section C.2. Indeed, the agency's voluntary guidelines are themselves grounded on the fact that wind turbines that fail to abide by basic standards for siting, construction, operation, and monitoring will take listed migratory birds in violation of the MBTA. Given the reality that the wind industry as a whole is in patent violation of the MBTA, FWS must ensure that the entire industry is brought into compliance with the Act, and that individual projects that refuse to comply will be subject to appropriate enforcement action. Such a comprehensive approach would be the simplest and most efficient method for assuring industry-wide compliance with the Act.

The reality is that migratory birds and wind turbines often tend to congregate in the same locations – corridors where strong winds blow. A majority of the nation's wind farms are located in major wind corridors – in general, the harder and more often the wind blows, the more efficiently the turbine works and the more power it creates. Given this reality and the high likelihood of conflict between wildlife protection and the industry, there is an urgent need for an appropriate means to resolve this conflict, and that is through an effective legal mechanism, i.e., regulations that balance the two objectives in a manner that promotes the industry by proving it with a reasonable degree of regulatory and legal certainty while at the same time protecting wildlife in compliance with federal wildlife law. Accordingly, this Petition seeks a permitting scheme that will facilitate siting decisions in a manner that avoids and minimizes wildlife impacts, and effectuates ABC's long-standing position with regard to wildlife impacts of wind energy projects – you can make a good site better through operational measures, but you cannot make a bad site good. In sum, the wind power industry is killing and otherwise harming migratory birds in clear violation of federal law and, consequently, steps need to be undertaken to bring the industry into conformance with the law while not needlessly impeding the development of wind power. The proposed regulations set forth in the Appendix to this Petition are designed to accomplish that result.

E.3. FWS should exercise its broad permitting authority to address the ongoing unregulated and wholly unlawful take of protected birds by wind energy projects.

As detailed below, there are several reasons grounded in fact, law and policy, for FWS to promulgate regulations governing the wildlife impacts of wind energy projects.

i. *FWS must encourage wind energy development by providing the industry a concrete and lawful means to comply with the MBTA.*

The crux of the problem is that the wind energy industry as a whole is in violation of the MBTA because essentially all projects are taking or inevitably will take MBTA-protected birds. See supra Section C.2; see also, e.g., supra Map 2.1 (map showing wind energy turbines that have been proposed in several areas of critical importance to birds). However, in the absence of a permitting system, even wind energy developers that know that their projects will take migratory birds and desire to operate within the law have no concrete means of doing so, short of abandoning the project.

The inadequate solution devised by FWS and the Committee, i.e., "voluntary" Guidelines in return for vague non-enforcement "assurances," does nothing to resolve this problem because the "guidelines do not authorize take under MBTA or BGEPA," and, regardless of efforts by individual projects to comply with the Guidelines, "[v]iolations of those statutes may result in prosecution." See Wind Guidelines Third Draft at 13. Indeed, the legal complications related to the voluntary

Guidelines have raised concerns not only among many in the conservation community but also by the U.S. Department of Justice.[137] In this regard, it is important to stress that federal agencies are not exempt from the MBTA's broad strict-liability take prohibition, and consequently any federal agency action that in effect authorizes or leads to take of migratory birds – in the absence of the specific mechanisms provided for in the MBTA – is itself a violation of the Act. See Humane Soc'y of the U.S. v. Glickman, 217 F.3d 882 (D.C. Cir. 2000). Thus, FWS itself is subject to the MBTA and therefore its actions, such as adoption of voluntary Guidelines that essentially endorse the unauthorized taking of migratory birds – by providing projects with any non-enforcement assurances at all – is in clear tension with the Act. See Migratory Bird Executive Order.

In Glickman, plaintiffs challenged implementation of a management plan for Canada Geese, which did not require the Department of Agriculture to seek permits before taking or killing such birds. The federal defendants argued that federal agencies were not subject to the MBTA and therefore need not obtain a permit before taking migratory birds. The court of appeals rejected the government's argument and held that the Department was required to seek a permit before implementing the management plan. That case may be particularly relevant in the context of the voluntary Guidelines, since there the court held that the Department of Interior's interpretive policy statement that allowed federal agencies to take without a permit violated the MBTA. Thus Glickman's ruling that mere non-binding policy statements of a federal agency could be in violation of the MBTA has clear implications for the legality of the voluntary Guidelines, because the Guidelines essentially endorse unauthorized take by wind energy projects without a permit, which is a clear violation of the MBTA by the agency.

Indeed, an agency need not itself be killing or taking birds to be in violation of the Act. See, e.g., Hill v. Norton, 275 F.3d 98, 106 (D.C. Cir. 2001) (subsequently superseded by statute) (holding that failure of the Department of Interior to list mute swans under the MBTA "ha[d] led to numerous adverse actions - including killing and egg destruction" and was therefore an action that violated the MBTA and was reviewable under the APA). Thus, FWS's failure to make the Guidelines mandatory – while providing assurances to developers that their compliance with the Guidelines will limit the agency's enforcement discretion – will likely lead to the unauthorized "taking" of birds by wind energy projects without a permit under the MBTA. Accordingly, FWS cannot, through non-binding Guidelines, absolve developers of liability for violation of the Act resulting from incidental take; and by purporting to do so FWS would itself be violating the MBTA and running afoul of the ruling in Glickman and other cases.

On the other hand, the Act expressly provides a mechanism for permitting take in Section 704, i.e., permitting take through "suitable regulations." 16 U.S.C. § 704(a). FWS should

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[137] This was communicated by FWS during the public comment session in the Wind Federal Advisory Committee meeting held on September 21, 2011. Further, ABC has repeatedly requested FWS to provide the meeting summary and recording of the September 2011 Committee meetings (as required under FACA, 5 U.S.C. App. 2 §§ 10(b)-(c)), and has to date not been provided the same.

implement Section 704 of the Act by promulgating regulations that not only establish mandatory standards for the industry, but also enable developers to cooperate with FWS in obtaining formal authorization through incidental take permits for appropriate projects, as envisaged in the Proposed Regulations. In sum, this is the critical juncture at which FWS must take stock of the legal and empirical inadequacy of the approach taken to date and then commit to a different one – which can build on the hard work done in drafting the Guidelines – under which wind energy developers have both a meaningful, reliable mechanism to site and operate their projects in a bird-friendly fashion, and a well-placed concern for potential agency enforcement if they do not.

ii. ***Mandatory standards for wind energy projects are necessary particularly due to the lack of enforcement of the MBTA by FWS against the wind industry.***

The MBTA does not have a citizen suit provision and therefore FWS has the primary responsibility to administer and enforce the Act. Many prosecutions for incidental take have been pursued by FWS under the MBTA, including against companies involved in resource and energy production. In 2009, for instance, the electric utility PacifiCorp paid approximately $1.4 million in fines and restitution and approximately $9.1 million to repair and replace equipment in order to minimize impacts on migratory birds, after pleading guilty to 34 counts of unlawfully taking Golden Eagles, hawks, and ravens in violation of the MBTA.[138] Also in 2009, Exxon-Mobil pled guilty to 85 violations of the MBTA for failure to take precautions to prevent the death of migratory birds at one of the company's petroleum facilities, and paid $600,000 in fines. Thus, there is a long history of these types of prosecution. See, e.g., United States v. Moon Lake Electric Ass'n Inc., 45 F.Supp. 2d 1070 (D. Colo. 1999) (prosecution of electric company for failing to take reasonable measures to minimize the impact of power lines on migratory birds); United States v. Stuarco Oil Co., 73-CR-129 (D. Colo. 1973) (prosecution of oil company for the death of 23 birds resulting from the company's failure to build oil sump pits in a manner that could keep birds away); United States v. Equity Corp., Cr. 75-51 (D. Utah 1975) (oil company charged for the death of 14 ducks caused by the company's oil sump pits); United States v. Union Tex. Petroleum, 73-CR-127 (D. Colo. 1973) (prosecution of oil company for no proper maintenance of oil sump pit).

As explained supra, see Section D.3, FWS has the primary responsibility to administer and enforce the MBTA. However, to date, despite conceded rampant violations of the MBTA by wind energy projects, FWS has never brought enforcement action against wind energy developers for incidental take. See Laura J. Beveridge, The Migratory Bird Treaty Act and Wind Development (N. Am. Wind Power, Sept. 2005) (opinion of attorney representing the energy sector that the government's ongoing reluctance to prosecute wind energy projects provides assurance to developers that they will not be held liable for avian deaths), Attachment Q.

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[138] FWS News Release: Utility Giant to Pay Millions for Eagle Protection (July 10, 2009), http://www.fws.gov/mountain-prairie/pressrel/09-47.html (last visited Nov. 8, 2011).

Further, the agency is aware of large-scale illegal killing and potential take of MBTA-protected birds at many wind energy projects across the country not merely in violation of federal statutes but also, in some cases, in clear violation of the specific standards provided in the voluntary guidelines. See, e.g., Memo from Alan Forster, NedPower Mt. Storm LLC to Laura Hill, FWS, NedPower September 25, 2011 Monitoring Event (Oct. 10, 2011) (describing an "unusual number of bird casualties" found near a single turbine), Attachment R; Letter from FWS to Amber Zuhlke, Wind Capital Group, Big Lake Wind Facility in Palm Beach, Florida (July 1, 2011) ("Many recommendations within the Draft Eagle Guidance were not included in the pre-construction monitoring plan for identifying potential risk to eagles. The Service requests the Draft Eagle Guidance be followed…"), Attachment K. Thus, there are situations in which a company flatly admits bird mortality at its project, and yet FWS fails to bring any enforcement action. See, e.g., Memo from Stantec Consulting (consultants for developer) to Laura Hill, FWS, Bird Mortality at Laurel Mountain Substation Memo (Oct. 25, 2011) (reporting the death of 314 birds), Attachment J; Louis Sahagun, Federal Officials Investigate Eagle Deaths At DWP Wind Farm (L.A. Times, Aug. 3, 2011) (explaining that the Los Angeles Department of Water had reported raptor mortalities to FWS at its Pine Tree Wind Project in the Tehachapi Mountains).[139]

Although FWS has considerable discretion in deciding whom to prosecute for violation of the MBTA, Alaska Fish & Wildlife Fed'n & Outdoor Council v. Dunkle, 829 F.2d 933 (9th Cir. 1987), courts have held that an ongoing "pattern of non-enforcement of clear statutory language" amounts to "an abdication of its statutory responsibilities," which is a violation of the APA. Heckler v. Chaney, 470 U.S. 821, 833 n.4 (1985) (citing Adams v. Richardson, 480 F.2d 1159 (D.C. Cir. 1973) (emphasis added)); see also id. at 839 (Brennan, J., concurring) ("It may be presumed that Congress does not intend administrative agencies, agents of Congress' own creation, to ignore clear jurisdictional, regulatory, statutory, or constitutional commands[.]"). Accordingly, an ongoing practice and policy of non-enforcement while wind energy projects openly flout the MBTA may open FWS to suit under the APA, for engaging in a "pattern of non-enforcement of clear statutory language." This is still another reason why the promulgation of a system for permitting wind power projects is far preferable to FWS's existing approach, under which it has, at least as a practical matter, made it abundantly clear that it has no intention of enforcing the MBTA against such projects.

In fact, FWS is further exacerbating the problem of non-enforcement and implementation of the MBTA, by endeavoring to provide "assurances" to wind energy developers that they will not be prosecuted for violations of the MBTA even when the Service disagrees with their reasons for siting in a particular location and the project results in take of migratory birds. Even worse, the most recent published version of the wind Guidelines (as of this writing) recommends that "if the developer seeks to have the benefit of the enforcement discretion" of FWS, it must merely maintain

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[139] Available at http://articles.latimes.com/2011/aug/03/local/la-me-wind-eagles-20110803 (last visited Nov. 16, 2011).

"contemporaneous documentation of how the developer evaluated [FWS's] advice and the reasons for any departures from it." Wind Guidelines Third Draft at 13 (emphases added). Simply put, what this means is that a private company can claim to be in "compliance" with the Guidelines and entitled to non-enforcement assurances, while at the same time refusing to abide by the position of the biologists of the federal agency whose stated mission is to "conserve, protect, and enhance" migratory birds "for the continuing benefit of the American people" and which has the statutory duty under the MBTA to protect and prevent taking of migratory birds. FWS, Mission Statement;[140] see also Wind Guidelines Third Draft at 1 (explaining that the "the advice of the Service is not binding" and that "the guidelines leave decisions up to the developer.").

This is a counterproductive and almost certainly unlawful approach to managing migratory bird impacts, especially because FWS is frequently in disagreement with the developer's analysis of the wildlife risks posed by its project. See, e.g., Letter from Deborah Carter, FWS to Curry & Kerlinger, LLC (environmental consultants of developer) at 2 (Sept. 30, 2009) (explaining that the agency "disagreed" with the developer's "conclusions drawn from [the risk assessments]."), Attachment S; Letter from Laury Zicari, FWS to Dana Vallieu, TRC (May 11, 2011) at 6 (explaining that the studies conducted by the developer's consultants were insufficient to assess the project's impacts on Golden Eagles and providing several recommendations to modify the developer's approach), Attachment T; Letter from Gary Miller, FWS to Sue Oliver, Or. Dep't of Energy (Feb. 14, 2011) at 8-9 ("Throughout this energy facility siting process, the Service and [developer] have reached agreement on some issues, but many remain. The Service continues to have concerns with this Project…"), Attachment U; see also id. at 13-16 (FWS providing a chart of items identifying the developer's response to agency recommendations - on some issues the developer had "declined" to follow the agency's recommendations).

In particular, the voluntary Guidelines do not effectively address the most crucial problem related to impacts of wind energy projects on birds, i.e., poor siting, because they allow developers to build projects in high risk areas so long as they communicate with the agency and record their reasons for departure from the agency's advice. See, e.g., Letter from Michael D. George, FWS to Jay Prothro, BP Wind Energy, Southwest Power Pool Docket #ERII-3833 (Oct. 11, 2011) (FWS expressing frustration with developer's decision to proceed with the project in complete disregard to the agency's recommendations – "British Petroleum representatives and their consultants have repeatedly been advised of the unacceptability of the proposed BP wind project west of Merna given its high risk to whooping cranes and other migratory birds. The Service again recommends that the proposed BP wind project not proceed as planned [because it] provides an abundance of suitable habitat for the federally endangered whooping crane."), Attachment V; see also Letter from Robert D. Williams, FWS to Tim Carlson, Nevada Wind, Proposed Virginia Peak Wind Facility and Existing Golden Eagle Resources in the Pah Rah Range, Washoe County, Nevada (Aug. 13, 2010) at 2 (FWS contacted the developer by telephone when it had not heard back from the developer for

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[140] Available at http://www.fws.gov/info/pocketguide/fundamentals.html (last visited Nov. 11, 2011)

more than a year since communication of its recommendations, only to find out that construction of the project was to begin in 45 days without regard for its recommendations), Attachment W; Letter from Scott Hicks, FWS to Xio Cordoba, Heritage Sustainable Energy (Nov. 4, 2011) (even though FWS had for many years recommended that the developer "not construct a commercial wind energy development on the Garden Peninsula because of the high potential for avian mortalities and violations of Federal wildlife laws," the developer informed FWS that it "intended to move forward with construction of the wind energy development, regardless of [FWS's] previous recommendations and wildlife concerns."), Attachment X.

Thus, although FWS provides certain recommendations to the wind industry, such as its recommendations that developers apply the tiered approach adopted in the Guidelines and that they communicate extensively with the agency, the reality remains that these Guidelines are entirely non-binding and there is no means to ensure that developers follow the recommendations of the very authority that has the statutory mandate to protect migratory birds and other wildlife.

Being the primary authority responsible for protecting wildlife and enforcing federal wildlife statutes such as the MBTA, FWS has the statutory responsibility to either enforce the Act effectively so that future violations are deterred or to establish a comprehensive regulatory regime that avoids and minimizes wildlife impacts at wind energy projects. By refusing to regulate or prosecute wind energy companies, FWS is essentially providing the industry a free pass to violate federal wildlife law, and at the same time creating a regulatory limbo which simply cannot afford legal certainty to projects that are in fact in violation of the MBTA.

iii. *Regulations are crucial in order to require wind energy developers to share information with FWS at the earliest stage of the project.*

Given that proper siting of wind energy projects is the most important element in avoiding and minimizing wildlife impacts, FWS has urged developers to "'come to us at the get-go, before a site has been selected [and] before a landowner agreement has been signed.'" John Clapp, FWS Official Urges Cooperation (N. Am. Windpower June 2011) (quoting Albert Manville, Senior Wildlife Biologist, FWS);[141] see also Letter from FWS to Chris Taylor, Element Power (Jan. 31, 2011) ("Developers should seek this consultation ***prior to*** making irrevocable commitments."), Attachment Y.

Unfortunately in the absence of mandatory rules requiring developers to obtain permits to proceed with particular projects, at present FWS is facing a situation where it is not only having difficulties in obtaining information from the industry but is also in some cases entirely unaware of the existence of projects that may have serious wildlife impacts. Clapp, supra (quoting Albert

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[141] Available at http://www.wind-watch.org/news/2011/06/03/fws-official-urges-cooperation/ (last visited Nov. 17, 2011).

Manville, Senior Wildlife Biologist, FWS, "'[u]nfortunately, right now in many cases, we find out about the development of a project through a news release or something on the evening news when we have not been consulted whatsoever, and that's frustrating.'" (emphasis added)); see also, e.g., Letter from Robert D. Williams, FWS to Tim Carlson, Nevada Wind, Proposed Virginia Peak Wind Facility and Existing Golden Eagle Resources in the Pah Rah Range, Washoe County, Nevada at 1 (Aug. 13, 2010) (stating that FWS "first became aware of this project when a local state agency contacted it"), Attachment W.

Further, increasingly some wind energy developers are becoming less forthcoming in sharing information with FWS and are proceeding with construction without regard to the agency's recommendations. See, e.g., Letter from Laury Zicari, FWS to Nicholas D. Livesay, Pierce Atwood LLP (attorneys of the developer) (Mar. 31, 2011) (FWS response to developer's application for an incidental take permit under BGEPA expressing "surprise" "to learn that USDA funded the project" and "to learn that groundbreaking for the project occurred despite the many concerns that [FWS] raised concerning this project" and even before completion of "two full seasons" of pre-construction studies as recommended by FWS for avoiding risks to Bald Eagles), Attachment Z; Letter from FWS to Chris Taylor, Element Power (Jan. 31, 2011) (despite developer's assurance that it would submit an ABPP based on the agency's recommendations, no such information was forthcoming from the developer – "Service biologists have not heard from any representative of the company, nor has the Service received a revised ABPP… We note that these deficiencies persist despite our attempts to work -cooperatively with the company to correct them."), Attachment Y; Letter from Robert D. Williams, FWS to Tim Carlson, Nevada Wind, Proposed Virginia Peak Wind Facility and Existing Golden Eagle Resources in the Pah Rah Range, Washoe County, Nevada at 2 (Aug. 13, 2010) ("We requested that you provide this information to us for review so that we could assist you in determining the level of risk of your project to golden eagles. To date we have not received the requested resource information."), Attachment W.

In addition, in some cases, developers are entering into confidentiality agreements with their hired biological consultants, thereby making it more difficult for the agency, and the public, to study the wildlife impacts of the projects.[142] See Manville 2009 Paper at 9 ("The transparency of research results conducted by wind industry consultants continues to be a recurrent frustration for USFWS—in part because of early project industry confidentiality issues.") (emphasis added).

[142] In fact, when asked about the utility of such "confidentiality" agreements, a wind industry representative recently stated that the industry considered wildlife mortality information as "proprietary information." Statements made by FWS and Wind Industry Representative in a panel discussion on BGEPA during a conference on 'Reshaping the Migratory Bird Treaty Act_'organized by Lewis and Clark Law School (October 21, 2011). More information on this conference is available here: http://law.lclark.edu/programs/environmental_and_natural_resources_law/conferences_and_lectures/2011_migratory_bird_treaty_act/

In addition, recent incidents have documented the inherent problems associated in having surveys, monitoring and assessments of wildlife impacts at wind energy projects conducted by consultants retained by and paid for by the project developers themselves. For example, in finding a wind power project in violation of the ESA, a federal district court expressly rejected the findings of one such developer-hired consultant in favor of other independent experts who appeared before the Court. See Animal Welfare Inst. v. Beech Ridge Energy LLC, 675 F. Supp. 2d 540, 582 (D. Md. 2009). In Beech Ridge, the court found that the developer-hired consultant performed minimal surveys, presented result-oriented analyses, and even suppressed important acoustic data, placing the interests of the company ahead of wildlife protection interests. As the Beech Ridge ruling makes clear, often consultants have inherent conflicts of interest that lead to their adoption of "a minimalist approach to [their] responsibilities," leading to the sort of unacceptable, insufficient, and result-oriented studies done at Beech Ridge. 675 F. Supp. 2d at 582.

Indeed, the wildlife mortality estimates documented by many wind energy projects are underestimates of actual mortality levels because of inconsistent reporting of incidental mortality, which is not handled in a standard way across the industry. Incidental mortality refers to carcasses found in addition to the official mortality searches, either occurring at a different time than the scheduled searches, or at a wind turbine that wasn't searched. Mortality studies generally do not include all of a facility's wind turbines. Not all mortality studies report incidental finds. For example, a report about bird and bat mortality at wind facilities in the Montezuma Hills of California did not include Swainson's Hawk fatalities in the report even though the researchers were aware of them and the Swainson's Hawk is a species of conservation concern. See H. T. Harvey & Assocs., Bird and Bat Movement Patterns and Mortality at the Montezuma Hills Wind Resource Area;[143] see also Shiloh IV Wind Energy Draft Environmental Impact Report 4-7 (Aug. 23, 2011) (noting the Swainson's Hawk fatalities were found during the above study at some wind projects), Attachment AA.

A significant amount of the mortality for many species as a whole may be found incidentally, not during the standardized searches. See K. Shawn Smallwood & Brian Karas, Comparison of Mortality Estimates in the Altamont Pass Wind Resource Area When Restricted to Recent Fatalities 3 (June 2008).[144] For example, often the bird and bat mortality estimates are based only on carcasses found in routine searches. Such estimates often do not take into consideration, (a) carcasses found incidentally (i.e., found outside regular/routine carcass searches); and (b) bird and bats killed due to major fatality incidents (usually caused due to lights being left on at a turbine or substation, or heavy fog). See, e.g., Curry & Kerlinger, LLC, A Study of Bird and Bat Collision Fatalities at the

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[143] Available at http://www.co.solano.ca.us/civicax/filebank/blobdload.aspx?blobid=10104 (last visited Dec. 11, 2011).

[144] Available at http://www.altamontsrc.org/alt_doc/p101_smallwood_karas_mortality_restricted_to_recent.pdf (last visited Dec. 11, 2011).

Mountaineer Wind Energy Center, Tucker County, West Virginia: Annual Report for 2003 (Feb. 14, 2004) at 5 (wildlife mortality estimate did not take into consideration a major fatality incident that took place in May 2003, thus only carcasses found during standardized searches were used to calculate the mortality estimate).[145]

Finally, it has long been known that scavengers can remove carcasses before they are found and searchers do not always find all carcasses. Although mortality studies now attempt to correct for these factors, recent research suggests that some of the adjusted mortality numbers may still be too low. See K. Shawn Smallwood et al., Novel Scavenger Removal Trials Increase Wind Turbine–Caused Avian Fatality Estimates 74(5) J. Wildlife Mgmt. 1089 (2010), Attachment BB. Thus, there appears to be a serious problem of underestimating actual wildlife mortality at many wind energy projects.

In sum, a skewed picture of actual wildlife mortality at wind energy projects is emerging. In this regard, regulations requiring the developer to consult with FWS will enable the agency to thoroughly scrutinize the studies conducted and conclusions drawn by hired consultants in order to ensure unbiased biological information collection and surveying, and accurate analysis of biological data.

In the absence of mandatory regulations requiring the developer to consult FWS and share requested information, FWS cannot simply expect or rely upon the goodwill or cooperation of the industry. In any event, mandatory rules are required to resolve environmental conflicts in any given industry and are especially necessary to regulate the uncooperative actors in the industry that do not follow the law. Indeed, the good corporate actors that diligently follow the law are in effect penalized by a system that relies entirely on voluntary compliance because they will incur costs whereas less responsible companies will not.[146] Thus, there is a crucial need for establishing uniform industry-wide regulations so that FWS can exercise oversight on those developers and operators who will not otherwise cooperate with the agency.

The problems posed by a lack of information and failure to consult with FWS is further exacerbated by the fact that most wind energy projects are constructed on private lands. See Nat'l Research Council, Environmental Impacts of Wind-Energy Projects (Nat'l Academies Press, 2007) at 194. Thus, often, there is no "federal nexus" for wind energy projects to trigger NEPA review.

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[145] Available at http://www.wvhighlands.org/Birds/MountaineerFinalAvianRpt-%203-15-04PKJK.pdf (last visited Nov. 17, 2011).

[146] Good examples of such actors in the wind energy industry that are truly concerned about the impacts of their projects on migratory birds are some that have recently decided to abandon sites that are particularly adverse to wildlife. See, e.g., Richard Cockle, Developers drop plans for two wind farms on Steens Mountain slopes, but still plan a third (The Oregonian, Nov. 17, 2011), http://www.oregonlive.com/pacific-northwest-news/index.ssf/2011/11/developers_drop_plans_for_two.html (last visited Nov. 22, 2011)

See Manville 2009 Paper at 9 ("Since the vast majority of wind development is currently on private lands, the USFWS lacks any strong federal nexus"). Simply put, this means that there may be hundreds of wind turbines on private lands entirely outside the scrutiny of FWS due to the lack of any current mechanism that triggers FWS review. See, e.g., Email from Wende S. Mahaney, FWS to Donald E. Murphy, Maine Department of Conservation, First Wind - Blue Sky East, LLC Bull Hill Wind Project Development Application (Mar. 07, 2011)[147] (FWS biologist stating that the agency will not be submitting comments on the state permit application of a wind energy developer because "[i]t is our understanding that all wetland fill impacts are being avoided, so the project does not trigger federal jurisdiction with the Corps of Engineers. That being the case, there is no requirement for consultation under the federal Endangered Species Act … So, I don't believe USFWS will be submitting any comments… Many bird and bat issues are "flying under the radar screen" (pun intended......) for USFWS."). Indeed, many more bird impacts due to wind energy projects will be "flying under the radar screen" of FWS under the approach adopted in the voluntary Guidelines, where FWS staff are required to respond to wind energy developers within a truncated 60 day review period. As explained supra, see Section C.3, the Guidelines impose the 60-day review requirement on FWS, regardless of the size or complexity of the project, or its risk to wildlife.

iv. *FWS should take action to prevent destruction of migratory birds before the actual taking occurs.*

The MBTA is a strict liability statute. See United States v. FMC Corp., 572 F.2d 902 (2d Cir. 1978). In essence what this means is that regardless of intent to violate the law, "when one enters into a business or activity for his own benefit, and that benefit results in harm to others, the party should bear the responsibility for that harm." Id. at 907. "The [MBTA] does not include as an element of the offense 'willfully, knowingly, recklessly, or negligently' [because] Congress recognized the important public policy behind protecting migratory birds." Id. at 908 (emphasis added).

The "public policy behind protecting migratory birds" informs FWS's "federal trust responsibility" over migratory bird species. Specifically, this policy governs FWS's MBTA-permit program which is premised on the need to prevent destruction of migratory birds by taking precautionary measures, such as requiring appropriate permits, before the actual taking or killing of birds takes place. See, e.g., 50 C.F.R. § 21.22(a) (banding permits required "before any person may capture migratory birds"); id. § 21.23(a) ("scientific collecting permit is required before any person may take"); id. § 21.24(a) (taxidermist permit is required before any person may perform taxidermy"); id. § 21.27(a) ("special purpose permit is required before any person may lawfully take"); see also Fund For Animals v. Norton, 281 F.Supp.2d 209, 217 (D.D.C. 2003) ("The MBTA authorizes the Secretary of the Interior to promulgate regulations permitting the taking of migratory birds as long as the regulations are consistent with the Convention. The regulations prohibit the

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[147] Available at http://www.maine.gov/doc/lurc/projects/Windpower/FirstWind/BlueSkyEast/DP4886/Application/ Comments/Federal_Agencies_Comments.pdf (last visited Nov. 15, 2011).

taking [] of any migratory birds except as allowed by a valid permit." (Citing 50 C.F.R. § 21.11) (emphasis added and other citations omitted)).

The precautionary approach is further reiterated in the MBTA definition of "take" which, like the definition of "take" under the ESA, prohibits "acts that lead to the taking of protected species." United States v. Apollo Energies, 611 F.3d 679, 684 n.3 (10th Cir. 2010) (citing Babbitt v. Sweet Home Chapter of Cmtys. for a Great Or., 515 U.S. 687 (1995) ("The *regulatory* definition of 'take' [in the MBTA] is the same as the ESA's *statutory* definition except that the regulatory definition omits to 'harass' and 'harm.'"). Further, in the context of ESA enforcement, courts have accepted the reasonable certainty of future unlawful takes as sufficient to support remedies designed to prevent such takes from occurring, such as issuing an injunction against construction and operation until the developer obtains an appropriate take permit. See, e.g., Beech Ridge Energy LLC, 675 F. Supp. 2d at 545, 580 (holding that ESA requires courts to carefully scrutinize an activity that may take endangered species without a permit and granting injunction against wind energy project for likely take of endangered Indiana bat). In Beech Ridge, the court examined the potential conflict between two federal policies relevant to wind energy projects, one favoring the protection of endangered species under the ESA, and the other encouraging development of renewable energy resources, and observed that "[t]he two vital federal policies at issue in this case are not necessarily in conflict" so long as the project developer obtains take authorization in accordance with the ESA. Id. at 582-583. The court admonished the industry that, "[t]he development of wind energy can and should be encouraged, but wind turbines must be good neighbors" and that "the only way in which the Court will allow the [wind energy] project to continue" was through the permitting process under Section 10 of the ESA. Id.

Analogies for preventative regulations can also be drawn from conservation schemes in other federal wildlife laws that are premised on the precautionary approach to wildlife protection and are designed to prevent or minimize the taking of protected wildlife. The ESA and the Marine Mammal Protection Act ("MMPA"), 16 U.S.C. § 1361 et seq., also prohibit unauthorized take of protected wildlife. Further, like the MBTA those statutes provide FWS with broad rulemaking authority to protect such wildlife. For example, FWS has promulgated regulations under the ESA and the MMPA for protecting manatees through the establishment of "manatee protection areas" where waterborne activity is prohibited or subject to restrictions. 50 C.F.R. §§ 17.100-108. FWS describes the manatee regulations as "protective regulations," designed to "reduce the incidence of manatee injuries and deaths." FWS, Final Rule Providing for the Establishment of Manatee Protection Areas, 44 Fed. Reg. 60962 (Oct 22, 1979).

Similarly, in the case at hand, FWS should establish a mechanism through regulations to anticipate incidental take by wind energy projects and to be actively involved in ensuring that such projects are not constructed on sites that pose an undue risk to migratory birds and that any impacts that do occur are minimized and mitigated. Indeed, the incontrovertible evidence that wind energy projects, if operated as designed, will foreseeably take some migratory birds protected under the MBTA, strongly supports creation of a system for limiting the amount of take that will occur.

v. *The wind energy industry particularly lends itself to federal oversight through appropriate regulations established under the MBTA.*

As explained above, FWS has the authority to regulate incidental take and there are several concrete reasons for establishing such a regulatory scheme for incidental take by wind energy projects. Further as explained infra, see Section E.4, the permitting scheme recommended in this Petition is particularly beneficial for regulating the incidental take by wind energy projects. Other mechanisms may be more appropriate for other incidental takes. See, e.g., Memo from Willie R. Taylor, FWS to FCC, FCC Draft Programmatic Environmental Assessment (DPEA), Antenna Structure Registration (ASR) Program (recommending that FCC "create a programmatic approach to authorizing communication towers that, along with its goal of avoiding and minimizing hazards to air navigation, explicitly seeks to avoid or minimize bird mortality."), Attachment CC.

The wind energy industry has sought to trivialize incidental take of birds by wind energy projects by comparing it to the level of avian mortality due to other incidental takes, such as cat predation, collision with windows and vehicles, and other external threats – presumably in order to downplay the risk of wind energy projects to wildlife. See, e.g., EDP Renewables, FAQs: Wind Technology[148] (website of leading wind energy developer arguing that "wind's overall impact on birds is lower than other sources of avian mortality such as vehicles, buildings and house cats."). Further, objections have been raised (mostly by the industry) that incidental take regulations for wind energy projects will mean that FWS will be required next to regulate all forms of incidental take.

This justification (that other actions are incidentally taking birds as well) is a specious argument that fails to recognize several key issues, explained in detail below, including that bird mortality is cumulative across the full spectrum of causes and that different sources of anthropogenic bird mortality variously impact different species. It also sidesteps the crucial issue, i.e., are bird mortalities from wind farms an issue of concern from an environmental standpoint, and is a permitting scheme an appropriate way of addressing it? The simple answer to both questions is "yes." Wind turbines have burgeoned and continue to develop across the nation in critical bird areas and constitute a serious threat to many bird species. A permitting process is an appropriate means of both alleviating that threat and allowing wind energy development in a more bird friendly fashion. See supra Section C.2. In addition, as explained below, it is eminently clear that incidental take by wind energy projects is distinct from many other modes of incidental take and is, in any event, particularly appropriate for regulation by FWS.

FWS itself has expressly recognized that "[s]iting of a wind energy project is the most important element in avoiding effects to species and their habitats." Wind Guidelines First Draft at

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[148] Available at http://www.edprenovaveis.com/Technology/WindTechnology/FAQs (last visited Nov. 10, 2011).

8; Letter from FWS to Amber Zuhlke, Wind Capital Group, Big Lake Wind Facility in Palm Beach, Florida (July 1, 2011) ("[FWS] supports properly-placed renewable energy projects and is willing to assist companies in positioning these projects on the landscape in locations that are compatible with wildlife and their habitats."), Attachment K. Indeed, FWS biologists have recognized that even a single turbine can pose a serious threat to wildlife if it is constructed in an improper site. See, e.g., Letter from Mary Knapp, FWS concerning the operation of a single 25 kW wind turbine at Kelleys Island, Ohio at 6 (June 8 2011) ("The Service is concerned that the proposed project may result in take of migratory birds due to its location… While the small size and rotor-swept area of the turbine may aid in minimizing the likelihood of a migratory bird being struck, overall the Service believes this site poses a high risk to birds."), Attachment DD; see also Cornell Lab of Ornithology, Scientists to Investigate Impacts of Wind Energy on Migratory Wildlife (July 27, 2009) ("'We know that in some locations a small percentage of wind turbines may cause the majority of bird and bat deaths. For example, Altamont Pass, east of Oakland, California, is an extreme case: in an area used regularly by migrant and resident raptors, only a fraction of the 5,000 turbines are responsible for most of the raptor deaths annually."' (quoting Dr. Andrew Farnsworth of the Cornell Lab of Ornithology)).[149]

FWS has also recognized that in certain situations the most appropriate means to address the potential wildlife impacts of any given wind energy project is that the project is simply not constructed at a particular site. See, e.g., Wind Guidelines Third Draft at 36 (recommending abandoning a project site if there is "a high probability of significant adverse impacts to species of concern or their habitats"); Wind Guidelines Second Draft at 16 (explaining the possible outcomes arising from collection of information and cooperation with FWS and describing one such outcome as "the project site is abandoned because the risk is considered unacceptable."); see also Cornell Lab of Ornithology, Scientists to Investigate Impacts of Wind Energy on Migratory Wildlife (July 27, 2009)[150] ("Due to our significant [wildlife] concerns over the proposed project location, we encourage [the developer] to consider alternative locations to explore wind energy in the Southeast, with consideration of the issues outlined").

Thus, for some projects, the best available scientific information will indicate that the project should not be constructed at that site. As more and more projects are being constructed in pristine forested mountains and ridgelines, designated Important Bird Areas, and high risk areas crucial to migratory birds such as migratory bird flyways, feeding and nesting areas, and areas of high bird concentrations (i.e., rookeries, leks, state or federal refuges, staging areas, wetlands, riparian corridors, etc.) – without any mandatory standards and regulation whatsoever – mortality and habitat fragmentation due to wind energy projects is increasing tremendously. See, e.g., Letter from Thomas R. Chapman, FWS to Colonel Philip Feir, Corps at 10 (Mar. 12, 2009) ("Wind turbines located on ridgelines in the project area may pose multiple threats to migrating birds."), Attachment

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[149] Available at http://www.birds.cornell.edu/pr/wind_wildlife_pr.html (last visited Nov. 14, 2011).

[150] Available at http://www.birds.cornell.edu/pr/wind_wildlife_pr.html (last visited Nov. 14, 2011).

EE; Letter from David A. Stilwell, FWS to Michael Speerschneider, EverPower Wind Holdings (July 11, 2011) (discussing potential for incidental take of Bald Eagles or Golden Eagles as a result of the turbine blades striking eagles during migration, or as they pass through the project area on their way to foraging or roosting sites and cautioning that the project is located in an Important Bird Area), Attachment FF. In light of the unique significance of siting of massive wind turbines – which are inherently hazardous to birds and other flying animals – and hence the need for developers to work with FWS at the early stages of the project, the wind energy industry lends itself to appropriate regulation under the MBTA.

Additionally, it is also important to identify the particular species at risk at wind energy projects. Comparing other mortality threats, such as cat predation, to bird mortality from wind turbines is a misleading comparison because the birds threatened by wind turbines, often placed in critical bird migratory routes and habitats, disproportionately include species of particular conservation concern, particularly raptors such as the Bald Eagle, Golden Eagle, Ferruginous Hawk, Swainson's Hawk, and American Peregrine Falcon. See, e.g., Letter from Laury Zicari, FWS to Dana Vallieu, TRC (May 11, 2011) at 6 ("New information about migration and movements of golden eagles suggest this species may be the raptor most vulnerable to wind power in the eastern U.S." (emphasis added)), Attachment T; see also supra Section C.2. For example, a comparison of the types of bird species adversely impacted by wind energy projects with those that are taken due to cat predation demonstrates that this is an apples-to-oranges comparison – not only is it infeasible to develop a permitting scheme addressing cat predation but it is extremely unlikely that Bald Eagles could fall prey to house cats, or that California Condors could collide with skyscrapers, and yet they are at risk from poorly sited wind projects.

In addition, for many activities resulting in incidental take of migratory birds, implementing the MBTA wholly through post hoc enforcement actions (instead of establishing formal regulations for the same), may be feasible in light of the ready availability of effective avoidance and mitigation measures, such as use of anti-perching devices on power lines to avoid electrocution of birds, specific types of glass for tall buildings to avoid bird collisions, and bird-proofing oil drilling equipment to avoid bird deaths in oil and waste pits. Imposing sanctions for a company's failure to implement such measures may be an appropriate way of both punishing an individual violator and sending the message to an entire industry as to what is necessary to avoid migratory bird takes. At present, however, the best available science does not provide a similar 'quick-fix' solution for wind turbines to avoid bird mortality. See FWS 2011 MBTA Conference Presentation (explaining that FWS is lacking uniform best management practices for the industry, "except through *proper site location*"). Further, there may never be an across-the-board readily-applicable measure for avoiding and mitigating impacts of wind energy projects on migratory birds because, as explained above, due to the inherently hazardous nature of wind power for birds, the most significant step for avoiding impacts is proper siting of wind turbines, and, hence, in some situations, the best solution is to identify another site for the project. Post hoc enforcement, even if pursued by FWS – and, as discussed supra, Section E.3.ii, it never is pursued when it comes to wind power projects – is simply not an effective means for addressing poor facility siting, the most fundamental factor in avoiding or minimizing bird impacts.

Moreover, the fact that other threats to birds exist does not provide a free pass to the wind industry to exacerbate wildlife mortality and violate the MBTA and other wildlife protection laws. To the contrary, the fact that migratory birds are killed by preexisting sources is an additional reason to avoid, minimize, and mitigate a new source of mortality before it irreversibly contributes to a further decline in bird populations. See FWS 2011 MBTA Conference Presentation at 16 (Comparing direct impacts of wind to other sources of anthropocentric mortality is not helpful since "overarching issues are about cumulative impacts – ALL things impacting birds"); see also, e.g., Letter from Laury Zicari, FWS to Dana Vallieu, TRC (May 11, 2011) at 6 (explaining that given that Golden Eagles in Maine were seriously impacted by pesticide contamination, "the potential harm to golden eagles from an additional source of mortality makes careful evaluation of the siting and effects of proposed wind power facilities essential"), Attachment T. Indeed, once again, the need to properly avoid, minimize and mitigate wildlife impacts is especially crucial for an industry that seeks to market itself as "green energy" and environmentally friendly.

Lastly, with regard to the oft-cited unjustified objection against regulating incidental take of wind energy projects under the MBTA, i.e., that the agency would eventually be required to regulate innocent incidental takes (such as accidentally killing a bird while driving a car), it should be noted that courts have clarified that the MBTA does not lead to such "absurd results." United States v. Moon Lake Elec. Ass'n, 45 F. Supp. 2d 1070, 1084 (D. Co. 1999). Such cases of incidental take from activities that have a low likelihood of impacting migratory birds – such as the probability that any single driver will kill a bird -- can clearly be distinguished from incidental take by wind energy projects on the basis of foreseeability of wildlife impacts, i.e., "if the injury be one which might be *reasonably anticipated or foreseen as a natural consequence of the wrongful act.*" Id. at 1085 (internal citation and quotation marks omitted). In Moon Lake the Court observed as follows:

> Because the death of a protected bird is generally not a probable consequence of driving an automobile, piloting an airplane, maintaining an office building, or living in a residential dwelling with a picture window, such activities would not normally result in liability under § 707(a), even if such activities would cause the death of protected birds. Proper application of the law to an MBTA prosecution, therefore, should not lead to absurd results…

Id.

In fact, in Moon Lake, the Court examined the many facets of the MBTA and its implementing regulations that enable avoiding such "absurd results," and expressly identified, as an example, Section 704 of the MBTA under which "the Secretary has established when and how migratory birds may be taken, killed, sold, etc." Id. (citing implementing regulations establishing permit requirements under the MBTA). Indeed, in the context of incidental take by wind energy projects, the "absurd result" is that in the absence of appropriate regulations the industry's ordinary operation will inevitably and predictably place it in violation of federal law. FWS should promulgate regulations establishing mandatory standards and an incidental take permit system in order to avoid such a situation of having an industry (that the federal government especially wants to encourage and support) that is largely violating the MBTA.

In the end, FWS cannot refuse to promulgate needed permitting regulations for wind energy projects merely because other threats to wildlife exist or because such regulations will have purported implications for incidental bird deaths from everyday acts such as driving a car. Massachusetts v. E.P.A., 549 U.S. 497, 533 (2007) (an agency must proffer a "reasoned justification" for declining to regulate where it has statutory authority to do so).

E.4. Incidental Take Permits for Certain Wind Energy Projects Will Effectively Protect Migratory Birds, And Also Afford More Certainty to Wind Energy Developers.

As explained supra, Section D.2, FWS has very broad rulemaking authority under the MBTA to promulgate regulations so long as the regulations are "compatible" with the four migratory bird treaties. 16 U.S.C. § 704(a). In accordance with the MBTA, FWS has expressed statutory authority to promulgate regulations establishing a broad framework for wind energy development subject to mandatory conditions. Id.; see also id. § 712(2). ABC strongly recommends that such regulations adopt a process for issuing individual incidental take permits for certain wind energy projects, as recommended in the Proposed Regulations. See Appendix: Proposed Regulations.

The Proposed Regulations enable FWS to effectively carry out its statutory mandate to protect wildlife through establishing a clear permitting process under which the agency can regulate the siting of wind energy projects and their impacts on wildlife. As set forth in the Appendix, the Proposed Regulations would categorically require both land-based and offshore wind power projects to apply for MBTA permits. Both operating and planned projects would be required to comply with the Regulations, although the obligations would differ somewhat in light of the reality that siting alternatives for operating projects differ from those for projects that are still in the planning phase. With respect to the latter, the Proposed Regulations would afford a clear, up-front mechanism by which the Service can steer projects away from the most problematic sites. In addition, for both operating and planned projects, the Proposed Regulations would require FWS to adopt measures for minimizing and mitigating impacts on migratory bird populations to the maximum extent practicable.

In contrast to the present system – in which the conservation and independent scientific communities have, at best, ad hoc access to pertinent information and involvement in the review of wind power projects – the Proposed Regulations would ensure that there is at least some opportunity for public comment before an MBTA permit is issued. At the same time, as to projects for which the Service determines there is a low likelihood of adverse impact on bird populations, the Proposed

Regulations would provide for expediting project review and permit approval. Because the issuance of an MBTA permit is a federal action necessitating review under NEPA, the proposed permitting scheme would also afford a firm basis on which significant impacts to wildlife otherwise unprotected by federal law (e.g., unlisted bat species, and birds unprotected by the MBTA) would be addressed.

For a variety of reasons, implementing an effective incidental take mechanism along the lines of the Proposed Regulations is advantageous to the wind industry, FWS, and wildlife interests, in that it recognizes the value of renewable energy development and provides greater regulatory and legal certainty to the industry, while also enabling FWS to far more effectively carry out its statutory mandate to conserve federally protected wildlife, and avoid and minimize the harmful taking of migratory birds to the maximum extent practicable.

i. *The permit mechanism recommended in the Proposed Regulations enables FWS to require developers to consult FWS and to establish mandatory standards for the siting, construction, and operation of wind energy projects.*

Unlike the Wind Guidelines, the Proposed Regulations enable FWS to require developers to consult and share information with the agency at the earliest stage of project planning. The Proposed Regulations enable FWS to ensure that projects are not constructed in high risk areas. For other projects that may have adverse impacts but which can be avoided or minimized through effective mitigation measures, FWS may issue individual incidental take permits that authorize the project subject to the terms and conditions stipulated in the permit. For the remaining projects that may have minimal impacts, the Proposed Regulations envisage a broad framework for authorizing such projects subject to a determination by the agency, and other standards and criteria that are prescribed in the Proposed Regulations and otherwise by the agency.

In the context of military incidental take, FWS chose to implement the MBTA through a broad authorization subject to mandatory conditions, in lieu of an approach that required individual take permits. However, the Service's reason for not imposing more comprehensive and concrete obligations on the Armed Forces is related to the reasonable expectation that the Armed Forces will be addressing the impacts of its actions through the NEPA process. See Military Final Rule at 8939-40. As NEPA only applies to federal agency actions, the same treatment cannot be assured for wind energy projects that lack any clear nexus to a federal agency action. Further, three other reasons provided by FWS for structuring the regulatory system for military incidental in the form of a "broad, automatic authorization," and that distinguish it from incidental take by wind energy projects are – (1) that military readiness activities rarely have significant impacts; (2) that the Armed Forces like other federal agencies are required to comply with the Migratory Bird Executive Order; and (3) that it was especially important not to create a complex process in light of the importance of military readiness to national security. Id. at 8947. This indicates an acknowledgment by FWS that it has the authority to promulgate regulations for issuing individual permits for incidental takes - but chose not to exercise this authority in the military take context given the unique features of that context. See id. ("Without the rule, the Armed Forces might not be able to complete certain military readiness activities that could result in the take of migratory birds pending issuance of an MBTA take permit[.]").

Further, the reality that FWS is lacking uniform best management practices for the industry, "except through *proper site location*," FWS 2011 MBTA Conference Presentation, only strengthens the case for imposing concrete obligations on developers to consult FWS, in advance of project construction, in accordance with the "precautionary" principle that FWS itself has expressly relied on while advising wind energy developers. See, e.g., Letter from FWS to Amber Zuhlke, Wind Capital Group, Big Lake Wind Facility in Palm Beach, Florida (July 1, 2011) ("Wind facilities have not previously been sited in areas with Everglade snail kite presence or habitat; thus, there are no data indicating the potential risk of wind turbines on snail kites. Therefore, a conservative approach using precautionary principles is required."(emphasis added)), Attachment K.

ii. *The Permit mechanism recommended in the Proposed Regulations provides a means to protect species of concern that are not yet listed under federal wildlife laws, such as certain bat species.*

The permit mechanism in the Proposed Regulations will do more than protect birds listed under the MBTA – it will trigger NEPA review providing much needed protection for bats and other wildlife. One justification often cited for retaining "voluntary" guidelines in lieu of mandatory standards for wind energy projects is that the voluntary guidelines need not necessarily be tied to existing federal wildlife laws such as the ESA, MBTA, and BGEPA, and would therefore facilitate protection of both birds and bats that are not listed or protected under those statutes. See, e.g., Julia Pyper, New Bird Kills Raise Questions About Growth Of Wind Industry (E&E ClimateWire, Oct. 31, 2011) (quoting John Anderson, AWEA's Director of Siting Policy, that "there will actually be greater protection if the guidelines are voluntary" because this would entail protection of wildlife outside the scope of certain federal wildlife laws).

Although certain bat species such as hoary bats, red bats, and silver-haired bats, and certain birds, including such as sage grouse and prairie chickens[151] are not presently protected under the ESA, MBTA, or any other federal wildlife protection statute, and they could in theory be addressed

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[151] Both the Lesser Prairie-Chicken and the Greater Sage-Grouse, are ESA candidate species and FWS Birds of Conservation Concern, which are not covered by MBTA. The population of the Lesser Prairie-Chicken is estimated at merely 32,000, while that of the Greater Sage-Grouse is estimated at only 150,000. Wind energy development is a serious threat to both species because much of the species' remaining ranges coincide with areas containing strong wind resources. Thus, wind turbines and associated transmission lines are likely to be a barrier to movements of both Greater Sage-Grouse and Lesser Prairie-Chicken. For example, in 2009, in Oklahoma alone there were approximately 250 wind turbines in Lesser Prairie-Chicken range, with at least another 1,300 proposed. Christin L. Pruet et al., It's Not Easy Being Green: Wind Energy and a Declining Grassland Bird, 59 BioScience 257, 260 (Mar. 2009), http://vmpincel.bio.ou.edu/download/publications/bio.2009.59.3.10.pdf.

by the Wind Guidelines, those Guidelines, once again, are entirely voluntary, and may be complied with by a project developer merely recording its reasons for disagreeing with the Service on site selection or any other issues. Therefore, the Guidelines will not effectively protect any wildlife.

On the other hand, the permit process in the Proposed Regulations will afford a far better mechanism for addressing project impacts on even non-MBTA protected birds, unlisted bat species, and other wildlife currently unprotected under federal law. This is because the proposed issuance of a federal MBTA permit will trigger NEPA review, which will necessarily encompass any significant impacts on any wildlife populations. See 42 U.S.C. § 4332 (requiring an analysis of "environmental impact[s] of the proposed action" for "major Federal actions significantly affecting the quality of the human environment"); 40 C.F.R. § 1508.18 (defining "Major Federal Action" as "actions with effects that may be major and which are potentially subject to Federal control and responsibility" such as "[a]pproval of specific projects… approved by permit or other regulatory decision."). NEPA requires the agency to consider a "range of alternatives" to the proposed action, including the no-action alternative, and to identify appropriate mitigation measures to address the various impacts of the proposed action. 40 C.F.R. § 1505.1(e). Thus, the proposed regulations do encompass a mechanism of protection of both listed and non-listed wildlife and, because the permitting process, as proposed, would also involve public comment, it would allow for a far more meaningful opportunity to address impacts on otherwise unprotected birds, bats, and other wildlife than under the entirely voluntary Guidelines, which, among other problems, afford no basis on which conservation groups or other members of the public may weigh in on project impacts on an ongoing basis.

Moreover, nothing in the proposed regulations would preclude FWS from establishing both a mandatory permitting system for species protected under the MBTA, and voluntary guidelines for otherwise unprotected species – just as the existence of permitting processes under the ESA and BGEPA did not preclude the Service from drafting the current Guidelines. In fact, the process proposed here and guidelines focused on otherwise unprotected species could function in an entirely complementary fashion, with such Guidelines being brought to bear on the NEPA analysis that must be conducted on the MBTA permit application.

iii. *The permit mechanism recommended in the Proposed Regulations enables an evaluation of cumulative effects of wind energy development on a regional and national level.*

As discussed previously, the cumulative effects of the ever-escalating increase in wind projects, along with other impacts on migratory birds, pose extremely serious threats to the survival, habitat and behavior of migratory birds. In particular, habitat fragmentation from poorly sited wind power projects is an important contributor to cumulative impacts. Under the Proposed Regulations, the extent to which a proposed project will contribute to habitat loss and fragmentation, and other forms of cumulative impact, can be thoroughly evaluated in light of the early blueprints of a project, especially since the project's footprint and infrastructure needs (such as access roads, transmission lines, and substations) should already be fairly well determined by that time. Similarly, consideration of adjacent projects and other habitat-harming activities can be accomplished early in project planning (although they may need to be reviewed if other projects are added during the development phase).

In contrast, the approach adopted by FWS in the voluntary Guidelines utterly fails to provide appropriate measures and directives to study, avoid and mitigate cumulative effects at a national or regional level. The Guidelines explicitly state that "where there is no federal nexus, individual developers are not expected to conduct their own cumulative impacts analysis." Thus, the Guidelines recommend an analysis for cumulative effects by federal agencies only for projects that have "a federal nexus" such as those that "require a federal permit." Id. at 21. This does not result in a thorough analysis of cumulative effects of wind energy development, particularly because most wind energy projects are constructed on private lands with no "federal nexus," other than the impact on birds protected under MBTA and BGEPA. Further, the Guidelines recommend that the developers "communicate" with the agency about cumulative effects of the project only in the final phase of the project where construction is complete and the developer is considering the need for post-construction studies. See Wind Guidelines Third Draft at 14-15 (recommending in Tier 5 – tier dealing with post-construction studies and research – that the developer "communicate with the Service about ways to evaluate cumulative impacts on species of concern, particularly species of habitat fragmentation concern"). In short, FWS has so far failed to take any concrete and effective measures to address the cumulative impacts of wind energy development. This is especially troubling since, as illustrated supra, see Map 2.1, there are hundreds of wind energy projects that have likely been constructed (and more in the pipeline) and many of these projects are built along common migratory corridors and have serious direct and indirect impacts on birds.

iv. *The Permit mechanism recommended in the Proposed Regulations provides an opportunity for concerned citizens to ensure compliance with the MBTA.*

Citizen suits are useful tools that empower citizens, including individuals and non-profit groups, to enforce federal law and supplement federal enforcement of the law. Unlike the ESA, however, the MBTA does not contain a citizen suit provision that allows "any person" to bring a civil suit to enjoin violation of the statute. 16 U.S.C. § 1540(g)(1)(A). The only means by which a private lawsuit can be brought to enforce the MBTA is via the APA and only then in the event that there is a federal agency action involved in project planning or pursuit, i.e., lawsuits under the APA cannot be brought directly against a private party or state/municipal agencies and may only be brought against federal agencies when they take a final action that is connected to the alleged violation (for example where a wind energy project is located on public lands, or where it requires a permit from the Corps or another federal agency). Consequently, with regard to incidental take by wind energy projects, at present, the primary means of enforcing the MBTA must be through FWS enforcement actions – an avenue for enforcement that is essentially meaningless and is certainly not an effective check unless FWS opts to enforce the Act for at least flagrant violations of the Act, which has never happened in the context of wind power projects. See supra Section D.3.

The permit mechanism envisaged in the Proposed Regulations will effectively address this overriding problem of non-enforcement of the MBTA because the process is specifically designed to delineate the conditions under which the Service may authorize the take of migratory birds in connection with wind power projects. In addition, issuance of a federal incidental take permit under the MBTA will constitute a final federal agency action thereby triggering the availability of APA review. Consequently, the grant (or denial) of a permit can be set aside by a federal court if it is found to be "arbitrary, capricious, an abuse of discretion, or otherwise not in accordance with law." 5 U.S.C. § 706(2).

v. ***The Permit mechanism recommended in the Proposed Regulations will not unnecessarily constrain the agency's staff and resources.***

For many years now, FWS has been grappling with drafting and implementing voluntary Guidelines for wind power projects, thereby expending a large amount of time, money and other resources of the agency on a cause that, unfortunately, has proven to be of little value in attaining its stated objective, i.e., to effectively avoid and minimize wildlife impacts of wind energy projects. In 2011 alone, FWS has issued three iterations of voluntary Guidelines (in a process that substantially weakened the initial agency recommendations), and as of the date of this writing is yet to finalize the Guidelines. In the meantime, wind power projects continue to proliferate, and adverse impacts on migratory birds and other wildlife continue to become ever more severe in the absence of better mechanisms for addressing and ameliorating such impacts.

Further, for wind energy developers that do consult the agency, the Guidelines envisage a "tiered approach" whereby the agency is expected to be involved in all phases of the project, albeit on an informal "voluntary" basis. While the Guidelines essentially treat the agency as a quasi-permitting authority requiring it to evaluate extensive information and provide advice to the developers, unlike a formal permitting system, FWS does not obtain appropriate permit fees which typically provide some amount of resources and revenue to the agency. See, e.g., 50 C.F.R. §13.1(d)(4) (specifying applicable fee for take permits under federal wildlife laws such as the MBTA, BGEPA, and ESA). Thus, this is plainly not a cost-effective arrangement because under the Guidelines, the agency is in any event using extensive resources and expending the time of its experienced staff, to make non-binding recommendations that the project proponents are free to disregard (so long as they document their reasons for disagreeing).

In sharp contrast, under the proposed permitting system, FWS will inevitably obtain much more conservation bang for its buck – and will also be able to defray at least some of its expenses in processing applications through appropriate permit fees, as it has done with other permitting regimes.

vi. ***The Permitting mechanism recommended under the Proposed Regulations complements the protections afforded by the ESA and BGEPA.***

While a wind energy developer is able, when the relevant criteria are satisfied, to obtain an incidental take permit for impacts on endangered or threatened species of birds under the ESA, there is presently no comparable mechanism for authorizing take by developers under the MBTA, which strictly prohibits take of all birds protected under the Act in the absence of a permit issued pursuant to the Act. This places project developers in the legally untenable position of obtaining a federal permit under one law (the ESA) for taking a particular species, but being in violation of another law for taking the very same species. See Memorandum from Pete Raynor, Assistant Solicitor, Fish and Wildlife Branch, to John Rogers, Deputy Director, FWS, Permitted Incidental Take of Migratory Birds Listing Under the Endangered Species Act (Feb. 5, 1996) at 2 ("ESA incidental take documents do not provide any relief from the prohibitions of the MBTA and BGEPA; indeed, some of those documents specifically state that they do not provide any such relief. Therefore, an applicant that wants complete protection from prosecution for the take of an ESA-listed migratory bird pursuant to an ESA incidental take document must also seek a permit under the MBTA, or []BGEPA"), Attachment P. In addition, by issuing an ITP that authorizes a project that will result in the take of migratory birds – in the absence of any permitting mechanism under the MBTA for doing so – FWS places itself at risk of being sued under the APA. See supra Section D.3. The Proposed Regulations rectify these problems and legal confusion, at least insofar as wind power projects are concerned by authorizing FWS to issue take permits under the MBTA, as well as the ESA.

The Proposed Regulations will also resolve legal anomalies involving Golden Eagles and Bald Eagles, and result in enhanced protection of those species. Although incidental take permits can be issued for eagles under BGEPA, in the absence of a permitting scheme under the MBTA, even wind power projects receiving BGEPA permits will be in at least technical non-compliance with the MBTA. More importantly, while providing for the issuance of take permits, nothing in the BGEPA regulations categorically requires wind power projects to obtain such a permit, even where FWS biologists believe that eagle take is likely. Worse, the current version of the Guidelines provide that if project developers themselves do "not anticipat[e]" taking eagles, and "adhere" to the Guidelines by documenting their disagreement with the Service concerning the likelihood of take, this alone "would give rise to assurances regarding enforcement discretion if an unexpected taking occurs." Wind Guidelines Third Draft. Accordingly, with regard to wind power projects, the Guidelines undercut any potential safeguards afforded by the BGEPA regulations, by not only providing that project developers may override the concerns of FWS biologists, but that they may even obtain "assurances regarding enforcement discretion" if they do so and nonetheless kill or otherwise take a Bald or Golden Eagle. Id.

The Proposed Regulations would both resolve the legal anomaly concerning compliance with the MBTA and BGEPA, and also far better protect eagles than at present. The Proposed Regulations would categorically provide that all wind power projects must, prior to construction, obtain an

MBTA permit, thus necessarily triggering a FWS (and public) review of all potential migratory bird impacts, including to eagles in the vicinity or migrating through the project site.

vii. *The Permitting Mechanism recommended under the Proposed regulations will afford more legal and regulatory certainty to the wind power industry than can be afforded under the current, confusing regulatory regime.*

According to the wind power industry, regulatory uncertainty and potential criminal liability under the MBTA has been a barrier to the growth of the industry and has proven to be especially troubling in terms of securing investor confidence. See, e.g., Bryan McBournie, Q&A with Peter Duprey: Leading in an uncertain energy industry (interview with CEO of Broadwind Energy, a provider of products and services primarily for the wind-energy industry, who stated, "[w]e undoubtedly need more regulatory certainty to help tame the volatility of the wind industry in the U.S., as the industry will remain challenged without it." (emphasis added)).[152] The wind industry desires regulatory and legal certainty particularly with regard to the application of federal wildlife laws to wind energy projects.

In contrast to the voluntary Guidelines, the establishment of a permitting scheme under the Proposed Regulations would provide far greater regulatory and legal certainty to wind energy developers and their investors, and will also establish a level playing field for all wind energy developers. By failing to impose clear regulatory obligations on wind energy projects to anticipate and avoid migratory bird impacts before they occur, and by largely allowing the industry itself to make siting decisions, FWS has not only effectively penalized those companies that do attempt to comply with the agency's guidance – since they are essentially placed at a competitive disadvantage with those companies that refuse to do so – but has also tacitly approved widespread disregard for wildlife statutes the Service is entrusted to enforce. Indeed, since the Service cannot lawfully extend non-enforcement assurances for compliance with voluntary Guidelines – particularly Guidelines that allow wind power projects to "comply" merely by recording their reasons for disagreeing with the Service's concerns – under the current regime, wind power projects will necessarily be facing an ongoing risk of prosecution when they, inevitably, take migratory birds in violation of the MBTA. In addition, there is nothing to prevent a new Administration from adopting, if it so chooses, a tougher stance when it comes to enforcing the MBTA against wind power projects that are in fact in violation of the law. And, where there is a federal nexus to a project, compliance with anemic Guidelines surely will not insulate a project from APA review and a potential ruling by a federal court that an agency's approval of a project should be set aside because it will lead to migratory bird takes in violation of the MBTA.

In short, with a valid permit in hand, wind power developers would not face these risks, but rather would be provided assurance against prosecution so long as they comply with the terms and conditions of the permit. Thus, the Proposed Regulations will enable the wind industry to have far

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[152] Available at http://smartblogs.com/leadership/tag/renewable-energy/ (last visited Dec. 11, 2011).

greater predictability and regulatory certainty, while also far better establishing itself as a genuinely green and environmentally protective industry.

E.5. The Proposed regulations are compatible with the international migratory bird treaties.

As explained supra, Section D.1, the MBTA is the domestic implementing legislation for various international treaties designed to safeguard migratory birds and their habitats. Accordingly, the present system of non-regulation of wind power projects, and reliance on voluntary Guidelines and industry self-certification of compliance with them, flouts not only the statute, but also the underlying conventions. On the other hand, regulation of incidental take by wind energy projects, as proposed in this Petition, is entirely compatible with the terms of the migratory bird conventions. Indeed, the large-scale ongoing taking of a wide variety of bird species protected under the migratory bird conventions, coupled with lack of oversight, regulation, and enforcement of the law by FWS, is a clear contravention of the conventions.[153] Further, FWS has previously determined, albeit in the context of military incidental take, that regulations permitting incidental take are compatible with all four migratory bird conventions. See Military Take Final Rule at 8946.

i. *Convention between the United States and Canada*

The United States entered into a convention with Great Britain (for Canada) in 1916 for the protection of migratory birds in the United States and Canada. See 39 Stat. 1702 (1916). This convention was amended in 1995 by a protocol which replaced most of the provisions of the original convention. See Protocol Amending the 1916 Convention for the Protection of Migratory Birds, S. Treaty Doc. No. 104-28, 1995 WL 877199 ("1995 Protocol") (hereinafter jointly referred to along with the convention as "Canada Treaty").

The 1995 Protocol recognized the commitment of both parties towards "long-term conservation of shared species of migratory birds" through a comprehensive international framework that involves, among other things, regulation of take. See Preamble, 1995 Protocol. The Treaty requires the parties to "ensure the long-term conservation of migratory birds" in accordance with certain "conservation principles" such as managing migratory birds internationally, ensuring a variety of sustainable uses, sustaining healthy migratory bird populations for harvesting needs, providing for and protecting habitat necessary for the conservation of migratory birds, and restoring depleted populations of migratory birds. Id. Art. II. The Treaty recognizes that the conservation principles may be achieved through means such as monitoring and regulation. Id. Further, the Treaty expressly provides that "subject to laws, decrees or regulations to be specified by the proper

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[153] Moreover, the obligation of nations, to ensure that activities within their jurisdiction or control do not harm the environment beyond their territory, is also firmly entrenched in customary international law. See, e.g., Co-operation in the Field of Environment Concerning Natural Resources Shared by Two or More States, U.N.G.A.Res. 3129 (XXVIII) (1973).

authorities," the taking of migratory birds may be allowed at any time for specific purposes consistent with the conservation principles. Id. Art. II(3). In addition, the Treaty requires parties to seek means to prevent damage to migratory birds. Id. Art. IV(a).

In sum, the Canada Treaty contemplates the permitting of take through regulation "for specific purposes" consistent with the conservation principles of the Treaty and subject to appropriate regulations. Regulations monitoring and regulating incidental take by wind energy projects will likely be compatible with the terms of the Canada Treaty. Such regulations facilitate the parties' long-term commitment to conserve migratory birds through appropriate regulations and are consistent with the conservation principles adopted in the Treaty.

ii. *Convention between the United States and Mexico*

In 1937, the United States entered into a convention with Mexico for the protection of migratory birds and game mammals. See Convention between the United States of America and Mexico for the Protection of Migratory Birds and Game Mammals, 50 Stat. 1311, T.S. No. 912 (1937) ("Mexico Treaty"). The Treaty recognized that "it is right and proper to protect the said migratory birds . . . in order that the species may not be exterminated," and that there is a need "to employ adequate measures which will permit a rational utilization of migratory birds for sport as well as for food, commerce and industry." Id. Preamble (emphasis added).

Specifically, the Mexico Treaty allows the parties to use "adequate methods which will permit…the utilization of [migratory birds] rationally for purposes of sport, food, commerce and industry." Id. Art. I (emphases added). Towards this end, the Treaty requires the parties "to establish laws, regulations and provisions" to satisfy the need to permit rational utilization of migratory birds for various uses, including, commerce and industry. Such regulations may adopt various appropriate measures such as establishment of "refuge zones" in which taking will be prohibited, and prohibition of the killing of migratory insectivorous birds. Id. Art. II.

In sum, the Mexico Treaty allows parties to adopt regulations permitting take of migratory birds for industry or commerce on a rational utilization basis. Thus, regulations permitting incidental take by wind energy projects will likely be compatible with the terms of the Mexico Treaty so long as the taking is based on a rational utilization of the resources and measures are adopted to ensure against the extermination of any species.

iii. *Convention between the United States and Japan*

The United States entered into a treaty with Japan in 1972 for the protection of migratory birds and birds in danger of extinction. See Convention Between the Government of the United States of America and the Government of Japan for the Protection of Migratory Birds and Birds in Danger of Extinction, and Their Environment, T.I.A.S. No. 7990, 25 U.S.T. 3329, 1974 WL 166630 (U.S. Treaty) (1974) ("Japan Treaty"). The Japan Treaty recognizes that the "great value" of migratory birds can be "increased with proper management," and that there is a need to take measures for the "management, protection, and prevention of the extinction of certain birds." Id. Preamble (emphasis added).

The Japan Treaty prohibits the taking of migratory birds. Id. Art. III. However, "[e]xceptions to the prohibition of taking may be permitted in accordance with the laws and regulations [of the parties]….[for] specific purposes not inconsistent with the objectives of this Convention." Id. Further, the Treaty recognizes that special protection is required for preservation of birds that are in danger of extinction. Id. Art. IV(1). In addition, the Treaty provides that the parties shall endeavor to establish sanctuaries and other facilities for the protection and management of migratory birds. Id. Art. III(3). The parties are also required to "take measures necessary to carry out the purposes" of the Treaty. Id. Art. VII.

In sum, the Japan Treaty allows parties to permit taking through regulations in accordance with applicable law so long as it is consistent with the objectives of the conventions. Thus, regulations governing incidental take by wind energy projects will likely be compatible with the terms of the Japan Treaty if it facilitates the objectives of the Treaty and, as stated in its preamble, protects and prevents the extinction of migratory birds.

iv. *Convention between the United States and Russia*

The United Stated entered into a treaty with Russia in 1978 to conserve migratory birds and their environment. See Convention between the United States of America and the Union of Soviet Socialist Republics Concerning the Conservation of Migratory Birds and Their Environment, T.I.A.S. No. 9073, 29 U.S.T. 4647, 1978 WL 182150 (U.S. Treaty) (1978) ("Russia Treaty"). The Russia Treaty recognizes that - the value of migratory birds can be "increased under proper management;" that there is a need to protect migratory bird species along with their flyways, and breeding, wintering, feeding and moulting areas; and that certain endangered bird species are in need of particular protective measures. Id. Preamble (emphasis added).

The Treaty requires the parties to prohibit the taking of migratory birds. Id. Art. II(1). "Exceptions to these prohibitions may be made on the basis of laws, decrees or regulations" for "specific purposes" not inconsistent with the principles of the Treaty. Id. (emphasis added). To the extent possible, the parties are required to prevent "detrimental alteration" of the environment of migratory birds. Id. Art. IV(1). Accordingly, the parties are required to identify areas of breeding, wintering, feeding and moulting that are of special conservation importance to migratory birds. Id. Art. IV(2)(c). In addition, the Treaty enables the parties to enter into special agreements for the conservation of particular species of migratory birds, id. Art. II(3), and to undertake necessary measures to establish preserves, refuges, and protected areas for the conservation of migratory birds and their environment. Id. Art. VII. The Treaty specifically provides that parties may adopt stricter domestic measures that are deemed to be necessary to conserve migratory birds and their environment. Id. Art. IX.

Similar to the other conventions, the Russia Treaty allows parties to devise exceptions to the take prohibition so long as it is consistent with the principles of the Treaty. Regulations governing incidental take by wind energy projects are necessary to ensure that important bird areas such as flyways are protected and that wind turbines are not constructed in such areas of special conservation importance. Thus, regulations for take by wind energy projects are not only compatible with the terms of the Russia Treaty, but will likely also facilitate the Treaty's mandate to prevent "detrimental alteration" of migratory bird habitat.

F. CONCLUSION

ABC requests that FWS issue, as expeditiously as possible, new regulations based on those proposed in this Petition, see Appendix: Proposed Regulations, pursuant to Sections 704(a) and 712(2) of the MBTA, for establishing a framework for regulating and authorizing conditional take by wind energy projects.

APPENDIX: PROPOSED REGULATIONS

PERMITS FOR WIND POWER PROJECTS PURSUANT TO THE MIGRATORY BIRD TREATY ACT

Subpart A – Introduction

§ 1.1 Purpose of Regulations

These regulations are designed to facilitate the development of wind power projects while, to the maximum extent practicable, avoiding, minimizing, and mitigating their adverse impacts on birds protected by the Migratory Bird Treaty Act ("MBTA"). The regulations contained in this part supplement the Department of the Interior's general permit regulations contained in Part 13 of this subchapter, as well as the Department's general regulations implementing the MBTA contained in Part 21 of this subchapter. Compliance with the regulations contained in this part does not relieve wind power projects from also complying, where applicable, with other regulations that impose requirements or prohibitions concerning particular migratory birds, such as regulations implementing the Endangered Species Act ("ESA") and the Bald and Golden Eagle Protection Act ("BGEPA").

§ 1.2 Definitions

In addition to definitions contained in Part 10 of this chapter, and unless the context requires otherwise, as used in this part:

FWS or Service is the United States Fish and Wildlife Service.

Migratory bird is any species that is covered by the MBTA and treaties implementing the MBTA.

Person means any individual, corporation, partnership, academic institution or any legal entity formed in any manner for the purpose of developing, constructing, and/or operating a wind power project.

Practicable alternative is an alternative site for a proposed wind power project that would accomplish essentially the same objectives as the proposed project without significantly increased costs or other practical or financial constraints.

Wind power project means any land-based or offshore project that uses, or is designed to use, the wind to generate electricity within the jurisdiction of the United States and includes but is not limited to, the project's wind turbines and associated infrastructure such as transmission lines, substations, meteorological towers, and access roads.

§ 1.3 General Requirements and Exceptions

§ 1.3.1 General Permit Requirements

No person shall construct or operate a wind power project except as may be permitted under the terms of a valid permit issued pursuant to the provisions of this part and Part 13, as well as any other applicable regulations issued pursuant to the ESA, BGEPA, or other pertinent law. A wind power project that is in receipt of a valid permit issued pursuant to this part and that is in compliance with that permit shall not be subject to criminal or civil penalties for violation of the take prohibition of the MBTA.

§ 1.3.2 General Exception to Permit Requirement

Any wind power project that is operational – *i.e.*, generating any electricity through turbine operation – on the date that these regulations become effective may continue to operate without a permit issued pursuant to this part so long as a complete application for such a permit that complies with § 1.5, as set forth below, is submitted to FWS within 120 days of the date that these regulations become effective. For the purpose of these regulations, any substantial upgrade, modification, or expansion of the project that has the potential to impact migratory birds – *e.g.*, an expansion in the number of turbines or the rotor swept area – is treated as a new project.

§ 1.4 Specific Permit Provisions Applicable to Non-Operational Wind Power Projects

§ 1.4.1. General Requirement

The requirements of this part must be satisfied in order for any non-operational wind power project – *i.e.*, a project that is not generating electricity on the date that these regulations become effective – to obtain a permit pursuant to this part.

§ 1.4.2. Contents of Permit Application

Each application for a permit pursuant to this section must contain the following, along with any other information that FWS may prescribe in guidance supplementing these regulations:

(a) a detailed description of the proposed site for the project, including the proximity of the site to known ridges and other migratory routes, nesting locations, wetlands and other areas where migratory birds are present, and other resources of particular importance to migratory birds;

(b) detailed descriptions and results of all preconstruction surveys that are of sufficient duration, nature, and scope to reasonably evaluate the extent to which (1) a particular proposed site is used by specific species of migratory birds; (2) the degree of risk that the site poses to the various species of birds that use the site; and (3) local siting of turbines or other design modifications may be employed to avoid or mitigate the risk to affected bird species. In determining the duration, nature, and scope of surveys that will be deemed adequate for a particular site, and who is qualified to conduct such a survey, the project developer shall comply with any written guidance issued by FWS supplementing these regulations, and shall consult as appropriate with the Migratory Bird Permit Office of the Regional FWS Office in which the proposed project is located;

(c) a detailed description of the proposed project, including (1) the number, size and type of turbines contemplated; (2) the anticipated life of the project; (3) the proposed layout of the entire project, including turbines, transmission lines, power stations, roads, and other physical features; (4) the proposed schedule for project construction; (5) the applicant's proposed pre-construction and post-construction monitoring plans; (6) all measures that the applicant is proposing to undertake to avoid, minimize, and mitigate the effects of the anticipated take of migratory birds to the maximum extent practicable; and

(d) any other information that FWS may request to evaluate and study the wildlife impacts of the project.

§ 1.4.3. Public Comment

The public will be afforded an opportunity to comment on each application for a permit. The public comment period will be for a period of no less than thirty days. If, after reviewing the application, FWS believes that the project poses a low risk for migratory birds, and will not otherwise have any significant adverse environmental impacts, the Service's notice soliciting public comment will advise the public that the Service intends, subject to the consideration of public comments, to expedite its review of, and determination on, the application.

Prior to the initiation of the public comment period, FWS will make available to the public all survey data and other information submitted by the permit applicant in support of the application. If FWS complies with the National Environmental Policy Act ("NEPA") by preparing an Environmental Assessment ("EA") in connection with the permit application, the Service will make the EA available to the public prior to the initiation of the comment period on the permit application. If the Service complies with NEPA by preparing an Environmental Impact Statement ("EIS") in connection with the project, the Service will coordinate public comment on the permit application with public comment on the EIS.

§ 1.4.4. Evaluation of Permit Applications

In determining whether to issue a permit, the Service will evaluate all factors relevant to whether a permit may be issued consistent with the purposes of the MBTA, including but not limited to:

(a) the overall impact of the project on migratory birds and important migratory bird habitat, and the extent to which the project is compatible with the maintenance of populations of migratory birds likely to be affected by the project, taking into account the cumulative present and projected impacts of other activities on the affected bird species, including from other wind projects;

(b) the proximity of the project to important bird habitats, including migratory routes and nesting, roosting, and/or feeding areas;

(c) the proposal for pre-construction and post-construction monitoring;

(d) whether the applicant has proposed avoidance, minimization, mitigation, and monitoring measures to reduce the take and the adverse effects of the take to the maximum extent practicable;

(e) the extent to which the project will result in adverse impacts to any species that FWS has determined qualify as a Bird of Conservation Concern and any species that is a candidate for listing under the ESA; and

(f) whether there are practicable alternative sites for the project that would have a less deleterious impact on migratory bird populations and habitats.

§ 1.4.5 Required Determinations

Before issuing a permit, FWS must find that:

(a) the effects of the anticipated take and required mitigation, together with cumulative effects of other activities and additional factors affecting the bird populations and habitats impacted by the project, are compatible with the maintenance and conservation of bird populations, particularly populations of birds designated by FWS as Birds of Conservation Concern and bird species that are candidates for listing under the ESA;

(b) the permit applicant will conduct appropriate, adequate pre-construction and post-construction monitoring;

(c) the permit applicant will to the maximum extent practicable avoid, minimize, and mitigate adverse effects on migratory birds and important migratory bird habitats;

(c) the permit applicant will conduct such monitoring and adaptive management as the Service determines is necessary to fully and effectively evaluate the impact of the project, including the efficacy of minimization and mitigation measures, on migratory birds and migratory bird habitat, and to evaluate whether changes need to be made in the project's operation in order to better minimize and mitigate the impact on migratory birds; and

(d) there are no practicable alternatives to the project as proposed that would entail less adverse impact on migratory birds.

§ 1.4.6 Permit Conditions

FWS will attach to any issued permit such terms and conditions, including if appropriate specified take limits, and requirements for additional mitigation, adaptive management and monitoring, as are deemed necessary to avoid, minimize, and mitigate to the maximum extent practicable the adverse effects of the project on migratory birds. The permit holder must comply with all such terms and conditions, as well as with the avoidance, minimization, and mitigation measures set forth in the permit application and approved by the Service.

§ 1.4.7 Permit Duration

The duration of each permit issued under this section will be designated on its face, and will be based on the duration of the proposed project, the level of anticipated impacts, the difficulty of reliably predicting the impacts, and the likelihood that adaptive management will be able to address impacts beyond those anticipated. In no event, however, will the permit length exceed five years unless it is extended in response to a renewal request that must be made available for public comment in accordance with this subpart prior to action by FWS.

§ 1.4.8 Monitoring and Incident Reports

The permit terms and conditions shall specify the frequency with which monitoring reports must be prepared and submitted to FWS but in no event will such reports be required less than annually. In addition, the permit terms and conditions will require the permit holder to promptly submit incident reports containing detailed information about any incidents involving major wildlife mortality. All monitoring and incident reports will promptly be made available to the public.

§ 1.4.9 Revocation, Suspension and Modification

The Service shall revoke and/or suspend any permit when it determines that a permitted project is failing to comply with the requirements in this subpart, or, for any reason, is having a significant adverse effect on a migratory bird population and that is not promptly addressed by modification of the permit. The Service may modify the terms and conditions of the permit if necessary to avoid, minimize and mitigate the impacts of the project, and subject to public comment. Any member of the public may petition the Service to revoke, suspend, or modify a permit on these grounds, and the Service shall respond to any such petition in a timely manner and no later than 90 days after receipt of the petition. For purposes of this provision, a significant adverse effect is one that could, within a reasonably foreseeable period of time, diminish the capacity of a population of migratory birds to sustain itself at a biologically viable level. A population is 'biologically viable' when its ability to maintain its genetic diversity, to reproduce, and to function effectively in its native ecosystem is not significantly harmed**.**

§ 1.5 Permit Provisions Applicable to Operational Wind Power Projects

All of the foregoing provisions shall also be applicable to operational projects, except that the applicant need not address the practicability of alternative sites and the Service will not base any decisions on that factor. In imposing any permit terms or conditions the Service will take into account the extent to which ongoing project operations may reasonably be modified without causing significant disruptions in the operation of the project.

§ 1.6 Review Period

FWS will review and make a decision on whether to grant a permit within a reasonable time in light of such factors as the complexity and size of the project and the degree of risk it poses to migratory birds. For a project for which the Service decides to prepare an EA rather than an EIS, the

Service will ordinarily make a final decision on a permit application no later than 12 months after a complete application is received by the Service.

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LIST OF ATTACHMENTS

A. Daniel J. Lebbin et al., ABC, The North American Bird Conservancy Guide to Bird Conservation (2010) (excerpts)

B. Tamara Enz & Kimberly Bay, Post-Construction Avian and Bat Fatality Monitoring Study, Tuolumne Wind Project, Klickitat County, Washington, Final Report, April 20, 2009 to April 7, 2010 (July 6, 2010) (excerpts)

C. J. K. Fiedler et al., Results of Bat and Bird Mortality Monitoring at the Expanded Buffalo Mountain Windfarm, 2005 (June 28, 2007) (excerpt)

D. David P. Young, Jr. & Zapata Courage, Avian/Bat Monitoring September 25, 2011 Memo (Sept. 30, 2011)

E. BioResource Consultants Inc., 2009/2010 Annual Report Bird and Bat Mortality Monitoring, Pine Tree Wind Farm, Kern County, California (Oct. 14, 2010)

F. Albert Manville, FWS, Presentation on Shoreline, Near-shore, and Offshore Wind Energy Development in Texas State Waters: Tools to Help Avoid or Minimize "Take" of Waterbirds and Other Avifauna (2011)

G. Albert Manville, FWS, Presentation on Framing the Issues Dealing with Migratory Birds, Commercial Land-based Wind Energy Development, USFWS, and the MBTA (Oct. 21, 2011)

H. Letter from Laury Zicari, FWS to Jennifer McCarthy, Corps (May 11, 2011)

I. Albert Manville, FWS, Towers, Turbines, Power Lines, and Buildings – Steps Being Taken By the U.S. Fish and Wildlife Service to Avoid or Minimize Take of Migratory Birds at These Structures (July 17 2009)

J. Memo from Stantec Consulting (consultants for developer) to Laura Hill, FWS, Bird Mortality at Laurel Mountain Substation Memo (Oct. 25, 2011)

K. Letter from FWS to Amber Zuhlke, Wind Capital Group, Big Lake Wind Facility in Palm Beach, Florida (July 1, 2011)

L. Letter from Allan M. Strand, FWS to Jayson Hudson, Corps (Aug. 15, 2011)

M. Nathanial Gronewold, Texas is Bullish on Offshore Wind (E & E News, Nov. 21, 2011)

N. Email from Tylan Dean, FWS to Keith Hastie, FWS (Mar. 30, 2011)

O. Anacapa Island Restoration Project, Channel Islands National Park, Phase I MBTA Summary Report (2002)

P. Memorandum from Pete Raynor, Assistant Solicitor, Fish and Wildlife Branch, to John Rogers, Deputy Director, FWS, Permitted Incidental Take of Migratory Birds Listing Under the Endangered Species Act (Feb. 5, 1996)

Q. Laura J. Beveridge, The Migratory Bird Treaty Act and Wind Development (N. Am. Wind Power, Sept. 2005)

R. Memo from Alan Forster, NedPower Mt. Storm LLC to Laura Hill, FWS, NedPower September 25, 2011 Monitoring Event (Oct. 10, 2011)

S. Letter from Deborah Carter, FWS to Curry & Kerlinger, LLC (environmental consultants of developer) (Sept. 30, 2009)

T. Letter from Laury Zicari, FWS to Dana Vallieu, TRC (May 11, 2011)

U. Letter from Gary Miller, FWS to Sue Oliver, Or. Dep't of Energy (Feb. 14, 2011)

V. Letter from Michael D. George, FWS to Jay Prothro, BP Wind Energy, Southwest Power Pool Docket #ERII-3833 (Oct. 11, 2011)

W. Letter from Robert D. Williams, FWS to Tim Carlson, Nevada Wind, Proposed Virginia Peak Wind Facility and Existing Golden Eagle Resources in the Pah Rah Range, Washoe County, Nevada (Aug. 13, 2010)

X. Letter from Scott Hicks, FWS to Xio Cordoba, Heritage Sustainable Energy (Nov. 4, 2011)

Y. Letter from FWS to Chris Taylor, Element Power (Jan. 31, 2011)

Z. Letter from Laury Zicari, FWS to Nicholas D. Livesay, Pierce Atwood LLP (attorneys of the developer) (Mar. 31, 2011)

AA. Shiloh IV Wind Energy Draft Environmental Impact Report (Aug. 23, 2011) (excerpt)

BB. K. Shawn Smallwood et al., Novel Scavenger Removal Trials Increase Wind Turbine–Caused Avian Fatality Estimates, 74(5) J. Wildlife Mgmt. 1089 (2010)

CC. Memo from Willie R. Taylor, FWS to FCC, FCC Draft Programmatic Environmental Assessment (DPEA), Antenna Structure Registration (ASR) Program

DD. Letter from Mary Knapp, FWS concerning the operation of a single 25 kW wind turbine at Kelleys Island, Ohio (June 8 2011)

EE. Letter from Thomas R. Chapman, FWS to Colonel Philip Feir, Corps (Mar. 12, 2009)

FF. Letter from David A. Stilwell, FWS to Michael Speerschneider, EverPower Wind Holdings (July 11, 2011)

Arnold Schwarzenegger
Governor

PERMITTING SETBACK REQUIREMENTS FOR WIND TURBINES IN CALIFORNIA

PIER INTERIM PROJECT REPORT

Prepared For:
California Energy Commission
Public Interest Energy Research Program

Prepared By:
California Wind Energy Collaborative

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Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Energy Commission), conducts public interest research, development, and demonstration (RD&D) projects to benefit the electricity and natural gas ratepayers.

The PIER program strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy-Related Environment Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

Permitting Setback Requirements for Wind Turbines in California is an interim report for the Windplant Optimization project (contract number 500-02-004, work authorization number MR-017) conducted by the California Wind Energy Collaborative. The information from this project contributes to PIER's Renewable Energy Technologies program.

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Abstract

The California Wind Energy Collaborative was tasked to look at barriers to new wind energy development in the state. Planning commissions in the state have developed setback standards to reduce the risk of damage or injury from fragments resulting from wind turbine rotor failures. These standards are usually based on overall turbine height. With the trend toward larger capacity, taller towers and longer blades, modern wind turbines can be "squeezed out" of parcels thus reducing the economic viability of new wind developments.

Current setback standards and their development are reviewed. The rotor failure probability is discussed and public domain statistics are reviewed. The available documentation shows rotor failure probability in the 1-in-1000 per turbine per year range. The analysis of the rotor fragment throw event is discussed in simplified terms. The range of the throw is highly dependent on the release velocity, which is a function of the turbine tip speed. The tip speed of wind turbines does not tend to increase with turbine size, thus offering possible relief to setback standards. Six analyses of rotor fragment risks were reviewed. The analyses do not particularly provide guidance for setbacks. Recommendations are made to use models from previous analyses for developing setbacks with an acceptable hazard probability.

Keywords: Wind turbines, wind power, wind energy, permitting, zoning, ordinances, hazards

Executive Summary

Introduction

California counties have adopted setbacks for wind turbines primarily to account for the risk of fragments from the rotor. These setbacks are usually based on overall turbine height, which includes the tower height and the radius of the blade. With evolution in the industry to larger turbines, these setbacks increase in total distance and become a hindrance to wind energy development. The authors present a hypothetical example where the total energy production of a windplant is reduced with the application of larger, modern turbines.

Purpose

The purpose of this report is to summarize wind turbine setbacks in California and to describe any connection between rotor failure and windplant setback requirements.

Project Objectives

The objectives of this study of wind turbine setbacks were to:

- Document and compare current wind turbine setbacks in California
- Report on how the setbacks were developed
- Report on the probability of rotor failure
- Study existing analyses of the rotor fragment hazard and determine if setback criteria can be developed with existing information.

Project Outcomes

The outcomes of the project were:

- The authors gathered information regarding turbine setbacks by interviewing county planning personnel, studying the county ordinances, and conducting a literature search of the subject. Wind turbine setbacks were documented for California counties with existing and future wind energy development, including Alameda, Contra Costa, Kern, Merced, Riverside, and Solano counties. Comparisons were made between the various ordinances.
- From this data the authors developed a picture of how the turbine setbacks were established. The majority of the ordinances were developed by ad hoc groups of local interests and the fledgling wind energy industry.
- The authors conducted a literature survey regarding the probability of rotor failure. Several sources of information were obtained. These include failure reports of turbines in Alameda County, failure data from Denmark and Germany reported in the WindStats periodical, and a Dutch report on European rotor

failures. The probability of rotor failure varied from 1-in-100 to 1-in-1000 turbines per year.

- The authors present a simplified analysis of the rotor fragment hazard to compare to more complex analyses. The analyses of six researchers were found in a literature survey of varying complexity. Results were compared to determine if setback criteria could be developed.

Conclusions

Wind turbine setbacks vary by county. The counties typically base the setback on the maximum of a fixed distance or a multiple of the overall turbine height. A common setback is three times the overall turbine height from a property line.

There is no evidence that setbacks were based on formal analysis of the rotor fragment hazard.

The most comprehensive study of wind turbine rotor failures places the risk of failure at approximately 1-in-1000 turbines per year.

The maximum range of a rotor fragment is highly dependent on the release velocity that is related to the blade tip speed. Tip speed tends to remain constant with turbine size; therefore, the maximum range will tend to remain constant with turbine size. In the analysis of rotor fragment trajectories, the most comprehensive models yielded results that showed the shortcomings of simpler methods. Overall, the literature shows the possibility of setbacks for larger turbines may be based on a fixed distance and not the overall height.

Recommendations

The authors recommend that a comprehensive model of the rotor fragment hazard be developed based on the results of the literature review. This tool would then be used with a variety of turbine sizes with the objective to develop risk-based setback standards.

Benefits to California

The information provided in this report can be used by California planning agencies as a background for evaluating wind turbine setbacks. Researchers can also use the information as background for developing models of the rotor fragment hazard.

1.0 Introduction

1.1. Background and Overview

California has played a pivotal role in the creation and evolution of the wind-based electric power generation industry. Wind power is unique in the visibility and exposure to the public as compared to other forms of power generation. By necessity, communities have become involved in planning for the development of wind power in their jurisdiction. Both the regulation and technology of wind power evolved together in the last two decades.

Particular attention was made to protect the public from hazards. With the advent of a new technology, the probability of failure tends to be higher because the physics are not well understood. The engineering of the technology must also be balanced with economics, and the balance is very tenuous at the beginning of a new venture. Equipment and business failures plagued the industry in the last two decades, and legacy equipment still fails at a relatively high rate today.

One hazard possibility of wind turbines is the failure of a portion of the rotor resulting in fragments being thrown from the turbine. Concerns over public exposure to this risk led the counties to develop setbacks from adjacent properties and structures. The development of county ordinances took place independently of each other; however in most cases the fledgling wind power industry was involved in the development (McClendon and Duncan 1985). In general, the setbacks were based on the heights of the turbines.

Utility scale turbines installed in California have evolved from 50 kilowatt (kW) machines of 25 meter (m) overall height to 3.0 megawatt (MW) machines of 126 m overall height. The nature of that evolution, in general, is that manufacturers stop production of smaller turbines due to improved economics of the new larger turbines. With increased overall height, the setback distance is increased, and modern turbines can be “squeezed out” of developments.

The California Wind Energy Collaborative (CWEC, http://cwec.ucdavis.edu/), through its “Windplant Optimization” task, was directed to prepare this white paper on permitting issues in regards to the rotor fragment risk. The concern over restrictions on development was the impetus to study current ordinances and the rotor fragment risk. Two possibilities offer the potential for relief in this area. Modern wind turbines might offer higher reliability, thus lowering the risk of rotor failure. Second, in the event of a rotor failure, the hazard area is governed by the blade tip speed. The tip speed tends to remain constant with turbine size. Therefore, more appropriate setbacks might be a fixed distance, and not a function of the turbine size. These possibilities, along with background research, are discussed in this report.

1.2. Example Windplant and the Problem with Current Setbacks

Setbacks are established to minimize risk of damage or injury from component failure on property and personnel. The setbacks are usually a multiple of the total turbine height, from tower base to upper extreme point of the rotor (see Figure 1). Generally the setbacks can vary from 1.25 to 3 times the overall machine height. Larger setbacks are sometimes required for special areas. In contrast to these standards, counties in California with more rural development, such as Merced and San Joaquin, use building setbacks and do not distinguish wind turbines separately.

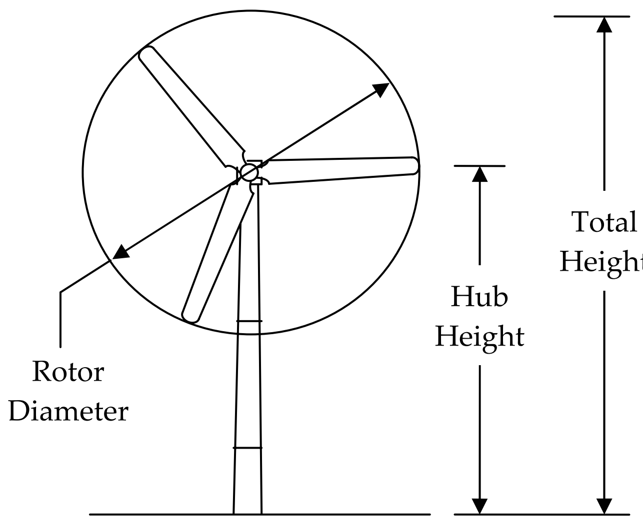

Figure 1. Wind turbine dimensions

As an illustration of the potential of setbacks limiting modern wind energy development, consider the following hypothetical situation. A developer has a 1000 by 1000 m (1 square kilometer or 247 acres) parcel of land available in a county requiring a setback three times machine total height. The site has a strong prevailing wind direction, and the machines are to be spaced in consideration of wake effects of 3 diameters crosswind and 10 diameters downwind. Two machines are considered:

1.2.1. 1. Vestas V-47

- 660-kW full rating
- 47 m rotor diameter
- 50 m tower height

1.2.2. 2. General Electric GE 1.5s

- 1500-kW full rating
- 70.5 m rotor diameter
- 65 m tower height

The layouts are shown in Figure 2 and Figure 3, with shaded zones representing the setback areas. The overall height is the sum of the tower height plus half the rotor diameter.

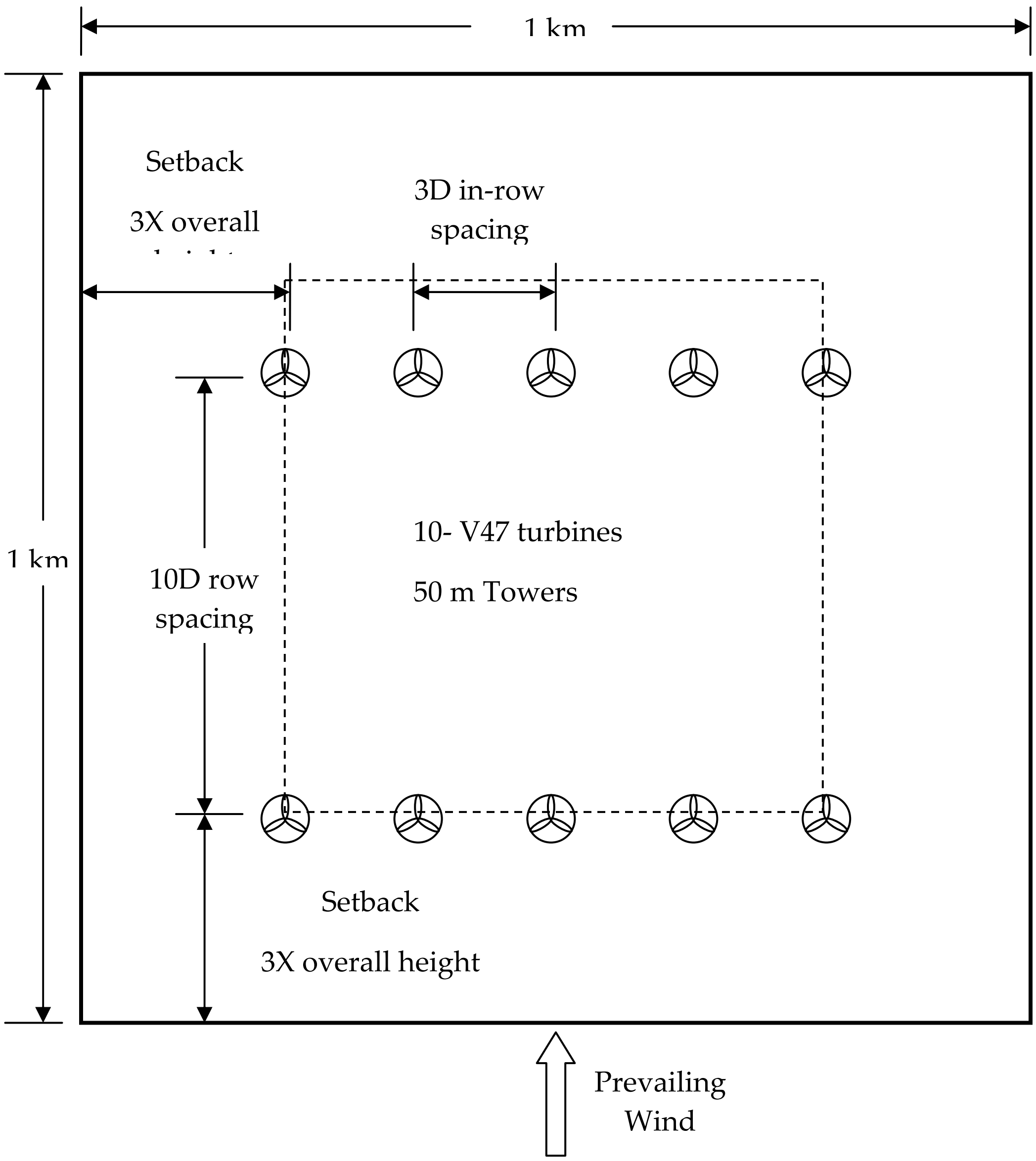

Figure 2. Layout for V-47 wind turbines based on setback requirement of three times total turbine height

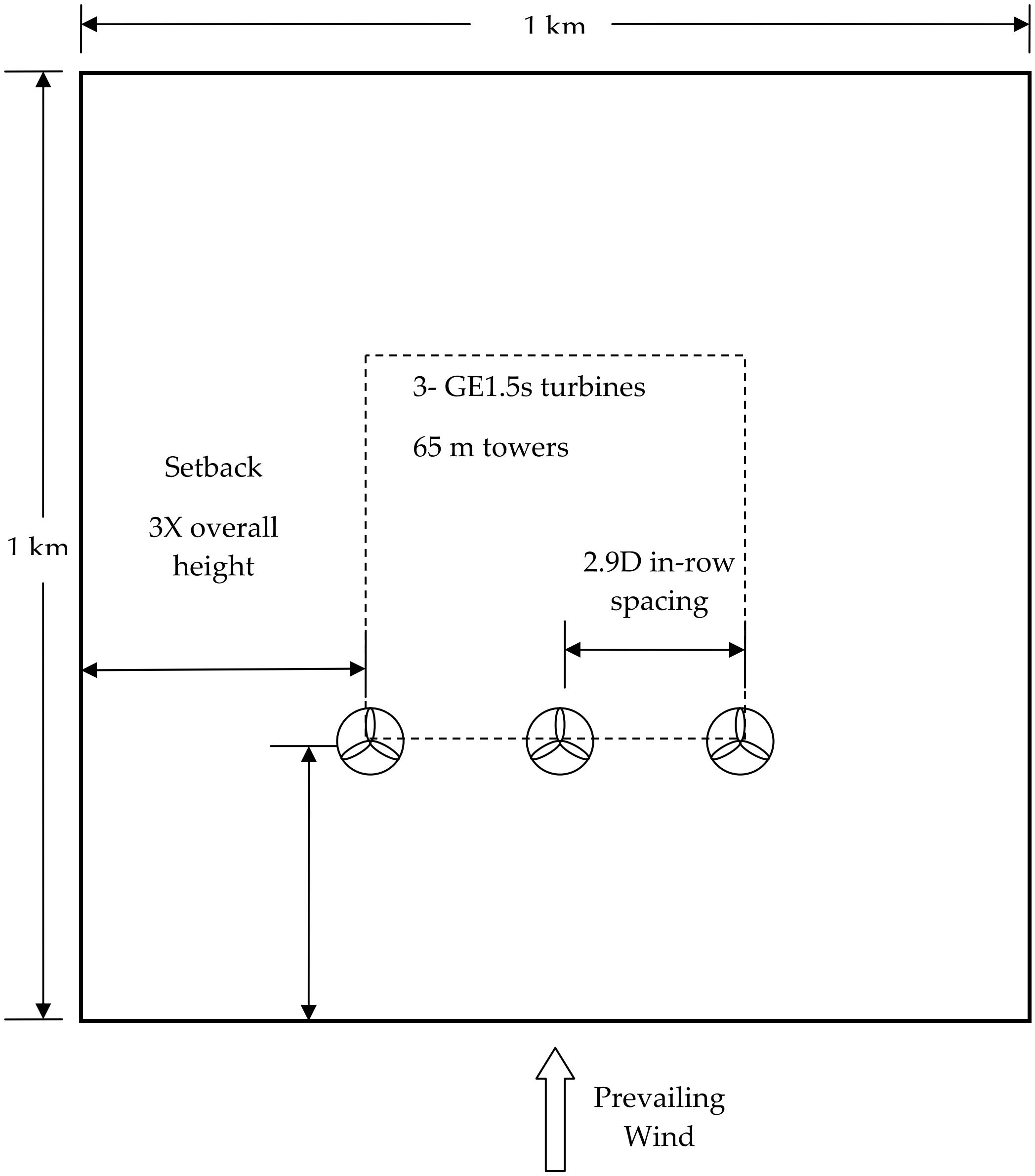

Figure 3. Layout for GE 1.5s machines based on setback requirements of three times total turbine height

For the V47 machine, the spacing requirements and setbacks allow for 10 machines with total rating of 6.6 MW. In contrast, the requirements allow only three GE 1.5 turbines with total rating of 4.5 MW. The crosswind spacing in this case would probably be reduced slightly. Downwind spacing requirements would force a second row of turbines off the parcel. The setback requirements for this example result in lower energy production with the application of larger, modern machines. The options available to a developer are further constrained with the current trend of manufacturers producing larger machines, and phasing out the production of smaller machines such as the V-47.

1.3. Project Objectives

Project objectives for this study were to:

- Document and compare current wind turbine setbacks in California
- Report on how the setbacks were developed
- Report on the probability of rotor failure
- Study existing analyses of the rotor fragment hazard and determine if setback criteria can be developed with existing information.

Wind turbine setbacks are codified for reasons other than safety. Scenic corridors might be established so that views are not adversely impacted by new structures. Acoustic emissions from turbines might limit siting. Maximum sound pressure levels might be established at property lines or dwellings, constraining the placement of turbines. This report deals specifically with the issue of the rotor fragment hazard.

2.0 Project Approach

For each of the project objectives, the authors took the following approaches:

- Document and compare current wind turbine setbacks in California

The authors considered only counties with existing utility-scale wind power development. These counties are Alameda, Contra Costa, Kern, Merced, Riverside, San Joaquin, and Solano. The authors obtained the majority of the county ordinances from the Internet. Many counties have their codes residing on Ordlink (http://ordlink.com/), a LexisNexis product. All county planning departments were contacted for any additional information. In some cases, the wind energy ordinance was a separate document (Solano 1987) or part of an Environmental Impact Report (Alameda 1988b). The setbacks were organized into a tabular format for comparison.

- Report on how the setbacks were developed

The authors conducted interviews with county planning personnel on this topic. The authors also conducted a literature survey on the Internet and reviewed the conference proceedings of the American Wind Energy Association, the British Wind Energy Association, and the European Wind Energy Association.

- Report on the probability of rotor failure

The authors conducted a literature survey on this topic with the sources mentioned above, and searched the annual conference proceedings of the American Society of Mechanical Engineers technical conference on wind energy.

During the study, CWEC obtained records of Alameda County turbine failures. These data were compiled and analyzed. The authors also compiled failure data from European turbines reported in *WindStats,* a quarterly newsletter of Windpower Monthly. CWEC also translated and reviewed an interim report on rotor failures prepared by the Netherlands Energy Agency.

- Study existing analyses of the rotor fragment hazard and determine if setback criteria can be developed with existing information.

The authors conducted a literature survey with sources mentioned above, and developed a simple model of the rotor fragment hazard to outline certain characteristics of the problem. The method and results for each researcher is described. Where possible, the results are compared across analyses.

3.0 Project Outcomes

3.1. Current Wind Energy Ordinances

The majority of the county ordinances were obtained from the Internet. The authors strongly suggest checking the current information available on the websites. Checking the requirements is especially important during the lifetime of a development project. Current ordinances and their safety setback requirements are summarized in Table 1.

Table 1. Setback references in California county ordinances

	Internet Site	Ordinance	Setback Reference
Alameda	Code for wind energy not available on internet	Draft Environmental Impact Report, Repowering a Portion of the Altamont Pass Wind Resource Area, Appendix A, Alameda County Windfarm Standard Conditions	Paragraph 15. Safety Setback
Contra Costa	http://www.co.contra-costa.ca.us/	County Code, Title 8 Zoning, Ch. 88-3 Wind Energy Conversion Systems	88-3.602 Setback Requirements
Kern	http://ordlink.com/codes/kerncoun/	Title 19 Zoning, Chapter 19.64 WIND ENERGY (WE) COMBINING DISTRICT	19.64.140 Development standards and conditions
Merced	http://web.co.merced.ca.us/planning/zoningord.html	Zoning Code (Ordinance) Ch. 18.02, Agricultural Zones	Table 5 Agricultural Zones Development Standards
Riverside	http://www.tlma.co.riverside.ca.us/planning/ord348.html	Ordinance 348, Section 18.41, Commercial Wind Energy Conversion Systems Permits	18.41.d(1) Safety Setbacks
Solano	Code for wind energy not available on internet	Wind Turbine Siting Plan and Environmental Impact Report 1987	Page 17 Safety Setbacks

Table 2 compares setbacks for several of the counties organized by feature that the turbine must be displaced from, such as a property line. The distances are stated in multiples of overall turbine height (Figure 1). If a fixed distance is included with the multiple, then the maximum of the two values must be used for the setback.

Table 2. Safety setback comparison. Note: for reference purposes only. Check counties for current zoning requirements.

	Property Line	Dwelling	Roads	Reductions in Setbacks
Alameda County	3x/300 ft (91 m), more on slope	3x/500 ft (152 m), more on slope	3x/500 ft (152 m), 6x/500 ft from I-580, more on sloped terrain	maximum 50% reduction from building site or dwelling unit but minimum 1.25x, road setback to no less than 300 ft (91 m)
Contra Costa County	3x/500 ft (152 m)	1000 ft (305 m)	None	exceptions not spelled in ordinance can be filed with county
Kern County	4x/500 ft (152 m) <40 acres or not wind energy zone, 1.5x >40 acres	4x/1000 ft (305 m) off-site	1.5x	With agreement from adjacent owners to no less than 1.5x
Riverside County	1.1x to adjacent Wind Energy Zones	3x/500 ft (152 m) to lot line with dwelling	1.25x for lightly traveled, 1.5x/500 ft (152 m) for highly traveled.	None
Solano County	3x/1000 ft (304 m) adjacent to residential zoning, 3x from other zonings	3x/1000 ft (304 m)	3x	Setback waived with agreement from owners of adjacent parcels with wind turbines

Table 2 shows that counties have different requirements. Riverside County maintains the minimum setback distances to properties with adjacent wind energy zoning.

Alameda County has adjustments for sloping terrain. If the ground elevation of the turbine is two or more times the height of the turbine above the feature, the setback distance increases from three times to four times. With the exception of Riverside County, all allow for reduction of the setback distance with special consideration. The Altamont Repowering EIR (Alameda County 1998) is an example of a reduced setback, which resulted from a developer submitting a rotor fragment risk analysis as substantiation for the reduction.

Merced County has some wind energy development in the Pacheco Pass area, and utilizes standard building setbacks for wind turbines in agricultural districts. San Joaquin County has similar requirements for the development in the Altamont Pass area.

3.2. Setback Development

With the exception of Solano County, the ordinances are not explanatory documents. Background information is not provided. The most comprehensive paper on the subject of wind energy permitting in California comes from McClendon and Duncan. Although this paper was written in 1985, it captures the essence of the process at the time and generally, not much has changed in the interim. Another paper by Throgmorton (1987) focuses on Riverside County development exclusively. Further clues to the development of standards are found in Environmental Impact Reports written for the counties on specific developments. The counties are discussed separately below.

References in the literature to safety setbacks are scarce. One is found in Taylor (1991). Taylor proposed setbacks for a 30 m diameter rotor machine, but no tower height is mentioned. The proposed setbacks were 120–170 meters from a habitation or village, 50 meters from a lightly traveled road, and 100 meters from a heavily traveled road. A Windpower Monthly article regarding a rotor failure in Denmark (Møller 1987) mentions setbacks for safety. A setback of 90 meters plus 2.7 times the rotor diameter was proposed. The Wind Energy Permitting Handbook available from the National Wind Coordinating Committee (NWCC 2002) provides no guidance on setbacks. In all the above references, there is no discussion of the technical basis for the setbacks.

3.2.1. Alameda County Ordinance

Alameda County, encompassing most of the Altamont pass, was one of the first regions in the world to have large-scale wind energy development. Until recently, the Altamont Pass area has been isolated from population centers, lowering the possibility of conflict with the community. The McClendon and Duncan paper (1985) reported that concerns over safety and reliability of wind turbines resulted in an ad-hoc public/industry group to develop new standards. The setbacks as they stand today are found in Resolution Number Z-5361 of the Zoning Administrator of Alameda County, dated September 5, 1984. There is no known technical description on how the setbacks were developed.

3.2.2. Contra Costa County Ordinance

Contra Costa encompasses the northern portion of the Altamont pass. The zoning language is much less specific than Alameda County, but the setbacks are similar.

3.2.3. Kern County Ordinance

According to county personnel and McClendon and Duncan (1985), the standards for Kern County were developed with an ad-hoc committee of wind energy people and other interests, as in the case with Alameda County. Kern has stricter setbacks for properties not zoned for wind energy development, but is less restrictive for roads (see Table 2).

3.2.4. Riverside County Ordinance

Riverside County is an area of intense development. Regulations were established after an extensive Environmental Impact Report (EIR) by Wagstaff and Brady (Riverside County California, United States Bureau of Land Management et al. 1982). Clues to the majority of the setback distances are in the report. Although there is no technical basis for the original setback of three times the total height of the turbine, one can infer that this distance arose from the discussion of wake effects. It was expected that in-row spacing for wake effects would be six diameters, and adjacent wind energy parcels would require a spacing of at least half this distance. The report also mentions an estimate of the fragment throw distance for the MOD-0A, an early Westinghouse machine. The stated value of 500 ft (152 m) translates to three times overall height for this turbine. Evolution of the ordinance resulted in reduction of some of the setbacks, which now seem to offer a buffer for the possibility of tower collapse.

3.2.5. Solano County Ordinance

Solano County also developed wind turbine requirements with industry involvement in 1985. The outcome of this work was the Solano County Wind Turbine Siting Plan (Solano County 1987), which remains the guide for permitting in the county. The plan supercedes the current language in the zoning ordinance that has setbacks of 1.25 times the overall turbine height. This plan was developed by the authors of the Riverside County EIR, and proposes a "three times" setback. The estimated rotor fragment risk of the MOD-0A is again mentioned. There is a comparison of the setbacks with the rotor fragment risk of the MOD-2 turbine. The throw distance of this turbine in a vacuum was estimated to be 1300 feet (396 m, 3.7 times overall turbine height) for a broken tip and 700 feet (213 m, 2 times overall turbine height) for the whole blade. There is no technical discussion for these values and they are not tied into the proposed spacing. The Montezuma Hills EIR (Solano County and Earth Metrics 1989), proposed a three times diameter safety setback, with no consideration for turbine height. Neither reference provides a technical basis for the setback distance.

3.3. Rotor Failure Probabilities

This section discusses the probability of a rotor failure occurring. Probabilities will be discussed in terms of ratios. For example, a coin toss with heads has a one in two probability, represented equally as 0.5, ½, 5×10^{-1}. A probability of something occurring once in one-hundred trials can be represented as 10^{-2}. The probability applied to rotor failures will be stated as the probability of failure for a turbine in one year of operation. A probability of 10^{-2} per turbine per year can then be understood that on average there will be one rotor failure in a year for every 100 turbines.

Reporting on turbine failures is very limited, most likely due to the sensitivity of the industry. There are few accounts of turbine failure in the literature. There are statistics in the public domain that will be discussed below.

Types of rotor failures are as follows:

- Root-connection full-blade failure
- Partial-blade failure from lightning damage
- Failure at outboard aerodynamic device
- Failure from tower strike
- Partial-blade failure due to defect
- Partial-blade failure from extreme load buckling

Some of the causes of rotor failures:

- Unforeseen environmental events outside the design envelope
- Failure of turbine control/safety system
- Human error
- Incorrect design for ultimate loads
- Incorrect design for fatigue loads
- Poor manufacturing quality

Not surprisingly, most failures are a combination of these factors, which points to the complexity of the technology. The probabilities of some events are highly correlated with each other. For example, loss of grid power is highly correlated with high wind events. The potential then exists for a control system malfunction due to loss of power to coincide with a high loading event. Thus the turbine designer must plan for both events occurring simultaneously.

3.3.1. Rotor Failures in the Literature

One of the earliest documented rotor failure events comes from one of the first applications of utility-scale wind energy (Putnam 1948). It is also one of the few accounts with a published distance. The Smith Putnam 1.25 MW turbine suffered a rotor failure in its test campaign resulting in a blade throw of 750 ft (230 m), or 3.7 times the overall height. The failure was attributed to lack of knowledge of the design loads for the turbine. The blade throw was probably exacerbated by siting on a slope (approximately ten degrees). The blade was of steel construction, with a weight of eight tons (mass of 7260 kg). That is at least 50% heavier than modern construction. A heavier blade could fly farther due to a reduced drag-to-weight ratio (Eggers, Holley et al. 2001).

The next period of literature deals with the analysis of large-scale turbines under development in the 1970s and early 1980s. Although the possibility of failure was discussed, no mention of the probability was placed forward for the Department of Energy (DOE) MOD series turbines such as the General Electric MOD-1 (General Electric 1979) and the Boeing MOD-2 (Lynette and Poore 1979). The Solar Energy Research Institute (SERI) conducted a preliminary study of wind turbine component reliability (Edesess and McConnell 1979). Using an analysis of the individual failure rate estimates and inspection intervals of the rotor and braking systems, the authors predicted a failure rate for the wind turbine rotor at 1.2×10^{-2} per turbine per year.

A strong early wind program in Sweden prompted studies of the subject (Eggwertz, Carlsson et al. 1981) where the first attempts at analyzing the rotor fragment risk were made. The first guess at the probability of failure was made at 1 in 100,000 (10^{-5}) failures per turbine per year.

The evolution of the wind industry back to smaller turbines brought large scale manufacturing and experience was gained with equipment failures. In a 1989 paper (De Vries 1989) conducted a blind survey of manufacturers that reported on 133 turbine failures in the industry. De Vries also placed probabilities at 2×10^{-2} rotor failures per turbine per year for the Netherlands, 3 to 5×10^{-3} for Denmark and 3×10^{-3} for the United States. This is two to three orders of magnitude higher than that predicted by Eggwertz, but closer to the SERI analysis.

Failures are occasionally reported in Windpower Monthly. They have reported a rotor overspeed failure in Denmark (Møller 1987) and full-blade failures in Spain (Luke 1995). A report in the technical literature comes from Germanischer Lloyd (Nath and Rogge 1991), one of the certification bodies for wind energy. The paper describes two medium-size turbine rotor failures. The rotor diameter and tower height were not reported. One failure was attributed to insufficient shutdown braking force resulting in overspeed, and blades were thrown to 150 and 175 meters. The other failure was attributed to poor manufacturing quality and blade fragments were thrown 200 meters. Updates to certification requirements were made as a result of the failure investigations. These certification requirements call for redundancy in safety shutdown systems and quality control in the blade manufacturing process. De Vries had also earlier suggested stricter certification requirements to reduce the rotor failure rate.

One wind turbine manufacturer has made a public testimonial of their rotor failure rate. A managing engineer at Vestas, in testimony for the Kittitas Valley Wind Power Project in Washington State (Jorgensen 2003), declared that there had been only 1 blade failure in 10,000 units for 12 years. The failure reported occurred in 1992 on a V39-500 kW machine when a blade was thrown 50–75 meters. If an average of six years of total operation for the entire fleet is assumed, the failure rate would be estimated at 1.6×10^{-5} rotor failures per turbine per year.

3.3.2. Alameda County Turbine Failure Data

Under Article 15 of the Alameda County Windfarm Standard Conditions (Alameda County 1998a), a windfarm operator must notify the County Building Official of any tower collapse, blade throw, fire, or injury to worker. Recent files of failure data from the county building department were compiled by the CWEC in order to determine failure rates. County representatives claim that not all operators have been diligent in their reporting, but one operator of Kenetech 56-100 machines has been. These turbines are 100 kW machines with 56 ft (17 m) diameter rotors. The majority were manufactured in the 1980s. The failure reports only indicate the failure type. There is no mention of rotor fragment distance (if fragments were thrown from the turbine), or the conditions at time of failure. The failures could have been discovered as the result of an inspection before any part had separated from the turbine. The failure data covered the year 2000 to fall of 2003. The number of Kenetech 56-100 machines in operation by this operator was obtained from the California Wind Performance Reporting System (http://wprs.ucdavis.edu/).

For the time period of the reports, the rotor failure rate was 5.4×10^{-3} failures per turbine per year. This value coincides well with that reported by De Vries (1989). As a comparison the failure rate for the tower was 6.9×10^{-4} failures per turbine per year, an order of magnitude less probable than the rotor failure rate.

3.3.3. WindStats Turbine Failure Data

WindStats is a technical publication for the wind industry published quarterly in Denmark. Failure data are available for wind turbines located in Denmark and Germany. The Denmark data have been available since 1993; the Germany data since 1996. Like the Alameda County data, the data only indicate failure type. There is no mention of rotor fragment distance (if it occurred at all), or the conditions at the time of failure, are mentioned. CWEC compiled data through the spring 2004 issue.

For Denmark, the failure rate for rotors was 3.4×10^{-3} failures per turbine per year. Again, this is within the values reported by De Vries (1989) in the late 1980s. The tower failures for the same period are 1.0×10^{-4}. As with the Alameda data, the tower failure probability is an order of magnitude lower than the rotor failures. For Germany, the data are reported as "rotor" failures, which for the reporting period were 1.5×10^{-2} failures per turbine per year. This is an order of magnitude higher than the Denmark data, but on the same order of the Netherlands in De Vries. There are no apparent trends in the data indicating changes in failure rates over time.

3.3.4. Dutch NOVEM Report

During the writing of this report the Netherlands Agency for Energy and the Environment (NOVEM) was writing a handbook on wind turbine siting due to the risk posed by wind turbines. The overall report is summarized in English by Braam and Rademakers (2004) from the Energy Research Centre of the Netherlands, ECN, and the report was published in Dutch in 2005 (Braam, van Mulekom et al. 2005). The CWEC received approval from the authors to translate Appendix A of the handbook and it is included in Appendix A of this document.

The appendix from the handbook reviews data from two large databases of wind turbines in Denmark and Germany. The database covers turbine operation from the 1980s until 2001. The authors analyzed the data and recommended values of risk for the following failure events:

- Failure at nominal operating rpm 4.2×10^{-4}
- Failure at mechanical breaking (~1.25 time nominal rpm) 4.2×10^{-4}
- Failure at mechanical breaking (~2.0 time nominal rpm) 5.0×10^{-6}

The authors compared these results to earlier values developed by European agencies in the earlier 1990s, with the overall blade failure rate declining three times. It is expected that with the maturity of the industry blade failures will continue to decrease.

Documented blade failures and distances were also reported in the handbook. The maximum distance reported for an entire blade was 150 m, for a blade fragment the maximum distance reported was 500 m.

3.4. Rotor Fragment Analyses

This section discusses the estimates of rotor fragment risk as determined by six researchers. The impetus behind these investigations was to study the hazard potential of the rotor failure. While rotor failures can occur with the machine operating or stationary, these studies were limited to the operating case.

3.4.1. Background of Rotor Fragment Models

Parked Turbines

Wind turbines are parked if the wind speed is out of the operating range, or if there is fault detected while the wind speed is within the operating limits. The typical high wind shutdown for a wind turbine is 25 meters/second, m/s. The turbine is usually designed to withstand a peak gust outlined by the International Electrotechnical Commission (IEC). Peak gusts for various wind classes are shown in Table 3. The peak gust is defined as a three-second average gust that has a fifty percent probability of occurring in fifty years, more succinctly known as "50-year wind." The IEC wind classes are also distinguished by the annual average wind speed. All wind speeds are designated at hub height.

Table 3. IEC peak gusts

IEC Class	I	II	III
50-year wind	70 m/s	59.5 m/s	52.5 m/s
Annual Average	10 m/s	8.5 m/s	7.5 m/s

If a rotor has failed in a parked condition, there is no initial velocity of any fragment coming off. Any movement away from the turbine is governed by gravity and the aerodynamic force on the fragment. None of the analyses studied the failure of the parked turbine, and it is assumed that failure during operation will result in a higher probability of the blade or the blade fragment flying farther.

Ballistics Models

Analysis of rotor failure uses methods of classical dynamics in order to describe the problem. Figure 4 is a representation of a rotor failure. If there is a rotor failure, either a fragment or the entire blade, the motion of the fragment is governed by specific forces. If the failure has taken place while the turbine is operating, the fragment has an initial velocity due to rotation, while in flight the motion is constrained by gravity and aerodynamic forces. The initial velocity of the rotor fragment is a function of the tip velocity, determined by Equation 1:

Equation 1 $$V_{tip} = \Omega R$$

where:

$\Omega =$ Rotor rotational speed, and

$R =$ Rotor radius

Normal operating tip speeds of the turbines studied in the literature varied from 40 m/s to 100 m/s. Modern wind turbines fall within this range. The tip speed is chosen to meet the performance requirements for the turbine and also to minimize acoustic emissions. The lower the tip speed, the lower the loads and noise from the blades for a given blade design. This can be compared to the low/high switch setting for a fan.

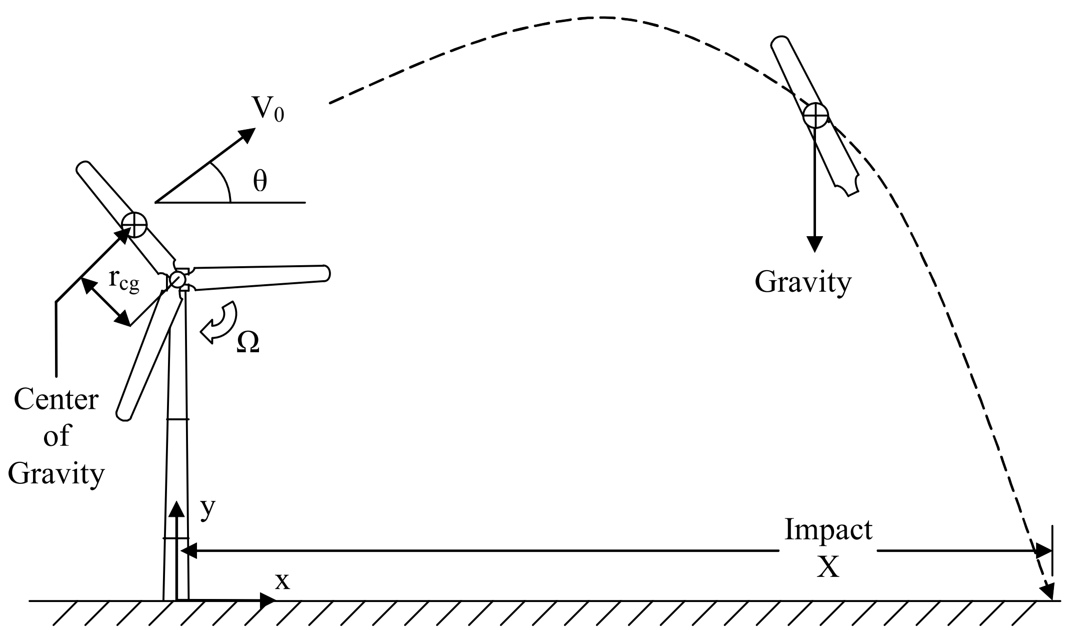

Figure 4. Rotor fragment schematic

If there is a failure of the rotor and a fragment is released, the initial velocity at separation is given by Equation 2:

Equation 2 $$V_0 = \Omega r_{cg}$$

where:

$V_0 =$ Initial velocity of fragment at center of gravity

$r_{cg} =$ Radial position of the fragment center of gravity

At the time of separation, the blade or fragment has the same angular velocity (or spin) as the rotor.

A rudimentary model of ballistics is the path of a fragment in a vacuum. The only force acting on the fragment is gravity. This model is found in most elementary dynamics textbooks, such as Schaum's (Nelson, Best et al. 1998). The total ground range achieved by the fragment, with release height and impact height equal, is given by Equation 3.

Equation 3 $$X = \frac{V_0^2}{g} \sin 2\theta$$

where:

X = Horizontal total ground range of a fragment in a vacuum

g = Gravitational acceleration

θ = Release angle between the velocity vector and horizontal

The release angle is directly related to the blade azimuth, which is the position of the rotor at a particular time.

In a vacuum the aerodynamic forces are not modeled, the fragment is not affected by the ambient winds. The maximum range in a vacuum is achieved when the release angle is 45°. With this value of the release angle, Equation 3 becomes Equation 4.

Equation 4 $$X_{\max} = \frac{V_0^2}{g}$$

where:

$X_{\max}$ = Maximum horizontal range of a rotor fragment in a vacuum

The values of range from this simple model are not realistic because the atmosphere is not a vacuum. However, this simple model shows the importance of the release velocity because it is a squared term. For example, a 10% increase in release velocity increases the maximum range by 21%. This model also shows the dependence on the release angle. In any probability study, this would be a random parameter, because it is assumed that a rotor failure would not be dependent on the azimuthal angle.

Other models increase on the complexity of the vacuum model. The most common approach is to assume that the aerodynamic force is proportional to the square of the instantaneous velocity. The aerodynamic force is separated into lift and drag, and the constants of proportionality are called coefficients of lift and drag (C_L and C_D). Both the crosswind and downwind distances are determined. The solutions for the fragment range from these models (so-called two-degrees-of-freedom or 2 DOF models) cannot be solved directly and require numerical methods.

The next level of complexity assumes that C_L and C_D are dependent on the orientation of the fragment, and the fragment is allowed to rotate and translate (3 DOF or 6 DOF models).

Rotor Overspeed

One particularly hazardous failure scenario is turbine overspeed. The increased velocity in overspeed will over stress the rotor blade, and, in the event of a failure, increase the range of the fragment. The rotor is usually designed with a safety factor of 1.5. If the rotor loads are approximately proportional to the rotor speed (Eggers, Holley et al. 2001), the rotor could possibly fail at 150% of nominal rotor speed. To prevent this possibility, most wind turbines are equipped with redundant safety systems to shutdown the rotor. A turbine with industry certification (e.g. Germanischer Lloyd 1993), must have a safety system completely independent of the control system. The safety system must also have two mutually independent braking systems. Usually the blades pitch to release the aerodynamic torque while a brake is applied to the shaft. In the event of a failure in one system, the other system must be able to hold the rotor speed below maximum. An emergency shutdown is typically designed to occur if the rotor speed exceeds 110% of nominal. Even with redundant safety systems, rotor overspeed still occurs in industry, sometimes by human error when the safety systems have been defeated during maintenance.

Impact Probabilities

The analyses next turn to the probability that a fragment will land on a certain target or in a particular area in the range of the turbine assuming a rotor failure. The studies follow various approaches to determine this probability; this will be discussed below. The probability of impact is then multiplied by the probability of rotor failure, discussed in the previous section. The final result is the probability that a target fixed at a certain range from the turbine will be hit in one year. If targets are not fixed, such as cars on a roadway, then the probability must be multiplied again by the probability that the target will be in position. Mobile targets are not discussed in the analyses.

A simplified impact probability can be derived from Equation 3. Since this relationship is only valid for a ground release, only release angles of 0 to 180° (see Figure 4) result in movement away from the release point. Release angles of 180 to 360° result in impact at the base. The random release angle is assumed to have uniform distribution from 0° to 360°. Using methods of probability, the probability that a fragment will fall within an annulus that is less than the maximum range is given by Equation 5.

Equation 5
$$P\{X_1 \le X \le X_2 \le X_{max}\} = \frac{2}{\pi}\left[\arcsin\frac{X_2}{X_{max}} - \arcsin\frac{X_1}{X_{max}}\right]$$

where:

$X_1 =$ inner radius of annulus.

$X_2 =$ outer radius of annulus.

This relationship is plotted in Figure 5 for a normalized annular width of 0.05. Note that the relatively high probability of the fragment landing directly under the tower is not shown. The nature of the equation results in an increasing probability of impact in the outermost annuli, due to a wide range of release angles that provide nearly the maximum range. However, the annular area increases with increasing radius.

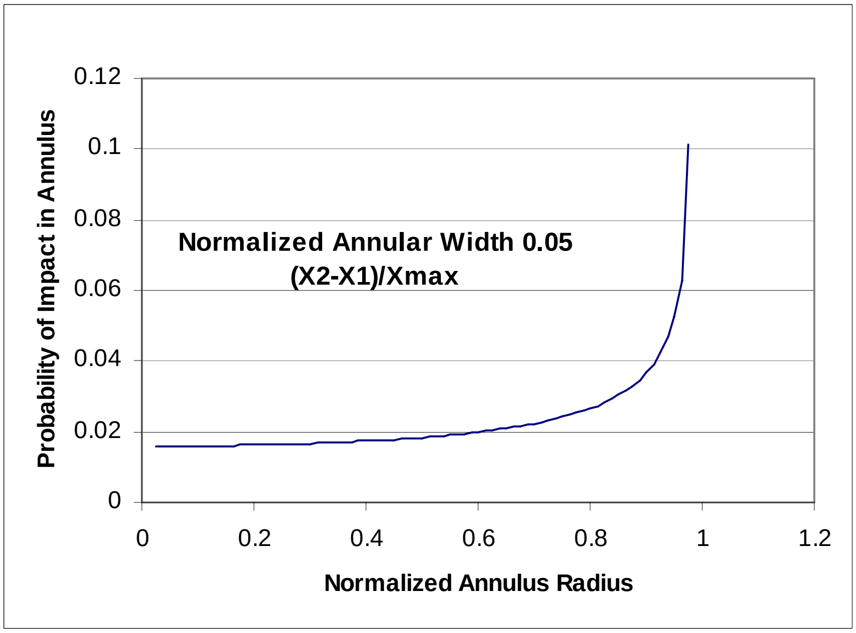

Figure 5. Probability of impact within an annular region

We next assume that the target is an annular sector, as in Figure 6.

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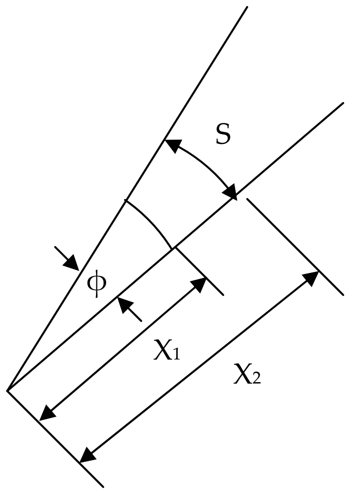

Figure 6. Target annular sector

In order to make the sector size roughly equal throughout the ballistic range, we set the outer arc length (S) equal to the annular width, given by Equation 6:

$$\text{Equation 6} \qquad S \equiv X_2 - X_1$$

The arc length is also given by

$$\text{Equation 7} \qquad S = X_2 \times \varphi$$

where:

$\varphi =$ Sector angle in radians (assumed to be small)

Equating Equation 6 and Equation 7 and solving for the sector angle we obtain:

$$\text{Equation 8} \qquad \varphi = \frac{X_2 - X_1}{X_2}$$

The probability of impact in this annular sector, assuming equal probability in all directions, is given by:

$$\text{Equation 9} \qquad P\{X_1, X_2, \varphi\} = \frac{\varphi}{\pi^2}\left[\arcsin\frac{X_2}{X_{max}} - \arcsin\frac{X_1}{X_{max}}\right]$$

This relationship is plotted in Figure 7. This simplified model shows a peak in probability near the tower base, and then a relatively constant probability until the probability rises again near the maximum range. This behavior is similar to more complex models incorporating aerodynamics. The peak at maximum range places a constraint on the overall hazard and acceptable setback distances.

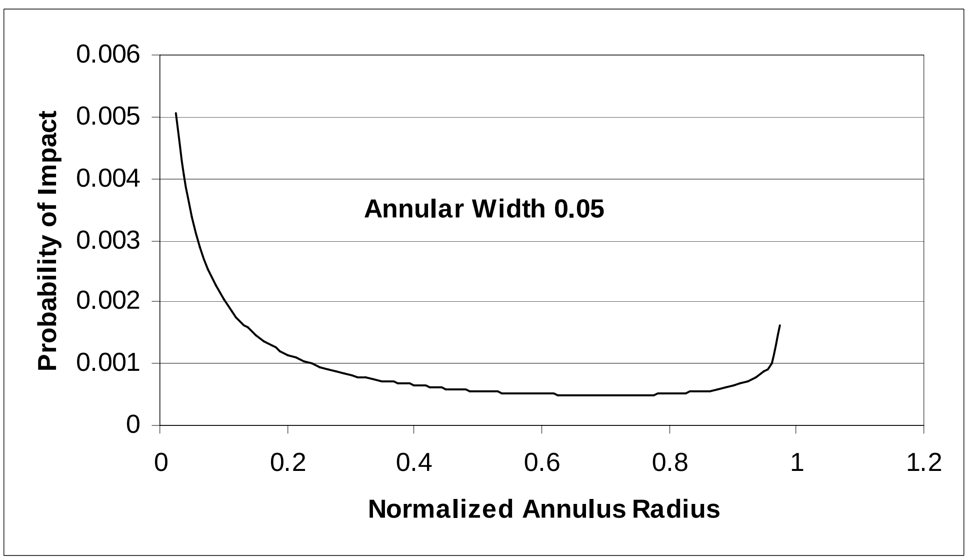

Figure 7. Probability of impact within annular sector

Multiple Turbines

If there is more than one turbine in the area, such as in a wind plant, then the individual probabilities must be added for a particular area. This is mentioned briefly in Macqueen (1983). The probabilities add according to the Law of Total Probability; for two turbines this is represented inEquation 10.

$$\text{Equation 10} \qquad P(A+B) = P(A) + P(B) - P(A,B)$$

where:

$P(A+B) =$	Probability of A or B or both occurring
$P(A) =$	Probability of A occurring
$P(B) =$	Probability of B occurring.
$P(A,B) =$	Probability of both A and B occurring (Equation 11)

$$\text{Equation 11} \qquad P(A,B) = P(A)P(B/A) = P(B)P(A/B)$$

where:

$P(B/A) =$	Conditional probability B occurring given A has occurred
$P(A/B) =$	Conditional probability of A occurring given B has occurred

If the events are independent, which would be the case in a random failure, the conditional probabilities are from Equation 12 and Equation 13.

$$\text{Equation 12} \qquad P(B/A) = P(B)$$

$$\text{Equation 13} \qquad P(A/B) = P(A)$$

The overall probabilities become Equation 14.

$$\text{Equation 14} \qquad P(A+B) = P(A) + P(B) - P(A)P(B)$$

As an example, consider a region that has a 10^{-4} probability of impact from a Turbine "A" and a 10^{-5} probability of impact from Turbine "B". From Equation 14, the overall probability of impact is:

$$P(A+B) = 10^{-4} + 10^{-5} - (10^{-4} \times 10^{-5})$$
$$P(A+B) = 1.1 \times 10^{-4}$$

These formulae can be expanded for multiple turbines.

Overall Probability

The overall probability can then be compared to other risks. De Vries (1989) mentions a government policy in the Netherlands of one-in-a-million (10^{-6}) per year risk level for new industrial activities. This is on the same order of present-day industry quality programs, such as "Six-Sigma," with a failure rate objective of three-in-a-million. Previously we discussed rotor failure probabilities on the order of one-in-a-thousand (10^{-3}) to one- in-a-hundred (10^{-2}). If we assume a conservative value of one-in-a-hundred (10^{-2}), this results in a required probability of impact of less than one-in-ten-thousand (10^{-4}) per year.

3.4.2. Rotor Fragment Analyses in the Literature

Eggwertz, Sweden 1981

This is the first documentation of a rotor fragment analysis, and is a comprehensive report on turbine structural safety for the Swedish industry. At the time, megawatt-size turbines were being considered for power production in Sweden. The analysis referenced previous work in Sweden on the possibility of fragment gliding due to spin; however the extension of the fragment flight was considered negligible. For the examination of risk areas, the drag coefficient in the analysis was fixed at 0.5 for lateral and downwind directions, and the lift coefficient was assumed to be zero.

For the probability analysis the blade and azimuth locations were divided into equal spanwise sections and equal weighting was applied to failure at these sections. This allowed for a semi-random probability of failure of the blade at a particular section and at a particular azimuth. A total of 144 fragment releases were modeled. A discussion was made of the probability of rotor failure, mentioned in the Rotor Failure section, but no criteria were applied in the final analysis.

The discussion of the physics and probability of impact is very detailed. The risk area included considerations of sliding and rotation of the rotor fragment. The fragment was assumed to translate on the ground and come to a complete stop due to friction. The area surrounding the turbine was divided into 10-m rings and the fragment impact area within the ring was divided by the total ring area. The probability calculated assumes equal probability of launch for all wind directions. The result was the risk level that a target within a ring will be hit.

The overall analysis was conducted for a 39 m radius machine at an 80 m hub height operating at 25 rpm in a 7 m/s wind speed. This was considered to be the most likely operating condition. Assuming that a failure had occurred, the probability was high at the tower base and then relatively even at 10^{-3} until 200 m. The analysis showed the probability of impact from any fragment dropped off dramatically (below 10^{-5}) at 220 m. This throw distance is 1.8 times the overall turbine height. The throw distance for a probability of 10^{-4} is only slightly less than this value. The dramatic drop off in the probability at 220 m was used as a basis for the safety area around the turbine; however, the calculations were made at nominal operating conditions and at a single wind speed. Failures in an overspeed conditions would increase this area.

Montgomerie, Sweden 1982

Montgomerie (Montgomerie 1982) expanded on Eggwertz's work by modeling the fragment with a full six-degrees of freedom. The aerodynamic model is not explained but is referenced from an unpublished thesis in Sweden. Similar work would later be developed by Sørensen (1984a).

Montgomerie presents results for an example turbine similar to Eggwertz's. The break at the rotor and the azimuth at break are treated with equal probability. However, the new model includes a wind speed and wind direction distribution from the wind turbine site. The normally circular hazard contour is only made slightly oval with the wind direction distribution. The maximum throw distance for the example exceeds 1600 m and the distance for 10^{-4} probability is 1500 m. These values are much greater than Eggwertz's results; however, there is no explanation for the discrepancy between them. The results are also relatively higher than results presented by other researchers.

Macqueen, United Kingdom 1983

This work was conducted in the United Kingdom for the Central Electricity Generating Board. As in Sweden, the United Kingdom was considering generating electricity with megawatt-size wind turbines. Macqueen starts by bounding the problem with an analysis of the maximum launch velocity of a rotor fragment being limited by the approach of the speed of sound. An estimate of the maximum velocity is 310 m/s in an extreme overspeed condition for a typical turbine. The fragment distance would not exceed 10 km using classical ballistics results with no aerodynamic drag. It is unreasonable to expect setback criteria of this distance; the turbine rotor would probably fail at a much lower velocity, plus the aerodynamic drag acting on the fragment would greatly reduce the distance. However this provides an upper extreme limit.

The analysis followed the same lines as Eggwertz with analysis of gliding and tumbling and classical ballistics with average lift and drag coefficients. The tumbling analysis was to determine the conditions for stable, gliding flight of a fragment. Macqueen reasoned that the flight time of a fragment was several times longer than one tumbling period and therefore stable flight could not be expected. However gliding was considered as a rare case if the fragment did not leave with sufficient rotational energy. For the tumbling case, Macqueen reasoned a C_L of 0.0 and a C_D of 1.0. For gliding, lift was chosen as C_L= 0.8 and C_D= 0.4. Macqueen estimated the probability of gliding occurring in a potential failure at 10^{-2} to 10^{-3}.

Macqueen also included a discussion of a three-dimensional model of fragment flight, and concluded that the model did not show the fragment achieving a stable gliding condition. Macqueen concludes that the effect of lift in the three-dimensional case increases the range of flight by no more than 10%.

A series of runs at equally spaced azimuthal positions were used to develop the probability distributions. The possibility of sliding after impact was not addressed in the current work. He then separated the analysis into two failure events, one at a 10%

overspeed at average winds, the other at the maximum possible release velocity with an extreme gust. The turbine studied was of similar geometry to the MOD-2, with 91 m diameter rotor and 61 m hub height.

The probability of impact is weighted by area (per square meter), and assumes equal distributions in all directions. Probability distributions showed peaks near the tower and at the maximum range, similar to the results of the simplified model in Figure 7. The probability of impact was then a function of the target and fragment size. Macqueen reasoned that the rotor fragments would be large compared to target, making the probability independent of target size; however this would not be the case with a busy roadway, with many targets over a large area.

For overall probabilities Macqueen used the Eggwertz probability of 10^{-5} for rotor failures. Macqueen also compared the probabilities to a statistic of risk of death by lightning strike in the United Kingdom at 10^{-7} per year. For the turbine studied, a large 2.5 MW unit, the risk of being hit by a rotor fragment within 210 m (approximately two times overall height) is equivalent to being struck by lightning. However, these results were based on the rotor failure probability of 10^{-5} and the assumption of a target size less than the overall fragment area.

Sørensen, Denmark 1984

This investigation was part of the wind power program of the Ministry of Energy and the Electric Utilities in Denmark. The conference paper (Sørensen 1984b) was a summary of the full report in Danish. Detailed sensitivity studies are found in the Wind Engineering paper (Sørensen 1984a). The analysis is unique in that the aerodynamics of the fragment under ballistic motion was fully modeled. Sørensen used synthesized data from a NACA 0012 wing to simulate the fragment under various alignments. The blade fragment was broken into segments and the aerodynamic forces were determined independent of each other. The total force was then a summation of the individual forces. This approach is similar to current state-of-the-art modeling of wind turbine rotors in the industry. Three turbines of increasing size were studied.

The modeling showed that the fragment tumbling motion decayed as it reached the maximum height with the heavy end directed down as the fragment fell back to earth. This behavior was also described by Eggwertz in scaled model studies. The model behavior places into question the pure tumbling and constant aerodynamic coefficients of the other models. Comparison with these models showed that the average drag coefficient for the lateral throw would have to be varied from 0.15 to 0.4 to achieve similar results to the full aerodynamic model. These coefficients are lower than what has been considered by the other researchers. For the downwind range, the constant coefficient models predicted a much lower distance. Therefore, constant coefficient models would tend to predict shorter overall throw distances compared to Sørensen's method.

The *Wind Engineering* paper went through several sensitivity studies of the modeling parameters. A summary of these studies is presented in Table 4.

Table 4. Sensitivity studies by Sørensen in *Wind Engineering* paper

Subject	Description	Results
Airfoil Data	Analysis conducted on four airfoil data sets	7% spread in maximum range
Aerodynamic Unsteadiness	Dynamic aerodynamic loads modeled	12% reduction in maximum range with unsteady model
Autorotation	Model tendency of fragment to glide like helicopter rotor	Substantial reduction in range
Center of Gravity Location	Vary chordwise center of gravity position on fragment	Negligible effect for typical 25-35% chord line placement
Blade Pitch Angle	Blade pitch angle at moment of release	Large influence; pitch of maximum thrust had maximum range
Wind Velocity	Ambient wind velocity at moment of release	Large influence, partially due to dependence on pitch angle effect

The impact probabilities reported in the conference paper (Sørensen 1984b) assumed the target as a one-meter sphere. Sliding of the wreckage was assumed, with 25 meters of slide assumed for a throw greater than 75 m range. As stated before in the Macqueen (1983) discussion, these probabilities would have to be adjusted for targets larger than the blade fragment, such as a busy roadway, or a dwelling. The probability analysis followed the same approach as Eggwertz (1981) by dividing the region around the turbine into ring segments. Uniform wind direction was assumed.

Probabilities were only presented for the Project "K" turbine for a full 30-m blade throw and 10-m blade fragment throw. This turbine is of 1.5 to 2.0 MW size with a 60 m hub height. Release angle and wind speed were varied and multiple throws were calculated. The probabilities were presented as a function of tip speed. Results are shown in Figure 8, comparing the range with 10^{-4} probability (the "risk" range) to the maximum range.

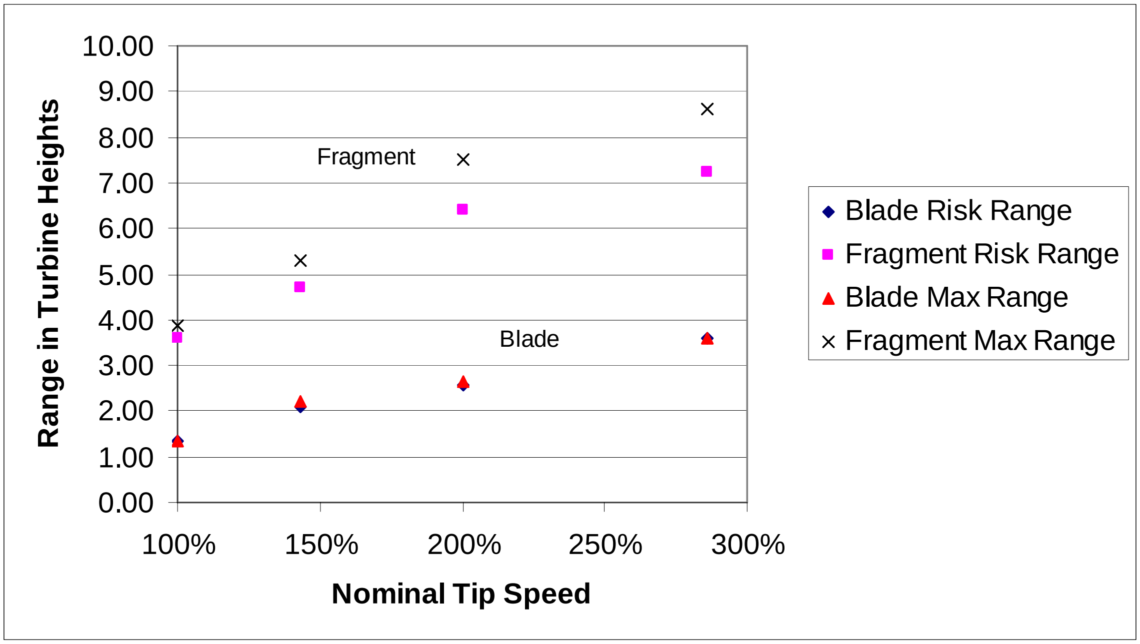

Figure 8. Throw distances in Sørensen conference paper with 1 × 10^{-4} probability risk range

The maximum ranges do not increase exponentially as would be predicted for a vacuum in Equation 4. This is the result of including the aerodynamic forces. Also, there is negligible difference for the full blade maximum range and range with 10^{-4} probability. This is not true for the fragment.

Turner, United Kingdom 1986 and 1989

Turner's (1986) work was a further expansion of MacQueen's work. He starts by developing a model of the probability similar to that in Section 0. He uses this model to form conclusions of the overall statistics of the more advanced problem. He used a Monte Carlo method to run simulations of fragment throws with the simple model, and then performed a chi-squared test with the exact solution of the simple problem to show the validity of the Monte Carlo method. He also developed a method to determine confidence levels after a certain number of throws so that an appropriate number of throws can be determined.

Turner assumed a geometric distribution for the probability of the rotor break point. It was assumed that inboard portions of the blade were twice as likely to break as outboard portions. Equal distribution was assumed for the azimuth position of break. For impact, he developed a bouncing model that he considered conservative based on data from artillery tests. He used a cutoff angle of 20° above which bouncing was not permitted. He also used Eggwertz model for sliding after impact.

Turner later expanded on his work to include a six-degree of freedom model of the fragment (Turner 1989). His model dynamics were similar to (Montgomerie 1982). The aerodynamic model used two-dimensional airfoil data with no adjustment for off-axis flow. A small drag value was added for spanwise flow. He presented results of Monte-Carlo simulations for several model conditions.

Eggers, United States 2001

This is the most recent analysis (Eggers, Holley et al. 2001) generated for the National Wind Technology Center in Colorado. The analysis used classical ballistic theory and assumed constant values of aerodynamic force coefficients. A discussion and analysis is made of the possibility of gliding flight assuming the blade achieves a stable gliding angle; it is assumed negligible. The low probability of this is reasoned due to the complex geometry of the blades, with varying chord, airfoil section, and twist. The mean values of drag ($C_D = 0.5$) and normal force coefficients are considered constant during flight. Half and full-blade fragments are analyzed.

An example turbine was studied with a 15.2 m rotor radius operating at 50 rpm in 11.2 to 22.4 m/s winds. A probability distribution, assuming equal weighting for all directions, was determined analytically and solved numerically. This method was unique in that several trials of throws were not necessary to obtain the distributions. Also assumed was that the failure was the result of an overspeed, and that the range of the overspeed failure was a Gaussian distribution between 1.25 and 1.75 times the nominal speed. Eggers, like Macqueen (1983), confirms peaks in the probability distribution near the tower and at maximum range. Two tower heights were also studied, showing higher probability at the tower base for the shorter tower. Probability values cannot be determined from the paper due to the limited resolution of figures.

3.4.3. Comparisons of Rotor Fragment Analyses

Studies of example turbines were performed in all the analyses discussed previously. A comparison is shown below in Figure 9. The maximum attainable lateral throw distance, normalized by overall turbine height, for a failure at nominal operating conditions is shown for the various analyses. The results show the drop in the normalized maximum throw distance with increasing turbine size.

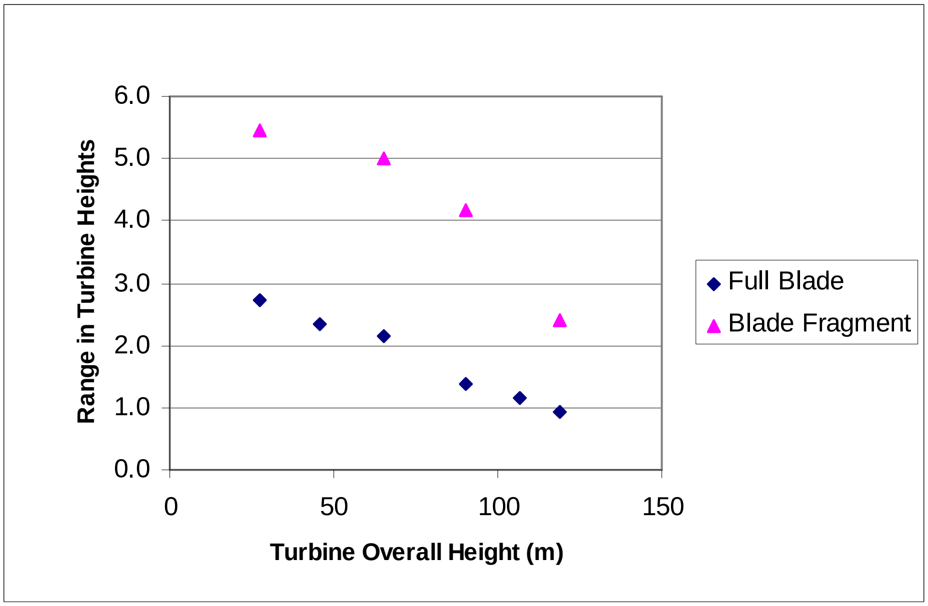

Figure 9. Comparison of rotor fragment analyses for maximum range at nominal operating conditions

4.0 Conclusions and Recommendations

4.1. Conclusions

This study was performed on setbacks for permitting of wind energy. Counties with past and future development of wind energy have setbacks based on overall turbine height. A simple example was presented showing the negative economic impact of setbacks based on size for modern turbines. The application and size of the setbacks varied widely across the counties. However, a common setback is three-times the overall turbine height from a property line.

Most setbacks were established early in the development of the wind industry and were outcomes of ad hoc groups of government and industry. Other counties followed suit based on the example of the early developments. There is some evidence for Riverside County that the "three-times" rule may have been an outcome of expected spacing to reduce waked operation losses. There is no evidence that setbacks were based on formal analysis of the rotor fragment risk.

CWEC also studied the probability of wind turbine rotor failure. Reporting of wind turbine failures are scarce in the literature, but available data from Alameda County and Europe show rotor failures from approximately one-in-one-hundred (10^{-2}) to one-in-one-thousand (10^{-3}) per turbine per year. The most comprehensive study from the Netherlands reported failures for European turbines of approximately one-in-one thousand (10^{-3}) per turbine per year.

Six studies examined modeling of the rotor fragment risk in detail. Several researchers analyzed but discounted the possibility of gliding flight, and instead used simplified aerodynamic models. Sørensen (1984a) used a three dimensional analysis of the rotor fragment flight and showed the limitations of the simplified models. The literature does not offer any guidance for applying setback distances that would be useful for wind energy planning.

Two observations can be made from a comparison of the analyses with failure at the nominal operating condition. The first is that as the overall turbine height increases, the range normalized by overall height decreases. This is primarily because the maximum range is dependent on turbine tip speed. As discussed previously, the tip speed has remained nominally unchanged as turbine size has increased. The other conclusion is that blade fragments fly farther than full blades. This is because the initial velocity at failure tends to be higher for the fragment than the entire blade. This result indicates that setbacks based on overall turbine height may be reduced for larger turbines.

4.2. Recommendations

The setback literature reviewed in this report does not provide an analytical rationale for determining wind turbine setbacks. However, after reviewing the literature for analysis of the rotor fragment hazard, CWEC proposes the following items to develop guidelines for setbacks.

4.2.1. Rotor Failure Rate and Operating Conditions at Failure

The rotor failure probabilities presented by Rademakers and Braam in Appendix A represent the most comprehensive study. The values presented in Section 3.3.4 should be used for analysis of the overall hazard. These values are organized by rotor speed, which can be used to set the release velocity at failure. However, the wind conditions at failure are not known. Simulations can be performed at several wind speeds, and either the worst case could be used, or the results can be weighted by a standard wind speed distribution.

Turbine Sizes

A mixture of turbine sizes should be studied to determine if setbacks should be a standard distance or a function of the turbine size. Turbine sizes currently marketed are 660 kW to 5 MW. Smaller turbines should be studied for stand-alone applications and review of existing hazards.

4.2.2. Position of Blade Break

Since the position of the failure cannot be predicted with certainty, the approach of Eggwertz (1981) to divide the blade into sections should be used. In addition to randomizing the break position, turbines with blade components such as aerodynamic devices, blade dampers, and lightning protection should be studied as fragments.

4.2.3. Aerodynamic Model

The methods of Sørensen (1984a) should be applied for the aerodynamic model. This model was the most comprehensive and showed the limitations of constant aerodynamic coefficient models. The model is well documented and can be updated to modern programming languages. There was an effort to update this program to MATLAB® at the Technical University of Denmark (DTU); however the status of this work is unknown.

Further studies could be conducted to incorporate shear and turbulence into the model. With these effects included, the rotor fragment might exhibit constant lift coefficient and drag coefficient behavior which might warrant use of simpler models.

The model should be built as a tool that can be used by the industry for use on any turbine to study specific cases, such as permitting waivers.

4.2.4. Impact Modeling

The methods of (Turner 1986) and Eggwertz (1981), or Sørensen (1984a) should be used to model the physics at impact. The methods include bouncing at impact and the effects of rotation and translation after impact.

4.2.5. Slope Effects

Slope effects were not included in the reviewed analyses. Because of the common placement of turbines on ridgelines, as in the Altamont and the Tehachapi wind resource areas, modifications to the setback distance should be studied. Modifications should be stated in simple language, similar to the language in the Alameda ordinance.

4.2.6. Validation Effort

None of the analyses have been validated with actual failures. Validation with an actual failure can be made with the following information:

- Turbine tower height
- Rotor diameter
- Position of failure on rotor
- Azimuth of failure (would be very hard to obtain)
- Rotor speed
- Pitch of blades
- Geometric details of the fragment (planform, airfoils, weight, center of gravity, twist distribution)
- Wind speed, direction, and local air density
- Distance and bearing of blade or fragment from tower base

Another effort would be to deliberately cause a rotor failure and obtain the above information. This test could be conducted on a turbine at the end of its useful life in a clear field. Explosive bolts or a ring charge could be used to separate the blade or fragment from the turbine. The azimuth at break must be carefully determined.

5.0 Benefits to California

Researchers should use the information as background for developing models of the rotor fragment hazard. California planning agencies should then use this new rotor fragment hazard information, together with the information in this report as a tool for modifying or establishing wind turbine setbacks.

A better understanding of the risks involved with wind energy will permit the development of appropriate methods to manage that risk, thereby increasing the acceptance of wind energy developments by local governments and the general public.

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7.0 Glossary

Specific terms and acronyms used throughout this paper are defined as follows:

Acronym	**Definition**
C_D	Coefficient of drag
C_L	Coefficient of lift
CWEC	California Wind Energy Collaborative
DOE	U.S. Department of Energy
DOF	degrees of freedom
DTU	Technical University of Denmark
EIR	Environmental Impact Report
IEC	International Electrotechnical Commission
kW	Kilowatt (1000 Watts)
m	Meters
m/s	Meters per second
MW	Megawatt (1,000,000 Watts)
NREL	National Renewable Energy Laboratory
RPM	Revolutions per minute
SERI	Solar Energy Research Institute (predecessor of NREL)
WECS	Wind Energy Conversion System

Attachment I

ANALYSIS OF RISK-INVOLVED INCIDENTS OF WIND TURBINES

Version 1.1, January 2005

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1. INTRODUCTION

As part of the project "Handboek Risicozonering Windturbines (Guide for Risk-Based Zoning of Wind Turbines)," research was conducted on incidents involving wind turbines that may pose a risk to their surroundings. This information is used to quantify the failure events, as well as for the development of a method, described in the Guide, to calculate the risks. These risks include blade failure, tower failure, or any other parts of the wind turbine falling off. In order to determine these risks, it is necessary to understand the possible failure events, and the frequency of these events. Validation of the calculation method is impossible by means of experimentation, but in order to gain sufficient trust in the method it is necessary to have information on what part of the blade has fallen off, its size, and the distance it traveled after separation from the turbine.

To determine the failure frequency of blades, towers, and other parts of a particular wind turbine, the ISET (Institut für Solare Energieversorgungstechnik) in Germany and the EMD (Energie- og Miljødata) in Denmark have provided information [1,2]. Both institutes have a database containing energy production, incident, and maintenance information for most of the wind turbines in Germany and Denmark, respectively. Incidents and occurrences of importance are selected based on the raw data that is extracted from the ISET and IMG databases, in order to obtain insight into possible failure events. This information is also used to determine the frequency of failure events per year, as well as to provide information about the uncertainties. In this appendix the extracted data from the ISET and EMD databases are combined and then applied to calculate failure frequencies.

A supplementary study was conducted based on the throw distance, dimensions of thrown parts, etc. Based on information from the internet, magazines, and detailed information in ISET and EMD reports, a summary of incidents and the related throw distances for different types of turbines was made. The results of this research are included in this appendix.

When reading this report and applying the information in it, it is important to keep in mind the following:

- The data, particularly the number of incidents, are never complete. Not all incidents are reported or known to the ISET, EMD, or ECN. To prevent this from leading to false results, the population of wind turbines for which statistics are calculated is specifically chosen so that all incidents involving these turbines are known.
- It is not always possible to determine the way an accident developed. Sometimes it is clearly reported that a blade (or two blades) has broken off and landed 100 m from the turbine. Sometimes it is only reported that a blade has been damaged and replaced, without any reports of pieces that may have broken off and been thrown from the

turbine. In cases where the extracted data were incomplete, a suitable conservative interpretation of the data was applied.

Based on the information, five separate categories have been determined that are of importance for the risk analysis.

1. Whole turbine blades or very large blade pieces breaking off and being thrown.
2. Brake tips and other blade pieces such as blade surface panels, composite material, bolts, etc. being thrown from the turbine.
3. Tower collapsing.
4. Large parts, such as the nacelle, the whole rotor, or other main components, falling down.
5. Small parts, such as the anemometer or bolts, falling down from the nacelle or the hub.

The reasons for this classification are as follows.

1. A blade that has broken off can be thrown relatively far and has a large mass. It can cause relatively heavy damage to another object.
2. A brake tip or a small part of a blade can be thrown very far. Because it has a small mass, the chance of doing damage to another object is smaller than that of an entire blade.
3. The collapse of a tower usually means great risk to anything in close proximity of the turbine. The entire turbine has an extremely large mass and can therefore cause heavy damage to anything close to the turbine.
4. Similarly to the tower collapse, the fall of a large component such as a nacelle can cause heavy damage to anything close to the turbine.
5. Small parts that fall down cannot cause heavy damage. The risk area for this situation is limited to just a few meters from the tower.

Each category requires a different approach to the risk analysis.

The shedding of ice is not listed here explicitly. The calculation of vulnerable distance and risks for ice can be based on those for category 2 "brake tips and small parts of blades." The frequency of ice being thrown from a blade is very location dependent and therefore the importance of this phenomenon cannot be determined generally for a turbine. Furthermore, the AMvB [3] stipulates that wind turbines with ice on their blades are forbidden to start up.

In this report the following topics are addressed consecutively:

- Results of the analysis of the EMD database.
- Results of the analysis of the ISET database.
- Calculation of the frequency of failure for the categories listed above.
- Results of the analyses concerning the development of a calculation method for throw distances.
- A summary of the failure frequencies and a recommendation on the application of these values in risk analyses.

2. ANALYSIS OF DANISH FAILURE DATA

2.1 Introduction

Energie- og Miljødata (EMD) has a database that contains approximately 6000 turbines in Denmark. The energy production and failure data are registered for over half of these turbines. The owners of the turbines can voluntarily submit a monthly report to the Danish Association of Turbine Owners. This association performs an initial analysis of the information and then codes it. The data is then sent to EMD. EMD feeds the information into their database. In total, EMD has selected and reported 210 risk involved incidents [1].

The main goal of the analysis of the EMD-provided information is the selection of incidents and the calculation of failure frequencies for the five categories (blades, tips, tower, nacelle and rotor, or small parts). In determining the number of relevant incidents and determining the size of the population of turbines, attention is paid to the following.

- The size of the total population of turbines is not always known. Not all turbine owners submit monthly information. This can mean that there were no incidents, or that the incidents were not reported. In particular, energy production numbers of turbines that belong to electric utilities are submitted monthly, but incidents are seldom or never submitted. Of the remaining turbines, incident reports are regularly submitted with the energy production numbers. EMD has followed a conservative approach, and only included those turbines for which incidents are regularly reported. Most turbines belonging to electric utilities are therefore left out of the analyses. It is very probable that most turbines larger than 1 MW belong to the electric utilities. This is exactly the type of turbine that is most important for future risk analyses.
- Blade fracture is relevant to all turbines; a flyaway tip is only relevant to stall regulated turbines with blade tips. Therefore, the size of the total population can be different for each analysis.
- Most incidents are poorly documented, and the actual number of risk-involved incidents cannot be determined for certain. EMD uses codes to indicate which component failed, the reason for failure, and whether parts were thrown from the turbine. From the codes it is difficult to determine the size of the thrown object, the distance thrown, and the order of events. In some cases this information is included in the comments. Between 1993 and 2000 the code was expanded. Between 1984 and 1992, the code was severely restricted. It was seldom even noted whether a compromised turbine had done damage to the surrounding area. This made it possible for a turbine that had a complete failure and lost many parts (see Fig. 2.1) to be reported exactly like a turbine that had a complete failure and posed no risk to the surrounding area (see Fig. 2.2).

Fig. 2.1: Two examples of incidents that pose possible danger to the surrounding area.

Fig. 2.2: Two examples of turbines that failed, but caused no danger to their surroundings.

2.2 Turbine Population

The turbine population from 1984 through 2000, as provided by EMD, is separated into the different types. The results are presented in Fig. 2.3. At the end of the year 2000 the total turbine population reached about 2900 turbines. The total number of operating years reached almost 30,000. By far the most turbines are stall-regulated turbines.

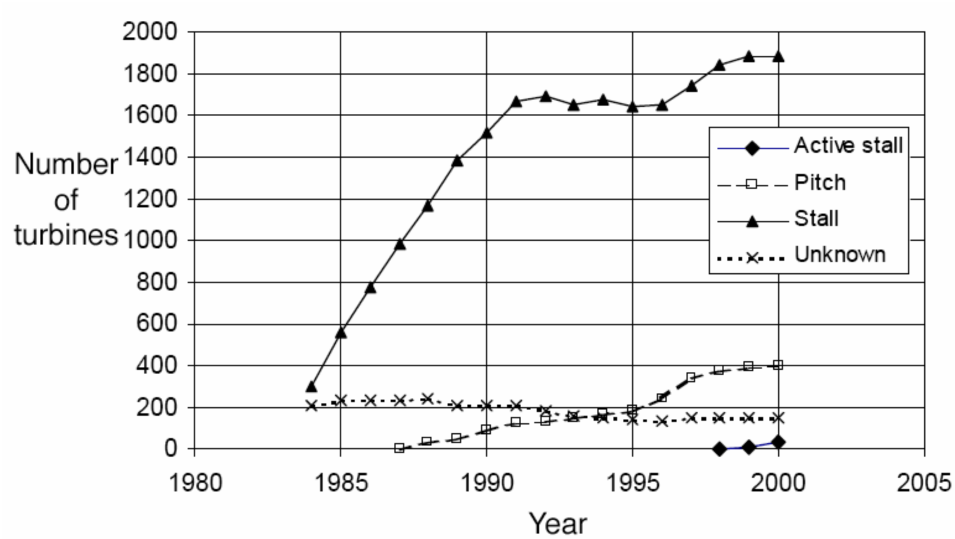


Fig. 2.3: **Number of wind turbines in the EMD database, separated by type.**

When the turbines are separated into groups based on rated output, the distribution as shown in Table 2.1 is established.

Table 2.1: **Number of operating years, separated into groups based on rated output**

Rated Output [kW]	Operating Years	Percentage
0 - 50	3229	11.0%
51 - 300	24368	82.8%
301 - 750	1769	6.0%
751 - 1300	47	0.2%
1301 -	0	0.0%
Total	29413	100.0%

2.3 Failures and Incidents

As is briefly discussed in paragraph 2.1, not all incidents are reported with enough detail to make unambiguous conclusions. EMD has created the following four categories to indicate how dangerous an incident is:

3. Definitely dangerous, unambiguously reported
2. May be dangerous, but not for certain
1. Not dangerous, unambiguously reported
0. Necessary information missing

In many cases it appeared difficult to indicate exactly whether a turbine had indeed lost parts as in Fig. 2.1, or was just heavily damaged as in Fig. 2.2. The final results from the selection of risk involved incidents are given in Table 2.2. The total can be seen in Table 2.3. This table includes the total number of operating years for each type. This number is obtained by summing the number of turbines in operation per year over all the years.

Table 2.2: Number of risk involved incidents per year for each regulation type. For each type, number of turbines in operation at that point is given per year.

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Active stall															3	10	30
Blades																	
Tips																	
Turbine, nacelle, large parts																	
Small parts																	1
Pitch				4	35	53	88	126	134	153	170	183	239	339	373	389	399
Blades																	
Tips																	
Turbine, nacelle, large parts																	
Small parts																1	
Stall	300	557	772	984	1167	1386	1517	1664	1689	1648	1675	1642	1651	1743	1839	1885	1887
Blades							2	3		2	1	1		1	1		1
Tips									1						1	1	
Turbine, nacelle, large parts			1							1						1	
Small parts											5	2	4	1	2	3	2
Unknown	210	230	234	237	245	209	208	207	181	155	152	144	136	150	153	154	150
Blades			1		1												
Tips																	
Turbine, nacelle, large parts				1			1		2								
Small parts																	
Total # turbines	510	787	1006	1225	1447	1648	1813	1997	2004	1956	1997	1969	2026	2232	2368	2438	2466
Total # failures with dropped parts	0	0	2	1	1	0	3	3	3	3	6	3	4	2	4	6	4

Table 2.3: Total of all risk involved incidents, total for all operating years, and the number of operating years for each type of turbine.

	1984-1992	1993-2000	Total
Active Stall	**0**	**43**	**43**
Blades			
Tips			
Whole Turbine			
Small Parts		1	1
Pitch	**440**	**2245**	**2685**
Blades			
Tips			
Whole Turbine			
Small Parts		1	1
Stall	**10036**	**13970**	**24006**
Blades	5	7	12
Tips	1	2	3
Whole Turbine	1	2	3
Small Parts		19	19
Unknown	**1961**	**1194**	**3155**
Blades	2		2
Tips			
Whole Turbine	4		4
Small Parts			
Turbine Years	**12437**	**17452**	**29889**
Total Incidents	**13**	**32**	**45**
Total Suspected Incidents	55	51	106

In the time period between the years 1993 and 2000, in total there were 11 "category 3 incidents" reported, and 66 "category 2 incidents." Based on the information provided by EMD, and after reading the commentary, there appeared to be 51 suspicious incidents; of the 77 total incidents, 26 could be eliminated. Of the 51 suspicious incidents, 32 were proven risky and were included in the analysis. Between 1984 and 1992 there were 55 suspicious incidents, and 13 ended up being included in the analysis.

From the detailed analysis of the incidents, it seems that some cases involved multiple parts breaking off and being thrown. With blades, for example, it is possible for one, two, or three blades to be thrown. In the seven incidents involving blade throw between 1993 and 2000, a total of ten blades were thrown. There were no incidents reported that involved more than one object when it came to the tips and small parts. Clearly when the incident involved the tower or nacelle, only one object can be affected. That is why there is a multiplication factor of 10/7 used in calculating risk for the blades. The total number of incidents and the corresponding population of turbines are tabulated in Table 2.4.

In EMD's report, only failures of the whole turbine were reported; no distinction was made between the categories "nacelle and rotor" and tower failures. When the part listed was the "turbine," it was not immediately clear whether it was the tower or the nacelle that was affected. Later analyses of the raw data, according to tables 2.2 and 2.3, showed that at least 2, maybe even 3, of the 7 incidents involved the whole tower collapsing. That is why in table 2.4 there are half incidents.

Table 2.4: Overview of incidents in the total wind turbine population

Part	84-92	93-00	84-00	Factor	Total	Turbine Years	Notes
Blades	7	7	14	1.4	20	29889	Total number of turbines
Tips	1	2	3	1.0	3	24006	Total number of stall turbines
Nacelle	3.5	1	4.5	1.0	4.5	29889	Total number of turbines
Tower	1.5	1	2.5	1.0	2.5	29889	Total number of turbines
Small Parts		21	21	1.0	21	17452	Total number of turbines between 1993 and 2000
TOTAL	**13**	**32**	**45**				

As can be deduced from the previous paragraphs, determining the number of incidents within the scope of the entire turbine population is done with much uncertainty. The population used by EMD involves mostly three-bladed, stall regulated turbines, with a rated output of up to 750 kW. This population is made up of about 2900 turbines. Future turbines for which the risk analysis is being done will most likely be pitch regulated turbines with an output greater than 1 MW. It is these types of turbines for which EMD has little information. It is not clear if there were indeed no incidents, or if they merely were not reported.

2.4 Trends

Simultaneously the correlation between the age of a turbine and its frequency of failure was researched. For this the 32 critical incidents between 1993 and 2000 were divided into four time periods (0-5 years, 5-10 years, etc.). The number of incidents in each time period is divided by the number of turbines that fall into that category. (Note that determining the population of turbines in each category could not be done with great accuracy. The number of turbines between 0 and 5 years old was determined by subtracting the number of turbines in operation in 1995 from the number of turbines in operation in 2000. It is unclear whether there were turbines taken out of operation or replaced). Most failures were caused by turbines between 5 and 10 years old.

The relationship between the rated-power category of the turbines and their failure frequency was also researched. The number of incidents in each rated-power category is divided by the number of years in operation for each category. No trend is found.

3. ANALYSIS OF GERMAN FAILURE DATA

3.1 Introduction

ISET has made an inventory of "critical losses" that have occurred in Germany over the past 10 years. ISET has defined a "critical loss" in the following way.

A critical loss is a sudden and lasting change in a wind turbine that can potentially or definitely cause damage to the surrounding area. The cause of the change can be due to external sources (e.g. lightning and storm), or internal sources (fatigue).

It is therefore not conclusive that the recorded cases did cause damage to the surrounding area. This inventory is in principle based on the WMEP database (Wissenschaftliches Meß- und Evaluieringsprogramm), which is managed by ISET. Additional information was obtained from technical publications and the internet.

Information from approximately 1500 turbines in Germany has been collected in a systematic manner in the WMEP database since 1989. The results of these 1500 turbines provide a representative overview for the approximately 10,000 total turbines that have been installed in Germany. The database contains over 48,000 entries. In order to facilitate analysis of the database, the above definition for a critical loss is used as a starting point.

Based on this definition, a number of search criteria have been devised for the database. The most important criteria used are:

1. The shutdown of a turbine has to be the result of a failure (preventive maintenance and other planned activities are thereby eliminated);
2. Eligible failure modes are:
   - Storm
   - Lightning
   - Defective component
   - Defective assembly or mounting
   - Other causes;
3. A repair or a replacement is required for one of the following main components:
   - Rotor hub

- Blade
- Nacelle
- Tower

Repairs or replacements of gear boxes or generators are not included, because a failure of these components rarely causes potential danger to the surrounding area.

The automatic search of the database with the aforementioned criteria resulted in 152 matches. These matches are subsequently scrutinized one at a time by ISET, resulting in a further reduction of the number of incidents. This finally resulted in 43 cases that could actually be reported as involving serious damage.

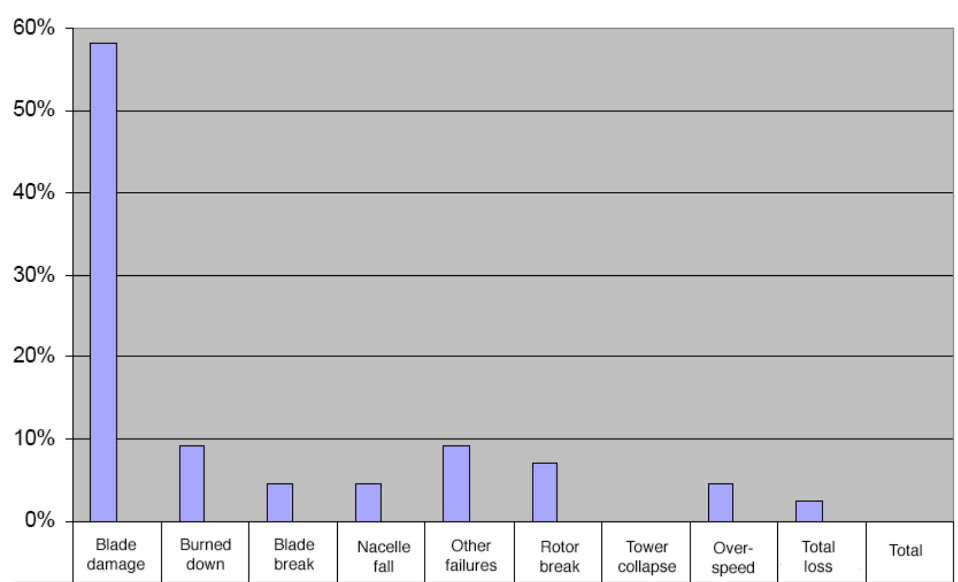
These 43 cases involve the time period from 1991 until July 2001.

3.2 Turbine Population

The total number of operating years of all 1566 wind turbines included in the database at the end of July 2001 was about 13,000 years. The 43 serious damage incidents correspond to 0.33 critical incidents per 100 operation years.

3.3 Failures and Incidents

The 43 cases of turbine damage from the WMEP database are arranged by type of damage. The results are presented in Figure 3.1.



	Blade damage	Burned down	Blade break	Nacelle fall	Other failures	Rotor break	Tower collapse	Over-speed	Total loss	Total
	58%	9%	5%	5%	9%	7%	0%	5%	2%	100%
Number	25	4	2	2	4	3	0	2	1	43

Fig. 3.1: Type of damage for 43 cases involving serious damage.

Blade fracture, rotor failure, nacelle fall, and tower collapse are all of importance to risk analyses, because it is these phenomena that can cause damage to people or objects in the nearby surroundings. The other types of damage result only in economic damages.

With regards to blade fracture, there has been one report of a case where one blade broke off the turbine. For the second case, no information is given on the number of fractured blades. For further analysis, a conservative conclusion was made that all three blades had fractured. So, in total, there were four broken blades in the two cases of blade fracture.

Three cases of rotor failure were reported. With this type of failure there are a few possibilities:

1. The rotor failure causes the blades to break off and to be thrown from the turbine.
2. The rotor breaks off and falls from the turbine. The parts fall close to the turbine and the effects are similar to those of a fallen nacelle.

One case was reported that involved blades striking the tower, and then breaking off. As a result, the number of cases of blade fracture becomes seven. In the other two cases it was reported that damage was found, but not whether blades were broken or a rotor fell. For these two cases it is assumed that it was the rotor that fell. It should be noted that there is no mention of brake tips falling, or of small parts falling from the nacelle or hub.

The total number of critical turbine damage cases that are relevant to the risk analysis is shown in Table 3.1. The research done by ISET focused on critical cases, therefore there is no information on small parts. Nowhere is there mention of brake tip failure.

Table 3.1: Number of critical turbine damage cases with the potential to cause danger to the surrounding area

Part	Number	Turbine Years
Blade separation	7	13000
Fallen nacelle and/or rotor	4	13000
Tower failure	0	13000

3.4 Trends

From the analysis conducted by ISET, the following trend develops. Lightning seemed to cause a great percentage (34%) of the heavy damage to turbine blades. However, as the blades include better lightning protection systems, the number of heavy damage cases decreases significantly. Now lightning causes only limited damage to the blade surface, near the receptors which during preventive maintenance can be repaired.

4. FAILURE FREQUENCIES

In Chapters 2 and Chapter 3 overviews are given for the total number of incidents per turbine part. The failure frequencies are calculated based on all reported incidents, from the EMD database as well as the ISET database. Table 4.1 gives an overview of the total number of incidents, and the number of turbine-years for which the incidents have relevance.

Table 4.1 also gives the calculated failure frequencies. The expected failure frequency value for each part is calculated by dividing the total number of incidents by the number of relevant turbine-years. It appears that the number of incidents is small compared to the number of turbine-years, so the calculated expected value has a non-negligible uncertainty that can be quantified by the probability density function of the expected value. The occurrence of a particular incident can be modeled with a Poisson process. In a Poisson process there is an invariable chance of an incident occurring in time. For *n* incidents in *T* turbine-years, the probability density function for the failure frequency per turbine-year, $f(\lambda)$, is given by the Gamma function [4], or

$$f(\lambda;\alpha,\beta) = \frac{\beta^{-\alpha}\lambda^{\alpha-1}\exp\left(\frac{-\lambda}{\beta}\right)}{\Gamma(\alpha)}$$

where

$$\alpha = n$$

$$\beta = 1/T$$

Next to the expected value in Table 4.1 is also listed the 95 % upper limit for the failure frequency.

Table 4.1: Failure frequencies per part.

Part	Total EMD and ISET		Failure Frequency [1/turbine-year]	
	Number	**Turbine years**	**Expected Value**	**95% upper limit**
Blades [1])	27	42889	$6.3*10^{-4}$	$8.4*10^{-4}$
Tips	3	24006	$1.2*10^{-4}$	$2.6*10^{-4}$
Nacelle	8.5	42889	$2.0*10^{-4}$	$3.2*10^{-4}$
Tower	2.5	42889	$5.8*10^{-5}$	$1.3*10^{-4}$
Small Parts	21	17452	$1.2*10^{-3}$	$1.7*10^{-3}$

[1]) Failure frequency is based on total number of turbine-years, so this indicates the chance of blade failure per turbine per year.

5. ANALYSIS OF INCIDENTS AND THROW DISTANCES

In addition to determining the failure frequencies of blades, tips, turbines, and small parts, attention was also paid to accident scenarios. To calculate the risk turbines pose to their surroundings, it is important to know what throw distances are probable and how large the separated parts are. Therefore, an analysis was done of incidents and accidents that are published in detail, for which the following sources are consulted:

- http://wilfriedheck.tripod.com/unf.htm
- http://querulant.com/querulant/wind
- http://home.wxs.nl/%Ewindshnieuws.htm
- http://home.wxs.nl/~hzwarber/wind/feiten/veilig.htm
- Energie- en Milieusp. 4-95
- Windnieuws ODE 94/1
- Windnieuws ODE 94/2
- Windnieuws ODE Febr. 95
- Windnieuws ODE April 95
- Windnieuws ODE Jan. 96
- Windnieuws ODE Juni 96
- Windnieuws ODE Sept. 96
- Duurzame Energie Dec. 95
- Duurzame Energie Febr. 95

The results of the analyses are presented in Figures 5.1 through 5.4. In these figures, one for each type of incident, the reported throw distance is presented (x-axis) as a function of the rated power (y-axis). The curves in each graph relate the approximate rotor diameter associated with corresponding rated power level. The curves are added to put the throw distances in perspective.

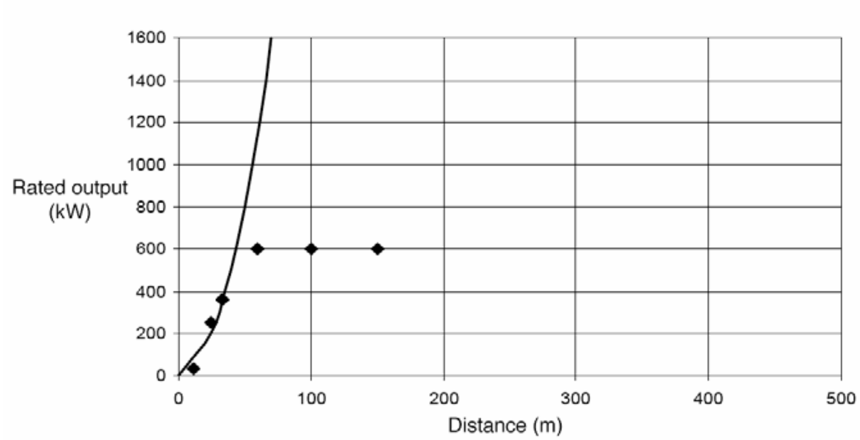


Fig. 5.1: **Throw distance of entire blades as a function of the rater power output, the drawn line gives the rotor diameter.**

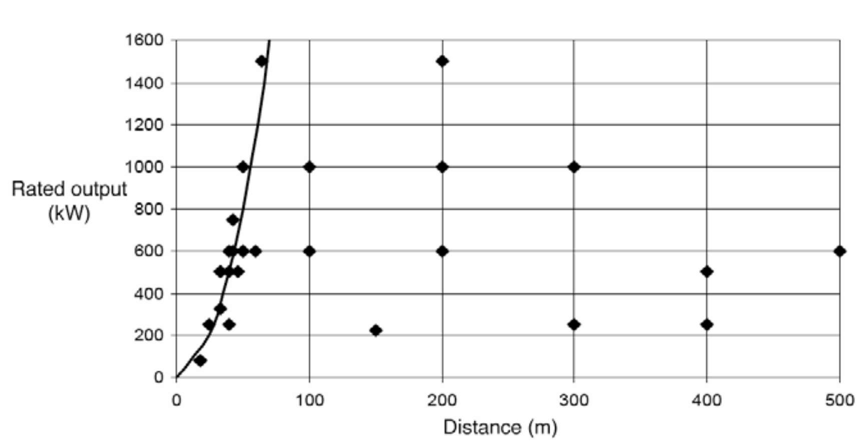


Fig. 5.2: **Throw distance of tips and small blade pieces as a function of the rated power output, the drawn line gives the rotor diameter.**

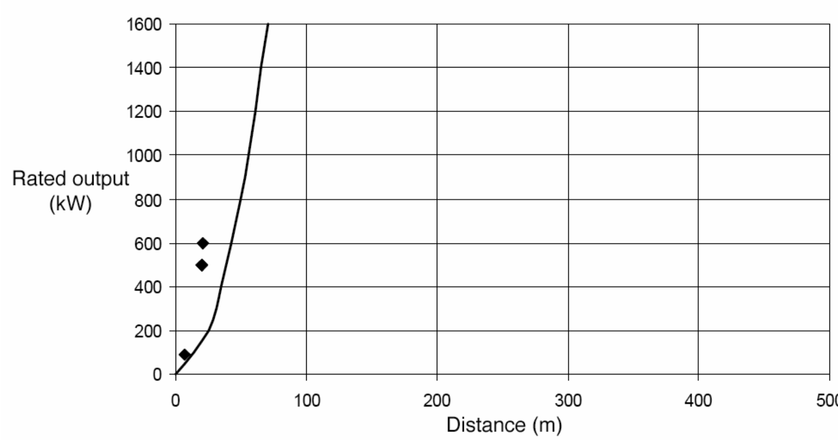


Fig. 5.3: **Throw distance due to fall of nacelles and rotors, as a function of the rated power output, the drawn line gives the rotor diameter.**

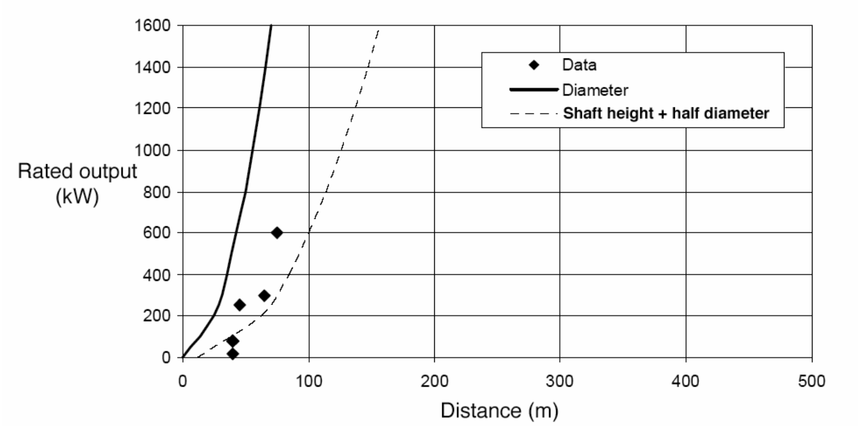


Fig. 5.4: Throw distance due to tower collapse as a function of the rated power output, the drawn line gives the rotor diameter. The dotted line gives the shaft height plus rotor radius (half diameter).

The following can be concluded from Figures 5.1 through 5.4.

- Small blade parts and tips can fly very far. The maximum distance reported is 500 m.
- The maximum throw distance of an entire blade found during this analysis is about 150 m. Distances of 400 and 600 meters for entire blades were also reported in publications. Nevertheless, attempts to confirm these numbers through contacting the owner or the publisher were unsuccessful.
- When a rotor or nacelle falls down, the risk zone is approximately equal to half a rotor diameter.
- When an entire tower fails, the risk zone is equal to the height of the tower plus half a rotor diameter.

6. CONCLUSIONS

6.1 Recommended Risk Analysis Values

ECN has analyzed the reported incident information for a large population of wind turbines in Denmark and Germany and determined the frequencies of:

- Blade fracture;
- Tips and other small parts breaking off;
- Tower failure at the tower root;
- Rotor or nacelle falling down;
- Small parts falling from the rotor or nacelle.

The chance of blade fracture is further separated into:

- Failure at nominal operating rpm (revolutions per minute);
- Failure during mechanical braking;
- Failure due to overspeed.

The ECN also did an in-depth study of the possible throw distances due to turbine failure. The results of this analysis are summarized in Table 6.1.

Table 6.1: Failure frequencies and maximum reported throw distances

Part	Failure frequency per turbine per year			Maximum throw distance [m] (reported and confirmed)
	Expected Value	95% upper limit	Recommended Risk Analysis Value [1/yr]	
Entire blade	$6.3*10^{-4}$	$8.4*10^{-4}$	$8.4*10^{-4}$	150
Nominal rpm			***$4.2*10^{-4}$***	
Mechanical braking			***$4.2*10^{-4}$***	
Overspeed			***$5.0*10^{-6}$***	
Tip or piece of blade	$1.2*10^{-4}$	$2.6*10^{-4}$	**$2.6*10^{-4}$**	500
Tower	$5.8*10^{-5}$	$1.3*10^{-4}$	**$1.3*10^{-4}$**	Shaft height + half diameter
Nacelle and/or rotor	$2.0*10^{-4}$	$3.2*10^{-4}$	**$3.2*10^{-4}$**	Half diameter
Small parts from nacelle	$1.2*10^{-3}$	$1.7*10^{-3}$	**$1.7*10^{-3}$**	Half diameter

6.2 Closing Remarks

Until now ECN, NRG, and KEMA and other organizations have conducted various risk analyses. The failure frequencies used for these analyses were derived from a study of Danish failure frequencies like those published between 1990 and 1992 in WindStats with the expected values for the failure frequencies of blade fracture per turbine split up into:

- Failure at nominal operating rpm $1.3*10^{-3}$ per year
- Failure during mechanical braking (~1.25 times nominal rpm) $1.3*10^{-3}$ per year
- Failure by overspeed (~2 times nominal rpm) $5.0*10^{-6}$ per year

The total chance of blade fracture per turbine was $2.6*10^{-3}$ per year. The analysis of the new failure information shows that this chance is decreased by a factor of 3.1 to $8.4*10^{-4}$. The recommended risk analysis value is 3.1 times smaller than the one used in the past.

Failure during overspeed is not reported in either ISET's or EMD's data. The ISET data did reveal that two incidents led to a long-lasting overspeed situation. The chance of this happening is therefore 2/13,000 = $1.5*10^{-4}$. The blades stayed in one piece in these situations. Until now the chance of overspeed was determined by multiplying the chance of electric grid failure (5 times per year), the chance of failure of the first brake system (10^{-3} per claim), the chance of failure of the second brake system (10^{-3} per claim), and the chance of blade fracture in this situation (=1). Here it is recommended to retain the old calculation value for blade fracture during overspeed, as $5.0*10^{-6}$ per year.

Information about the tower failures was until now never derived from failure frequency databases. Until now the assumption was made that the chance of a tower failure had to be at least ten times smaller than that of a blade failure because it goes nearly unreported. The calculation value of $1.0*10^{-4}$ was used. The new calculation value based on the 95% upper limit is 1.3 times larger than the value that was used in the past.

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Draft
Eagle Conservation Plan Guidance

U.S. Fish & Wildlife Service
January 2011

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EXECUTIVE SUMMARY

The mission of the U.S. Fish and Wildlife Service is to work with others to conserve, protect and enhance fish, wildlife, plants and their habitats for the continuing benefit of the American people. As part of this, we are charged with implementing statutes including the Bald and Golden Eagle Protection Act (BGEPA), the Migratory Bird Treaty Act, and the Endangered Species Act. The draft Eagle Conservation Plan Guidance (draft Guidance) is intended to assist parties to avoid, minimize, and mitigate adverse effects on bald and golden eagles. The draft Guidance calls for scientifically rigorous surveys, monitoring, assessment, and research designs proportionate to the risk to eagles. The draft Guidance describes a process by which wind energy developers can collect and analyze information that could lead to a programmatic permit to authorize unintentional take of eagles at wind energy facilities.

The *Draft Eagle Conservation Plan Guidance Module 1: Wind Energy Development* (Draft Eagle Conservation Plan Guidance) provides recommendations for the development of *Eagle Conservation Plans* (ECPs) to support issuance of eagle programmatic take permits for wind facilities. Programmatic take permits will authorize limited, incidental mortality and disturbance of eagles at wind facilities, provided effective offsetting conservation measures that meet regulatory requirements are carried out. To comply with the permit regulations, conservation measures must avoid and minimize take of eagles to the maximum degree, and, for programmatic permits necessary to authorize ongoing take of eagles, advanced conservation practices (ACPs) must be implemented such that any remaining take is unavoidable. Further, for eagle management populations that cannot sustain additional mortality, any remaining take must be offset through compensatory mitigation such that the net effect on the eagle population is, at a minimum, no change. The Draft Eagle Conservation Plan Guidance interpret and clarify the permit requirements in the regulations at 50 Code of Federal Regulations (CFR) 22.26 and 22.27, and do not impose any binding requirements beyond those specified in the regulations.

The Service recommends that ECPs be developed in five stages. Each stage builds on the prior stage, such that together the process is a progressive, increasingly intensive look at likely effects of the development and operation of a particular site and configuration on eagles. The objectives, recommended actions, and recommended data sources for each of the five stages in the ECP are described in the following table. The Draft Eagle Conservation Plan Guidance recommends that project proponents employ fairly specific procedures in their site assessments so the data can be combined with that from other facilities in a formal adaptive management process. This adaptive management process is designed to reduce uncertainty about the effects of wind facilities on eagles. Project proponents are not required to use the recommended procedures, however, if different approaches are used, the proponent should coordinate with the Service in advance to ensure that proposed approaches will provide comparable data.

The Draft Eagle Conservation Plan Guidance recommend that at the end of each of the first four stages, project proponents determine which of the following categories the project, as planned, falls into: (1) high risk to eagles, little opportunity to minimize effects; (2) high to moderate risk to eagles, but with an opportunity to minimize effects; (3) minimal risk to eagles; or (4) uncertain.

Projects in category 1 should be moved, significantly redesigned, or abandoned because the project would likely not meet the regulatory requirements for permit issuance. Projects in categories 2, 3, and possibly 4 are candidates for ECPs. Service biologists are available to work with project proponents in the development of their ECP. Frequent close coordination from the outset is beneficial to the Service and the project proponents and it will help ensure the ECP meets the needs and requirements of all parties involved.

	Objective	**Actions**	**Data Sources**
STAGE 1	Identify potential wind facility locations with manageable risk to eagles at the landscape level	Broad, landscape-scale evaluation	Literature, agency files, on-line databases, experts
STAGE 2	Obtain site-specific data to predict eagle fatality rates and disturbance take at wind-facility sites that pass Stage 1 assessment.	Site-specific surveys (on and within 10 miles of project footprint) to determine eagle exposure rate in project footprint, the location and pre-construction occupancy and productivity of potentially-affected eagle nests, and to locate eagle migration corridors and stopover sites, foraging concentration areas, or communal roosts in the project area	800-m radius point count surveys in project footprint, nesting surveys in the project area, migration counts on likely migratory routes in the project area, roost searches and counts in the project area. Ideally conducted for 3 years pre-construction
STAGE 3	Conduct turbine-based risk assessment and estimate the fatality rate of eagles for the facility evaluated in Stage 2, excluding possible advanced conservation practices (ACPs)	Assess risk factors for each turbine, such as nearby cliff rim, migration pass, or prey concentration. Use results of this risk factor assessment along with an estimate of eagle exposure rate derived from Stage 2 data in Service-provided models to predict the annual eagle fatality rate for the project	Point count data from Stage 2 and turbine-based, risk-factor assessment
STAGE 4	Identify and evaluate ACPs that might avoid or minimize fatalities identified in Stage 3. When required to do so, identify compensatory mitigation necessary to reduce any remaining fatality effect to a no-net-loss standard	Re-run fatality prediction models with risk adjusted to reflect application of ACPs. Calculate required compensatory mitigation amount and identify the method to accomplish it	Turbine-based risk-factor assessment modified on a turbine-by-turbine basis after application of ACPs, and point count data from Stage 2
STAGE 5	Document annual eagle fatality rate and disturbance effects. Identify additional ACPs to reduce observed level of mortality, and determine if initial ACPs are working and should be continued. When appropriate, monitor effectiveness of compensatory mitigation	Conduct fatality monitoring in project footprint. Monitor occupancy and productivity of nests of eagle pairs that are likely using the project footprint. Monitor eagle use of communal roosts in the project area	Use line-transect surveys in project footprint to estimate the eagle fatality rate. Monitor nests adjacent to the project footprint to determine productivity for comparison with pre-construction levels. Count eagles at roosts for comparison with pre-construction levels, for 3 years post-construction, and targeted thereafter to assess effectiveness of any additional ACPs.

A. INTRODUCTION AND PURPOSE

The mission of the U.S. Fish and Wildlife Service (Service) is to work with others to conserve, protect and enhance fish, wildlife, plants and their habitats for the continuing benefit of the American people. As part of this, we are charged with implementing statues including the Bald and Golden Eagle Protection Act (BGEPA), the Migratory Bird Treaty Act, and the Endangered Species Act. BGEPA prohibits all take of eagles unless otherwise authorized by the Service. A goal of BGEPA is to achieve and maintain stable or increasing populations of bald and golden eagles. The draft Eagle Conservation Plan Guidance (draft Guidance) is intended to provide a means of compliance with BGEPA by:

(1) conducting early pre-construction assessments to identify important eagle use areas;
(2) avoiding, minimizing, and/or compensating for potential adverse effects to eagles; and,
(3) monitoring for impacts to eagles during construction and operation.

The draft Guidance calls for scientifically rigorous surveys, monitoring, risk assessment, and research designs proportionate to the risk to eagles. The draft Guidance was developed as a tool to assist wind energy developers and facility operators during the decision-making process, and describes a means by which to collect and analyze information that could lead to a programmatic permit to authorize unintentional take of eagles at wind energy facilities. The process described here is not required, but project proponents should coordinate closely with the Service concerning alternatives.

1. Purpose

The U.S. Fish and Wildlife Service (Service) published a final rule (Eagle Permit Rule) on September 11, 2009 under the Bald and Golden Eagle Protection Act (BGEPA) (50 Code of Federal Regulations [CFR] 22.26) authorizing limited issuance of permits to take bald eagles (*Haliaeetus leucocephalus*) and Golden Eagles (*Aquila chrysaetos*) ''for the protection of . . . other interests in any particular locality'' where the take is compatible with the preservation of the bald eagle and the golden eagle, is associated with and not the purpose of an otherwise lawful activity, and cannot practicably be avoided (USFWS 2009a). The Draft Eagle Conservation Plan Guidance explains the Service's approach to issuing programmatic eagle take permits under this authority, and provides guidance to permit applicants (project proponents), Service biologists, and biologists with other jurisdictional agencies on the development of draft *Eagle Conservation Plans* (ECPs) to support permit issuance.

Since finalization of the Eagle Permit Rule, the development and planned development of wind facilities (developments for the generation of electricity from wind turbines) has increased dramatically in the range of the Golden Eagle in the western United States. Golden Eagles are vulnerable to collisions with wind turbines (Hunt 2002, Chamberlain *et al.* 2006), and in some areas such collisions are a major source of mortality (Hunt *et al.* 1999, 2002). Although significant numbers of bald eagle mortalities have not yet been reported at North American wind facilities, the closely related white-tailed sea eagle (*Haliaeetus albicilla*) has been killed regularly at wind facilities in Europe (Krone 2003, Cole 2009). Because of this risk to eagles, many of the current and planned wind facilities require permits under this provision in the regulations in order to be in compliance with the law. In addition to being legally necessary to comply with BGEPA and 50 CFR 22.26, the conservation practices and adaptive management necessary to meet standards required for issuance of these permits can offset the short- and long-term effect of wind facilities on eagle populations.

Because of the urgent need for guidance on permitting eagle take at wind facilities, this initial module focuses on this issue. Many of the concepts and approaches outlined in this module can be readily exported to other situations, and we expect to release other modules in the near future specifically addressing other forms of eagle take. In all cases, the Draft Eagle Conservation Plan Guidance are intended to provide interpretive guidance to Service biologists and others in applying the regulatory permit standards as specified in the rule. They do not in-and-of themselves impose additional regulatory requirements.

The Draft Eagle Conservation Plan Guidance is written to guide wind-facility projects starting from the earliest conceptual planning phase. For projects already in the development or operational phase, implementation of all stages of the recommended approach in these Draft Eagle Conservation Plan Guidance may not be applicable or possible. Project proponents with operating or soon-to-be operating facilities at the time this Draft Eagle Conservation Plan Guidance were first released that are interested in obtaining a programmatic eagle take permit should coordinate with the Service. The Service will work with project proponents to determine if the facility might be able to meet the permit requirements in 50 CFR 22.26 by conducting eagle fatality and disturbance monitoring and by agreeing to adopt reasonable operational avoidance and minimization measures that might reduce the eagle fatalities detected through monitoring. Sections of the Draft Eagle Conservation Plan Guidance that address these topics are relevant to both planned and operating wind facilities.

The Draft Eagle Conservation Plan Guidance is compatible with the more general guidelines provided in the *U.S. Fish and Wildlife Service Draft Land-based Wind Energy Guidelines* (guidelines which project proponents should consult on addressing other migratory bird issues associated with wind facilities). However, because the Draft Eagle Conservation Plan Guidance describes actions which help to comply with the regulatory requirements in the BGEPA for an eagle take permit as described in 50 CFR 22.26, they are more specific.

2. Legal Authorities and Relationship to Other Statutes and Guidelines

BGEPA is the primary law protecting eagles. It defines “take” as “to pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, destroy, molest, disturb individuals, their nests and eggs” (16 USC 668c). “Disturb” is defined by regulation at 50 CFR 22.3 in 2007 as “to agitate or bother a bald or golden eagle to a degree that causes…injury to an eagle, a decrease in productivity, or nest abandonment…” (USFWS 2007). A goal of BGEPA is to achieve and maintain stable or increasing populations of bald and golden eagles.

In 2009, two new permit rules were created for eagles. Under 50 CFR 22.26, the Service can issue permits that authorize limited take of bald and golden eagles when the take is associated with, but not the purpose of an otherwise lawful activity, and cannot practicably be avoided. Further, as explained above, the regulation also authorizes ongoing or programmatic take, but requires that any authorized programmatic take is unavoidable after implementing advanced conservation practices. Under 50 CFR 22.27, the Service can issue permits that allow the intentional take of eagle nests where necessary to alleviate a safety emergency to people or eagles, to ensure public health and safety, where a nest prevents use of a human-engineered structure, and to protect an interest in a particular locality where the activity or mitigation for the activity will provide a net benefit to eagles. Only inactive nests are allowed to be taken except in cases of safety emergencies.

The new Eagle Permit Rule provides a mechanism where the Service may legally authorize the non-purposeful take of eagles. However, BGEPA provides the Secretary of the Interior with the authority to issue eagle take permits only when that the take is compatible with the preservation of each species, defined in USFWS (2009a) as "…consistent with the goal of increasing or stable breeding populations." The Service ensures that any take it authorizes under 50 CFR 22.26 does not exceed this preservation standard by setting regional take thresholds for each species determined using the methodology contained in the National Environmental Policy Act (NEPA) Final Environmental Assessment (FEA) developed for the new permit rules (USFWS 2009b). The details and background of the process used to calculate these take thresholds are presented in the FEA (USFWS 2009b).

The programmatic permits under the BGEPA were originally envisioned to be broad, industry-wide take permits. However, the greatest demand in practice has been from individual companies, and as a result, we are seeing a demand for many smaller-scale permits covering individual installations that may take few eagles individually, but cumulatively could take many.

The Draft Eagle Conservation Plan Guidance is not intended to relieve any individual, company, or agency of its obligations to comply with any applicable Federal, state, tribal, or local laws, statutes, or regulations. Wind facility projects that are expected to cause take of endangered or threatened wildlife species must still receive incidental take authorizations under sections 7 or 10 of the Endangered Species Act (ESA) of 1973 as amended (ESA; 16 United States Code [USC] § 1531 *et seq*.). A project proponent seeking an Incidental Take Permit (ITP) through the ESA section 10 Habitat Conservation Plan process may be issued an ITP only if the permitted activity is otherwise lawful (section 10(a)(1)(B)). If the project and covered activities in the HCP are likely to take bald or golden eagles, the project proponent must obtain a BGEPA permit or include the bald or golden eagle as a covered species in the HCP. If bald and golden eagles are included as covered species in an HCP, the avoidance, minimization, and other mitigation measures in the HCP must meet the BGEPA permit issuance criteria of 50 CFR 22.26, and include flexibility for adaptive management. If a BGEPA permit is denied, an ITP may not be issued in association with the proposed HCP because the activities covered by the proposed HCP are not otherwise lawful if they cause unauthorized take of eagles. If the project proponent proposes to include the bald or golden eagle as a covered non-listed species in the ITP but the minimization and mitigation measures are found not to meet the BGEPA permit issuance criteria an ITP may not be issued in association with the proposed HCP because the permit revocation criterion at 50 CFR 22.11(a) applies when the permitted activity is incompatible with the preservation of the bald eagle or golden eagle.

In addition to the ESA, wind facility project proponents must comply with the Migratory Bird Treaty Act (MBTA). The Migratory Bird Treaty Act (MBTA; 16 USC § 703 *et seq*.) prohibits the taking, hunting, killing, collecting, capture, possession, sale, purchase, transport import, and export of migratory birds, their eggs, parts, and nests, except when authorized by the Department of Interior. Because neither the MBTA nor its permit regulations at 50 CFR Part 21 currently provide a specific mechanism to permit "incidental" take, it is important for project proponents to work proactively with the Service to avoid and minimize take of migratory birds. The Service is actively working to develop guidance for the development of plans specific to migratory birds other than bald and golden eagles, as well as other species listed under the ESA.

The National Environmental Policy Act of 1969 as amended (NEPA) (42 U.S.C. 4321 *et seq.*) applies to issuance of eagle take permits because issuing a permit is a federal action. While providing technical assistance to agencies conducting NEPA analyses, the Service will participate in the other agencies' NEPA to the extent feasible, in order to streamline subsequent NEPA related to a project. For actions that may result in applications for or development of programmatic permits, the Service may participate as a cooperating agency to streamline the permitting process.

If no other federal nexus exists, the Service must complete a NEPA analysis before it can issue a permit. The Service will work with the project proponent to conduct a complete NEPA analysis, including assisting with data needs and determining the scope of analysis. Developers should coordinate closely with the Service for projects with no federal nexus other than the eagle permit, and to facilitate timely preparation of NEPA documents, project proponents may provide assistance in accordance with 40 CFR §1506.5. Close coordination between project proponents and the Service regarding the data needs and scope of the analysis required for a permit will reduce delays.

Through 50 CFR 22.26 and the associated FEA, the Service defined "mitigation" as per the Service Mitigation Policy (46 FR 7644, Jan. 23, 1981), and the President's Council on Environmental Quality (40 CFR 1508.20 (a–e)), to sequentially include the following: (1) Avoiding the impact on eagles altogether by not taking a certain action or parts of an action; (2) Minimizing impacts by limiting the degree or magnitude of the action and its implementation; (3) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment; (4) Reducing or eliminating the impact over time by implementing preservation and maintenance operation during the lifetime of the action; and (5) Compensating for the impact by replacing or providing substitute resources or environments. The NEPA on our permits and the discussion of mitigation in this document follow this system, and in this Draft Eagle Conservation Plan Guidance we refer to (1) – (4) as avoidance and minimization measures, and to (5) as compensatory mitigation. To the extent that the Service acknowledges a developer's commitments to mitigate adverse environmental impacts, the Service will work with the developer to achieve those commitments, monitor how they are implemented, and report on the effectiveness of the mitigation. Additionally, the Service will make generic information on take and mitigation monitoring available to the public.

Eagles are highly significant species in Native American culture and religion (Palmer 1988) and may be viewed as contributing elements to a "traditional cultural property" under Section 106 of the National Historic Preservation Act (NHPA). Some locations where eagles would be taken have traditional religious and cultural importance to Native American tribes and thus have the potential of being regarded as traditional cultural properties under NHPA. Permitted take of one or more eagles from these areas, for any purpose, could be considered an adverse effect to the traditional cultural property.

Indian tribes have a special status in American law as sovereign nations. Tribes also possess certain rights that are different from the rights of other Americans. Some of the special rights of tribes are based on treaties, some are based on acts of Congress, some are based on actions taken by the Executive Branch of the federal government, and others are clarified by federal court rulings. The Service will consult with tribes on a government-to-government basis as described under Executive Order 13175 and Secretarial Order 3206 during the public comment period on the draft Eagle Conservation Plan Guidance. During the process for bald eagle and golden eagle permitting, the Service will, where appropriate, and to the extent practicable and permissible by law, engage with tribes in open and meaningful communication. Consultation regarding eagle permits under 50 CFR 22 and management of eagle populations will be consistent with overall Service guidance for tribal consultation, but may include additional provisions specific to bald and golden eagles. This draft Guidance changes nothing from the September 2009 regulations concerning eagle take permits in 50 CFR 22.26 and 50 CFR 22.27.

3. Background and Overview of Process

Increased energy demands and the nationwide goal to increase energy production from renewable sources have intensified the development of energy facilities, including wind energy. The Service supports renewable energy development that is compatible with fish and wildlife conservation. The Service closely coordinates with state, tribal, and other federal agencies in the review and permitting of wind energy projects to address potential resource effects, including effects to bald and golden eagles. However, our knowledge of these effects and how to address them at this time is limited. Given this and the Service's statutory and regulatory mandate to only authorize actions that are "compatible with the goal of stable or increasing breeding populations" of eagles has led us to adopt an adaptive management framework for consideration and issuance of programmatic eagle take permits. This framework consists of case specific considerations applied within a national framework, and with the outcomes carefully monitored so that we maximize learning from each case. The knowledge gained through monitoring can then be used to update and refine the process for making future permitting decisions, as well as to consider operational adjustments at individual projects at regular intervals. The Draft Eagle Conservation Plan Guidance provides the background and information necessary for wind facility project proponents to prepare an ECP that assesses the risk of a prospective or operating project to eagles, and how siting, design, and operational modifications can mitigate that risk. The final ECP must reduce predicted eagle take, and the population level effect of that take, to a degree compatible with regulatory standards to justify issuance of a programmatic take permit by the Service.

a. Risks to Eagles

Energy development can affect bald and golden eagles in a variety of ways. First, structures such as wind turbines can cause direct mortality through collision (Hunt 2002, Krone 2003, Chamberlain *et al.* 2006). This is the primary threat to eagles from wind facilities, and the monitoring and avoidance and minimization measures advocated in the Draft Eagle Conservation Plan Guidance primarily are aimed at this threat. Second, activities associated with pre-construction, construction, or maintenance of a facility can cause disturbance and result in loss of productivity at nearby nests or disturbance to nearby concentrations of eagles. Third, if disturbance or mortality effects are permanent, they can result in the permanent or long term loss of a nesting territory. All of these impacts, unless properly permitted, are violations of BGEPA (USFWS 2009a). Additionally, disturbances near areas that are important for roosting or foraging might stress eagles to a degree that leads to reproductive failure or mortality elsewhere; these impacts are of concern as well as they would likely amount to prohibited take. Thus, the Draft Eagle Conservation Plan Guidance addresses both direct mortality and disturbance.

b. General Approach to Address Risk

Applicants for permits under 50 CFR 22.26, non-purposeful eagle take, are required to avoid and minimize the potential for take of eagles to the maximum degree practicable. Permits for wind-energy development are programmatic in nature as they will authorize recurring take, rather than isolated incidences of take. For programmatic take permits, the regulations at 50 CFR 22.26 require that any authorized take is unavoidable even though ACPs are being implemented. 50 CFR 22.3 defines “advanced conservation practices” as “scientifically supportable measures that are approved by the Service and represent the best available techniques to reduce eagle disturbance and ongoing mortalities to a level where remaining take is unavoidable.”

Where take is unavoidable and when eagle populations at the scale of the eagle management unit (as defined in USFWS 2009b) are not healthy enough to sustain additional mortality over existing levels, applicants must reduce the effect of permitted mortality to a no-net-loss standard, best accomplished through compensatory mitigation. No-net-loss means that additional mortality caused by the permitted activities is offset by compensatory mitigation that reduces another, ongoing form of mortality by an equal or greater amount. Compensatory mitigation may also be necessary to offset substantial effects in other situations as well (USFWS 2009a). The approach described in the Draft Eagle Conservation Plan Guidance is applicable for all land-based wind facility projects within the range of the bald and golden eagle where interactions with wind facility infrastructure are reasonably expected to occur. The Draft Eagle Conservation Plan Guidance is intended to provide a national framework for assessing and mitigating risk through development of ECPs.

As part of the application process for a programmatic eagle take permit, the Service recommends that project proponents should prepare an ECP that outlines the project development process and includes conservation and monitoring plans as described in this Draft Eagle Conservation Plan Guidance. The Draft Eagle Conservation Plan Guidance provides examples of ways that applicants can meet the regulatory standards in the rule, and while other approaches may be acceptable, they will be determined on a case-by-case basis.

B. ASSESSING RISK AND EFFECTS

1. Areas of Importance to Eagles for Consideration When Assessing Risk

Bald eagles and golden eagles associate with distinct geographic areas and landscape features throughout their respective ranges. The Service defines these "important eagle-use areas" as "an eagle nest, foraging area, or communal roost site that eagles rely on for breeding, sheltering, or feeding, and the landscape features surrounding such nest, foraging area, or roost site that are essential for the continued viability of the site for breeding, feeding, or sheltering eagles" (USFWS 2009b). Because migration corridors and migration stopover sites provide important foraging areas for eagles during migration (e.g., Restani *et al.* 2001, Mojica 2008), we believe these areas fall within the regulatory definition of important eagle-use areas, and we include them as such in this Draft Eagle Conservation Plan Guidance.

Wind energy projects that overlap important eagle use areas may pose risks to the eagles for reasons described earlier. Project proponents should identify the location and type of all important eagle use areas on and within a 10-mile perimeter of a project footprint (the project footprint is the minimum convex polygon that encompasses the wind facility area inclusive of a 100 meter-radius of all turbines and any associated infrastructure, including utility lines, out-buildings, roads, etc.). The 10-mile perimeter is derived from the definition of project area nesting population in the regulations at 50 CFR 22.26 (see below). Evaluating the spatial area described above for each wind facility is a key part of the programmatic take permitting process. As described later, surveys should be conducted initially to obtain data to predict effects of wind facility projects on eagles, and then after the facility begins operating, studies will again be conducted to determine the actual effects. The following sections include descriptions and criteria for identifying important eagle-use areas in these assessments.

a. Nests and Breeding: Implications of the Nesting Territory, Nest Spacing, and Non-Breeding Individuals for Risk Assessment

An eagle territory is defined in 50 CFR 22.3 as an area that contains, or historically contained, one or more nests within the home range of a mated pair of eagles. Newton (1979) considered the nesting territory of a raptor as the defended area around a pair's nest site and defined the home range as "...the area traveled by the individual in its normal activities of food gathering, mating, and caring for the young." For golden eagles at least, the extent of the home range and territory during nesting season generally are similar; the eagle defends its territory by undulating flight displays near the home range boundaries and adjoining territories barely overlap (Harmata 1982, Collopy and Edwards 1989, Marzluff *et al.* 1997). The nesting season home range is, at a most basic level, described as a minimum-convex polygon formed by connecting the outermost occurrences of an eagle or pair of eagles during the nesting season (Mohr 1947).

Size and shape, and distribution of use of bald and golden eagle nesting territories vary with topography, prey availability, region, and between sexes and both species. To adequately describe the nesting territory of an individual eagle or pair of eagles, systematic, direct observation (Walker *et al.* 2005), telemetry (Kenward 2001, Fuller et al. 2005), or a combination of the two (McGrady *et al.* 2002) for at least three years is recommended, and in areas where prey availability is known to vary among years, many years of data may be required to fully account for annual variations in territory size and shape. An eagle's distribution of use within its territory can then be estimated by using standard kernel analyses (Worton 1989, 1995, Seaman and Powell 1996, Kenward 2001) or other probabilistic approaches, comparable to Moorcroft *et al.* (1999), McGrady *et al.* (2002), and McLeod *et al.* (2002). The size and shape of use areas can vary seasonally (Newton 1979), so documentation of spatial use by resident eagles should encompass all seasons.

Spatial disturbance avoidance zones have been prescribed to protect nests and other types of eagle use areas. Recommendations for the size of avoidance zones for nests of bald and golden eagles have been based on documented distances between nests and territory boundaries. For example, McGrady *et al.* (2002) and Watson and Davies (2009) indicated nesting territories of golden eagles extend to at least four miles from their nests. Garrett et al. (1993) found that bald eagle territories extend at least 2 miles from nests, though studies in areas of dense bald eagle breeding territories in superior habitat suggest home ranges may be much smaller (Sherrod *et al.* 1976, Hodges and Robards 1982, Anthony 2001). Spatial avoidance recommendations for eagle nests are not accurate throughout the entire range of both species due to marked variation in the size and configuration of nesting territories of both species; spatial avoidance prescriptions have been conservative because site-specific data on territory location and spatial extent are rare in the published and unpublished literature.

Directly determining home-range size and utilization contours of individual eagles requires that birds be captured or marked, usually using radio- or satellite-telemetry. Benefits of this approach are that it can provide information on behavioral responses and spatial use of eagles that is relevant to more than assessing the risk of mortality within the project footprint. This additional information can also be useful in identifying and assessing important prey sources, displacement of eagles, behavioral responses to turbines, and cumulative effects from habitat impacts. However, the down side to this approach is that specific target eagles must be captured, and not all eagles using a wind-facility footprint are equally likely to be captured or provide useful data (e.g., migrants or floaters [adult eagles that have not yet settled on a breeding territory] are not as likely to be captured or monitored). Furthermore, the process of capturing and radio-marking eagles can have behavioral and use-area effects (e.g., Marzluff *et al.* 1997, Gregory *et al.* 2002), and these need to be better understood before widespread use of these techniques can be recommended for wind-facility effect assessments. Despite these caveats, the Service recognizes that telemetry studies can yield considerably more detailed area-use information than observational studies, and as such in specific situations it can inform important pre-construction turbine siting decisions and aid in assessing site risk.

The approach that we recommend as a standard practice in this Draft Eagle Conservation Plan Guidance for evaluating siting options and for assessing disturbance effects of wind facilities on eagles breeding on proximate territories is to determine locations of occupied nests of bald and golden eagles within the project footprint and within 10 miles of the perimeter of the footprint, then for each species calculate the mean nearest neighbor distance between the occupied nests (the project-area inter-nest distance). We use a 10-mile distance because the Service has defined the area nesting population for Golden Eagles to be the "number of pairs of Golden Eagles known to have a nesting attempt during the preceding 12 months within a 10-mile radius of a golden eagle nest" (50 CFR 22.3). To avoid confusion with the regulatory term and definition, we use the term project-area nesting population to describe the eagle population targeted in these surveys.

We also recommend application of this survey approach and scale for bald eagles for the purposes of this Draft Eagle Conservation Plan Guidance. However, where the project area nesting density is high-enough to make the 10-mile perimeter infeasible, we recommend an alternative approach (see Appendix C). The effectiveness of this approach for targeting nest searches will be evaluated through post-construction monitoring and the adaptive management framework described later in this Draft Eagle Conservation Plan Guidance. One-half the inter-nest distance has been widely used as a coarse approximation for the territory boundary in a number of raptor studies (e.g., Thorstrom 2001, Wichmann *et al.* 2003, Soutullo *et al.* 2006).

For the purposes of this Draft Eagle Conservation Plan Guidance, we use the mean value of the project-area inter-nest distance (project-area inter-nest distance) to delineate which territories and associated breeding and juvenile eagles are likely to be affected by the wind facility, either through injury, mortality, or disturbance. This information is useful in decisions on whether the wind facility might be able to meet permit requirements at 50 CFR 22.26, for evaluating various siting alternatives, and in monitoring for disturbance effects. The advantages of this approach are that it does not require capture and marking of individual eagles, and it weights all territories equally, not just those on which eagles can be captured and marked.

This approach has the disadvantage of not providing the fine scale behavioral and spatial use information that can be helpful in analyses of behavior. Overall, we believe the advantages of this approach outweigh the disadvantages for most wind facility studies. The data used to calculate the project area inter-nest distance should be secured during the initial site specific surveys, as described later in this Draft Eagle Conservation Plan Guidance. If site specific data are lacking, or if nesting habitat is patchily distributed or nests are widely spaced, calculating the project area inter-nest distance can be problematic. We provide alternative suggestions for these circumstances in Appendix H. If information from the literature is adopted, conservative values should be used because nearest neighbor distances vary widely across populations of both species. For example, mean distances to nearest nests were 2.7 to 3.3 miles for golden eagles in Wyoming and in two areas in Idaho (Craig and Craig 1984, Kochert 1972, Phillips et al. 1984), but 13.4 miles for golden eagles in western Arizona (Millsap 1981).

The presence of nesting territories can also be a predictor for the occurrence of eagles that are not nesting. The non-breeding component of eagle populations includes juveniles (fledged that year), subadults, and, in healthy populations, adult "floaters" that have not settled on a breeding territory (Hunt et al. 1995, Hunt 1998). Many non-breeding eagles exist on margins of territories occupied by breeding adults (Watson 1997, Hunt 1998, Caro et al. 2010). Floaters have been shown to be more vulnerable to collision with turbine blades at wind energy projects than locally breeding adults and juveniles (Hunt et al. 1999, 2002). Wind turbines sited proximally to eagle nesting territories may pose significant risks to eagle populations, because population stability hinges on a robust non-breeding cohort, especially surplus adults in the form of floaters, to replace breeding individuals that die. A systematic, observational approach for documenting frequency of eagle use of the project footprint has the substantial advantage of accounting for any eagle regardless of its breeding or residency status. The Draft Eagle Conservation Plan

Guidance recommends such an approach (point count surveys) for the collection of data that will be used to predict eagle fatality rates at wind facilities.

b. Concentration Areas: Communal Roosts and Foraging Concentrations

During the breeding season, some non-breeding individuals, especially bald eagles, roost communally. Outside the breeding season, communal roosts include individuals of all ages and residency status. Bald eagles may roost singly or in small groups but larger communal roosts are common throughout the year (Platt 1976, Mojica *et al.* 2008). Large roosts tend to be associated with nearby foraging areas. Direct, systematic observation in early morning and evening is the most practical means of locating roosts and documenting numbers of eagles and movements of eagles to and from roosts on a local scale (Steenhof *et al.* 1980, Crenshaw and McClelland 1989). Aerial surveys may be needed for repeated surveys of eagles at extensive roosts (Chandler *et al.* 1995). Direct observation has been used to compare occurrence and activity of eagles before and after construction and operation of a project (Becker 2002), and may be a valid means to identify disturbance effects on roosting concentrations.

c. Migration Corridors and Stopovers

Bald and golden eagles tend to migrate during midday along north-south oriented cliff lines, ridges, and escarpments, where they are buoyed by uplift from deflected winds (Kerlinger 1989, Mojica *et al.* 2008). Bald eagles typically migrate during midday by soaring on thermal uplift or on winds aloft, the onset of migration being influenced by rising temperatures and favorable winds (Harmata 1984). Bald and golden eagles often hunt during this type of migration flight. Both species of eagle will forage during migration flights, though for bald eagles foraging is often restricted to wetland systems (Mojica *et al.* 2008). Both species use lift from heated air from open landscapes to move efficiently during migration and seasonal movements, gliding from one thermal to the next and sometimes moving in groups with other raptor species.

Passage rates of migrant eagles can be influenced by temperature, barometric pressure, winds aloft, storm systems, weather patterns at the site of origin, and wind speed (Yates et al. 2001). Both species avoid large water bodies during migration and funnel along the shoreline, often becoming concentrated in situations where movement requires water crossings (Newton 1979). Eagles annually use stopover sites with predictably ample food supplies (e.g., Restani *et al.* 2000, Mojica *et al.* 2008), although some stopovers may be brief and infrequent, such as when optimal migration conditions suddenly become unfavorable and eagles are forced to land and seek roosts. Presence of a migration corridor or stopover site in the project area is best documented and delineated by using a standard hawk migration counting protocol as recommended in this Draft Eagle Conservation Plan Guidance as a component of the site-specific surveys.

2. Eagle Risk Factors

Factors known or thought to be associated with increased probability of collisions between eagles and other raptors and wind turbine blades and structures are given in Table 1 (page 18). While some of these factors are not known to affect eagles, because of the similarity of flight behavior between eagles and the other soaring raptors we include them here because they may have applicability for eagles. Evidence across multiple studies suggests three main factors contribute to increased risk of collision by eagles: (1) the interaction of topographic features, season, and wind currents to create favorable conditions for slope soaring or kiting (stationary or near-stationary hovering) in the vicinity of turbines; (2) behavior that distracts eagles and presumably makes them less vigilant (e.g., active foraging or inter- and intra-specific interactions); and (3) residence status, with resident adults and young less vulnerable and dispersers and migrants (especially sub-adults and floating adults) more vulnerable. This latter point should not be taken to undercut the potential severity of the risk to breeding adult eagles and their young, as loses from these segments of the population, especially breeding adults, can have serious consequences to populations.

Table 1. Factors potentially associated with wind turbine collision risk in raptors

Risk Factor	Status of Knowledge from Literature	Citations
Bird Density	Mixed findings; likely some relationship but other factors have overriding influence across a range of species	Barrios and Rodriguez (2004), De Lucas *et al.* (2008), Hunt (2002), Smallwood *et al.* (2009)
Bird Age	Higher risk to subadult and adult Golden Eagles	Hunt (2002)
Bird Residency Status	Mixed findings, higher risk to resident adults in Egyptian vultures (*Neophron percnopterus*), but higher risk to subadults and floating adults and lower risk to resident adults and juveniles in Golden Eagles	Barrios and Rodriguez (2004), Hunt (2002)
Season	Mixed findings, with general consensus that risk is higher in seasons with greater propensity to use slope soaring (fewer thermals) or kiting flight (windy weather) while hunting across a range of species	Barrios and Rodriguez (2004), De Lucas et al. (2008), Hoover and Morrision (2005), Smallwood *et al.* (2009)
Flight Style	High risk associated with slope soaring and kiting flights across a range of species	Barrios and Rodriguez (2004), De Lucas *et al.* (2008), Hoover and Morrision (2005)
Interaction with Other Birds	Higher risk when interactive behavior is occurring, across a range of species	Smallwood et al. (2009)
Active Hunting / Prey Availability	High risk when hunting close to turbines, across a range of species	Barrios and Rodriguez (2004), De Lucas *et al.* (2008), Hoover and Morrision (2005), Hunt (2002), Smallwood et al. (2009)
Turbine Height	Mixed, contradictory findings across a range of species	Barclay *et al.* (2007), De Lucas *et al.* (2008)
Turbine Type	Higher risk associated with lattice turbines for Golden Eagles, higher risk with tubular towers for Burrowing Owls (*Athene cunicularia*)	Hunt (2002), Smallwood *et al.* (2007)
Rotor Speed	Higher risk associated with higher blade-tip speed for Golden Eagles	Chamberlain *et al.* (2006)

Perch Availability	Possible higher risk with higher perch availability in the general project area for golden eagles	Chamberlain *et al.* (2006)
Rotor-swept Area	Mixed findings; higher mortality associated with larger rotor-swept area in one study for non-raptors, meta-analysis found no effect	Barclay *et al*. (2007), Chamberlain et al. (2006)
Topography	Several studies show higher risk of collisions with turbines on ridge lines and on slopes where declivity currents facilitate slope soaring and kiting flight of soaring raptors. Also a higher risk in saddles that present low-energy ridge crossing points. Higher risk for Burrowing Owls in canyons.	Barrios and Rodriguez (2004), De Lucas *et al.* (2008), Hoover and Morrission (2005), Smallwood and Thelander (2004), Smallwood *et al.* (2007)
Wind Speed	Mixed findings; general pattern of higher risk in situations that favor slope soaring or kiting (high winds in some locales, low winds in other, likely depending on degree of slope and aspect)	Barrios and Rodriguez (2004), Hoover and Morrision (2005), Smallwood *et al.* (2009)

3. Overview of Process to Assess Risk

The Draft Eagle Conservation Plan Guidance outlines a decision-making process that gathers information at each stage of project development, with an increasing level of detail. This approach provides a framework for making decisions sequentially at three critical phases in project development: (1) siting, (2) construction, and (3) operations. The greatest potential to avoid and minimize impacts to eagles occurs when eagle risk factors are taken into account at each stage. If siting and construction have proceeded without consideration of risks to eagles, significant opportunities to avoid and minimize risk may have been lost. This can potentially result in greater compensatory mitigation requirements or, in the worst case, an unacceptable level of mortality for eagles.

The related, but more general, *U.S. Fish and Wildlife Service Draft Land-based Wind Energy Guidelines* advocates using a five-tiered approach for iterative decision making relative to assessing and addressing wildlife effects from wind facilities. Elements of all of those tiers are applicable here, but the process for eagles is more defined and falls more into six broadly overlapping, iterative stages: Stage 1 site assessment; Stage 2 site-specific surveys and assessments; Stage 3 predicting eagle fatalities; Stage 4 avoidance and minimization of risk; and Stage 5 post-construction monitoring.

Stage 1 for eagles combines tiers 1 and 2 from the *U.S. Fish and Wildlife Service Draft Land-based Wind Energy Guidelines*, and consists of an **initial site assessment**. In this stage project proponents evaluate broad geographic areas to assess the relative importance of various areas to resident breeding and non-breeding eagles, and to migrant and wintering eagles. The Service is available to assist project proponents in identifying potential important eagle use areas and habitat at this stage. To increase the probability of meeting the regulatory requirements for a programmatic permit, Service biological advice should be requested as early as possible in the company's planning process, ideally prior to any financial commitment or finalization of any lease agreements. During Stage 1 the project proponent should gather existing information from publicly available databases and other available information, and use those data to refine potential project sites balancing suitability for development with potential risk to eagles.

Once a site has been selected, the next stage, **Stage 2**, is **site-specific surveys and assessment** (this is the first component of tier 2 in the *U.S. Fish and Wildlife Service Draft Wind Energy Guidelines*). During Stage 2 the project proponent should collect quantitative data through scientifically rigorous surveys designed to assess the potential risk of the proposed project to eagles at and surrounding the specific site(s) selected in Stage 1.

In **Stage 3**, **the initial fatality prediction stage**, the Service and project proponents use data from Stage 2 in standardized models linked to the Service's adaptive management process to generate predictions of eagle risk in the form of a predicted number of fatalities per year. These models can be used to comparatively evaluate alternative siting, construction, and operational scenarios, a useful feature in quantifying the predicted effects of ACPs. We encourage project proponents to use the recommended pre-construction survey protocol in this Draft Eagle Conservation Plan Guidance in Stage 2 to help inform our models in Stage 3. If Service-recommended survey protocols are used, this risk assessment can be greatly facilitated using Excel-based models provided by the Service. If project proponents use other forms of information for the Stage 2 assessment, they will need to employ and fully describe those methods and the analysis approach taken for the eagle risk assessment, and more time will be required for Service biologists to evaluate and review the data. For example, the Service will compare the results of the project proponent's eagle risk assessment with predictions from our generic, risk-averse models, and if the results differ, we will work with the project proponents to determine if the site specific data collected warrants modification of the Service's predictions. The risk assessments at Stage 2 and Stage 3 are consistent with developing the information necessary to assess the efficacy of ACPs, and to develop the monitoring required by the permit regulations at 50 CFR 22.26(c).

Stage 4 is the **application of ACPs and compensatory mitigation**. Regardless which approach is employed in the Stage 2 assessment, in Stage 4 the information gathered is used by the project proponent and the Service to determine potential ACPs that can be employed to avoid and/or minimize the predicted risks at a given site. The Service will compare the initial predictions of eagle mortality for the project with predictions that take into account proposed and potential ACPs to determine if the project proponent has avoided and minimized risks to the maximum extent achievable, thereby meeting the requirements for programmatic permits in 50 CFR 22.26 that remaining take is unavoidable. This final eagle risk assessment completed at the end of Stage 4 after application of ACPs along with a plan for compensatory mitigation if required (e.g., if unavoidable take exceeds that allowable under calculated take thresholds), will be used by the Service to determine if the applicant has met the regulatory standards for issuance of a programmatic take permit.

If a permit is issued and the project goes forward, **Stage 5** of the process is **risk validation**, equivalent to tiers four and, in part, five in the *U.S. Fish and Wildlife Service Draft Wind Energy Guidelines***.** During this stage, post-construction surveys are conducted to generate empirical data for comparison with the pre-construction risk-assessment predictions. Again, we recommend project proponents use the post-construction survey protocols included in this Eagle Conservation Guidelines for this monitoring, but we will consider other monitoring protocols provided by permit applicants, so long as they meet the permit-condition requirements at 50 CFR 22.26(c)(2). We will use the information from post-construction monitoring will be used in a meta-analysis framework to weight and improve pre-construction predictive models. Additionally, the Service and project proponents will use this data to explore operational changes that might be warranted at a project to reduce observed mortality and ensure that the permit condition requirements at 50 CFR 22.26(c)(7) are met. After implementation of any additional necessary ACPs, project proponents will be eligible for renewal of their eagle take permit. The effectiveness of the additional ACPs will be determined through continued post-construction monitoring.

4. Site Categorization Based on Mortality Risk to Eagles

We recommend project proponents use a standardized approach to categorize the likelihood that a site or operational alternative will meet standards in 50 CFR 22.26 for issuance of a programmatic eagle take permit (Figure 1). A proposed project can be categorized as either: (1) high risk to eagles, little opportunity to minimize effects; (2) high to moderate risk to eagles, but with an opportunity to minimize effects; or (3) minimal risk to eagles. The risk category of a project has the potential to change from one of higher risk to one of lower risk through additional site-specific analyses and application of measures to reduce the risk, as outlined in this document. Distance criteria for evaluating risk should not be considered as protective buffers, but instead as the bounds of zones of proximity to important eagle use areas where more specific data and measures may be necessary to evaluate and reduce risk. If a project cannot practically be placed in one of these categories, the project proponent and the Service should work together to determine if the project can meet programmatic eagle take permitting requirements in 50 CFR 22.26 and 22.27.

a. Category 1 – High risk to eagles/potential to avoid or mitigate impacts is low

A project is in this category, as sited and planned, if it is (1) likely to take eagles at a rate greater than is consistent with maintaining stable or increasing populations (taking into account opportunity for reasonable compensatory mitigation), and (2) the effects cannot be minimized to the degree that any take that occurs is unavoidable. In general, prospective project footprints that include important eagle use areas as described previously will fall into category 1. Examples include:

1. For breeding eagles
    a) The project footprint includes or is within half the project area inter-nest distance of an eagle nest or cluster of nests in an occupied territory.

b) Information (e.g., from radio or satellite telemetry) is available to demonstrate that the project footprint is visited regularly by eagles occupying a proximate nesting territory.

2. For non-breeding eagles
   a) The project footprint includes the roost location(s) or a primary foraging area associated with an eagle concentration, or a migration corridor, or stopover area.
3. For all eagles
   a) Based on site-specific survey data collected as part of the Stage 2 site assessment process (described later in this Draft Eagle Conservation Plan Guidance), the estimated eagle fatality rate for the wind facility cannot reasonably be mitigated.

Projects or alternatives in category 1 should be substantially redesigned so that they at least meet the category 2 criteria. If they cannot be redesigned, they should be moved or abandoned; construction of projects at sites in category 1 is not recommended because the project would likely not meet the regulatory requirements for permit issuance. However, when a project has been determined by the Service to be in category 1, Service biologists and Special Agents of the Service's Office of Law Enforcement may consider a detailed re-assessment of risks to eagles posed by the project if it is warranted by additional biological data made available by the project proponent.

b. Category 2 – High to moderate risk to eagles/opportunity to mitigate impacts

A project is in this category if, as currently sited and planned, it is (1) reasonably likely to take eagles at a rate greater than is consistent with maintaining stable or increasing populations, but (2) the risk might be minimized to the maximum degree achievable through a combination of conservation measures and reasonable compensatory mitigation, per an effective and verifiable ECP. These projects have a risk of ongoing take of eagles, but this risk can be minimized. For projects in this category an ECP should be prepared following this Draft Eagle Conservation Plan Guidance to assist the applicant in meeting the regulatory requirements for a programmatic permit. For Golden Eagles nationwide, and for bald eagles in the southwest management unit, the conservation measures in the ECP must result in no-net-loss to the breeding population to be compatible with the permit regulations. Examples of likely category 2 situations include:

1. the project as proposed has potential to cause take of eagles in the form of disturbance (e.g., it is within the project area inter-nest distance of a nest), either from the individual project or due to cumulative impacts of the project and other anthropogenic changes in the vicinity; or
2. the project is located where important eagle use areas are present within 10 miles of, but not within, the project footprint; or
3. is based on site-specific survey data collected as part of the Stage 2 site assessment process (described later in this Draft Eagle Conservation Plan Guidance), the estimated eagle fatality rate for the wind facility, after application of all indicated avoidance and minimization measures, can likely be mitigated; or
4. the project is located where important use areas of bald or golden eagles are at least 10 miles from the project footprint but the area within 10 miles contains potential breeding or foraging habitat and the population of eagles in the eagle management

unit (as defined in USFWS 2009b) is increasing or is expected to increase over the lifetime of the project; or

5. in rare circumstances where eagle nests are within or proximate to the project footprint but the project, with strong compensatory mitigation can meet the requirements in 50 CFR 22.27(a)(iv) for take of inactive eagle nests (these situations are not addressed in this Draft Eagle Conservation Plan Guidance, but will be addressed case-by-case basis between the project proponent and the Service).

c. Category 3 – Minimal risk to eagles

A project in this category poses little risk to eagles. A project proponent may wish to create an ECP that documents the project's low risk to eagles, and outlines mortality monitoring for eagles and a plan of action if eagles are taken during project construction or operation. If take should occur, the proponent must contact the Service to discuss ways to avoid take in the future. In general, projects that are unlikely to have or do not currently have important eagle-use areas within 10 miles of the project footprint will fall into category 3.

d. Category 4 – Uncertain risk to eagles

Sites lacking sufficient data to assign them to categories 1 through 3 should be placed in this category. In general, these are sites for which little or no pre-existing data is available to assign them to a category in the Stage 1 assessment. In these cases, assignment to a category (category 1, 2, or 3) should occur no later than Stage 2. It is recommended that project proponents delay making any commitments to sites in this category. After Stage 2 and Stage 3 analyses for the ECP are complete, the project can be put into one of the above risk categories for consideration.

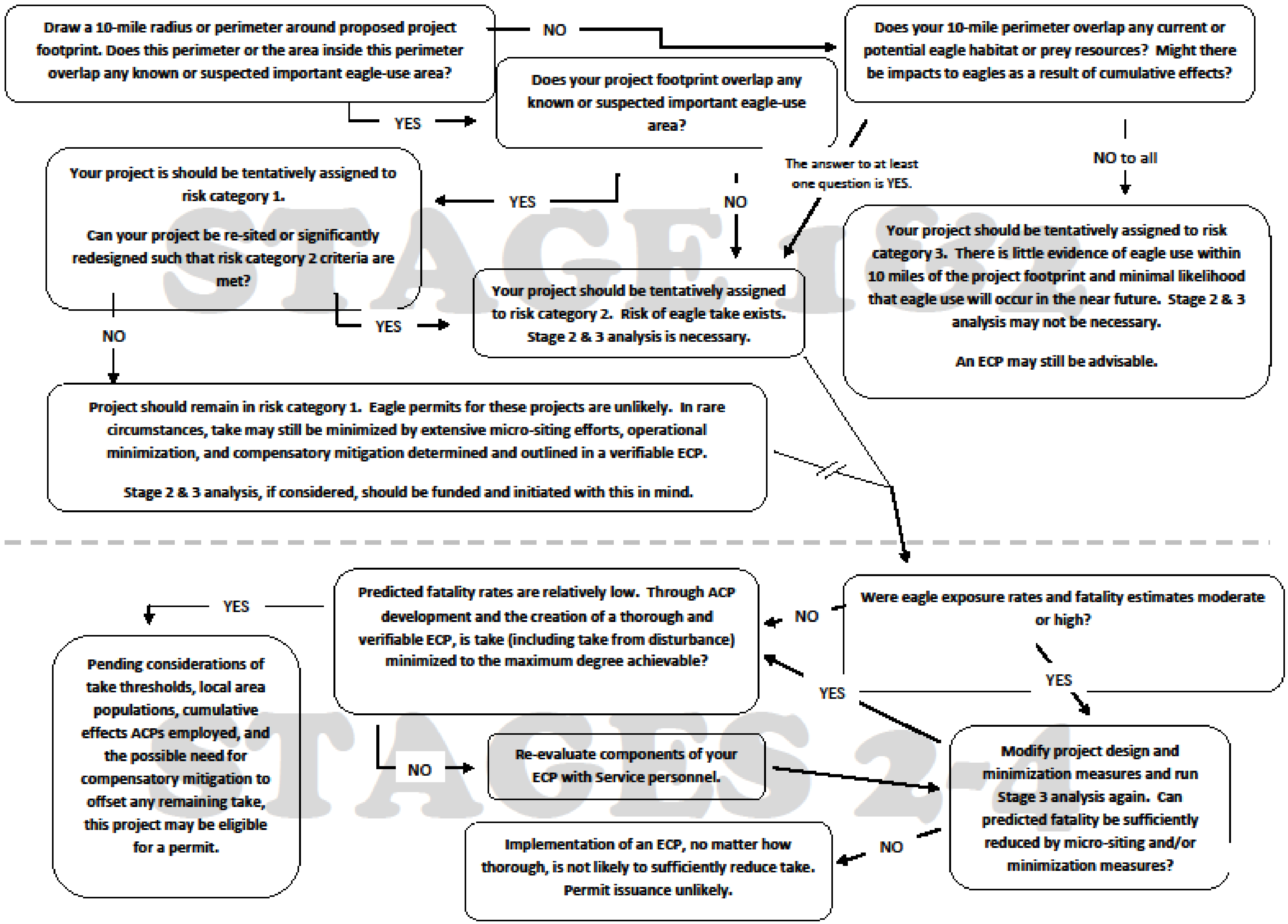

Figure 1. Flow chart for wind-facility site categorization in Stages 1 - 4

5. Cumulative Effects Considerations

a. Early Planning

Regulations at 50 CFR 22.26 require the Service to consider the cumulative effects of programmatic eagle take permits. Cumulative effects are defined as: "the incremental environmental impact or effect of the proposed action, together with impacts of past, present, and reasonably foreseeable future actions" (50 CFR 22.3). Thorough cumulative effects analysis will depend on effective analysis during the NEPA process associated with an eagle permit. Scoping and other types of preliminary analyses can help identify important cumulative-effects factors; set suitable boundaries for analysis; and identify applicable past, present, and future actions. Comprehensive evaluation during early planning may identify measures that would avoid and minimize the effects to the degree that take of eagles is not likely to occur. In that case, there may be no permit, and thus no need for NEPA associated with an eagle take permit. Where a permit is sought, a comprehensive cumulative effects analysis at the early planning stage will serve to streamline subsequent steps, including the NEPA process. In addition, considering cumulative effects is essential to developing appropriate ACPs.

The Service recommends that cumulative effects analyses be consistent with the principles of cumulative effects outlined in the Council on Environmental Quality (CEQ) handbook, "Considering Cumulative Effects under the National Environmental Policy Act (1997) (CEQ handbook). The Service recommends consideration of the following examples from the CEQ handbook that may apply to cumulative effects to eagles and the ecosystems they depend upon:

1. Time crowding - frequent and repetitive effects on an environmental system.
2. Time lags - delayed effects.
3. Space crowding - High spatial density of effects on an environmental system.
4. Cross- boundary - Effects occur away from the source.
5. Fragmentation - change in landscape pattern.
6. Compounding effects - Effects arising from multiple sources or pathways.
7. Indirect effects - secondary effects.
8. Triggers and thresholds - fundamental changes in system behavior or structure.

b. Analysis Associated with Permits

The cumulative effects analysis for a wind facility and a permit authorization should include whether the anticipated take of eagles is compatible with eagle preservation as required at 50 CFR 22.26, including indirect impacts associated with the take that may affect eagle populations. It should also include consideration of the cumulative effects of other permitted take and additional factors affecting eagle populations.

Whether or not a permit authorization is compatible with eagle preservation was analyzed in the FEA that established the thresholds for take (USFWS 2009b). The scale of that analysis was based upon eagle management units as defined in USFWS (2009b). However, the scale for cumulative effects analysis of wind facility projects and associated permits may include greater- and/or lesser- scales than in the FEA, and will be determined by the Service and project proponent on a case-by-case basis.

The cumulative effects analyses for programmatic permits should cover the time period over which the take will occur, not just the period the permit will cover, including the effect of the proposed action, other actions affecting eagles, predicted climate change impacts, and predicted changes in number and distribution of affected eagle populations. Effects analyses should note whether the project is located in areas where eagle populations are increasing or predicted to increase based on available data, over the lifetime of the project, even if take is not anticipated in the immediate future. In addition, conditions where populations are saturated should be considered in cumulative effects analyses. Numerous relatively minor disruptions to eagle behavior from multiple activities, even if spatially or temporally distributed, may lead to disturbance that would not have resulted from fewer or more carefully sited activities (e.g., Whitfield *et al.* 2007).

Additional detailed guidance for cumulative impacts analyses can be found on the Council on Environmental Quality website at http://ceq.hss.doe.gov/nepa/ccenepa/ccenepa.htm. The Service is developing additional specific guidance and recommendations on the scope and scale of cumulative effects analyses associated with programmatic eagle take permits.

C. ADAPTIVE MANAGEMENT

The role of adaptive management with respect to this Draft Eagle Conservation Plan Guidance is to improve our predictive capability relative to likely effects of wind facilities on eagles, and to improve our predictive capabilities relative to effective mitigation measures. There are many sources of uncertainty that can be reduced with better data. Generally, eagle monitoring at the level of the wind-facility site is needed to reduce uncertainty in four categories: (1) exposure risk, (2) rate of mortality, (3) direct and indirect effects on territory occupancy and productivity, and (4) measuring the success of compensatory mitigation. Much of the pre-siting and post-construction monitoring sections of this Draft Eagle Conservation Plan Guidance are devoted to describing advised, standardized monitoring methods that will provide data in a standardized format that will, for example, help us integrate eagle-use data with information on topography, weather, habitat, and prey density to predict, with increasing accuracy, rates of eagle mortality. The ultimate measure of success is a reduction in the number of dead eagles at a site, thus good mortality monitoring is essential to evaluating site risk and the efficacy of the avoidance and minimization measures undertaken by companies to reduce those risks.

Methods for estimating the number of annual eagle fatalities at a site are described in detail, and by comparing fatality rates before and after ACPs are undertaken by companies, we will be able to evaluate the effectiveness of those practices. These evaluations may show that additional ACPs are warranted to address documented problems, but they may also show that ACPs in place are not effective and need not be continued. We will also employ adaptive management to evaluate the effectiveness of compensatory mitigation actions to verify that predicted levels of mortality reduction are achieved. Adaptive management is, therefore, critical to determine the efficacy of applied ACPs and compensatory mitigation measures. This aids the Service in complying with both regulatory permit condition 50 CFR 22.26(c)(7), which determines when the Service may amend, suspend, or revoke a programmatic permit if new information indicates that revised permit conditions are necessary, and permit condition 50 CFR 22.26(c)(2), which requires monitoring after completion of an activity for purposes of adaptive management.

In an adaptive management framework, monitoring that evaluates factors that affect mortality risk, and evaluates the efficacy of measures taken to avoid, minimize, or compensate for mortality, should feed back into planning and operation of wind facilities at the site level with the ultimate goal of a gradual reduction in eagle mortality. Additionally, the data will roll up into population-wide models that incorporate survival, productivity, and population status information from many sources to assess the effects of our permits at the scale of continental eagle populations. By collecting these data in a systematic, unified, stepwise manner, ultimately a clearer picture will ultimately emerge about the nation's eagle populations and the effects that increasing energy developments and other factors have on them. By using adaptive management principles to guide eagle management, the Service in cooperation with our partners and industry can focus its attention on those actions that will most effectively meet our goal of stable or increasing breeding populations of both species of eagle, as established in USFWS (2009b). More information on adaptive management can be found in APPENDIX A.

D. DEVELOPMENT OF AN EAGLE CONSERVATION PLAN

The following sections of this Draft Eagle Conservation Plan Guidance, including attached appendices, provide a descriptive instructional template for developing an ECP. The ECP is an integral part of the permit process, and the following chronological step-by-step outline shows how the pieces fit together:

1. This Draft Eagle Conservation Plan Guidance offer recommends guidance for project proponents, the Service, and other jurisdictional agency biologists to reference when developing and evaluating ECPs.
2. Using these Draft Eagle Conservation Plan Guidance as a non-binding reference, the Service will work with programmatic take-permit applicants to develop an ECP, which documents how the applicant will comply with the regulatory requirements for programmatic permits and the associated NEPA process by avoiding and minimizing the risk of taking eagles up-front, and formally evaluating possible alternatives in (ideally) siting, configuration, and operation of wind projects. The Service's ability to influence siting and configuration factors depends on the stage of development of the project at the time the applicant comes to us.
3. ECPs should be developed following the five staged approach: (1) initial site assessment; (2) site specific surveys and assessment; (3) initial fatality prediction; (4) application of ACPs that avoid and minimize risk, and a re-assessment of fatality predictions; and (5) post-construction monitoring. During Stages 1 and 2, projects or alternatives should be categorized as either: (1) category 1 – high risk; (2) category 2 – moderate risk; and (3) category 3 – low risk. For projects that fall into category 1 or 2, the Service will either (a) accept an ECP that offers siting, configuration, and an operational alternative that avoids and minimizes take to the point any remaining take is unavoidable and, if required, mitigates that remaining take to meet the statutory preservation standard; or (b) determine that the project cannot be permitted because risk to eagles is too high such that the applicant would be unlikely to meet the regulatory permit requirements. If the Service determines the project can be permitted, the duration of the permit will be no longer than five years, with the expectation that the permit will be renewed if, at that time, all conditions have been satisfactorily met.

4. For permitted projects, the Service and the applicant will use the standardized models developed as part of the adaptive management process to predict unavoidable eagle mortality after implementing the acceptable alternative. These models will rely heavily on pre-construction monitoring by the applicant, ideally following the standardized protocol described in this Draft Eagle Conservation Plan Guidance. If the applicant cannot or chooses not to conduct pre-construction monitoring, the Service will generate a risk-averse estimate of annual mortality using a set of conservative, predictive models.
5. For predicted recurring eagle take that is in excess of calculated take thresholds (i.e., take in excess of the regional thresholds designed to meet the statutory preservation standard as described in USFWS 2009b), the Service will either (a) collect a compensatory mitigation payment from the applicant that will be deposited into a Service-established eagle conservation fund for pooled compensatory mitigation; or (b) approve a compensatory mitigation proposal from the applicant. Under either (a) or (b), the compensatory mitigation cost and actions will be calibrated so as to offset the predicted unavoidable take, such that we bring the individual permit's (and cumulatively over all such permits') predicted mortality effect to a net of zero. Compensatory mitigation may also be required in other situations where predicted effects to eagle populations are substantial.
6. Systematic, standardized, post-construction monitoring, ideally following protocols established in the Draft Eagle Conservation Plan Guidance, are recommended to derive an estimate of the number of eagle fatalities each year at each permitted wind facility and to document disturbance effects at nearby nests. This monitoring information will be used in a formal adaptive management framework to evaluate and improve the predictive accuracy of our models. In addition, the information will be used by the Service and the applicant to identify any project specific additional ACPs that can be implemented to potentially reduce eagle mortalities based on the observed, specific situation at each site. Continued monitoring will determine the effectiveness of any additional ACPs implemented in each situation.

Holders of programmatic eagle take permits will be required to allow Service personnel, or other qualified persons designated by the Service, access to the areas where take is possible, within reasonable hours and with reasonable notice from the Service, for purposes of monitoring eagles at the site(s). The regulations provide, and a condition of any permit issued will require, that the Service may conduct such monitoring while the permit is valid, and for up to three years after it expires (50 CFR 22.26(c)(4)). Typically, these follow-up site visits would be performed by Service employees.

In general, verifying compliance with permit conditions is a secondary purpose of site visits; the primary purpose is to monitor the effects and effectiveness of the permitted action and mitigation measures. This may be done if a project proponent is unable to observe or report to the Service the information required by the annual report—or it may serve as a "quality control" measure the Service can use to verify the accuracy of reported information and/or adjust monitoring and reporting requirements to provide better information for purposes of adaptive management.

1. Contents of the Eagle Conservation Plan

a. Stage 1 - Site assessment

The objective of the Stage 1 site assessment is to cast a broad look at the landscape of interest and identify, based on existing information and studies, known or likely important eagle-use areas. Based on that information, project proponents should work with the Service to place potential wind –facility sites in one of the three site categories described in Section B 4 of these Draft Eagle Conservation Plan Guidance. For detailed recommendations on the Stage 1 process, go to APPENDIX B.

b. Stage 2 - Site-specific surveys and assessments

In Stage 2, project proponents collect detailed, site-specific information on eagle use of the specific sites that passed review in Stage 1. The information collected in Stage 2 is used to generate predictions of the annual number of fatalities for a prospective wind facility site and to identify important eagle-use areas likely to be affected by the project. For detailed recommendations on the Stage 2 methods and metrics, go to APPENDIX C.

c. Stage 3 - Predicting eagle fatalities

In this section of the ECP, project proponents should work in coordination with the Service to determine risk factors associated with each turbine in the facility. Then, an annual predicted mortality rate for the project can be calculated by using the estimated annual eagle exposure rate generated from the Stage 2 assessment and Excel-based models. The initial estimate of mortality rate should not take into account possible ACPs; these will be factored in as part of Stage 4. Additionally, any loss of production that may stem from disturbance is not considered in these calculations, but is instead derived from post-construction monitoring as described in Stage 5. Specific elements of the adaptive management process will be further developed as they emerge in actual cases, through coordination with project proponents. Therefore, this stage and Stage 5 of the ECP will require close coordination between the project proponent and the Service. For detailed recommendations on Stage 3 methods and metrics, go to APPENDIX D.

d. Stage 4 - Avoidance and Minimization of Risk using ACPs, and Compensatory Mitigation

Siting of a wind facility is the most important factor when considering potential effects to eagles. Based on information gathered in Stage 2 and analyzed in Stage 3, the project proponent should revisit the site categorization from the Stage 1 assessment to determine if the site(s) still falls into an acceptable category of risk (at this stage, acceptable categories are 2 and 3, and very rarely 1). When information suggests that a proposed wind facility has a high eagle exposure rate and presents multiple risk factors, it should be considered a category 1 site; we recommend relocating the project to another area because a location at that site would be unlikely to meet the regulatory requirements for a programmatic permit. If the site falls into categories 2 or 3, or for some rare category 1 sites where there is potential to adequately abate risk, the ECP should next address ACPs that might be employed to minimize or, ideally, avoid eagle mortality and disturbance.

In this section of the ECP, we recommend project proponents re-run models predicting eagle fatality rates *after* implementing the scientifically supportable ACPs for all the plausible alternatives. This re-analysis serves two purposes: (1) it demonstrates the degree to which minimization and avoidance measures might reduce effects to eagle populations compared to the baseline project configuration, and (2) it provides a prediction of unavoidable eagle mortality. For detailed recommendations on considerations for the development of ACPs go to APPENDIX E.

Compensatory Mitigation

Compensatory mitigation occurs in the eagle permitting process if ACPs do not remove the potential for take, and projected take exceeds calculated take thresholds for the species or management population affected. Compensatory mitigation may also be required in other situations as described in the preamble to 50 CFR 22.26 (USFWS 2009a) and the following guidance applies to those situations as well. To be consistent with this compensatory mitigation guidance, project proponents must ensure their projects are "compatible with the preservation of the eagle" and "…consistent with the goal of increasing or stable breeding populations" (USFWS 2009a).

For new projects, compensatory mitigation will be required upfront before project operations commence because projects must meet the statutory and regulatory eagle preservation standard before FWS may issue a permit. For operating projects that may meet permitting requirements, compensatory mitigation should be applied from the start of the permit period, not retroactively from the initiation of project operations. Compensatory mitigation will also be applied in the future, at each permit reissuance or renewal point, so long as it is still necessary to meet the preservation standard at that time. As stated previously in the adaptive management section of this Draft Eagle Conservation Plan Guidance "monitoring that evaluates factors that affect mortality risk; and that evaluate the efficacy of measures taken to avoid, minimize, or compensate for mortality; all should feed back into planning and operation of energy facilities at the site level with the ultimate goal of a gradual reduction in eagle mortality at wind facilities." With this in mind, as new data are made available, the Service will modify the compensatory mitigation process to adapt to any improvements in our knowledge base.

To determine the level of compensatory mitigation required for a proposed or current project, the Service will estimate the quantitative potential for take of all age classes of eagles using informed modeling, as described in Stage 3 of the ECP (APPENDIX D). This fatality prediction will be one of several fundamental variables that will be used to populate a Resource Equivalency Analysis (REA). Economists extended the economic theory from valuation studies and information from scientific models to develop the REA model (based on Unsworth and Bishop 1994; Jones and Pease 1997).

An REA responds to the question, "What, but for the 'take,' would have happened to the eagles?" With REA, the services of the eagles killed are quantified in physical units of *bird-*

years.[1] The selected compensation is "scaled" so that the quantity of replacement bird years equals the quantity of lost bird-years in present value terms to fully compensate the public, accomplishing the stated objective of no-net-loss of birds. For the purposes of this document we refer to an REA as a stepwise replacement model (Sperduto *et al*. 1999, 2003) for eagles that will be taken. The Service will use REA to calculate mitigation offset for a wind facilities' estimated unavoidable take. Application of this model follows other comparable analyses used for white-tailed sea eagles (Cole 2009) and other species (Sperduto *et al*. 1999, 2003, Industrial Economics Inc. 2004).

The use of REA, while relatively new for Service raptor management, is consistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Oil Pollution Act (OPA), and Natural Resource Damage Assessment and Restoration (NRDAR) federal regulations, and has been explicitly identified in revised CERCLA regulations (2008). REA calculations using the stepwise replacement model involve wildlife population modeling, including elements of the Leslie matrix and life tables, and include discounting to provide compensatory mitigation costs per unit of take (See APPENDIX F; Cole 2009). The required life history parameters (e.g., survival, fecundity, and longevity) are based on the best available published data to document how individual eagles per age class may be removed from the population during the life of a project and offset through mitigation.

The REA will generate a project level eagle take calculation (debit), expressed in bird-years, as well as an estimate of the quantity of compensatory mitigation (credit) (e.g., power pole retrofits) necessary to offset this take. Compensatory mitigation will then be initiated, subsequently funded per an established rate, and implemented by one of the following mechanisms:

1. Project proponent will directly contract and fund Service-approved compensatory mitigation project; or
2. Project proponent will pay into a Service-established BGEPA account; or
3. Project proponent will pay into a third-party mitigation account identified by the project proponent and approved by the Service.

Effectiveness monitoring of the resulting mitigation projects should be included within the above options using the best scientific and practicable method available. All mitigation projects will be subjected to random inspections by the Service or appointed subcontractors to examine efficacy, accuracy, and reporting rigor.

The Service considered the following compensatory mitigation options to reduce or eliminate factors known or suspected to be negatively affecting eagles of one or both species: (1) improving range management prescriptions to eliminate loss of extant eagle territories; (2) environmental lead abatement; (3) addressing mortality due to collision or drowning; and (4) addressing potential electrocution due to non-APLIC standard powerlines. However, to be

[1]A *bird- year* refers to all services provided by one bird for one year. This measure of services is specific to the type of bird since different birds provide different services. So, e.g., the replacement services for 20 bird-years could be 20 birds for only one year, one bird over 20 years, or anything in between.

effective, any potential compensatory mitigation must have quantifiable adverse impacts and verifiable benefits that can be assessed on a per eagle basis, and have measurable metrics for monitoring.

The Service will focus initial compensatory mitigation efforts towards proactive power pole retrofitting, which is in addition to the reasonable corrective actions required of companies (after implementing ACPs) to avoid the unlawful take of eagles and other migratory birds. We focus mitigation efforts toward eliminating electrocutions because:

1. Utility power poles cause quantifiable adverse impacts to eagles,
2. the 'per eagle' and population effects of utility power pole retrofitting to create safe conditions for eagles are quantifiable and verifiable through accepted practices,
3. success of and subsequent maintenance to retrofitting can be monitored, and
4. electrocution causes a significant amount of eagle mortality and, in most cases, is correctable.

These efforts will be structured to reduce the electrocution hazard from high-risk transmission infrastructure to adult, subadult, and juvenile eagles throughout their range in North America (APLIC 2006, Lehman et al. 2007, Lehman et al. 2010, Millsap et al. 2004). If the benefits can be clearly demonstrated, other forms of compensatory mitigation may also be an option. The Service, in coordination with State and Tribal wildlife agencies, will evaluate and approve the final compensatory mitigation plans for non-power pole efforts. For details on the approach used to calculate appropriate compensatory mitigation values go to APPENDIX F.

e. Stage 5. Post-construction monitoring

In this section of the ECP, the project proponent should describe the proposed post-construction survey methodology for the project. The objective of post-construction monitoring is to estimate (1) the annual number and circumstances of eagle fatalities at operating wind facilities, and (2) disturbance effects in the form of reduced productivity at eagle territories proximate to operating wind facilities. 50 CFR 22.26 requires monitoring as a condition of eagle take permits for ongoing activities like wind facilities for as long as the data are needed to assess effects on eagles. Given the adaptive management framework the Service has adopted and the regulatory conditions at 50 CFR 22.26(c)(2)&(4), this will require wind-facility operators to monitor during construction and for at least three years post construction, to include a minimum of three years of operation, then assess monitoring data to consider whether additional ACPs are appropriate and warranted. If additional or different ACPs are warranted, an additional three years of monitoring data will be required to assess the effectiveness of the new or revised ACPs for at least three years post construction. Detailed recommendations for post-construction monitoring are in APPENDIX H. The Stage 5 post-construction monitoring plan is the final section of the ECP.

Post construction monitoring is essential to identify possible factors associated with eagle fatalities at wind facilities that might warrant additional ACPs or improvement or elimination of ACPs found to be ineffective. Implementation of these additional ACPs and further monitoring following identical (though perhaps more targeted) protocols will help the Service and project proponents rigorously evaluate the effectiveness of conservation measures under different conditions

E. INTERACTION WITH THE SERVICE

As noted throughout this Draft Eagle Conservation Plan Guidance, frequent and through coordination between project proponent and Service and other jurisdictional-agency biologists is crucial to the development of an effective and successful ECP. This is particularly true for the first several wind-facility projects that attempt to obtain programmatic eagle take permits, where many of the operational details of the ECP will be tested through application in the field. Close coordination will also be necessary in the refinement of the modeling process used to predict fatalities, as well as in post-construction monitoring to evaluate those models. We anticipate this Draft Eagle Conservation Plan Guidance and the recommended methods and metrics will evolve rapidly as the Service and project proponents learn together. The Service will continue to refine this Draft Eagle Conservation Plan Guidance with input from all stakeholders with the objective of maintaining stable or increasing breeding populations of both bald and golden eagles while simultaneously developing science-based eagle-take regulations and procedures that are neither excessive nor unduly burdensome.

F. GLOSSARY

Adaptive management – iterative process of decision making considering uncertainty, with the goal of reducing that uncertainty over time.

Advanced conservation practices — scientifically-supportable measures approved by the Service, representing the best-available techniques to reduce eagle disturbance and ongoing mortalities to a level where remaining take is unavoidable.

Adult – an eagle five or more years of age.

Alternate nests – additional sites within a nesting territory that are available to be used within a nesting season.

Area-nesting population – number of pairs of eagles known to have a nesting attempt during the preceding 12 months within a 10-mile radius of an eagle nest.

Avoidance and minimization measures – conservation actions targeted to remove or reduce specific risk factors (e.g., avoiding important eagle-use areas, placing turbines away from ridgelines).

Breeder (resident breeder) – an eagle that is a member of a breeding pair on a territory.

Calculated take thresholds – annual allowable eagle take limits established in USFWS (2009b).

Collision probability (risk) – the probability that an eagle will collide with a turbine during a minute of exposure.

Compensatory mitigation – an action in the eagle permitting process if ACPs do not completely remove the potential for take, and projected take exceeds calculated take thresholds for the species or the eagle management unit management population affected (or in some cases, under other circumstances as described in USFWS 2009a).

Conservation measures – actions that avoid (this is best achieve at the siting stage), minimize, rectify, and reduce or eliminate an effect over time. Determination of which conservation measure or suite of measures, will provide the most benefits to eagles will rely upon a thorough cumulative effects analysis, as well as close coordination with the Service and state and tribal wildlife agencies, and implementation of an adaptive management approach compatible with the process described in the Department of Interior (DoI) Adaptive Management Handbook (Williams *et al.* 2009).

Decorated nest – a nest with fresh whitewash, feathers, or with fresh greenery, all of which are evidence of occupancy.

Disturb - means to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available, (1) injury to an eagle, (2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or (3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior.

Eagle Conservation Plans (ECP) – a document produced by the project proponent in coordination with the Service that supports issuance of an eagle take permit under 50 CFR 22.26 (or demonstrates that such a permit is unnecessary).

Eagle Management Unit – regional eagle population defined in the FEA (USFWS 2009b). For Golden Eagle's regional management populations follow Bird Conservation Regions (see http://www.nabci-us.org/map.html), whereas for bald eagles they follow U. S. Fish and Wildlife Service regional boundaries.

Eagle exposure rate – a value expressed as eagle exposure minutes (flight minutes) per daylight hour within the footprint of the project, averaged over daylight hours and over the annual cycle.

Eagle territory - an area that contains, or historically contained, one or more nests within the home range of a mated pair of eagles.

Fatality monitoring – searching for eagle carcasses beneath turbines and other facilities to estimate the number of fatalities.

Floater (floating adult) – as adult eagle that has not settled on a breeding territory.

Home range - the area traveled by and eagle in its normal activities of food gathering, mating, and caring for young. Breeding home range is the home range during the breeding season, and the non-breeding home range is the home range outside the breeding season.

Important eagle-use area - an eagle nest, foraging area (to include as interpreted here migration corridors and migration stopover sites), or communal roost site that eagles rely on for breeding, sheltering, or feeding, and the landscape features surrounding such nest, foraging area, or roost site that are essential for the continued viability of the site for breeding, feeding, or sheltering eagles.

Inactive nest (from the regulations**) —** a nest that is not currently being used by eagles as determined by the continuing absence of any adult, egg, or dependent young at the nest for at least 10 consecutive days immediately prior to, and including, at present. An inactive nest may become active again and remains protected under BGEPA.

Initial site assessment (Stage 1) – where project proponents evaluate broad geographic areas to assess the relative importance of various areas to resident breeding and non-breeding eagles, and to migrant and wintering eagles

Inventory –systematic observations of the numbers, locations, and distribution of eagles and eagle resources such as suitable habitat and prey in an area.

Jurisdictional agency – a government agency with jurisdictional authority to regulate an activity.

Juvenile – an eagle less than one year old.

Kiting – stationary or near-stationary hovering by an eagle, usually while searching for prey.

Meteorological towers (met towers) – towers erected to measure meteorological events such as wind speed, direction, air temperature, etc.

Migration corridors - the routes or areas where eagles may concentrate during migration as a result of the interplay between weather variables and topography.

Migration counts – standardized counts that can be used to determine relative numbers of diurnal raptors passing over an established point during fall or spring migration.

Monitoring - inventories over intervals of time (repeated observations), using comparable methods to enable comparisons in time or space.

No-net-loss – no net change in the overall eagle population mortality rate after issuance of a permit that authorizes take, because required compensatory mitigation reduces another form of mortality, or increases natality, by a comparable amount.

Occupied nest – a nest used for breeding in the current year by a pair. Presence of an adult, eggs, or young, freshly molted feathers or plucked down, or current years' mutes (whitewash) suggest site occupancy. In years when food resources are scarce, it is not uncommon for a pair of eagles to occupy a nest yet never lay eggs; such nests are considered occupied.

Occupied territory – an area that encompasses a nest or nests or potential nest sites and is defended by a mated pair of eagles.

Operational adjustments – modifications made to an existing wind facility that changes how that facility operates (e.g., increasing turbine cut in speeds, implementing curtailment of turbines during periods of migration).

Overall collision probability – the cumulative probability across all turbines in a wind facility (i.e., the chance that an eagle will collide with one of the turbines in the facility) of a collision.

Patagial tags – wing markers that are used to individually identify an eagle.

Power analysis – a statistical procedure used to determine the sample size necessary to determine the minimum sample size required to accept the outcome of a statistical test with a particular level of confidence.

Project-area inter-nest distance – the mean distance between simultaneously occupied eagle nests of a species (including occupied nests in years where no eggs are laid). We recommend calculating this metric from the nesting territory survey in Stage 2, using all nesting territories within 10 miles of the project footprint over multiple years.

Project-area nesting population – number of pairs of eagles nesting within the project footprint or within a 10-mile perimeter of the project footprint. In cases where nesting density is very high the perimeter distance can be scaled to equal the project-area inter-nest distance.

Project footprint - the minimum-convex polygon that encompasses the wind-facility area inclusive of a 100 meter-radius of all turbines and any associated utility infrastructure, roads, etc.

Project proponent – any developer that proposes to construct a project.

Productivity ─ the number of juveniles fledged from an occupied nest, often reported as a mean over a sample of nests.

Pylons – tower base of a wind turbine.

Renewable energy – energy produced by solar, wind, geothermal or any other methods that do not require fossil fuels.

Risk-averse – a conservative estimate in the face of considerable uncertainty.

Risk validation – as part of Stage 5 assessment, where post-construction surveys are conducted to generate empirical data for comparison with the pre-construction risk assessment predictions to validate if the initial assumptions were correct.

Roosting – activity where eagles seek cover, usually during night or periods of severe weather (e.g., cold, wind, snow). Roosts are usually found in protected areas, typically tree rows or trees along a river corridor.

Seasonal concentration areas – areas used by concentrations of eagles seasonally, usually proximate to a rich prey source.

Site categorization – a standardized approach to categorize the likelihood that a site or operational alternative will meet standards in 50 CFR 22.26 for issuance of a programmatic eagle take permit.

Standard kernel analysis - a non-parametric way to smooth estimates of the density of a random variable, where inferences about the population are made based on a limited data. . Used in describing the probabilistic spatial distribution of an animal within its home range.

Stopover sites – areas temporarily used by eagles to rest, seek forage, or cover on their migration routes.

Subadult – an eagle between 1 and 4 years old, typically not of reproductive age.

Survey –is used when referring to inventory and monitoring combined.

Unoccupied nest - those nests not selected by raptors for use in the current nesting season.

U.S. Fish and Wildlife Service Draft Land-based Wind Energy Guidelines – A document produced, with substantial input and cooperation from wind industry, by the U.S. Fish and Wildlife Service that describes how to site, construct, and operate wind facilities with minimal impacts to wildlife exclusive of eagles.

Wind facilities – developments for the generation of electricity from wind turbines

Wind turbine – a machine capable of converting wind energy into electricity by means of a wind-driven generator; usually mounted on a tower structure.

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APPENDIX A

ADAPTIVE MANAGEMENT

Learn by doing. This simple statement is the essence of adaptive management. What is implied is that we take action to achieve a goal, pay attention to the outcome, and apply that learning to our next action. Adaptive management is an iterative process, often conceived of as a continuous loop consisting of four to six sequential steps. They are: Planning - defining and describing goals and objectives and available data; Design - more formally describing management with models; Action - applying management actions; Monitoring - collecting data resulting from the action; Evaluation - analyzing the results and improving the models; and back to planning again to adjust the project design to meet the management goal, but incorporating new information from analyses of monitoring data collected during or after the previous management action (Figure 1). A definition used to describe adaptive waterfowl harvest

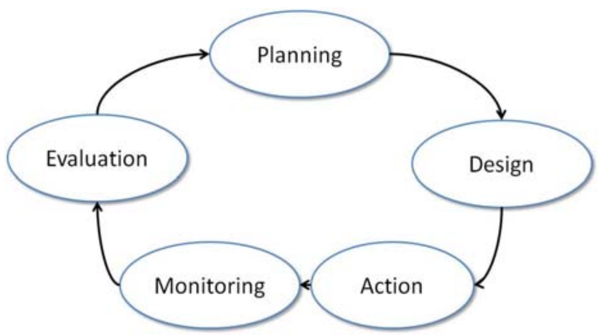

Figure A-1: Essential steps in an adaptive management framework, showing the iterative nature of the process designed to reduce uncertainty around decision making.

management is useful to describe our current task to manage eagle populations, and that is, "…managing in the face of uncertainty, with a focus on its reduction" (Williams and Johnson 1995).

In the case of managing eagle populations in the face of energy development there is considerable uncertainty to be reduced. For example, we believe that in some areas or specific situations, large soaring birds, specifically raptors, might be especially vulnerable to colliding with wind turbines (Barrios and Rodriguez 2004, Kuvlesky *et al*. 2007), but we are uncertain about the relative importance of factors that influence that risk. We are also uncertain about the best way to mitigate the effects of wind turbine developments on raptors; we suspect some strategies might be effective, others are worth trying. We also suspect that a few species, including golden eagles (USFWS 2009b), may be declining in numbers already (Farmer *et al.* 2008), and while we can point to likely causes of those declines we are uncertain about their relative importance or magnitudes. Thus, there are uncertainties at several levels that challenge our attempts to manage eagle populations: (1) at the level of understanding factors that affect collision risk, (2) at the level that influences population trends, and (3) about the efficacy of various mitigation options. The Service, our conservation partners, and industry will never have the luxury of perfect information before needing to act to manage eagles. We are therefore left to make management decisions clouded with uncertainty about the outcomes of those decisions. Our goal is to reduce that uncertainty through use of formal adaptive management, thereby improving our predictive capability over time. Applying a systematic, cohesive, nationally-consistent strategy of management and monitoring is necessary to accomplish this goal.

1. Adaptive Management as a Tool

Using adaptive management as a tool to manage wildlife populations is not new to the Service. We and other agencies are increasingly using the principles of adaptive management across a range of programs, including waterfowl harvest management, endangered species, and habitat management at local and landscape scales; and, in the future, landscape management against the threat of climate change (e.g., USFWS 2005). Applying adaptive management to complex resource management issues is promoted throughout the DoI (Williams *et al.* 2009).

Waterfowl harvest management is the classic example of adaptive resource management. Harvest rates are reset each year in the United States and Canada through the application of adaptive management principles (Johnson 2001). The central question in waterfowl management is to what extent is harvest mortality compensated for by reductions in non-harvest mortality or by increases in productivity (Williams et al 1996)? Various population models have been built based on competing hypothetical answers to this question (hypotheses). Every year the Service and its Canadian counterpart monitor waterfowl and environmental conditions to estimate mortality and productivity. Thousands of waterfowl are banded and some are recovered resulting in estimates of hunting mortality rates.

Wings collected from a sample of hunters each year are identified to age and sex, yielding estimates of relative rates of harvest of different age and sex classes within a species. Surveys by air and ground count breeding populations and assess habitat conditions, which yield estimates of productivity. These data feed into the various competing models, and the models are evaluated annually based on how well they predict inter-year changes in waterfowl populations. Models that perform best year-after-year accrue increasing weight (i.e., evidence in support of the underlying hypothesis). Weighted model outputs directly lead to recommended sets of hunting regulations (e.g., bag limits and season lengths) for the subsequent year. Over time, by monitoring the population effects of various harvest rates on survivorship, and environmental conditions on productivity, our uncertainty about the degree to which harvest is compensated by other factors has been reduced, allowing for the setting of harvest rates with greater confidence every year. The application of adaptive management principles to waterfowl harvest regulation has helped the Service and its partners achieve or exceed population goals for most species of waterfowl (USFWS 2005).

2. Applying Adaptive Management to Eagle Management

At the scale of continental populations, the central question for eagles is not altogether different than it is for waterfowl: to what extent is mortality from energy development, or any other anthropogenic source, compensated by reductions in mortality from other sources, or by increases in productivity? These questions are best answered by building population models founded on competing hypotheses that incorporate estimates of mortality, productivity, and the variation around those vital rates. What is required is a systematic effort to collect information on mortality, breeding, and population status to feed those models. As for waterfowl, reducing uncertainty in population-level models for eagle management will require rolling up the results of local monitoring and research across the distribution of eagles. The results will allow the Service to make more informed management recommendations to reach the Service's population goal of stable or increasing breeding populations for both eagle species.

APPENDIX B

STAGE 1 - LANDSCAPE-SCALE SITE ASSESSMENT RECOMMENDATIONS

Eagle use of the landscape varies across large geographic scales. Thus, the first step for project development is to identify sites within a broad geographic area that are both suitable for wind energy and have low potential for effects to eagles through a rigorous, landscape-scale site-assessment process. The initial coarse site assessment should begin before any significant resources have been committed to a particular site. The site assessment should evaluate the suitability of a potential wind energy site within the ecological context of eagles, including considerations for the entire eagle life-cycle (i.e., breeding, migration, dispersal, and wintering.) At this point, the objective is to assess the potential effects to eagles and their habitats from modification at the landscape scale. The primary objective at this stage should be to determine if prospective wind development sites fall within areas used by eagles, and the relative extent and type of eagle use they receive. Areas that receive considerable use by eagles are likely to fall into category 1, and should be avoided if at all possible because the Service likely could not issue a permit that complies with all regulatory requirements for a project in those areas.

To evaluate a site for potential wind-energy development and its ecological relationship to eagle biology, multiple data sources should be consulted. Information gathered should focus on geographic and biological factors that could affect eagle risk from wind energy development. Preliminary site evaluation could begin with a review of publically available data. Good data sources include resource databases such as NatureServe [http://www.natureserve.org/], information from relevant federal, tribal and state agencies, peer-reviewed literature, technical reports, state ornithological societies, and conservation organizations with eagle expertise.

Where data gaps occur, or when beginning to look at sites in more detail, site-level reconnaissance may be necessary. The site assessment should be coordinated with Service staff early in the process to ensure all appropriate information has been included in the evaluation. The specific questions project proponents should be answering at this stage include (but are not necessarily limited to):

1. What information is available in the literature or wildlife occurrence databases on recent or historic nesting and occurrence data for eagles from the project area?
2. What information is available in the literature or raptor migration databases on eagle migration or movement through the project area?
3. What eagle concentration area information (winter [e.g., the midwinter eagle survey at http://ocid.nacse.org/nbii/eagles/] or other) is available for the project area?
4. What vegetation data are available to develop maps of potential eagle habitat?
5. What topographic features are present in the project area that might attract or concentrate eagles?

Using these and other data sources, a series of questions should be answered to help place the project or project alternative into the appropriate risk category. Relevant questions include:

1. Have you contacted the relevant agencies to discuss project development?

2. Does existing or historic data/information indicate that eagles or eagle habitat (including breeding, migration, dispersal, and wintering habitats) may be present within the geographic region under development consideration?
3. Does existing or historic data/information indicate that eagle prey habitat may be present within the geographic region under development consideration?
4. Are there areas of intact eagle habitat in the area of development that would be lost, degraded, or fragmented due to the project?
5. Are their indications the area of interest may be of special importance to eagles, and if so, can those areas of importance be delineated?

The goal of the site assessment is to ultimately select one or more sites that will be the focus of the more detailed site-specific surveys and assessments. We recommend development of a map that, based on the answers to the above questions should allow development of a map that shows broad areas that fall under site category levels 1 through 4, in areas where wind development would pose: (1) a high risk to eagle populations, (2) a moderate risk to eagle populations, (3) a low risk to eagle populations, and (4) areas where the potential effects to eagles are uncertain due to lack of information about the site. In general, sites or alternatives that fall into category 1 should be dropped from consideration, whereas sites that fall into categories 2, 3, and 4 would potentially move on to Stage 2. However, site classification at this stage should be regarded as tentative pending the outcome of the site-specific assessment. Sites in any of the categories could change as more detailed information regarding the sites and eagle populations within or adjacent to them is obtained. For example, a site classified as a category 2 site during the broad geographic assessment could ultimately be dropped from consideration once more site-specific data are collected in the next stage. Conversely, a site deemed high risk due to historical data could become selected if current site-specific data indicate that, based on local factors, it is actually low risk.

APPENDIX C

STAGE 2 – SITE-SPECIFIC ASSESSMENT RECOMMENDED METHODS AND METRICS

Data collected in this stage will be used to generate model-based predictions of annual eagle fatalities for specific potential project sites. The predictions will be generated with models ideally using survey data collected from the project locale following the standardized approach outlined below. Project proponents are free to propose other forms of pre-construction surveys and monitoring, but they should yield data that will satisfy the adaptive management requirements and the regulatory monitoring requirements. Recommended site-specific sampling consists of three components: (1) fixed-radius point counts within the project footprint, (2) characterization of the local-area nesting population, and (3) determination of presence of seasonal eagle concentration areas. Components (1) and (3) provide information useful in predicting potential annual eagle fatality rates from wind facilities, whereas component (2) identifies nesting territories that may be negatively affected by disturbance.

1. Point Counts

The metric that feeds into models used to predict the number of expected eagle fatalities per year is the *eagle exposure rate*, expressed as eagle exposure minutes (flight minutes) per daylight hour within the footprint of the project, averaged over daylight hours and over the annual cycle. The recommended approach for estimating eagle exposure rate for a project is based on 30-minute point count surveys of eagles at 800-m radius plots within and adjacent to the project footprint. Point count surveys of birds on fixed-radius plots were described by Hutto *et al.* (1986). Use of large-plot, long-duration point counts, most typically 20- or 30-minute counts at 800-m radius plots, appears to be standard in pre- and post-construction assessment of use of wind energy projects by large (crow size or greater) species of birds (Hoover and Morrison 1996, Johnson *et al.* 2000, Smallwood *et al.* 2009).

Relative abundance data from point counts (i.e., the mean number of individuals or breeding pairs observed per count) often are used to coarsely predict fatality rates by referencing a regression between like data and associated post-construction fatality results from multiple studies, although this approach is called into question by data from some studies (Orloff and Flannery 1992, DeLucas *et al.* 2008). A common approach to using point count data for assessing risk is to generate a relative index of exposure based on the product of mean abundance from the counts, the proportion of individual birds that were flying when observed, and the proportion of individuals flying at heights within a specified risk zone, usually the rotor-swept zone (Johnson *et al.* 2000). Like comparison with a regression based on many pre- and post-construction data, this coarse index provides a notion of risk relative to other facilities and allows rough comparisons among species within a facility. However, it does not take into account significant factors including species-specific avoidance behavior and site-specific design features other than blade length and hub height of turbines. Point count data can support more detailed risk assessment models (reviewed by Madders and Whitfield 2006), such as recommended in the Draft Eagle Conservation Plan Guidance.

To support our recommended modeling approach, a random or random-systematic approach should be used to distribute points across the project footprint such that all parts of the footprint are represented in proportion to their areal cover. A range of 20-30 point count plots probably represents the maximum number of plots that can be surveyed twice monthly at wind energy projects of moderate (50-100 MW) to large (> 100 MW) capacity. We recommend a sampling frequency targeting a coefficient of variation (ratio of the standard deviation to the mean; CV) for eagle exposure rate of 0.2. Lower sample size and sampling frequency will result in less precise estimates and potentially necessitate use of a more risk-averse approach to predict fatality rates. The two-dimensional area sampled at each 800-m radius plot is $\pi 800^2$ = 201 ha and the total area sampled within the project footprint is the sum of the area sampled across all points. Exposure rate can be estimated based on data from sampling points that are not independent of one another, although points must be separated by at least 1600 m to avoid overlap among the 800-m radius plots that are centered on the points. Observers should use the most efficient, logical route to move among sampling points, changing the starting point with the beginning of each survey cycle such that each point is surveyed during a range of daylight hours.

Likelihood of detecting eagles during point count surveys is low during the first and last 2-3 hours of the day, but increases during midday when the eagles are most active. We recommend use of a temporally stratified sampling approach, allocating most survey effort to the midday period to reduce sampling variance and improve the precision of estimates while maximizing the opportunity for detections. This recommendation is particularly germane to surveys of golden eagles; over the course of a year there may be almost no detections of golden eagles early and late in the day. A pilot study can help validate this and support a power analysis to better ascertain minimum sample sizes. Surveying should be done under all weather conditions except if visibility approaches 0 (blinding snow or fog), or where visibility is less than 800 m horizontally and 200 m vertically. We recommend use of the National Oceanic and Atmospheric Administration's Earth System Research Lab's sunrise-sunset calculator to determine appropriate survey intervals and available daylight hours (http://www.srrb.noaa.gov/highlights/sunrise/sunrise.html).

Every point should be surveyed twice monthly in each of four seasons annually for at least 2 years, and preferably for 3 years. At each survey visit, the observer remains at the point for a set time (20 or 30 minutes is typical, and should be determined based on sampling considerations, ideally after analysis of pilot data from the site) and records the total number of minutes of eagle flight activity within 800 m, except that eagle flight activity more than 175 m above ground is not recorded. Thus, the "plot" actually is three-dimensional, forming a cylinder. As a practical way of documenting eagle exposure, we recommend dividing the total sample interval into 1-minute intervals and then recording the number of birds in flight within the plot in each interval (such that one eagle in flight in the cylinder in a given minute = 1 exposure minute; two eagles in flight in the cylinder in a given minute [or the same eagle in flight continuing into a second minute interval] = 2 exposure minutes, and so on). One exposure minute should be ascribed to an eagle perched within a plot during the entire 30-minute survey, but perched birds should be noted as such so that can be taken into account in the analyses. Because counts will be repeated, each point should be permanently marked. The perimeter of a plot can be temporarily marked in several places to help the observer approximate its location; this also can be done with a rangefinder. Because of the large size of an eagle, we assume a detection probability of about1.0; therefore, no detectability corrections are required. Topography, forest cover, or anthropogenic structures may obstruct views of portions of some plots. In such cases, an observer could estimate the percentage of the plot area that is visible and factor this into the calculation of area surveyed; if an assumption of randomness can be relaxed, the point location could be shifted to the nearest location that provides an unobscured view. Point count surveys for eagles may be conducted in conjunction with other wildlife sampling, provided the sampling frame outlined above (or a suitable alternative) is implemented and that observers are fully qualified to survey eagles. Objectives for using 800-m radius point counts for other large species of birds may require independence among sampling points. If so, the points should be separated by at least 2400 m.

Field data forms should include a large circle representing the point count plot on which the observer can record approximate flight paths and heights of eagles plus ancillary notes on general behavior and activity. Behavior prevalent during each 1-minute interval should be recorded as either soaring flight (circling broadly with wings outstretched), flapping-gliding, kiting-hovering, stooping or diving at prey, stooping or diving in an agonistic context with other eagles or other bird species, being mobbed, undulating/territorial flight, or perched. Observations of eagles outside the plot should also be recorded. Age of each eagle can be categorized as juvenile (recently fledged or fledged the previous year), subadult, adult, or unknown. An eagle's above-ground height should be estimated for each 1-min interval record, using broad categories relevant to the height of the rotor-swept zone and other risk-specific considerations (e.g., 1-20 m, 21-50 m, and so on; Walker *et al.* 2005). The rotor-swept zone (i.e., lowest to highest extent of turbine blades) of a generic 2- to 3-MW wind turbine is 35-135 m high. Weather data also should be recorded: wind direction and speed, extent of cloud cover, precipitation (if any), and temperature.

2. Characterization of the Project-area Nesting Population

The approach that we recommend in this Draft Eagle Conservation Plan Guidance for evaluating siting options and for assessing disturbance effects of wind facilities on eagles breeding on proximate territories is to determine locations of occupied nests of bald and golden eagles within the project footprint and within 10 miles of the perimeter of the footprint, then for each species calculate the mean nearest neighbor distance between the occupied nests (the project-area inter-nest distance). We use a 10-mile distance because the Service has defined the area nesting population for golden eagles to be the "number of pairs of golden eagles known to have a nesting attempt during the preceding 12 months within a 10-mile radius of a golden eagle nest" (50 CFR 22.3). To avoid confusion with the regulatory term and definition we use the term project-area nesting population to describe the eagle population targeted in these surveys. We also recommend application of this survey approach and scale to bald eagles for the purposes of these Draft Eagle Conservation Plan Guidance; however, where the project area nesting density is high-enough to make the 10-mile perimeter infeasible, we suggest considering use of one of the alternative approaches discussed below.

The objective of the project-area nesting population survey is to determine: (1) the number; (2) occupancy status; and (3) productivity of bald and golden eagle nesting pairs within the search area for three or more breeding seasons prior to construction. Where eagle nesting density is especially high and data are available (either from prior studies or a pilot study) to do so, the project-area inter-nest distance can be calculated and used as the width of the perimeter survey area, as the territories immediately adjacent to the footprint are the ones most likely to be affected by the project. This approach is especially appropriate in areas with high densities of nesting bald eagles. The Service strongly encourages that nesting surveys be conducted by experienced biologists with several year's prior experience conducting eagle nest surveys. Recommended approaches for conducting nesting surveys are provided below.

Eagles generally show strong fidelity to the nesting area annually, but not all pairs attempt to breed or successfully breed every year and it is easy to mischaracterize territories where pairs are present but do not breed as unoccupied. Occupancy determination via inventory of all available suitable habitat is the most important goal of nest searches. The project-area nesting population survey should include all potentially suitable eagle-nesting habitat within the project footprint and a 10-mile perimeter (unless a lesser distance is warranted based on factors described previously). A nesting territory or inventoried habitat should be designated as unoccupied by eagles only after ≥ two complete surveys at least 30 days apart in a breeding season. Where ground observations are used, at least two ground observation periods lasting ≥ four hours are necessary to designate an inventoried habitat or territory as unoccupied as long as all potential nest sites and alternate nests are visible and monitored. Dates of starting and continuing inventory and monitoring surveys should be sensitive to local nesting (i.e., laying, incubating, and brooding) chronologies. All surveys should be conducted during weather conditions favorable for survey and/or monitoring from medium to long range distances (> ½ mile).

A 'decorated' nest (a nest with fresh whitewash, feathers, or with fresh greenery) will be sufficient evidence to indicate the probable location of a nesting attempt. If a decorated nest or pair of birds is located, the search in that territory should be continued to locate and map alternate nest sites. Identification and enumeration of alternate nests will help determine the relative value of individual nests to a territory in cases of applications for permits to take 'inactive' nests, and when determining whether abandonment of a particular nest is likely to result in abandonment of a territory.

Helicopters are an accepted and efficient means to monitor large areas of habitat to inventory potential habitat and monitor known territories only if accomplished by competent and experienced observers, and if sufficient aerial time is budgeted for the survey. They can be the primary survey method, or can be combined with follow-up ground monitoring. Effective aerial surveys of woodland habitat for eagle nests may require two- to three-times as much time as aerial surveys for cliff nests. Cliffs should be approached from the front, rather than flying over from behind, or suddenly appearing quickly around corners or buttresses. Inventories should be flown at slow speeds, ca. 30 – 40 knots. All potentially suitable nesting habitats (as identified in coordination with the Service) should be surveyed; multiple passes at several elevation bands may be necessary to provide complete coverage when surveying potential nesting habitat on large cliff complexes, escarpments, or headwalls. Hovering for up to 30 seconds no closer than a horizontal distance of 20 meters from the cliff wall or observed nests may be necessary to discern nest type, document the site with a digital photograph of the nest, and if possible, allow for the observer to read patagial tags, count young, and age young in the nest (Hoechlin 1976). Nest occupancy may be confirmed during later flights at a greater horizontal distance. Aerial surveys may not be appropriate in some areas (e.g., bighorn sheep lambing areas).

Whether inventories are conducted on the ground or aerially, the metrics of interest to the Service for the project-area nesting population area as follows:

1. Number and location of nests within territories with an occupied nest (i.e., an occupied territory).
2. Number and location of likely eagle nests within apparently unoccupied territories (i.e., suspected or previously occupied eagle territories without an occupied nest in the current year).
3. Productivity (number of young surviving to ≥51 days of age) in each occupied nest.

Nest location information should be recorded in decimal-degree latitude longitude or UTM coordinates, and the substrate (tree species, cliff, ground, or structure) and nest elevation should be provided. Dates of each nest visit and nest status (occupied, eggs or young present, or failed and abandoned) should also be provided. These data should be provided to the Service in an Appendix to the project proponent's ECP.

3. Eagle Migration and Concentration Area Surveys

Non-breeding bald and golden eagles occasionally use communal roosts and forage communally, and both species can become concentrated on spring and fall migration under particular combinations of weather and topographic conditions. Therefore, pre-development site-specific surveys should be conducted if the Stage 1 site assessments suggest that migratory or transient eagles are likely to be seasonally concentrated in the project area, or if existing biological data are not available to make such a determination. These temporal pulses may be detected by the fixed-radius point counts, however the baseline point-count sampling intensity and sampling intervals may not be sufficient to detect or adequately characterize short-term migration or concentrated non-breeding eagle use. If either migration or non-breeding eagle concentrations are present in the project area, targeted spatio-temporal increases in the frequency of fixed-radius point counts may be advisable to provide more precise measures of the eagle exposure rate.

Migration counts can be used to determine relative numbers of diurnal raptors passing over an established point (Dunn *et al.* 2008), usually a migration concentration site. Migration surveys should be employed using established techniques with appropriate, qualified staffing during primary migration periods if the Stage 1 site assessment suggests the project area may be a migration concentration area. Migration counts may involve staffing observation posts up to 7 days per week during time periods (species and latitude dependent) and weather windows when eagles may be moving.

The Service recommends that project proponents conduct thorough exploratory fall and/or spring migration counts for eagles at possible concentration locations (e.g., north-south oriented ridgelines, peninsulas extending into large water bodies) in the project footprint in the initial site-specific survey year for the duration of the fall/spring passage period (see the Hawk Migration Association of North America's [HMANA] website for information of seasonal passage periods: http://www.hmana.org/index.php, last visited January 2, 2011). If migrating eagles are observed, migration counts should be continued for three years, and project proponents should consult with the Service to determine if increased sampling at fixed-radius points on likely migration flight routes during periods when migration is occurring is warranted. Migration counts should be conducted following standards established HMANA. Migration count data in the form requested by HAMANA should be provided to the Service as an Appendix to the ECP.

As with migration concentrations, the potential for non-breeding (either winter or summer) eagle concentration areas in or near the project footprint should be carefully considered in Stage 1. If seasonal concentration areas are possible, then exploratory aerial surveys (fixed-wing or helicopter) of potential habitat should be conducted in the initial year of site-specific surveys. General guidelines and recommendations for conducting eagle concentration area surveys are provided in Appendix F of the Northern States Bald Eagle Recovery Plan (USFWS 1983: http://www.fws.gov/midwest/eagle/recovery/be_n_recplan.pdf , last visited January 3, 2011). If eagle concentrations are present in the project area, then project proponents should consult with the Service to determine if increased sampling is warranted at fixed-radius points in likely seasonally important use areas.

APPENDIX D

STAGE 3 – RISK ANALYSIS RECOMMENDED METHODS AND METRICS

The objectives of the risk analysis are to predict the number of eagle fatalities to expect for a particular siting and operational configuration at a wind facility. Project proponents should work in coordination with the Service to determine risk-factors associated with each turbine in the facility. Then, an annual predicted mortality rate for the project can be calculated by using the estimated annual eagle exposure rate generated from the Stage 2 assessment and using explicit models with templates possibly supplied in a spreadsheet, such as Excel. The initial estimate of mortality rate should not take into account possible ACPs; these will be factored in as part of Stage 4. Additionally, any loss of production that may stem from disturbance is not considered in these calculations, but is instead derived from post-construction monitoring as described in Stage 5. Specific elements of the adaptive management process will be further developed as they emerge in actual cases, through coordination with project proponents. Therefore, this stage and Stage 5 of the ECP will require close coordination between the project proponent and the Service.

1. Risk-factor Analysis

Risk of collision varies from turbine to turbine in a wind facility based on the presence of one or more risk factors (see Figure 1, also Table 1 in the *Proposed Guidance for Eagle Conservation Plans Module 1. Wind Energy Development*) specific to each turbine. In the risk factor analysis, each turbine is evaluated to determine which of these site-based factors might be present:

1. Topographic features conducive to slope soaring
    - a. On or bordering the top of a slope oriented perpendicular to the prevailing wind direction
    - b. Near (within 50 meters) of a ridge-crest or cliff edge
2. Topographic features that create potential flight corridors
    - a. In a saddle or low point on a ridge line
    - b. Near a riparian corridor, at a forest or wetland edge, or near shorelines of large water bodies that eagles are reluctant to traverse
3. Proximate to potential foraging sites
    - a. Near perennial or ephemeral water sources that support a robust fishery or harbor concentrations of waterfowl
    - b. Near a prairie dog (*Cynomys* spp.) colony or area of high ground squirrel density
    - c. Near cover likely to support rabbits or hares
    - d. Near concentrations of livestock where carcasses and neonatal stock occur
    - e. Near sources of carrion
    - f. Near game dumps or landfills
4. Near likely perch structures or roost sites
5. In an area where eagles may frequently engage in territorial interactions
    - a. At about one-half of the mean project-area inter-nest distance (based or Stage 2 surveys) from an eagle nest site.
6. Other risk factors not identified above

Because of the importance of factor 3 above, the Service recommends project proponents conduct thorough surveys to document the distribution and availability of eagle food sources within the project footprint to inform the turbine-specific risk-factor analysis. Results of the risk factor analysis for each turbine should be compiled and provided as an appendix to the project proponent's ECP, along with the specific location (decimal-degree latitude longitude or UTM coordinates) of each turbine and its number or other identifier. The permit applicant and the Service will use the information collected to generate predictions of eagle fatality rates as described in the next section, and to facilitate consideration of specific, micro-siting alternatives (ACPs) in Stage 4 that could reduce risk.

2. Generating an Estimate of Annual Fatality Rate

The predicted number of fatalities per year is estimated from the product of exposure rate and collision probability. Exposure rate is the number of eagle flight minutes in the footprint per minute calculated from point count surveys in Stage 2. Exposure rate is dimensionless (i.e., exposure minutes/observation minutes) and proportional (i.e., each observation is made within a fixed sampling area and the estimate of exposure is scaled up to the footprint of the facility).

Collision probability (risk) is the probability than an eagle will collide with a turbine during a minute of exposure. Collision probability is estimated for the project footprint as a whole based on the risk factor analysis described above, and taking into account the proportion of the project area that represents a collision risk to an eagle (the area within 100 m of the base of a turbine). The overall collision probability is the cumulative probability across all turbines (i.e., the chance that an eagle will collide with one of the turbines in the facility). An assumption is that all collisions result in fatality. A general description of the approach with an example is provided in Table D-1, and a flow chart showing elements of the model is provided in Figure D-1.

Ideally, all parameters on the left (blue) side of Figure D-1 will not have to be estimated because the metric of eagle use is determined empirically through the point count surveys. However, the Service is developing predictive models that will include risk-averse estimates for parameters associated with eagle exposure rate so that conservative estimates of the eagle exposure rate can be generated where appropriate survey data are not available. The last term of the model defines the probability of collision during a minute of exposure. Collision risk is predicted using the collision part of the model (Figure 2), and is a function of its compliment, a basic avoidance rate (e.g., ~1% [Whitfield 2009]), adjusted downward based on the presence of one or more risk factors.

The actual number of fatalities per year is estimated using standardized line-transect surveys of carcasses in the footprint of the facility, corrected to account for imperfect detection, carcass scavenging, and carcass decay as described in Stage 5 (Buckland et al. 2001, 2004; Laing et al. 2003; Rivera-Milán et al. 2004). Updating the collision model using these Stage 5 monitoring data will lead to improved decision-making through adaptation (Nichols and Williams 2006). In addition, data collected across wind-power facilities in a state or region will be used for meta-analysis to better understand cumulative impacts of wind facilities on eagle populations.

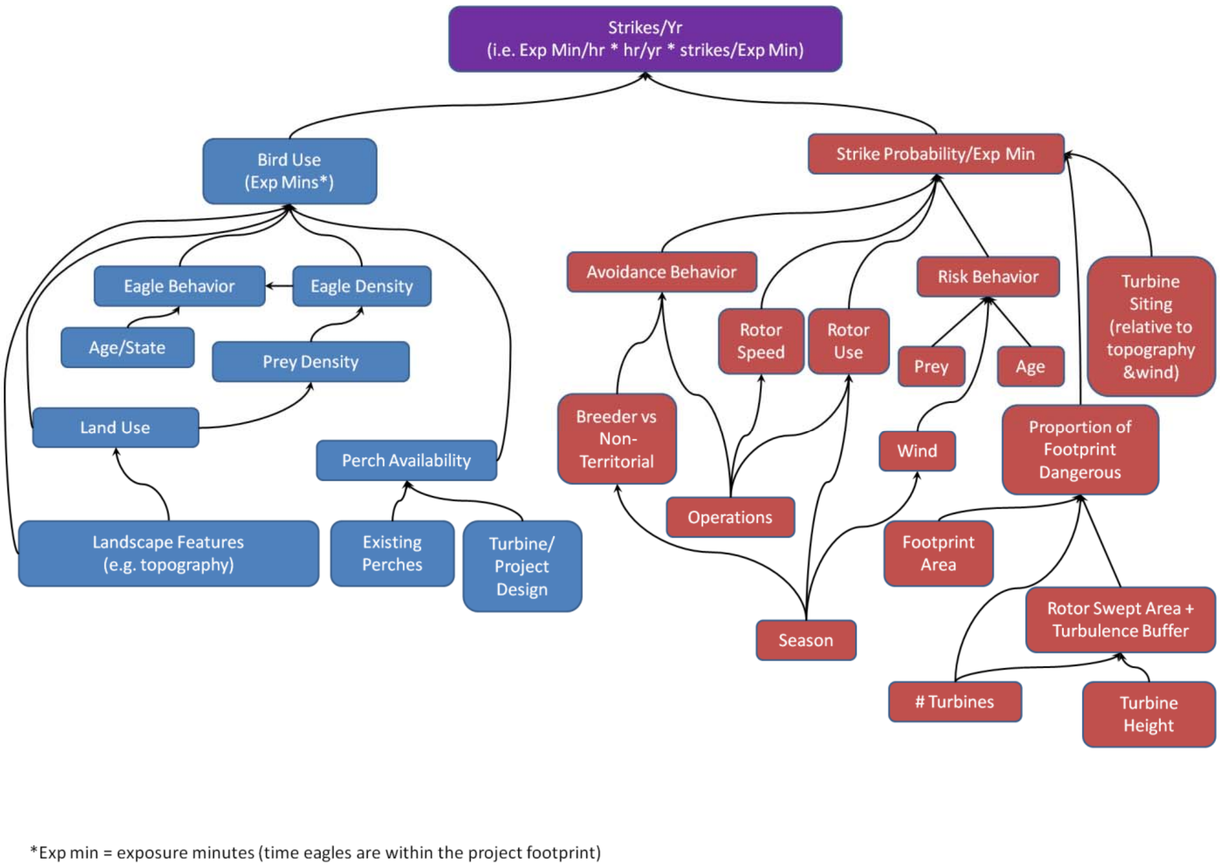

Figure D-1. Flow chart showing structure of the model used to predict annual eagle fatality rate at a wind facility. The proportion of the footprint that is dangerous is that within 100 meters of the base of a wind turbine.

Stage 2 and 3 Exposure Survey and Take Model Predictions Example

The predicted number of annual fatalities is estimated from three terms: (1) a measure of eagle use of the project area, (2) the proportion of the project area that is dangerous, and (3) the rate of collisions per minute in the danger zone based on the various site and turbine features. Eagle use (exposure) of the project area is determined from preconstruction surveys or estimated when survey data are insufficient or unavailable. The proportion of the project area that is dangerous (danger zone) is a direct calculation of hazardous areas relative to the total project area. The risk of a strike fatality is first determined from quantifying the risk of relevant turbine siting, model, and operating characteristics at first determined from expert elicitation and refined by applying a statistical model to results of Stage 5 carcass surveys. The product of these becomes the estimate of fatalities. To illustrate this, we use a simple, hypothetical example of what would be, by today's standards, an extensive wind energy facility, but which may also represent multiple adjoining facilities.

A wind facility has a planned foot print of A=1,000 km^2 (3183 turbines). A pre-construction survey was run for a year to estimate eagle exposure (minutes) relative to total daylight minutes (262,980). The facility conducted a systematic sample of n = 300 fixed radius (800m) points with $r = 5$ visits for each point i. (For this example, no observations were missing, but missing replicates are easily accommodated by allowing r to vary among points with the notation, r_i.) Areas ($a_i^{Sample} = \pi \times 0.8^2 = 2.01$ km^2) around each point were observed for t_{Sample} = 20 minutes and the time eagles were observed in the sample area recorded (eagle flight minutes). Although in this example all sample areas are complete, in practice observable area may be limited by topography or other features, and area a_i^{Sample} may vary among points.

Eagle Exposure

The example exposure per km^2 (eagle flight min/min/km^2) is obtained in 2 steps:

Let y_{ij} be the observed rate of exposure (eagle flight min per 20 minute sample period) at sample point i (i = 1 to n) and replicate observation j (j = 1 to r_i). First, the means at each sample point (i) are taken from all the replicate observations and standardized by the area sampled,

$$\bar{y}_i = \frac{\sum_{j=1}^{r_i} y_{ij}}{r_i a_i^{Sample}} = \frac{\sum_{j=1}^{r} y_{ij}}{r a^{Sample}}$$

(The right part of the equation is a simplified version when no observations are missing and all points have a_i = 0.8 km^2 sample area.)

Second, the average of the sample point means is calculated

$$E_{\text{km}^2} = \frac{\sum_i^n \bar{y}_i}{n} \qquad SD\left(E_{\text{km}^2}\right) = \frac{\sum_i^n \left(\bar{y}_i - E_{\text{km}^2}\right)^2}{n-1}.$$

In the example, this results in: $E_{\text{km}^2} = 5.53\times10^{-3}\ \frac{\text{eagle flight min}}{\text{daylight min}\times\text{km}^2}\ \left(\text{SD} = 2.072\times10^{-3}\right)$.

To get the exposure minutes for the project, multiply by project area, *A*, and the number of daylight minutes per year,

$$\text{Exposure}_{\text{Minutes}} = T_{\text{Min}} \times A \times E_{\text{km}^2} = 1,453 \text{ minutes}$$

$$\text{SE}\left(\text{Exposure}_{\text{Minutes}}\right) = \text{T}_{\text{Min}} \times \text{A} \times \frac{\text{SD}\left(\text{E}_{\text{km}^2}\right)}{\sqrt{\text{n}}} = 545$$

$\text{Exposure}_{\text{Minutes}}$ has a CV of 38 percent $\left(\text{CV} = \text{SE}\left(\text{Exposure}_{\text{Minutes}}\right)/\text{Mean}\left(\text{Exposure}_{\text{Minutes}}\right).\right)$

Danger Zone
This is the portion of the project footprint that is in the danger zone, D, where eagles are in danger from the turbines, power lines, or other project hazards. For wind turbines, the zone includes 100 m buffers placed around each turbine, $D = {n_{\text{Turbine}} \times \pi \times 0.1^2}/{A}$. In our example, the danger zone is ten percent of total area (3183 turbines).

Collision Rate
The rate of strikes per minute of eagle flight in the danger zone is determined turbine by turbine, depending on associated risk factors, c_{ij}. The levels of the factors j are assigned a risk for each turbine i. A unspecified function, $\text{f}_{\text{Collision Rate}}$, uses the factors to determine the turbine specific risk,

$$C_i^{\text{Turbine}} = \text{f}_{\text{Collision Rate}}\left(c_{i1},\cdots,c_{iJ}\right) = \exp\left(\sum_j \log\left(c_{ij}\right)\right)$$

An example function that keeps the rates positive might be a multiplicative function, exponentiating the sum of the logs.

The per turbine rates are averaged to get the overall collision rate.

$$C = {\sum_i^{n_{\text{Turbine}}} C_i^{\text{Turbine}}}\Big/{n_{\text{Turbine}}}.$$

In this example, let the overall collision rate be 0.0259.

The number of annual fatalities is the product of the three terms: exposure minutes, the proportion of the footprint in the danger zone, and the overall collision rate,

$$\text{Fatalities}_{\text{Project,Year}} = \text{Exposure}_{\text{Minutes}} \times D \times C$$

$$= (1453 \text{ minutes}) \times 0.10 \times \left(0.0259 \tfrac{\text{strikes}}{\text{minute}}\right).$$

Finally, the example eagle fatalities per year is 2.9. Because the only variation here is from the exposure survey the SE is 1.09.

To keep this example simple, exposure was not stratified into areas and times of the year thought to influence eagle use of habitat. With experience and data from projects, other parts of the model will be further refined, e.g., in Stage 3, the collision rate, C, will be updated in Stage 5 using data from the carcass surveys. Also, with data from multiple projects, the relationships among exposure, collision rate, and fatalities will be better understood and incorporated into the model.

APPENDIX E

STAGE 4 – DEVELOPMENT OF ADVANCED CONSERVATION PRACTICES

Siting of a wind facility is the most important factor when considering potential effects to eagles. Based on information gathered in Stage 2 and analyzed in Stage 3, the project proponent should revisit the site categorization from the Stage 1 assessment to determine if the site(s) still falls into an acceptable category of risk (at this stage, acceptable categories are 2 and 3, and very rarely 1. When information suggests that a proposed wind facility has a high eagle exposure rate and presents multiple risk factors (e.g., is proximate to an important eagle-use area and Stage 2 data suggest eagles frequently use the proposed wind-facility footprint), it should be considered a category 1 site; we recommend relocating the project to another area because a location at that site would be unlikely to meet the regulatory requirements for a programmatic permit. If the site falls into categories 2 or 3, or for some rare category 1 sites where there is potential to adequately abate risk, the ECP should next address Advanced Conservation Practices (ACPs) that might be employed to minimize or, ideally, avoid eagle mortality and disturbance.

In this section of the ECP, we recommend project proponents re-run models predicting eagle fatality rates *after* implementing the scientifically supportable ACPs for all the plausible alternatives. This re-analysis serves two purposes: (1) it demonstrates the degree to which minimization and avoidance measures might reduce effects to eagle populations compared to the baseline project configuration, and (2) it provides a prediction of the unavoidable eagle mortality. ACPs should be tailored to specifically address the risk factors identified in Stage 3 of the ECP. This section of the ECP should describe in detail the measures proposed to be implemented and their expected results.

1. Examples of ACPs Applicable Before and During Project Construction

Examples of avoidance and minimization measures that should be considered before and during project construction, depending on the specific risk factors involved, include:

1. Minimize the area and intensity of disturbances during pre-construction activities, such as monitoring and site reconnaissance, as well as during construction.
2. Consider undertaking real-time monitoring of proximate occupied nest sites, and curtailing activity if eagles exhibit signs of distress.
3. Prioritize locating development on disturbed lands that provide minimal eagle use potential.
4. Utilize existing transmission corridors and roads.
5. Avoid vegetation removal and construction during the breeding season.
6. Design project layout to reduce collision and electrocution:
    a. Site turbines in groups rather than spreading them widely but avoid areas where eagles concentrate which could result in high-risk rows of turbines (Smallwood and Thelander 2004).
    b. Consider using pylons at the ends of turbine rows, place pylons in ridge dips or leave dips undeveloped.

c. Set turbines back from ridge edges at least 100 m where soaring is/will likely take place.
d. Site structures away from high avian use areas and the flight zones between them.
e. Dismantle nonoperational turbines and meteorological towers.
f. Bury powerlines when feasible to reduce avian collision and electrocution.
g. Follow the Avian Power Line Interaction Committee (APLIC) guidance on power line construction (APLIC 2006) and power line siting (APLIC 1994).
h. Develop a transportation plan, including road design, locations and speed limits to minimize habitat fragmentation and wildlife collisions and minimize noise effects.
i. Minimize the extent of the road network.

7. Select project features that minimize effects to eagles:
    a. Avoid use of lattice or structures that are attractive to birds for perching.
    b. Avoid construction designs (including structures such as meteorological towers) that increase the risk of collision, such as guy wires. If guy wires are used, mark them with bird flight diverters (according to the manufacturer's recommendation).
    c. Minimize lighting at facilities (see *U.S. Fish and Wildlife Service Draft Land-based Wind Energy Guidelines* for detailed recommendations). Require that all security lighting be motion- or heat-activated, not left "on" overnight, and down-shield all security and related infrastructure lights.
    d. During construction, implement spatial and seasonal buffers to protect individual nest sites/territories and/or roost sites, including:
        i. Maintaining a buffer between activities and nest/communal roost sites;
        ii. Keep natural areas between the project footprint and the nest site or communal roost by avoiding disturbance to natural landscapes.
    e. Avoid activities that may disturb eagles.
8. Avoid siting turbines in areas where eagle prey are abundant and conduct practices that do not enhance prey availability at the project site.
9. Consider use of pylons to divert eagle flight paths away from risk zones.
10. Avoid areas with high concentrations of ponds, streams, or wetlands.

With respect to item 6d, buffers can help ensure nesting or roosting eagles are not disturbed by construction or maintenance because they serve to minimize visual and auditory effects associated with human activities. Our understanding of how to design effective buffers is limited at the present time, but it seems likely that the size and shape of effective buffers vary depending on the topography and other ecological characteristics surrounding the important eagle-use area. In open areas where there are little or no forested or topographic features to serve as buffers, distance alone must serve as the buffer. Effective use of buffers is one of the key areas where we hope to reduce uncertainty through the adaptive management process.

2. Examples of ACPS Applicable During Project Operations

Examples of avoidance and minimization measures that should be considered during project operation, depending on the specific risk factors involved, include:

1. Maintain facilities to minimize eagle effects:
    a. If rodents and rabbits are attracted to project facilities, identify and eliminate activities that may be attracting them (do not control for native wildlife without contacting the appropriate regulatory agencies). Coordinate in advance with the Service if poisons or lead-based ammunitions are contemplated for control purposes.
    a. Avoid management that indirectly results in attracting raptors to turbines, such as seeding forbs or maintaining rock piles that attract rabbits and rodents.
    b. Move stored parts and equipment, which may be utilized by small mammals for cover, away from wind turbines.
    c. If fossorial mammals burrow near tower footprints, where feasible on a case-by-case basis fill holes and surround pad with gravel at least 2 inches deep and out to a perimeter of at least 5 feet.
    d. Immediately remove carcasses (other than those applicable to post-construction fatality monitoring; see below) that have the potential to attract raptors from roadways and from areas where eagles could collide with wind turbines.
2. Ensure responsible livestock husbandry (e.g. removing carcasses, fencing out livestock) is practiced if grazing occurs around turbines.
3. Reduce vehicle collision risk to wildlife:
    a. Instruct project personnel and visitors to drive at low speeds (< 25 mph), and be alert for wildlife, especially in low visibility conditions.
    b. Plow roads during winter so as not to impede ungulate movement. Snow banks can cause ungulates to run along roads resulting in them colliding with vehicles. Roadside carcasses attract eagles, subjecting them to collision as well.
4. Follow procedures that reduce risk to wildlife:
    a. Instruct employees, contractors, and visitors to avoid disturbing wildlife, especially during breeding seasons and periods of winter stress.
    b. Reduce fire hazards from vehicles and human activities (e.g., use spark arrestors on power equipment, avoid driving vehicles off road).
    c. Follow federal and state measures for handling toxic substances.
    d. Minimize effects to wetlands and water resources by following provisions of the Clean Water Act (33 USC 1251-1387).

3. Additional ACPs

The project proponent and the Service at this point should consider additional scientifically supportable ACPs that might reduce predicted mortality even further. However, to date, few additional practices have been implemented and monitored sufficiently to be demonstrably effective in reducing eagle mortality at wind facilities. Therefore, unless compelling evidence suggests additional practices are warranted up-front, the Service may authorize permits for category 2 and category 3 projects without additional ACPs initially, but with a permit condition that post-construction monitoring data be evaluated to identify potential operational modifications that might be implemented experimentally in the future to the reduce mortality rates (e.g., if observed mortalities are limited to a single turbine in a single season, shutting down that turbine in that season would be a potential additional ACP). Permit renewal may be contingent on implementing and monitoring these empirically derived ACPs, as a component of the adaptive management process.

Examples of additional ACPs that may be identified initially or after evaluation of post-construction fatality monitoring data, depending on the specific risk factors involved, include:

1. Seasonal or daily shut-downs (particularly relevant in situations where eagle strikes are seasonal in nature and limited to a few turbines or occur at a particular time of day) or turbine relocation or removal.
2. Retro-fit existing horizontal turbines with new designs (e.g., vertical axis wind turbines).
3. Placing visual and/or auditory bird flight diverters in critical locations.
4. Hazing big game off property, specifically under turbines (coordinate in advance with the Service and state or tribal wildlife authorities).
5. Prey-base enhancements and/or land acquisition and management to draw eagles out of a project footprint.
6. Retro-fitting tower pads to prevent fossorial mammals from burrowing;
7. Removal of artificial and/or natural habitats attracting prey.
8. Limiting domestic livestock grazing within the project area (e.g., under turbines).
9. Adjusting turbine cut in speeds.
10. Painting blades to reduce visual “smear” (also painting with UV paint or applying different patterns).
11. Installing sound devices to disorient eagles either by having intermittent but frequent emissions, or emissions triggered by remote sensors or radar (Orloff and Flannery 1992).

APPENDIX F

USING RESOURCE EQUIVALENCY ANALYSIS TO DEVELOP A FRAMEWORK OF COMPENSATORY MITIGATION FOR POTENTIAL TAKES OF GOLDEN EAGLES FROM WIND ENERGY DEVELOPMENT

Introduction

When birds are killed—whether from oil spills, hazardous substance releases, permitted or illegal takes—their value can be difficult to quantify in ecological and economic terms. Exactly how much are they worth to an ecosystem, as well as to the public? How much compensation is enough to offset that 'take' or loss of that bird's contribution to the population? The field of resource economics has experienced tremendous advances in the development of tools to measure ecosystem services[1] since the mid 1990's. In particular, economists have extended the economic theory from valuation studies and information from scientific models to develop an alternative approach to economic valuation called resource equivalency analysis (REA) (based on Unsworth and Bishop 1994; Jones and Pease 1997). An REA responds to the question, "What, but for the event, would have happened to the injured species?" With REA, the services of the birds killed are quantified in physical units of *bird-years*.[2] The selected compensation is *scaled* so that the quantity of replacement bird-years equals the quantity of lost bird-years in present value terms to fully compensate the public for depletion of that individual or groups of individuals from the public trust, i.e., no net loss of birds.

REA is referenced in Interior's natural resource damage assessment (NRDA) regulations (2008) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); National Oceanic and Atmospheric Association's Oil Pollution Act (OPA) guidance documents; and is commonly used in NRDA cases (see, e.g., Sperduto *et al*. 1999, 2003; Natural Resource Trustees 2006; Skrabis 2005). The model has also been applied to Federal Energy Regulatory Commission (FERC) licensing, Endangered Species Act (ESA) permitted takes (see, e.g., Skrabis 2004, 2007), and enforcement actions for illegal takes. Internationally, the European Union adopted the US' REA methods for addressing environmental liabilities (Cole & Kriström 2008), and REA was used to estimate the avoided losses of sea eagles from electric

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[1] Although the fields of ecology and economics do not have a standard definition and measurement of ecosystem services, they are generally understood to be the benefits of nature to individuals, communities, and economies. Ecologists' general classification of provisioning, regulating, cultural, and supporting services aligns with the economic concepts of use and non-use values. In economics, direct use involves human physical involvement with natural resources (e.g., logging, fishing, cultural, and tourism); indirect use values resources that support humans or what humans directly use, e.g., climate regulation, flood control, animal/fish refugia, pollination, waste assimilation; and non-use does not involve physical interaction (i.e., bequest and option values).

[2] A *bird- year* refers to all services provided by one bird for one year. This measure of services is specific to the type of bird since different birds provide different services. So, e.g., the replacement services for 20 bird-years could be 20 birds for only one year, one bird over 20 years, or anything in between.

pole retrofitting as compensation for sea eagle mortalities from collisions with a wind farm in Norway (Cole 2009). With established methods and other comparable analyses, REA may be considered "informed modeling," as described in Stage 3 of the Eagle Conservation Plan, and thus an appropriate tool for estimating the required quantity of mitigation offset for estimated allowable or pre-permitted take of Golden Eagles from wind energy development.

For the purposes of the Draft Eagle Conservation Plan Guidance, the Service's Eagle Compensatory Mitigation Team (ECMT) has developed an REA example to calculate compensatory mitigation for the loss of golden eagles caused by wind power. The remainder of this paper provides a summary of the golden eagle REA results using the following scenario from the ECMT:

> **Example 1:** An annual take of five golden eagles over a five-year renewable permit, starting in 2011. Projected compensatory mitigation involves retrofitting electric power poles that pose a high likelihood of causing eagle mortality[3]. This power pole retrofit would occur in calendar year 2011, thus avoiding the potential loss of golden eagles from electrocution. Proper operation and maintenance (O&M) by the utility company of all retrofitted poles is an assumption; hereafter required for the 30-year life cycle of the wind power project. The results of the model are expressed in the total number of electric power poles to be retrofitted to equate to no net loss of 25 golden eagles (5 eagles annually over five years). The cost of the retrofit of the power poles may then be converted to an estimated minimum total cost of compensatory mitigation funded by the project proponent/ applicant.

An overview of REA methods, inputs, analysis, and references is also provided below.

Summary of Results

To expedite the REA for purposes of this draft guidance module on wind energy development, the best available peer-reviewed, published data and information from North American golden eagle experts were used.[4] It should be noted that additional modeling work within the REA may be needed, particularly on issues related to migration, super producers, adult female survivorship, natal dispersal, age at first breeding, and male-female productivity and population sex ratio, as identified and documented by experts.

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[3] Companies responsible for power poles and infrastructure are also responsible for taking all reasonable and prudent measures to ensure their equipment does not kill eagles, which includes immediately retrofitting poles that have killed an eagle, and proactively retrofitting poles that are likely to kill eagles in the future. This mitigation is intended to speed up the process of proactively retrofitting power poles, and does not absolve any utility company of liability associated with eagle or other migratory bird mortalities.

[4] Dr. Jim Watson, Pete Bloom, and Karen Steenhof, personal communications to the National Golden Eagle Compensatory Mitigation Team, 12/22/10.

As a *framework* for compensatory mitigation, it needs to be clear that the following results are an illustration of how the REA works given the *current* understanding of the Golden Eagle life history inputs, effectiveness of retrofitting lethal electric poles, the expected annual take, and the timing of both the permitting and mitigation. As would be expected, smaller or larger annual takes lead to a smaller or larger number of poles to be retrofitted. The lengths of permits affect the number of retrofitted poles. Delays in retrofitting would lead to more retrofitted poles owed. As permits are being renewed, new information on changes in the level of take, understanding of the eagle life history, or effectiveness of retrofitting would be expected to change the number of retrofitted poles required for compensation. Finally, while only electric pole retrofitting is considered in this REA, the metric of bird-years lends itself to consideration of other compensatory mitigation options used to achieve the no-net loss standard in the future. With enough reliable information, any mitigation that directly leads to an increased number of Golden Eagles (e.g., habitat restoration) or the avoided loss of golden eagles (e.g., reducing vehicle/eagle collisions, retrofitting livestock water tanks, lead ammunition abatement, etc.) could be considered for compensation within the context of the REA.

The language of REA, which is described in greater detail later, includes:

- The **direct loss** of golden eagles from the take (first part of the *debit* in bird-years);
- The **lost reproduction** over two generations that is foregone because of the take (second part of the *debit* in bird-years);
- The **relative productivity** of retrofitting lethal power poles, which is the effectiveness in avoiding the loss of golden eagles by electrocution as a mitigation offset (measured in total bird-years per pole for 30 years); and
- The **mitigation owed**, with is the total debit divided by the relative productivity (*scaling*) to identify the number of lethal power poles that need retrofitting to completely offset the take of golden eagles.

Using the scenario described above, Table F-1 provides a summary of the results:

Table F-1
Mitigation Owed for a 5-Year Permitted Take of 25 Golden Eagles
(5 Eagles Annually)

Total Debit	485.74	PV bird-years for 5 years of Golden Eagle take
÷ Relative Productivity of Electric Pole Retrofitting	÷4.20	Avoided loss of PV bird-years per retrofitted pole
= Mitigation owed	=115.61	Poles to be retrofitted to achieve no net loss

PV=Present Value

If *all* of the REA inputs remain the same when the permit is renewed, then the estimated 116 poles may be multiplied by the expected number of renewals to provide an estimate of the total number of poles that would eventually be retrofitted. For example, for the 30-year life cycle of an average wind project, 115.6 poles would be multiplied by 6 permit renewals to equal approximately **694 lethal power poles** to be retrofitted as mitigation for the take of 150 Golden

Eagles over 30 years (5 eagles annually). Proper O&M of these poles would need to be conducted to ensure the expected effectiveness of the mitigation is achieved.

REA Methods

Deciding to Conduct a REA

There are two basic approaches to measuring the compensation for injuries to natural resources. The "consumer valuation approach" focuses on the demand side; the "replacement cost" approach focuses on the supply side. The former seeks to determine how much the public demands the services of natural resources (e.g., using a survey method like contingent valuation). The latter seeks to measure how much it costs to replace the natural resource services that the public loses as a result of the injury (i.e., how much it costs to supply natural resource services). The REA model focuses on the supply side of compensation for natural resource injuries, i.e., the "replacement cost" approach, as a variation of habitat equivalency analysis (HEA) (based on Unsworth & Bishop 1994, and Jones & Pease 1997).

At the US Department of the Interior, REA generally refers to a stepwise replacement model[5] for killed or injured species, which was first used in the North Cape NRDA case (Sperduto *et al*. 1999, 2003). As discussed above, this approach is consistent with both the CERCLA and OPA NRDA regulations, and is explicitly identified in the revised CERCLA regulations (2008). The model has also been applied in other US settings and internationally adopted by the European Union for addressing a full range of environmental liabilities (Cole & Kriström 2008). REA calculations using the stepwise replacement model involve basic population modeling, including elements of the Leslie matrix and associated life tables, with appropriate discounting to provide the final results in present value. This approach documents how individuals are lost by age class over time in a stepwise fashion based on survival rates and longevity, and seeks to measure how much it costs to replace the natural resource services that the public lost as a result of the injury.

Interior currently uses REA extensively in NRDA cases to measure the losses associated with individuals, not population-level effects.[6] NRDA case teams typically decide to use the REA model because of its: (1) appropriate focus on individuals killed and their replacement, (2) relatively reliable results that are transparent and reproducible, and (3) cost-effectiveness. More specifically, the current state-of-the-art REA has:

1. **Appropriate Focus.** As noted across the REA literature, the number of individuals killed in an incident can be counted or estimated. Although lost individual-years (e.g.,

[5] Term coined by Hampton & Zafonte in the *Luckenbach Final DARP*, Appendix C, 2003, which appropriately describes how lost bird-years are calculated by the age classes over time in a stepwise fashion (i.e., # in age class (0-1) (Year 1) * survival rate = # in age class (1-2) (Year 2) * survival rate = # in age class (2-3) (Year 3), etc.). The stepwise concept reflects the Leslie Matrix used by biologists/ecologists. Similar terms are seen in the economics and political science literature to describe various trajectories over time.

[6] There have been some limited efforts to model population effects by NRDA consultants (e.g., Tank Barge Bouchard No. 120) and the State of California (e.g., M/V Kure oil spill, SS Jacob Luckenbach).

bird-years, fish-years) can be difficult to observe, simulations and arguments in the literature suggest that removing even a small number of individuals from a population can produce persistent impacts (e.g., Sperduto *et al.* 1999, Zafonte & Hampton 2005). Thus, it seems reasonable to focus on individuals killed using REA when quantifying appropriate compensation

2. **Relatively Reliable Results.** The reality is that the public's valuation of a resource is not necessarily equal to the total replacement cost identified in a REA, particularly in the case of unique and scarce resources. Zafonte & Hampton (2007) conducted experiments to explore the degree to which violations of REA assumptions can result in either under-compensation or over-compensation of the public. Specifically, they looked at whether the results of compensatory restoration diverged from monetized settlements. They found that a traditional REA is consistent with a monetized approach except in cases where the demand for resources is inelastic (i.e., no substitutes) and the impact to local resources is severe (public values are likely affected). Zafonte & Hampton (2007) believe their results suggest "the welfare biases intrinsic to a traditional REA methodology are probably minor for many NRDA cases" (p. 10). In sum, REA applies basic ecological concepts in a standard economic framework to provide relatively reliable estimates of compensation.

3. **Cost-Effective Assessment.** REA can be run and reviewed by all stakeholders, often using existing literature. Certain species require more local study, so even REAs can become more expensive in those situations. "However, because it is easier and less costly to measure the total replacement cost than the total public value, REA has an advantage over other methods, especially for small to medium-sized incidents with minimal impact on rare species" (Kure Final DARP 2008: C-2).

While the same basic REA model is being used in a variety of settings, there is some variation on the number of generations to include in the assessment. According to Zafonte and Hampton (2005), "[i]t is difficult, however, to construct a rationale that links population recovery to a specific number of entirely lost future generations (i.e., if one full generation of offspring is lost, why not the next?)" (pp. 9-10). Instead, recovery can be quantified by focusing on the production of juveniles from the remaining live birds rather than what was foregone from the dead birds (e.g., SS Jacob Luckenbach, Tank Barge Bouchard No. 120). Population models provide flexibility to specify recovery mechanisms that are based upon individuals remaining in the population. Specifying these types of mechanisms may be helpful for guiding calculations when full juvenile replacement is not expected. "The same flexibility that makes population modeling attractive can also work against it. Even simple population models may require (or imply) the specification of parameters and relationships that may not be needed when doing direct calculations of lost individuals. On one hand, specifying these relationships may help place the analysis in a broader context (e.g., by helping calibrate appropriate modeling inputs). However, it may also introduce additional uncertainty. Addition of model complexity should be done with care" (pp. 10-11).

Given the current state of the art in the REA modeling, the extensive bird expertise in the US Fish and Wildlife Service and many state agencies, and the analysis of uncertainty in more advanced population modeling by Zafonte & Hampton (2005), DOI NRDA cases typically have decided to apply zero to two generations. Most often two generations of reproductive losses are estimated based on the site-specific bird injuries. All of these factors seem relevant to any context that REA would be applied, including Golden Eagle mitigation.

Background on Conducting a Stepwise Replacement Approach REA

The stepwise replacement model is commonly used for bird kills. The basic conceptual approach to measuring losses in bird-years for one year of a take is provided in Figure F-1.

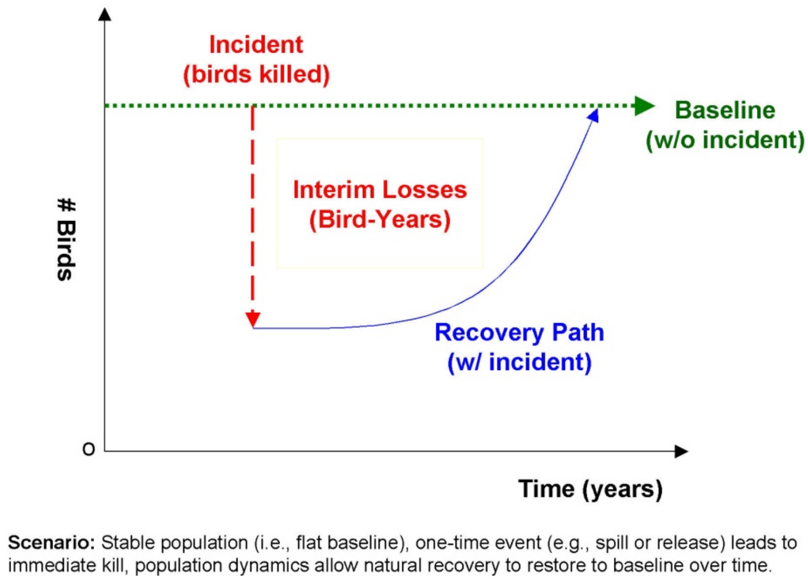

Figure F-2. Conceptually Measuring Lost Bird-Years in an REA

Mathematically, the stepwise replacement model approach is calculated as:

$$I = \sum_{t=o} [(NB_t - N_t) \div (1+r)^t] \quad (1)$$

where *I* is the injury in lost bird-years, *NBt* and *Nt* represent the number of individuals in the population (at time *t*) under existing baseline and take scenarios, respectively, *t* indexes time (usually years, but could be adjusted for months or days for short-lived and/or quick recovering species), and *r* is the annual discount rate (which can be adjusted for months or days depending on the units of *t*) (see, e.g., Sperduto *et al.* 1999, Zafonte and Hampton 2005).

REA using the stepwise replacement model is based upon the assumptions provided in Table F-2. These assumptions are necessary to obtain a static perspective of take and mitigation for compensation, which allows a reasonable simplification of the analysis by focusing on the dead birds and associated lost bird years (measuring injury (*I*) directly).

Table F-2 REA Assumptions

Assumption 1	Incident-related mortality is distributed across the various age classes of the injured population (unless an average age is assumed).
Assumption 2	The juvenile and adult survival rates are constant before and after the incident.
Assumption 3	The baseline and mitigated/restored populations are roughly constant in size and stable in age-distribution, as determined by demographic characteristics of the species (specifically survival rates and fecundity).
Assumption 4	There is a maximum age beyond which no individuals live that is constant before and after the incident.
Assumption 5	Reproductive rates by surviving individuals are unchanged by the incident (e.g., the number of post-spill nests equals the number of baseline nests).
Assumption 6	The real discount rate is 3%. Figures presented in *current value* have no discounting; the number presented is the actual number expected to occur in the year it appears. In contrast, figures reported in *present value* have been discounted, such that the number reported reflects its value today.

Sources: See, e.g., Sperduto *et al*. 2003; Natural Resource Trustees, SS Jacob Luckenbach 2006.

There are 16 steps in conducting any REA. There are 13 total steps involved in calculating the injury side (debit) of an REA, and three additional steps involved in estimating compensatory mitigation owed (credit).

On the injury side, the first five steps measure direct losses of birds, i.e., bird-years lost from the take of Golden Eagles by wind energy development.

Step 1: Identify how many eagles by age class should have been alive "but for" the take (REAs may use the % age distribution from a Leslie model, average age, or calculated age). The Eagle Compensatory Mitigation Team and supporting national eagle experts provided an age distribution of eagles killed. A Leslie model came up with similar results. A review of Cole (2009) showed an average age for the sea eagle used in the Norwegian wind power electrocution case study. Through personal communications, the author noted that the use of an average age was a "simplification based on a lack of data" (which has also been necessitated in some NRDA cases) and is making current efforts to "improve our estimates -- both the age of a collided bird and the age of an electrocuted bird" (1/12/11).

Step 2: Multiply the relevant survival rates by the lost birds per age class at the time of the incident (from Step 1), and identify the midpoint. The midpoint provides average bird-services for the year instead of overvaluing at the beginning of the year or undervaluing at the end of the year.

Step 3: For each subsequent year, multiply the number of birds progressing through each age class by the relevant annual survival rates for the remaining lifespan of the species.

Step 4: Total the lost bird-years across age classes and for each year of remaining lifespan to estimate the total direct loss in bird-years. Multiply by the discount factor to calculate the total lost bird-years in present value.

Step 5: Identify the subset of birds that are of reproducing age (i.e., Reproducing Subset).

The next three steps involve calculating the expected losses associated with the foregone production of one (dead) bird.

Step 6: Calculate the expected value in bird-years associated with one first-generation bird in the first year as the product of the annual survival rates over the expected lifespan.

Step 7: Multiply by the relevant discount factor to convert to present value.

Step 8: Extrapolate the results from Step 7 into future years using the 3% discount rate. Although some minor rounding error is introduced, the quickest and easiest way to adjust the future values is to continuously reduce the values by 3% by multiplying the previous year by 0.97.

The next five steps measure lost reproduction in bird-years.

Step 9: Using the Reproducing Subset identified in Step 5, calculate how many of the reproducing adults are females that would actually reproduce [# reproducing age (from Step 5) x proportion female x reproductive rate of females].

Step 10: Multiply the number of reproducing females (from Step 9) by the average number of young to estimate the total number of lost first-generation birds.

Step 11: Multiply the total number of lost first-generation birds (from Step 10) by the present value bird-years associated with their lifespan (from Steps 6-8).

Step 12: To calculate the number of lost second-generation birds, identify the total number of lost first-generation birds and follow Steps 2 through 5 to calculate the reproducing subset.

Step 13: Finally, to calculate the total second-generation reproductive losses, take the reproducing subset from Step 5 and repeat Steps 9 through 11.

Finally, there are three additional steps involved for scaling mitigation options to estimate the amount of compensatory mitigation required to offset the take of Golden Eagles.

Step 14: Identify the mitigation option(s). See the Eagle Compensatory Mitigation Team's mitigation option described above, which is based on the retrofitting of lethal electric poles.

Step 15: Identify the relative productivity of the mitigation. In this case, it is the number of bird-years per retrofitted electric pole over 30 years with proper O&M to ensure the relative productivity.

Step 16: Scale the mitigation project(s) by dividing the total lost bird-years (direct and reproductive losses) by the relative productivity of the mitigation option(s) to identify the size of the mitigation project (quantity of mitigation owed). Alternatively, a project of known size could be evaluated in terms of potential bird-years as an offset to the debit. This helps decision-makers understand whether they need to identify additional projects (not enough offset) or reduce the proposed mitigation project (too much offset).

Golden Eagle REA Inputs

Table F-3 provides a summary of the Golden Eagle life history inputs and assumptions used in this REA. As discussed above, to expedite the REA for purposes of this draft guidance module on wind energy development, the best available peer-reviewed, published data and information from North American Golden Eagle experts were used.

Table F-3
REA Inputs to Develop a Framework of Compensatory Mitigation
for Potential Takes of Golden Eagles from Wind Energy Development

Parameter	REA Input		Reference
Start year of permit	2011		Test run of model
Length of permit	5 years		Can test with other permit lengths
Estimated take	5 birds annually		Test run of model
Maximum lifespan	30 years		28 years, 3 months, Bird Banding Lab. Consistent with Cole (2009) approach.
Age distribution of birds killed	(0-1) (1-2) (2-3) (3-4) (4-5) (5-6) (6-7) (7-8) (8-9) (9-10) (10-11) (11-12) (13-14) (14-15) (15-16) (16-17) (17-18) (18-19) (19-20) (20-21) (21-22) (22-23) (23-24) (24-25) (25-26) (26-27) (27-28) (28-29) (29-30)	20% 11.67% 11.67% 11.67% 1.73%	• 20% juveniles; age class (0-1) • 35% sub-adults; age classes (1-2) through 3-4) —Dr. Jim Watson, Pete Bloom, Karen Steenhof, 12/22/10 • 45% adults; age classes (4-5) through (29-30) Assume distributed evenly over time. The Leslie model produces a very similar population distribution for the maximum lifespan: • 19.6% juveniles; age class (0-1) • 33.5% sub-adults; age classes (1-2) through 3-4) • 46.9% adults; age classes (4-5) through (29-30)
Age start reproducing	Age 5 [age class (5-6)]		Jim Watson, Pete Bloom, Karen Steenhof, 12/22/10
Expected years of reproduction	25 years		Maximum lifespan – Age start reproducing
% of adult females that reproduce	80%		Jim Watson (82%), Karen Steenhof (79%) 12/22/10
# eggs/nest	2		Jim Watson (2), Pete Bloom (1.5-1.8), Karen Steenhof (2; 1.6 brood size), 12/22/10
Nesting success—the proportion of nesting or laying pairs that	50%		Jim Watson, Pete Bloom, 12/22/10

Parameter	REA Input	Reference
raise young to the age of **fledging** (i.e., the age when a fully-feathered offspring voluntarily leaves the nest for the first time)(Steenhof & Newton (2007): 184)		
year 0-1 survival	61%	Division of Migratory Bird Management, US Fish and Wildlife Service, *Final Environmental Assessment: Proposal to Permit Take as Provided Under the Bald and Golden Eagle Protection Act*, April 2009.
year 1-2 survival	79%	
year 2-3 survival	79%	
year 3-4 survival	79%	
year 4+ survival	90.9%	
Relative productivity of mitigation option	0.0102 eagle electrocutions per pole per year over 30 years	R. Harness, R. Lehman, EDM International, Fort Collins, CO, unpublished. Mitigation involves retrofitting of electric power poles, thus avoiding the loss of Golden Eagles from electrocution. Proper operation and maintenance (O&M) of the retrofitted poles is required for the 30-year life of the wind power project to achieve this relative productivity.
Discount rate	3%	A 3% discount rate is commonly used for valuing lost natural resource services (Freeman, 1993; Lind, 1982; NOAA, 1999; and court decisions on damage assessment cases)
Additional factors		Migration in model, superproducer, natal dispersion, age at first breeding. Jim Watson, Pete Bloom, Karen Steenhof, 12/22/10

Golden Eagle REA

Tables F-4 through F-11 provide the results of the 16 steps of the Golden Eagle REA. The discount factor for a 3% discount rate is calculated as $(1+r)^{P-t}$, where *r* is the discount rate, *P* is the present time period, and *t* is the time period of lost services. In 2011, for example, the discount factor is 1.0, because any number raised to the zero power equals 1.0 ($1.03^{(2011-2011=0)} = 1.0$). Readers should be aware that more than the usual one or two significant digits are shown for the computed values. This choice is not intended to convey an excessive level of confidence in the calculations. Rather, the decision was made to provide sufficient information to maximize the transparency and reproducibility of the results.

Table F-4
Golden Eagle REA Debit: Direct Loss from a Take in 2011*
(REA Steps 1-5)

	Discount	Age Class									
Year	**Factor**	**(0-1)**	**(1-2)**	**(2-3)**	**(3-4)**	**(4-5)**	**(5-6)**	**(6-7)**	**(7-8)**	**(8-9)**	**(9-10)**
2011	1.00	1.000	0.583	0.583	0.583	0.087	0.087	0.087	0.087	0.087	0.087
2012	0.97		0.895	0.522	0.522	0.557	0.083	0.083	0.083	0.083	0.083
2013	0.94			0.707	0.412	0.475	0.506	0.075	0.075	0.075	0.075
2014	0.92				0.559	0.375	0.431	0.460	0.068	0.068	0.068
2015	0.89					0.508	0.341	0.392	0.418	0.062	0.062
2016	0.86						0.462	0.310	0.356	0.380	0.056
2017	0.84							0.420	0.282	0.324	0.346
2018	0.81								0.381	0.256	0.295
2019	0.79									0.347	0.233
2020	0.77										0.315

	Discount										
Year	**Factor**	**(10-11)**	**(11-12)**	**(12-13)**	**(13-14)**	**(14-15)**	**(15-16)**	**(16-17)**	**(17-18)**	**(18-19)**	**(19-20)**
2011	1.00	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087
2012	0.97	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083
2013	0.94	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
2014	0.92	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068
2015	0.89	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062
2016	0.86	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056
2017	0.84	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051
2018	0.81	0.314	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047
2019	0.79	0.268	0.286	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
2020	0.77	0.212	0.243	0.260	0.039	0.039	0.039	0.039	0.039	0.039	0.039
2021	0.74	0.286	0.192	0.221	0.236	0.035	0.035	0.035	0.035	0.035	0.035
2022	0.72		0.260	0.175	0.201	0.214	0.032	0.032	0.032	0.032	0.032
2023	0.70			0.237	0.159	0.183	0.195	0.029	0.029	0.029	0.029
2024	0.68				0.215	0.144	0.166	0.177	0.026	0.026	0.026
2025	0.66					0.196	0.131	0.151	0.161	0.024	0.024
2026	0.64						0.178	0.119	0.137	0.146	0.022
2027	0.62							0.162	0.108	0.125	0.133
2028	0.61								0.147	0.099	0.113
2029	0.59									0.134	0.090
2030	0.57										0.121

Table F-4 (continued)
Golden Eagle REA Debit: Direct Loss from a Take in 2011
(REA Steps 1-5)

Year	Discount Factor	(20-21)	(21-22)	(22-23)	(23-24)	(24-25)	(25-26)	(26-27)	(27-28)	(28-29)	(29-30)	Total Direct Bird-Years	Total Lost Bird-Years in PV	Reproducing Subset
2011	1.00	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	5.000	--	2.163
2012	0.97	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	4.561	4.428	2.065
2013	0.94	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	3.902	3.678	2.308
2014	0.92	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	3.395	3.107	2.461
2015	0.89	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	3.024	2.687	2.516
2016	0.86	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	2.692	2.322	2.692
2017	0.84	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	2.396	2.007	2.396
2018	0.81	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	2.131	1.733	2.131
2019	0.79	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	1.895	1.496	1.895
2020	0.77	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	1.684	1.291	1.684
2021	0.74	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	1.496	1.113	1.496
2022	0.72	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	1.328	0.959	1.328
2023	0.70	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	1.178	0.826	1.178
2024	0.68	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	1.045	0.711	1.045
2025	0.66	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.926	0.612	0.926
2026	0.64	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.820	0.526	0.820
2027	0.62	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.725	0.452	0.725
2028	0.61	0.121	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.641	0.388	0.641
2029	0.59	0.103	0.110	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.567	0.333	0.567
2030	0.57	0.081	0.094	0.100	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.500	0.285	0.500
2031	0.55	0.110	0.074	0.085	0.091	0.013	0.013	0.013	0.013	0.013	0.013	0.441	0.244	0.441
2032	0.54		0.100	0.067	0.077	0.083	0.012	0.012	0.012	0.012	0.012	0.389	0.209	0.389
2033	0.52			0.091	0.061	0.070	0.075	0.011	0.011	0.011	0.011	0.342	0.179	0.342
2034	0.51				0.083	0.056	0.064	0.068	0.010	0.010	0.010	0.301	0.153	0.301
2035	0.49					0.075	0.051	0.058	0.062	0.009	0.009	0.264	0.130	0.264
2036	0.48						0.068	0.046	0.053	0.056	0.008	0.232	0.111	0.232
2037	0.46							0.062	0.042	0.048	0.051	0.203	0.094	0.203
2038	0.45								0.057	0.038	0.044	0.138	0.062	0.138
2039	0.44									0.051	0.035	0.086	0.038	0.086
2040	0.42										0.047	0.047	0.020	0.047
Total													**30.194**	33.983

PV=Present Value

Table F-5
Golden Eagle REA Debit: Statistical Lifespan of One Eagle Fledgling Produced in 2011 (Services Start in 2012)
(REA Steps 6-7)

Year	Discount Factor		Bird-Years/ Fledgling		Bird-Years/ Fledgling in PV
2012	0.97		0.610		0.592
2013	0.94		0.482		0.454
2014	0.92		0.381		0.348
2015	0.89		0.301		0.267
2016	0.86		0.273		0.236
2017	0.84		0.249		0.208
2018	0.81		0.226		0.184
2019	0.79		0.205		0.162
2020	0.77		0.187		0.143
2021	0.74		0.170		0.126
2022	0.72		0.154		0.111
2023	0.70		0.140		0.098
2024	0.68		0.127		0.087
2025	0.66	x	0.116	=	0.077
2026	0.64		0.105		0.068
2027	0.62		0.096		0.060
2028	0.61		0.087		0.053
2029	0.59		0.079		0.046
2030	0.57		0.072		0.041
2031	0.55		0.065		0.036
2032	0.54		0.059		0.032
2033	0.52		0.054		0.028
2034	0.51		0.049		0.025
2035	0.49		0.045		0.022
2036	0.48		0.041		0.019
2037	0.46		0.037		0.017
2038	0.45		0.034		0.015
2039	0.44		0.030		0.013
2040	0.42		0.028		0.012
2041	0.41		0.025		0.010
					3.592

PV= Present Value

Table F-6
Golden Eagle REA Debit: 1st Generation Reproductive Losses from a Take in 2011
(REA Steps 8-11)

Year	Discount Factor	Total # Birds-- Reproducing Age	# Reproducing Females	Total # 1st Gen Fledglings	Bird-Years/ Fledgling in PV	1st Gen Lost Bird-Years Total in PV
2011	1.00	2.163	0.865	0.865	3.592	3.108
2012	0.97	2.065	0.826	0.826	3.484	2.878
2013	0.94	2.308	0.923	0.923	3.379	3.120
2014	0.92	2.461	0.984	0.984	3.278	3.227
2015	0.89	2.516	1.006	1.006	3.180	3.200
2016	0.86	2.692	1.077	1.077	3.084	3.321
2017	0.84	2.396	0.958	0.958	2.992	2.867
2018	0.81	2.131	0.853	0.853	2.902	2.474
2019	0.79	1.895	0.758	0.758	2.815	2.134
2020	0.77	1.684	0.674	0.674	2.730	1.839
2021	0.74	1.496	0.598	0.598	2.649	1.585
2022	0.72	1.328	0.531	0.531	2.569	1.365
2023	0.70	1.178	0.471	0.471	2.492	1.174
2024	0.68	1.045	0.418	0.418	2.417	1.010
2025	0.66	0.926	0.370	0.370	2.345	0.868
2026	0.64	0.820	0.328	0.328	2.274	0.746
2027	0.62	0.725	0.290	0.290	2.206	0.640
2028	0.61	0.641	0.257	0.257	2.140	0.549
2029	0.59	0.567	0.227	0.227	2.076	0.471
2030	0.57	0.500	0.200	0.200	2.014	0.403
2031	0.55	0.441	0.177	0.177	1.953	0.345
2032	0.54	0.389	0.156	0.156	1.895	0.295
2033	0.52	0.342	0.137	0.137	1.838	0.252
2034	0.51	0.301	0.120	0.120	1.783	0.215
2035	0.49	0.264	0.106	0.106	1.729	0.183
2036	0.48	0.232	0.093	0.093	1.677	0.156
2037	0.46	0.203	0.081	0.081	1.627	0.132
2038	0.45	0.138	0.055	0.055	1.578	0.087
2039	0.44	0.086	0.034	0.034	1.531	0.053
2040	0.42	0.047	0.019	0.019	1.485	0.028
Total		33.983	13.593	13.593		**38.723**

PV= Present Value

Table F-7
Golden Eagle REA Debit: 2nd Generation Reproductive Losses from a Take in 2011
(REA Steps 12-13)

		Age Classes									
Year	0	(0-1)	(1-2)	(2-3)	(3-4)	(4-5)	(5-6)	(6-7)	(7-8)	(8-9)	(9-10)
2011	0.865										
2012	0.826	0.697									
2013	0.923	0.665	0.550								
2014	0.984	0.743	0.525	0.435							
2015	1.006	0.793	0.587	0.415	0.343						
2016	1.077	0.810	0.626	0.464	0.328	0.312					
2017	0.958	0.867	0.640	0.495	0.366	0.298	0.284				
2018	0.853	0.771	0.685	0.506	0.391	0.333	0.271	0.258			
2019	0.758	0.686	0.609	0.541	0.399	0.355	0.303	0.246	0.234		
2020	0.674	0.610	0.542	0.481	0.427	0.363	0.323	0.275	0.224	0.213	
2021	0.598	0.542	0.482	0.428	0.380	0.389	0.330	0.293	0.250	0.203	0.194
2022	0.531	0.482	0.428	0.381	0.338	0.346	0.353	0.300	0.267	0.227	0.185
2023	0.471	0.428	0.381	0.338	0.301	0.308	0.314	0.321	0.273	0.242	0.207
2024	0.418	0.379	0.338	0.301	0.267	0.273	0.280	0.286	0.292	0.248	0.220
2025	0.370	0.336	0.300	0.267	0.237	0.243	0.249	0.254	0.260	0.265	0.225
2026	0.328	0.298	0.266	0.237	0.211	0.216	0.221	0.226	0.231	0.236	0.241
2027	0.290	0.264	0.235	0.210	0.187	0.192	0.196	0.201	0.205	0.210	0.215
2028	0.257	0.234	0.209	0.186	0.166	0.170	0.174	0.178	0.183	0.187	0.191
2029	0.227	0.207	0.185	0.165	0.147	0.151	0.155	0.158	0.162	0.166	0.170
2030	0.200	0.182	0.163	0.146	0.130	0.134	0.137	0.140	0.144	0.147	0.151
2031	0.177	0.161	0.144	0.129	0.115	0.118	0.121	0.125	0.128	0.131	0.134
2032	0.156	0.142	0.127	0.114	0.102	0.105	0.108	0.110	0.113	0.116	0.119
2033	0.137	0.125	0.112	0.101	0.090	0.093	0.095	0.098	0.100	0.103	0.106
2034	0.120	0.110	0.099	0.089	0.079	0.082	0.084	0.086	0.089	0.091	0.094
2035	0.106	0.097	0.087	0.078	0.070	0.072	0.074	0.076	0.079	0.081	0.083
2036	0.093	0.085	0.077	0.069	0.062	0.064	0.066	0.068	0.070	0.071	0.073
2037	0.081	0.075	0.067	0.061	0.054	0.056	0.058	0.060	0.061	0.063	0.065
2038	0.055	0.065	0.059	0.053	0.048	0.049	0.051	0.053	0.054	0.056	0.057
2039	0.034	0.045	0.052	0.047	0.042	0.043	0.045	0.046	0.048	0.049	0.051
2040	0.019	0.028	0.035	0.041	0.037	0.038	0.039	0.041	0.042	0.043	0.045
2041	0.000	0.015	0.022	0.028	0.032	0.033	0.035	0.036	0.037	0.038	0.040
2042	0.000	0.000	0.012	0.017	0.022	0.029	0.030	0.032	0.033	0.034	0.035
2043	0.000	0.000	0.000	0.009	0.014	0.020	0.027	0.028	0.029	0.030	0.031
2044	0.000	0.000	0.000	0.000	0.007	0.012	0.018	0.024	0.025	0.026	0.027
2045	0.000	0.000	0.000	0.000	0.000	0.007	0.011	0.016	0.022	0.023	0.024
2046	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.010	0.015	0.020	0.021
2047	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.009	0.014	0.018
2048	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.008	0.012
2049	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.008
2050	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004

Table F-7 (continued)
Golden Eagle REA Debit: 2^{nd} Generation Reproductive Losses from a Take in 2011
(REA Steps 12-13)

Year	(10-11)	(11-12)	(12-13)	(13-14)	(14-15)	(15-16)	(16-17)	(17-18)	(18-19)	(19-20)
2022	0.176									
2023	0.168	0.160								
2024	0.188	0.153	0.146							
2025	0.200	0.171	0.139	0.132						
2026	0.205	0.182	0.155	0.126	0.120					
2027	0.219	0.186	0.166	0.141	0.115	0.109				
2028	0.195	0.199	0.169	0.150	0.128	0.104	0.099			
2029	0.174	0.177	0.181	0.154	0.137	0.117	0.095	0.090		
2030	0.154	0.158	0.161	0.165	0.140	0.124	0.106	0.086	0.082	
2031	0.137	0.140	0.143	0.147	0.150	0.127	0.113	0.096	0.078	0.075
2032	0.122	0.125	0.127	0.130	0.133	0.136	0.116	0.103	0.088	0.071
2033	0.108	0.111	0.113	0.116	0.118	0.121	0.124	0.105	0.093	0.080
2034	0.096	0.098	0.101	0.103	0.105	0.108	0.110	0.112	0.095	0.085
2035	0.085	0.087	0.089	0.091	0.094	0.096	0.098	0.100	0.102	0.087
2036	0.075	0.077	0.079	0.081	0.083	0.085	0.087	0.089	0.091	0.093
2037	0.067	0.069	0.070	0.072	0.074	0.076	0.077	0.079	0.081	0.083
2038	0.059	0.061	0.062	0.064	0.065	0.067	0.069	0.070	0.072	0.074
2039	0.052	0.054	0.055	0.057	0.058	0.060	0.061	0.062	0.064	0.065
2040	0.046	0.047	0.049	0.050	0.051	0.053	0.054	0.055	0.057	0.058
2041	0.041	0.042	0.043	0.044	0.046	0.047	0.048	0.049	0.050	0.052
2042	0.036	0.037	0.038	0.039	0.040	0.041	0.043	0.044	0.045	0.046
2043	0.032	0.033	0.034	0.035	0.036	0.037	0.038	0.039	0.040	0.041
2044	0.028	0.029	0.030	0.031	0.032	0.032	0.033	0.034	0.035	0.036
2045	0.025	0.025	0.026	0.027	0.028	0.029	0.029	0.030	0.031	0.032
2046	0.022	0.022	0.023	0.024	0.025	0.025	0.026	0.027	0.028	0.028
2047	0.019	0.020	0.020	0.021	0.022	0.022	0.023	0.024	0.024	0.025
2048	0.017	0.017	0.018	0.018	0.019	0.020	0.020	0.021	0.022	0.022
2049	0.011	0.015	0.016	0.016	0.017	0.017	0.018	0.018	0.019	0.020
2050	0.007	0.010	0.014	0.014	0.015	0.015	0.016	0.016	0.017	0.017
2051	0.004	0.006	0.009	0.012	0.013	0.013	0.014	0.014	0.015	0.015
2052	0.000	0.003	0.006	0.008	0.011	0.012	0.012	0.013	0.013	0.013
2053	0.000	0.000	0.003	0.005	0.008	0.010	0.011	0.011	0.011	0.012
2054	0.000	0.000	0.000	0.003	0.005	0.007	0.009	0.010	0.010	0.010
2055	0.000	0.000	0.000	0.000	0.003	0.004	0.006	0.008	0.009	0.009
2056	0.000	0.000	0.000	0.000	0.000	0.002	0.004	0.006	0.008	0.008
2057	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.004	0.005	0.007
2058	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.003	0.005
2059	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.003
2060	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002

Table F-7 (continued)
Golden Eagle REA Debit: 2nd Generation Reproductive Losses from a Take in 2011
(REA Steps 12-13)

Year	(20-21)	(21-22)	(22-23)	(23-24)	(24-25)	(25-26)	(26-27)	(27-28)	(28-29)	(29-30)	Subset Total
2032	0.068										1.785
2033	0.065	0.062									1.717
2034	0.072	0.059	0.056								1.645
2035	0.077	0.066	0.054	0.051							1.570
2036	0.079	0.070	0.060	0.049	0.046						1.493
2037	0.084	0.072	0.064	0.054	0.044	0.042					1.415
2038	0.075	0.077	0.065	0.058	0.049	0.040	0.038				1.337
2039	0.067	0.068	0.070	0.059	0.053	0.045	0.037	0.035			1.260
2040	0.059	0.061	0.062	0.063	0.054	0.048	0.041	0.033	0.032		1.185
2041	0.053	0.054	0.055	0.056	0.058	0.049	0.044	0.037	0.030	0.029	1.112
2042	0.047	0.048	0.049	0.050	0.051	0.052	0.045	0.040	0.034	0.027	1.015
2043	0.042	0.043	0.044	0.045	0.046	0.047	0.048	0.040	0.036	0.031	0.924
2044	0.037	0.038	0.039	0.040	0.041	0.041	0.042	0.043	0.037	0.033	0.830
2045	0.033	0.034	0.034	0.035	0.036	0.037	0.038	0.039	0.039	0.033	0.736
2046	0.029	0.030	0.031	0.031	0.032	0.033	0.034	0.034	0.035	0.036	0.645
2047	0.026	0.026	0.027	0.028	0.028	0.029	0.030	0.030	0.031	0.032	0.554
2048	0.023	0.023	0.024	0.025	0.025	0.026	0.026	0.027	0.028	0.028	0.475
2049	0.020	0.021	0.021	0.022	0.022	0.023	0.023	0.024	0.025	0.025	0.406
2050	0.018	0.018	0.019	0.019	0.020	0.020	0.021	0.021	0.022	0.022	0.346
2051	0.016	0.016	0.017	0.017	0.018	0.018	0.018	0.019	0.019	0.020	0.294
2052	0.014	0.014	0.015	0.015	0.016	0.016	0.016	0.017	0.017	0.018	0.249
2053	0.012	0.013	0.013	0.013	0.014	0.014	0.015	0.015	0.015	0.016	0.211
2054	0.011	0.011	0.011	0.012	0.012	0.012	0.013	0.013	0.014	0.014	0.177
2055	0.009	0.010	0.010	0.010	0.011	0.011	0.011	0.012	0.012	0.012	0.148
2056	0.008	0.009	0.009	0.009	0.009	0.010	0.010	0.010	0.011	0.011	0.124
2057	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.010	0.103
2058	0.006	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.084
2059	0.004	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.069
2060	0.003	0.004	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.007	0.056
2061	0.001	0.002	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.045
2062	0.000	0.001	0.002	0.003	0.004	0.005	0.005	0.005	0.005	0.005	0.035
2063	0.000	0.000	0.001	0.002	0.003	0.004	0.004	0.004	0.004	0.005	0.027
2064	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.004	0.004	0.004	0.021
2065	0.000	0.000	0.000	0.000	0.001	0.002	0.002	0.003	0.003	0.004	0.015
2066	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.002	0.003	0.003	0.011
2067	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.007
2068	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.004
2069	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002
2070	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001
Total:											**44.477**

Table F-7 (continued)
Golden Eagle REA Debit: 2nd Generation Reproductive Losses from a Take in 2011
(REA Steps 12-13)

Year	Discount Factor	Total # Birds-- 1st Gen-- Reproducing Age**	# Reproducing Females	Total # 2nd Gen Fledglings	Bird-Years/ Fledgling in PV	2nd Gen Lost Bird-Years Total in PV
2017	0.84	0.284	0.114	0.114	2.992	0.340
2018	0.81	0.529	0.212	0.212	2.902	0.614
2019	0.79	0.784	0.313	0.313	2.815	0.882
2020	0.77	1.035	0.414	0.414	2.730	1.130
2021	0.74	1.271	0.508	0.508	2.649	1.346
2022	0.72	1.508	0.603	0.603	2.569	1.550
2023	0.70	1.685	0.674	0.674	2.492	1.680
2024	0.68	1.812	0.725	0.725	2.417	1.752
2025	0.66	1.895	0.758	0.758	2.345	1.778
2026	0.64	1.944	0.778	0.778	2.274	1.768
2027	0.62	1.963	0.785	0.785	2.206	1.732
2028	0.61	1.959	0.783	0.783	2.140	1.677
2029	0.59	1.935	0.774	0.774	2.076	1.607
2030	0.57	1.896	0.758	0.758	2.014	1.527
2031	0.55	1.845	0.738	0.738	1.953	1.441
2032	0.54	1.785	0.714	0.714	1.895	1.352
2033	0.52	1.717	0.687	0.687	1.838	1.262
2034	0.51	1.645	0.658	0.658	1.783	1.173
2035	0.49	1.570	0.628	0.628	1.729	1.086
2036	0.48	1.493	0.597	0.597	1.677	1.001
2037	0.46	1.415	0.566	0.566	1.627	0.921
2038	0.45	1.337	0.535	0.535	1.578	0.844
2039	0.44	1.260	0.504	0.504	1.531	0.772
2040	0.42	1.185	0.474	0.474	1.485	0.704
2041	0.41	1.112	0.445	0.445	1.440	0.641
2042	0.40	1.015	0.406	0.406	1.397	0.567
2043	0.39	0.924	0.370	0.370	1.355	0.501
2044	0.38	0.830	0.332	0.332	1.314	0.437
2045	0.37	0.736	0.295	0.295	1.275	0.376
2046	0.36	0.645	0.258	0.258	1.237	0.319
2047	0.35	0.554	0.222	0.222	1.200	0.266
2048	0.33	0.475	0.190	0.190	1.164	0.221
2049	0.33	0.406	0.162	0.162	1.129	0.183
2050	0.32	0.346	0.138	0.138	1.095	0.151
2051	0.31	0.294	0.118	0.118	1.062	0.125
2052	0.30	0.249	0.100	0.100	1.030	0.103
2053	0.29	0.211	0.084	0.084	0.999	0.084
2054	0.28	0.177	0.071	0.071	0.969	0.069
2055	0.27	0.148	0.059	0.059	0.940	0.056
2056	0.26	0.124	0.049	0.049	0.912	0.045
2057	0.26	0.103	0.041	0.041	0.885	0.036
2058	0.25	0.084	0.034	0.034	0.858	0.029
2059	0.24	0.069	0.028	0.028	0.832	0.023
2060	0.23	0.056	0.022	0.022	0.807	0.018
2061	0.23	0.045	0.018	0.018	0.783	0.014
2062	0.22	0.035	0.014	0.014	0.760	0.011
2063	0.22	0.027	0.011	0.011	0.737	0.008
2064	0.21	0.021	0.008	0.008	0.715	0.006

Table F-7 (continued)
Golden Eagle REA Debit: 2nd Generation Reproductive Losses from a Take in 2011
(REA Steps 12-13)

2065	0.20	0.015	0.006	0.006	0.693	0.004
2066	0.20	0.011	0.004	0.004	0.673	0.003
2067	0.19	0.007	0.003	0.003	0.652	0.002
2068	0.19	0.004	0.002	0.002	0.633	0.001
2069	0.18	0.002	0.001	0.001	0.614	0.000
2070	0.17	0.001	0.000	0.000	0.595	0.000
Total		44.477	17.791	17.791		**34.238**

Table F-8
Golden Eagle REA Debit: Extrapolation of the Debit from a Take in 2011
to the Total Debit for a Five-Year Renewable Permit

Year	PV Bird-Years
2011	103.155
2012	100.061
2013	97.059
2014	94.147
2015	91.323
Total PV Bird-Years	485.745

Table F-9
Golden Eagle REA Mitigation: Lethal Electric Power Pole Retrofitting;
The Avoided Loss of Direct and Reproductive Bird-Years Associated with
The Relative Productivity of 0.0102 Bird-Years per Pole in 2011
(REA Steps 14-15)

Source of Bird-Years	PV Bird-Years
Avoided Direct Loss of Eagles:	0.06
Avoided Loss--1st Gen	0.08
Avoided Loss--2nd Gen	0.07
Avoided Loss of Eagle Reproduction:	0.15
Relative Productivity (Direct+ Reproductive):	**0.21**

PV= Present Value

Table F-10
Golden Eagle REA Mitigation: Extrapolation of the Relative Productivity of Electric Pole Retrofitting in 2011 Over the 30 Years Associated with the Average Life Cycle of Wind Energy Projects

Year	PV Bird-Years/pole
2011	0.210
2012	0.204
2013	0.198
2014	0.192
2015	0.186
2016	0.181
2017	0.175
2018	0.170
2019	0.165
2020	0.160
2021	0.155
2022	0.151
2023	0.146
2024	0.142
2025	0.137
2026	0.133
2027	0.129
2028	0.125
2029	0.122
2030	0.118
2031	0.114
2032	0.111
2033	0.108
2034	0.104
2035	0.101
2036	0.098
2037	0.095
2038	0.092
2039	0.090
2040	0.087
Total PV Bird-Years	4.202

Table F-11
Golden Eagle REA Scaling: Mitigation Owed for a 5-Year Permitted Take of 25 Golden Eagles (5 Eagles Annually) (REA Step 16)

Total Debit	485.74	PV bird-years for 5 years of Golden Eagle take
÷ Relative Productivity of Electric Pole Retrofitting	÷4.20	Avoided loss of PV bird-years per retrofitted pole
= Mitigation owed	=115.61	Poles to be retrofitted to achieve no net loss

PV=Present Value

APPENDIX G

COMPENSATORY MITIGATION CASE STUDY[7]: POWER POLE RETROFITTING TO COMPENSATE FOR TAKE OF GOLDEN EAGLES

To offset projected and permitted take, retrofitting of non- Avian Power Line Interaction Committee (APLIC) compliant power poles has been selected by the Service as the initial focus of compensatory mitigation projects. Raptor electrocution is a known source of eagle mortality in the United States (Franson *et al.* 1995, Millsap *et al.* 2004, APLIC 2006, Lehman *et al.* 2007, Lehman *et al.* 2010). In particular, Golden Eagles are electrocuted more than any other raptor in North America; Lehman *et al.* (2007) noted Golden Eagles accounted for 50 – 93% of all reported mortalities of raptor electrocutions. Eagles often come into contact with non-APLIC compliant electric transmission poles. These poles are often responsible for the high incidence of eagle mortality, especially in open habitat devoid of natural perches.

Specific utility poles and line spans in need of retrofit due to known mortalities of eagles and other large raptors will be reviewed by the Service and selected for retrofit based on criteria specified below. Those 'problem' power poles and line spans will be referred to the utility companies to be replaced or retrofitted to make them safer for eagles.

The Service will concentrate compensatory mitigation on utility lines meeting the following categories:

1. Known eagle and raptor mortalities from specific power poles and/or span of line.
2. Located where topographic features suggest power poles and/or span of line is the sole perch, elevated above surrounding terrain, and/or provides a broad field of view.
3. Power pole and/or span of line is located 1) near and eagle territory or migration route, or 2) has a high incidence of eagles in the area documented through Breeding Bird Surveys, Christmas Bird Counts, or other annual standardized surveys.
4. Power pole and/or span of line has not received retrofit action since its initial construction.
5. Can be retrofitted within 1 year of permit issuance.
6. Power poles occur in same Bird Conservation Region as take is occurring.
7. Has already been identified as a priority replacement in an existing Avian Protection Plan.

Lehman *et al.* (2007:159) reviewed raptor electrocution literature and found that few research projects could "*demonstrate the reliability of standardized retrofitting procedures.*" Because of the lack of effective monitoring of attempts to reduce power-line mortalities through retrofitting procedures, the Service will emphasize that standardized, unbiased effectiveness monitoring techniques will be used by project proponents and utility companies involved in the compensatory mitigation process as a standard practice. Specific monitoring methods and study

[7] This REA for this case study used parameter estimates specific to golden eagles in the western United States and applies only to take associated with wind facilities and compensatory mitigation in the form of non-APLIC compliant power pole retrofits.

design will be pre-approved by the Service prior to final contracting for any and all monitoring activities. In all phases of this process, the Service's Office of Law Enforcement will be directly involved.

As stated in the Compensatory Mitigation section, a project proponent will have three options for providing compensatory mitigation:

> *Directly contract and fund a Service-approved compensatory mitigation project* - If a project proponent elects to directly contract for the mitigation project, the number of power poles retrofitted must be equivalent to or exceed the REA-generated estimate. The project proponent will have the burden of contracting either with the utility company owning the power poles or a third party to have the power poles retrofitted to protect eagles. Within one year of permit issuance, the project proponent will be responsible for providing the Service with evidence that the mitigation project was completed in the form of 1) documentation showing that the project proponent was financially responsible for the purchase of retrofitting equipment, 2) digital photographs of each power pole retrofitted, and 3) a Geographic Information System (GIS) shapefile containing the locations of all power poles retrofitted. The utility company will be responsible for effectiveness monitoring and maintenance of the retrofits.
>
> *Contribute funds to the National Fish and Wildlife Foundation's Bald and Golden Eagle Protection Act account (NFWF BGEPA)* - If a project proponent elects to contribute to the Service's NFWF NBGEPA account, the monetary contribution will be equivalent to the cost associated with retrofitting the number of power poles generated as compensation from the REA. The Service will use an estimate of $1,000 per pole for determining the monetary contribution based on current estimates ranging from $400 to >$2,000 per pole. These funds will be used to contract directly with a utility company or third party to have power poles retrofitted or otherwise removed to protect eagles. The utility company will be responsible for effectiveness monitoring and maintenance of the retrofits.
>
> *Identify and contribute funds to a third-party mitigation account approved by the Service* - If a project proponent elects to contribute to a third party account, the monetary contribution will be equivalent to the cost associated with retrofitting the number of power poles generated as compensation from the REA. The Service will use an estimate of $1,000 per pole for determining the monetary contribution based on current estimates ranging from $400 to >$2,000 per pole. These funds will be used to contract directly with a utility company or third party to have power poles retrofitted or otherwise removed to protect eagles. Within one year of permit issuance, the contractor will be responsible for providing the Service with evidence that the mitigation project was completed in the form of (1) documentation showing that the contractor was financially responsible for the purchase of retrofitting equipment, (2) digital photographs of each power pole retrofitted, and (3) a Geographic Information System (GIS) shapefile containing the locations of all power poles retrofitted. The utility company will be responsible for effectiveness monitoring and maintenance of the retrofits.

Any fiduciary delivery method should consider the costs of compensating for permitted take via the power pole retrofitting requirement, as well as contributing additional funds to cover the account's overhead charges. For example, the NFWF has minimal overhead charges; other mitigation accounts charges vary. If the NFWF BGEPA account is charged 5% overhead, then the project proponent must cover that overhead charge in addition to the compensatory mitigation charge.

In all three options above, the utility company receiving funds from either the project proponent or a mitigation account will be responsible for monitoring the effectiveness of power pole retrofits and the post-construction maintenance. The costs associated with these activities are not included as compensatory mitigation for permitted take, and therefore, are the responsibility of the utility company. Immediately following the completion of retrofits, monitoring will begin and include: 1) an initial survey to remove all carcasses from within a 10-meter radius centered on the base of each power pole; 2) monthly surveys for no less than 24 months to identify any post retrofit mortalities; 3) all mortalities and associated information should be reported to the Service using the Bird Injury and Mortality Reporting System (BIMRS) within 48 hours; and 4) submittal of monitoring reports to the local Service Ecological Services Field Office annually.

This initial effectiveness monitoring would insure that the method selected to retrofit power poles was immediately effective in stopping raptor mortality caused by the individual pole, or string of utility structures. In addition to this effectiveness monitoring, the utility company would also be responsible for monitoring and maintaining the retrofitted poles over their lifespan; for example, insuring that the retrofit maintains its effectiveness over a period of at least 25 years. This may include replacing any damaged or degraded plastic sleeves used to eliminate or reduce electrocution risk on one or multiple power poles. For a utility company that receives mitigation funds, we encourage development of an APP if they currently do not have one in place.

Monitoring reports should include the following minimal information for any detected mortalities:

1. Date.
2. Species (eagle carcasses must be submitted to the National Eagle Repository).
3. Age and sex.
4. Band number and notation if wearing a radio transmitter or auxiliary marker.
5. Observer name.
6. Decimal-degree latitude longitude or UTM coordinates of the pole and carcass.
7. Condition of the carcass (entire, partial, scavenged).
8. Power pole identification number.
9. High resolution photo of carcass.
10. Distance of the carcass from the pole.
11. Azimuth of the carcass from the pole.
12. Type of power pole.
13. High resolution photo of pole (to include the electrical structure).

As an example of how this process will work regarding contributions to the NFWF BGEPA account (or similar account), we provide the following example derived from the REA for the annual take of five Golden Eagles:

> For this example, we assume an annual take of five Golden Eagles over a five year renewable permit, starting in 2011. This power pole retrofit would occur in calendar year 2011, thus avoiding the potential loss of Golden Eagles from electrocution. Proper operation and maintenance by the utility company of all retrofitted poles is an assumption; hereafter required for the 30-year life cycle of the wind power project. The results of the model are expressed in the total number of electric power poles to be retrofitted to equate to no net loss of 25 Golden Eagles. The REA has estimated 116 power poles will need to be retrofitted to compensate for the estimated take of 25 eagles. The cost of the retrofit of the power poles may then be converted to an estimated minimum total cost of compensatory mitigation funded by the project proponent. If the project proponent chooses to contribute to an account, the cost will be $116,000 ($1,000 per pole X 116 poles) plus any administrative account overhead charges. At the 5 year renewal period for the life of the project, the Service will generate a new REA estimate for compensatory mitigation based on revised take estimates and any new cost estimates.

APPENDIX H

STAGE 5 – POST-CONSTRUCTION MONITORING RECOMMENDED METHODS AND METRICS

1. Fatality Monitoring

Fatality monitoring must be conducted at all wind facilities to meet regulatory permit requirements and should include a rigorous monitoring design that is able to accurately detect mortality events that result from all aspects of the facility operation (e.g., turbine collision, electrocution, collision with utility lines, etc). Fatality monitoring for eagles can be combined with monitoring mortality of other wildlife (and herein we borrow heavily from the *U.S. Fish and Wildlife Service Draft Wind Energy Guidelines*) so long as sampling intensity takes into account the relative infrequency of eagle mortality events. Fatality-monitoring efforts involve searching for eagle carcasses beneath turbines and other facilities to estimate the number of fatalities. The primary objectives of these efforts are to: (1) estimate eagle fatality rates for comparison with the model-based predictions prior to construction, and (2) to determine whether individual turbines or strings of turbines are responsible for the majority of eagle fatalities, and if so, the factors associated with those turbines that might account for the fatalities and which might be addressed via Advanced Conservation Practices (ACPs). This information is also relevant for evaluating micro-siting options when planning a future facility or expansion of the existing facility.

Fatality monitoring results should be of sufficient statistical validity to provide a reasonably precise estimate of the eagle mortality rate at a facility to allow meaningful comparisons with pre-construction predictions, and to provide a sound basis for determining if, and if so which, ACPs might be appropriate. The basic method of measuring fatality rates is the carcass search. All fatality monitoring should include estimates of carcass removal and carcass detection bias (scavenger removal and searcher efficiency) likely to influence those rates, using the currently accepted methods. Fatality and bias correction efforts should occur across all seasons to assess potential temporal variation. Where seasonal eagle concentrations were identified in the Stage 2 assessment, sampling protocols should take these periodic pluses in abundance into account in the sample design.

Some general guidance is given below with regard to the following design issues relative to protocols for fatality monitoring:

1. Duration and frequency of carcass searches.
2. Number of turbines to monitor.
3. Delineation of carcass search plots, transects, and habitat mapping.
4. General search protocol guidance.
5. Field bias and error assessment.
6. Estimators of fatality.

More-detailed descriptions and methods of fatality-search protocols for wildlife in general can be found on the Service Wind website at (http://www.fws.gov/habitatconservation/windpower/wind_turbine_advisory_committee.html).

a. Duration and Frequency of Carcass Searches

As noted previously, fatality monitoring will be required for a minimum of three years at all permitted facilities, likely followed by at least two additional years (or potentiallymore if permits are renewed), perhaps at lower intensity, to assess effectiveness of ACPs. This requirement is consistent with the permit condition stating that periodic monitoring may be required for as long as the data is needed to assess eagle impacts for ongoing activities that continue to cause take (50 CFR 22.26(c)(2)). The carcass-searching protocol should be adequate to estimate the density of eagle carcasses at an appropriate level of precision to make general conclusions about the project.

Carcass searches should occur in all seasons when eagle use of the project area is expected. The sampling protocol should take into possible temporal stratification to account for seasonal pulses in eagle occurrence. The search interval is the interval between carcass searches at individual turbines, and this interval may be lengthened or shortened depending on the carcass removal and decomposition rates and results of field bias and error trials. For large birds like eagles where carcass removal rates are typically low, a longer interval between searches may be sufficient. We recommend using a pilot study to determine an appropriate sampling frequency needed to estimate the density of eagle carcasses with a coefficient of variation (CV) of about 0.2.

b. Number of Turbines to Monitor

We recommend that a sufficient number of turbines be selected via a systematic sample with a random start point. A power analysis could be a useful tool to help decide the appropriate number of turbines to sample to achieve the desired CV in the fatality estimate. Sampling plans can be varied (e.g., rotating panels [McDonald 2003, Fuller 1999, Breidt and Fuller 1999, and Urquhart et al. 1998]) to increase efficiency as long as a probability sampling approach is used. If the project contains fewer than 10 turbines, it is recommended that all turbines in the area of interest be searched unless otherwise agreed to by the permitting or wildlife resource agencies. When selecting turbines, it is recommended that a systematic sample with a random start be used when selecting search transects to ensure interspersion among turbines. Stratification among different habitat types also is recommended to account for differences in fatality rates among different habitats (e.g., grass versus cropland or forest); a sufficient number of turbines should be sampled in each strata.

c. Delineation of Carcass Search Transects and Habitat Mapping

We recommend using a transect-based distance sampling framework for estimating fatalities (Buckland *et al.* 2001, 2004; Laing *et al.* 2003; Rivera-Milán *et al.* 2004). Three studies in Wisconsinshowed that bird carcasses could be found at least100 meters from the turbines (BHE Environmental, Inc. 2010; Drake *et al.* 2010; Gruver *et al.* 2009). We recommend using this distance as a general guide for placing transects relative to turbines, but final decisions regarding search transect placement should be made in discussions with the Service, state wildlife agency, local permitting agency, and/or tribes. Transect placement also needs to take into account distance-sampling assumptions that will need to be met in order to draw proper inferences from the data, including the assumption that transect distribution is independent of eagle carcass distribution (e.g., the perpendicular distance between any carcass and the transect centerline is independent of where the observer is along the centerline). Transects may need to be stratified according to vegetation or ground-cover class where delectability differs markedly between classes. If transects are so stratified, detection and removal biases need to be estimated for each class.

Fatality estimates in the form of carcass density estimates should be made for each class and summed for the total area sampled. Global positioning systems (GPS) are useful for accurately mapping the actual total area searched and area searched in each habitat visibility class, which can be used to adjust fatality estimates.

d. General Search Protocol Guidance

Personnel trained in proper search techniques should look for wildlife carcasses along transects or subplots within each plot and record and collect appropriate data (e.g., exact perpendicular distance from the transect center-line, GPS coordinates, and ancillary data outlined below).

Some locations and circumstances may best be searched using alternative methods such as human and dog teams (Arnett 2006). The olfactory capabilities of dogs could greatly improve the efficiency of carcass searches, particularly in dense vegetation (Homan *et al*. 2001) but using dogs also presents unique challenges that should be considered on a case by case basis. Other experimental mortality detection approaches (e.g., the use of bird-strike indicator sensors, such as microphones, accelerometers or fiber optic sensors, video cameras, or radar to identify circumstances of bird fatalities) are encouraged, but should be considered supplemental to transect surveys until their accuracy and utility has been confirmed by the project proponent and the Service. Where special techniques are employed to increase fatality detections, metadata associated with searches needs to clearly indicate when these tools were employed and when they were not so analyses can be appropriately partitioned.

Data that should be recorded for each search include:

1. Date.
2. Start time.
3. End time.
4. Interval since last search.
5. Observer.
6. Which turbine area was searched (including decimal-degree latitude longitude or UTM coordinates).
7. Weather data for each search, including the weather for the interval since the last search.

When a dead eagle is found, we recommend that the searcher place a flag near the carcass and continue the search. After searching the entire plot, the searcher should return to each carcass and record the following information on a fatality data sheet:

1. Date.
2. Species.
3. Age and sex (following criteria in Pyle 2008) when possible.
4. Band number and notation if wearing a radio-transmitter or auxiliary marker.
5. Observer name.
6. Turbine or pole number or other identifying character.
7. Distance of the carcass from the turbine or pole.
8. Azimuth of the carcass from the turbine or pole.
9. Decimal-degree latitude longitude or UTM coordinates of the turbine or pole and carcass.
10. Habitat surrounding the carcass.
11. Condition of the carcass (entire, partial, scavenged).
12. Description of the mortality (e.g., effect, wing shear, etc.).
13. Estimated time of death (e.g., ≤1 day, 2 days, etc.), and how estimated.
14. A digital photograph of the carcass should be taken.
15. Information on carcass disposition.

In some cases, eagle take permits may specify other biological materials or data that should be collected from eagle carcasses (e.g., feathers, tissue samples). Rubber gloves should be used to handle all carcasses to eliminate possible disease transmission and to reduce possible human-scent bias for carcasses later used in scavenger removal trials. All eagle fatalities (not just those found on post-construction surveys) and associated information should also be immediately reported to the OLE if the project proponent does not have a permit and to the Service's migratory bird permit issuing office if they have an eagle take permit. Mortality should also be reported to the Bird Injury and Mortality Reporting System (BIMRS) within 48 hours of discovery of a carcass. Examples of survey and fatality data sheets proposed for use should be included as attachments to the project proponent's ECP.

e. Field Bias and Error Assessment

Carcass searches underestimate actual mortalities at wind turbines. With appropriate sampling, however, carcass counts can be adjusted to account for biases in detection. Important sources of bias and error include: (1) low or highly variable fatality rates; (2) carcass removal by scavengers; (3) differences in searcher efficiency; (4) failure to account for the influence of site (e.g., vegetative) conditions in relation to carcass removal and searcher efficiency; and (5) fatalities or injured birds that may land or move outside search plots.

In situations like (1) above, when fatalities occur sporadically or in pulses, sampling error may be high. To account for this, we recommend that a sample of turbines be searched much more often than the overall sampling frame. To address bias categories 2-4 above, we recommend that all fatality monitoring efforts conduct carcass removal and searcher-efficiency trials using accepted methods (Kunz *et al.* 2007, Arnett *et al.* 2007, NRC 2007, Huso 2010; also see the

Service Wind website at:
http://www.fws.gov/habitatconservation/windpower/wind_turbine_advisory_committee.html).
Bias trials should be conducted throughout the entire monitoring period and searchers should be unaware of which turbines are to be used or the number of carcasses placed beneath those turbines during trials. There is no suitable method for addressing bias category 5 at present, although we anticipate that with increased post-construction monitoring, this factor will become better understood.

We recommend the following basic approach in designing bias and removal trials. Prior to a trial's inception, a list of random turbine numbers and random azimuths and distances (in meters) from turbines should be generated to guide placement of each carcass used in bias trials. Date of placement, species, turbine number, distance and direction from turbine, and visibility class surrounding the carcass should be recorded for each carcass. Before placement, each carcass should be uniquely marked in a manner that does not cause additional attraction, and its location should be recorded. There is no agreed upon sample size for bias trials, though some state guidelines recommend from 50 to 200 carcasses.

f. Disturbance Monitoring

Project proponents will also be required to monitor many of the eagle nesting territories and communal roost sites identified in the Stage 2 assessments for at least three years after project construction as stated in the permit regulations at 50 CFR 22.26(c)(2). The objective of such monitoring will be to determine if changes in (1) territory or roost occupancy rates, (2) nest success rates, or (3) productivity occur after project construction. Changes will be determined based on comparisons with mean values for each parameter from the Stage 2 assessment.

Eagle nesting territories most likely to be affected by disturbance from a wind facility are those that have use areas within or adjacent to the project boundary. In the absence of radio- or satellite-telemetry data to delineate the precise use areas of proximate nesting eagle pairs, the Service will accept an assumption that all pairs within the mean project-area inter-nest distance (as determined from the Stage 2 assessment) of the project boundary are territories that may be at risk of disturbance (e.g., if the mean distance between simultaneously occupied eagle territories in the Stage 2 assessment is five miles, we would expect disturbance to most likely affect eagles within 5 miles of the project boundary; Figures H-1 though H-4).

Where nesting habitat is patchy or eagle nesting density is low such that nearest neighbors are outside the survey area, we recommend either: (1) using a nearest-neighbor distance at the upper end of what has been recorded for the species in the literature as the project-area inter-nest distance (6.2 miles for Golden Eagles in western North America [Millsap 1981, Kochert *et al.* 2002], and 1.2 miles for bald eagles, from a study in Alaska [Sherrod et al.1976, Buehler 2000]); (2) extending the survey area outward to include nearest-neighbors (which, in this case, lie outside the project-area nesting-population boundary) for the purposes of estimating this value; or (3) undertaking detailed observational or radio- or satellite-telemetry studies of the adult eagles using the isolated nest site(s) to determine the home-range size. Regardless which approach is used, territories that meet this distance criterion should be re-sampled annually for at least three years post-construction following identical survey and reporting procedures as were used in the Stage 2 assessment.

If differences in territory occupancy, nest success, or productivity (taking into account statistical power limitations on detecting significant differences based on sample sizes) are observed, project proponents and the Service will consider possible ACPs that might reduce or eliminate disturbance, and if none are available, project proponents may be required to provide compensatory mitigation to offset the observed effective increase in mortality to the extent necessary to meet the statutory requirement to preserve eagles. For example, if the three-year average for productivity of proximate eagle territories in the Step 2 assessment was 0.8 young per territory over five territories, and during the post-construction monitoring the average was 0.2 young over the same five territories, the effective annual mortality rate from disturbance is 3 eagles per year.)

The Service and the project proponent should agree on a site-specific, post-construction survey protocol for eagle concentration areas identified in Stage 2 and make an *a priori* decision on how to interpret and act on potential outcomes. Mortalities of eagles using proximate communal roosts will be accounted for through the protocol for monitoring post-construction fatalities. However, if communal roosts are no longer used by eagles because of disturbance, that effect should be determined, quantified, and mitigated.

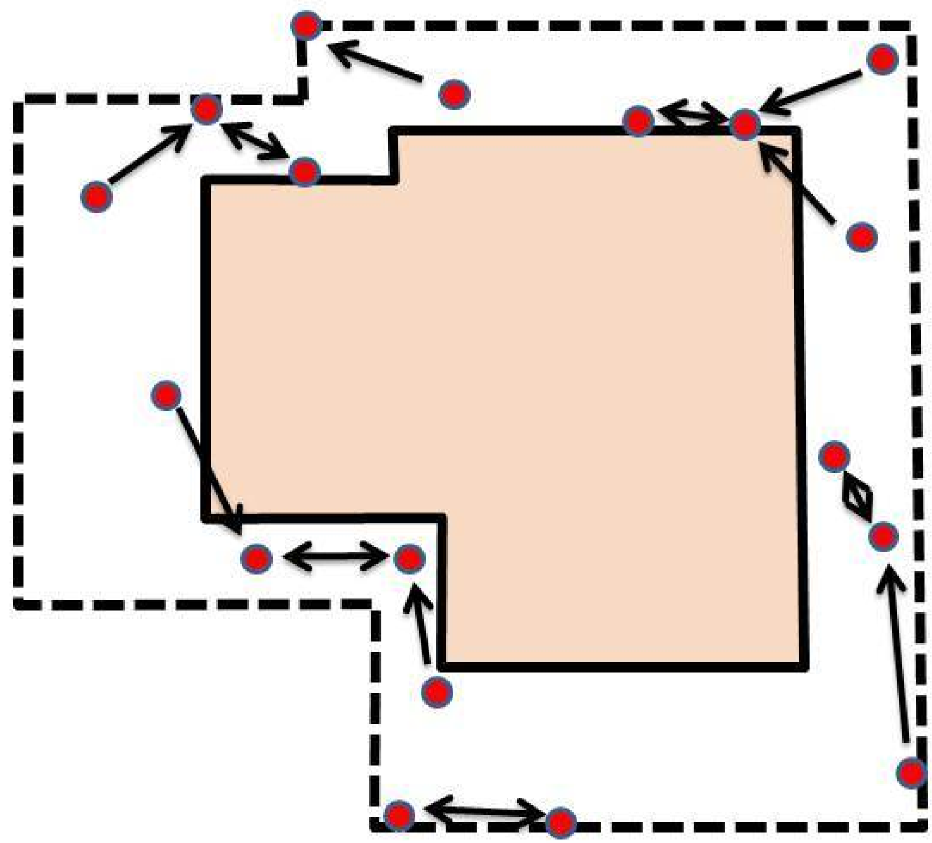

Figure H-1. Map showing hypothetical wind-facility project footprint (area inside the solid-black line, shaded peach), and the recommended project-area for eagle-use area surveys in Stage 2 (inside the dotted line). Red dots denote occupied eagle nests. Arrows represent distance measurements that would be collected and used in the calculation of the mean project-area inter-nest distance. In some cases, nests are reciprocal nearest neighbors (double arrows); in these cases the inter-nest distance is the same for both nests. In other cases, the relationship is not reciprocal (e.g., a nest's nearest neighbor may have closer to another nest; one-way arrows), in which case the two have different inter-nest distance values.

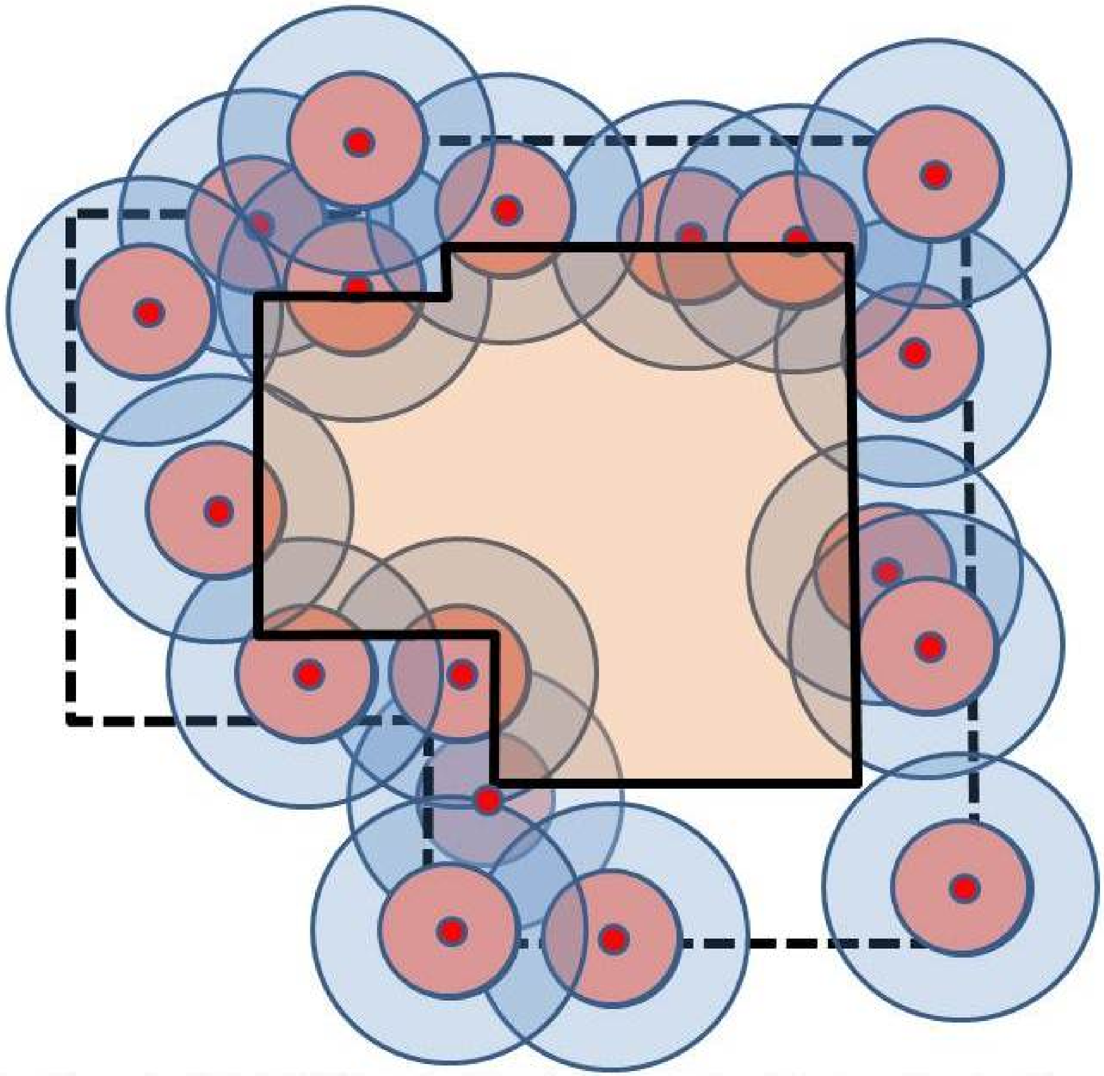

Figure H-2. Map of the same hypothetical wind-facility project as in Fig. H-1. Circles around occupied nests are at the radius of the mean project-area inter-nest distance (blue rings), and ½ the mean project-area inter-nest distance (pink rings), both calculated from the distance measurements collected as described in Fig. H-1.

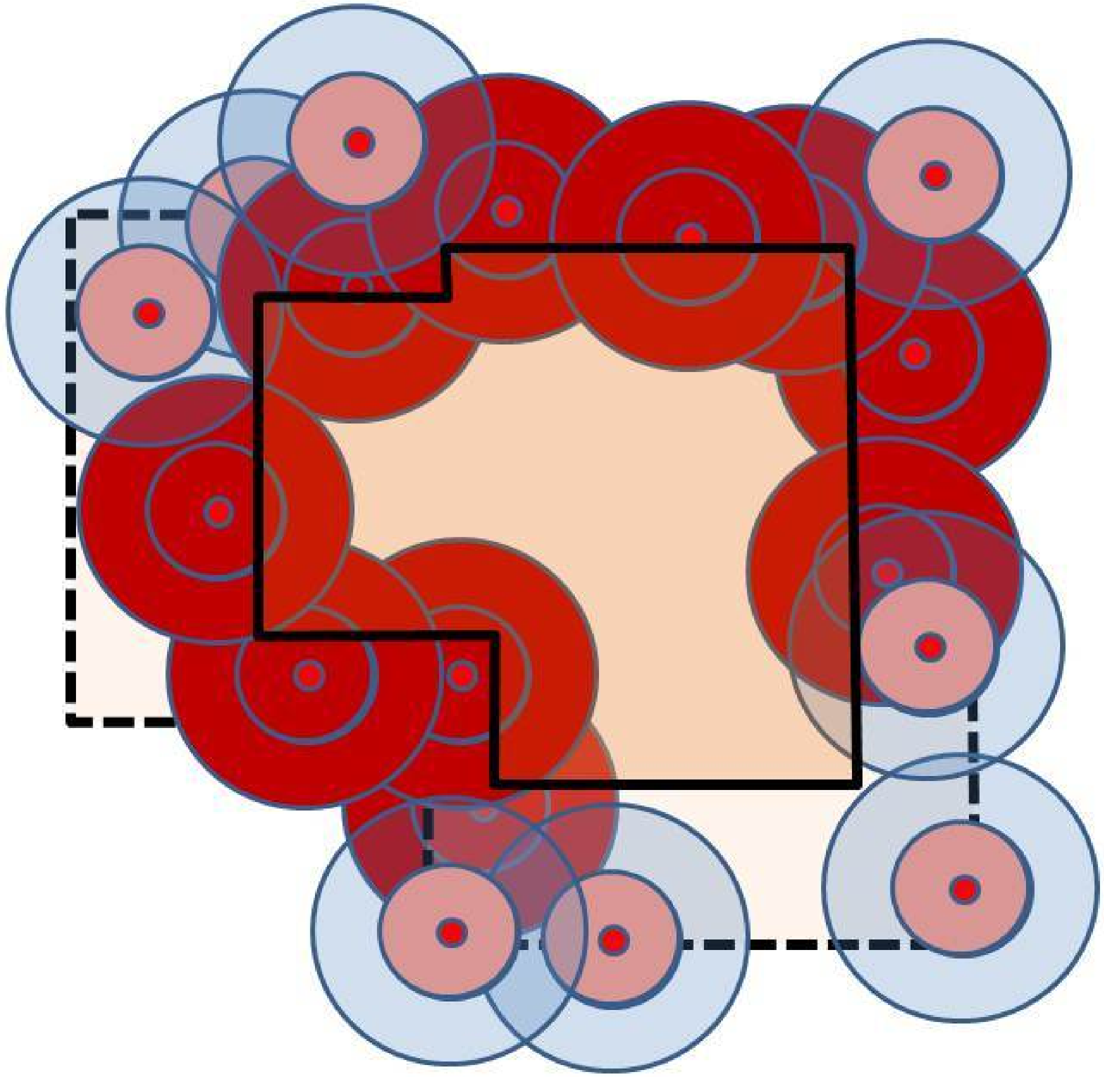

Figure H-3. Map of the same hypothetical wind-facility project area as in Figures H-1 and H-2, after applying site categorization criteria from the Guidelines. The site currently is in category 1 because the footprint includes important eagle-use areas, specifically the area within ½ the project-area inter-nest distance of those nests now highlighted in red.

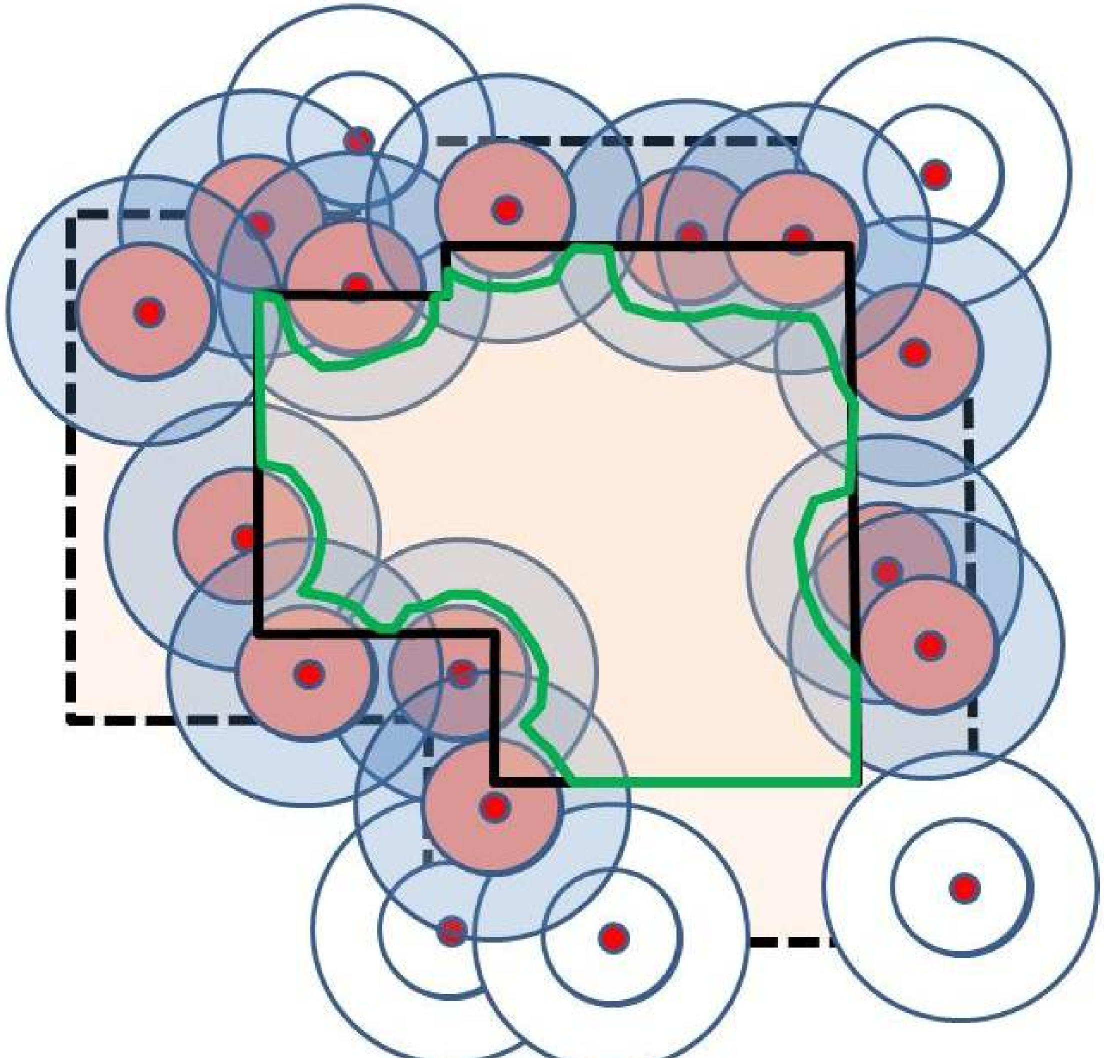

Figure H-4. The same hypothetical wind-facility project as in Figures H-1 – H-3, but re-designed such that the green line now includes the project footprint. The re-design results in the site now being placed in category 2. If the project moves forward and the project proponent receives a programmatic eagle take permit, those territories that are shaded should be monitored for disturbance effects following Stage 5 recommendations because they are at or within one project-area inter-nest distance of the project footprint.

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Rowan Gould, Director U.S. Fish and Wildlife Service

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REGULATING AVIAN IMPACTS UNDER THE MIGRATORY BIRD TREATY ACT AND OTHER LAWS: THE WIND INDUSTRY COLLIDES WITH ONE OF ITS OWN, THE ENVIRONMENTAL PROTECTION MOVEMENT

John Arnold McKinsey[*]

I. INTRODUCTION

In the renewable energy sector, wind-based energy development continues to expand. Federal and state-based programs encourage the development of renewable energy, and wind appears to be taking the lead. Conferences focused in wind energy abound, many at capacity. Many utilities and traditional energy

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companies are aggressively entering this sector. Amidst this booming era for wind energy, however, some problems have been gradually developing. Most are the types of problems any industry expansion must endure, such as equipment reliability problems with new, significantly larger scale, wind turbines.[1] Larger wind turbines mean more visibility, which, predictably, increases the likelihood of visual and aesthetic impact issues.[2] Transmission-related constraints have also arisen as wind energy deals with one significant disadvantage compared to fossil fuels: its immobility. Transmission must come to wind facilities, not vice-versa.[3]

One particularly interesting problem emerging in the wind industry, however, involves a long-time friend of the industry and a long-known issue. Wind energy, like most forms of renewable energy, has long been promoted as being environmentally friendly. To some extent, that is one reason for the push toward renewable energy—the reduced environmental footprint of renewable energy.[4] Thus, many protectors of the environment, long concerned over the effects of excess combustion of fossil fuels in generating electricity, promoted, if not championed, renewable energy in general and, in particular, wind energy. Wind energy is valued in part for its "green" character. It has no direct emissions of air contaminants or green house gasses, and involves almost no recognizable environmental harm in its installation and operation. That is, except for birds.

Avian impacts, originally mostly ignored by many in the development of wind energy, have become a significantly more visible issue for many wind projects.[5] In part, this is due to wind energy's success. As wind energy's role in the United States electricity industry has grown, so too has notice of avian impacts. Birds and bats,[6] of course, collide with wind turbine blades as they

1. During the first major development of wind energy following the energy crises of the 1970's, many designs of gearboxes in the wind turbines that stepped up the slow rotation of the blades to the higher speeds needed for the electricity generator prematurely failed. To some extent, the development of wind turbines was a large field test for the designs. To a lesser degree, the same field test is occurring again with new gearboxes that are larger in scale and size.

2. Witness the controversy raised over the Cape Wind Project off the coast of Massachusetts, where opponents have brought national attention to the visual/aesthetics issues surrounding modern, large wind turbines.

3. In this sense, wind and geothermal energy share the same burden, as both are geographically dependent. Solar, on the other hand, has significantly more flexibility, in terms of being able to be sited near major transmission corridors.

4. Because of their higher supposed environmental impacts, some forms of renewable energy are not as universally embraced, namely bio-mass combustion, hydro-electric, and geothermal power. Wind, solar, and some proposed forms of ocean, wave, current, or tidal energy systems are more universally accepted as "renewable" energy.

5. That is not to say that avian impacts are a new issue to the wind energy industry. The issue has been around for decades. Avian impacts are simply getting harder to resolve and beginning to hinder wind energy development.

6. Bats are not members of the avian class, but rather flying mammals; more specifically order Chiroptera of the class Mammalia. Bird are members of the sister class Aves. Both classes are members of phylum Chordata (vertebrates) of the Animalia kingdom. Bats are treated similar to birds for wind energy purposes because the nature of the impact upon them is the same. As noted later, bats present different issues in terms of assessing impacts because they are nocturnal. In many cases, bats present difficult problems for wind energy projects.

rotate in the sky.[7] Such impacts, often referred to as "avian mortality," would normally be evaluated and managed like many other undesired environmental side-effects. Avian impacts present an awkward issue for the environmental protectors that promoted wind energy. The historical origins of the wind energy industry, combined with several complicating federal laws—the Migratory Bird Treaty Act (MBTA)[8] in particular—have created a growing issue with no resolution in sight. How well the wind industry deals with avian impacts may determine the ability of the industry to continue its amazing success.

This article explores the complexity, and perhaps irony, of the avian impacts issue facing the wind industry. Section II provides background on the history and make up of the wind energy industry and its regulation. Section III explains the laws protecting avian wildlife, particularly the MBTA. The application and enforceability of the MBTA is explained in light of several recent cases that may lead to increased enforcement of the act against some wind projects. Section IV explores the confrontation between wind energy, with its avian impacts, on the one hand and the wildlife protection laws, with their green values and supporters, on the other hand. Section V evaluates the proposed root of the problem, conflicting values, and considers what policy and actions should be taken to resolve the conflict. The article concludes with a call for action by both the legislature and the agencies tasked with enforcement to create a cohesive and updated balance of law and policy that will allow the United States to further tap into its important and vast wind energy resource.

II. BACKGROUND

Wind energy has long been harnessed for its energy content. In terms of electricity production, the energy policies of the late 1970's and early 1980's sparked the first major explosion or growth of wind-based production of electricity. That period of growth lulled in the 1990's, but a new era of growth in the wind energy industry has begun. The current era of growth is fueled in part by improvements in the competitiveness of the underlying technology and in part by governmental policy, incentives, and laws supportive of renewable energy in general and wind energy in particular. The Energy Policy Act of 2005 (EPAct 2005)[9] is one example of recently enacted law and policy that has helped fuel the latest growth in wind energy.

EPAct 2005 promotes renewable energy by providing numerous incentives and assistance to the development of renewable forms of energy. Many states have also taken action to require or encourage the development of renewable energy. A key state-based program has been the Renewable Portfolio Standard (RPS) which requires energy utilities to procure certain percentages of their

7. A seemingly curious debate has long been whether the bird strikes the blade or the blade strikes the bird. The outcome of that debate, however, has serious ramifications for liability and is thus much more than a curious question.

8. 16 U.S.C. §§ 703-11 (2000).

9. Energy Policy Act of 2005, Pub. L. No. 109-58, 119 Stat. 594.

energy from renewable sources.[10] In general, renewable energy is in favor. The term "renewable energy," however, is not without debate as to its meaning.

Generally, renewable energy can be thought of as a source of electricity, heat, or combustible fuel that is consumed at a sustainable pace such that the earth's natural processes replenish those sources at a rate equal to or greater than the depletion.[11] Wind, solar, and geothermal energy are all generally considered types of renewable electricity sources. Of these sources of renewable electricity, harnessing wind energy appears to have the greatest potential for short term development when competitiveness and size of the resource are considered.[12] In 2005, developers installed 2,431 megawatts of wind energy capacity in the United States.[13] Wind energy generation capacity in the United States has grown from essentially zero in 1980 to more than 9,976 MW in 2006.[14]

Wind energy's success in responding to the call for more renewable energy is largely driven by improvements in efficiency, which in turn, are largely driven by a significant increase in the scale of wind projects. Whereas in the 1980's, typical wind projects might have used fifty small turbines and produced five megawatts,[15] today's wind projects might use fifty large wind turbines to produce 100 megawatts.[16] Thus, wind energy facilities have reached the "utility" scale where they are comparable in capacity to a thermal power plant combusting fossil fuels. At the same time, wind energy pricing has come down to close-to comparable levels as well. Wind energy facilities can produce electricity at prices reaching perhaps as low as five cents per kilowatt-hour, compared to three cents per kilowatt-hour for a combustion gas turbine power plant.[17] Since there are significant regions in the United States with untapped wind generation potential, the incentives for and encouragement of renewable energy have led many companies and individuals into a wind land rush. Traditional energy companies, such as Florida Power and Light and AES have joined the ranks of companies devoted to renewable or wind energy, such as Horizon Wind Energy or enXco. Electrical cooperatives, investor owned utilities, and municipal utilities are also increasingly making efforts to develop wind energy.

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10. Adoption of requirements for energy utilities to procure certain percentages of their energy from renewable sources is common. Renewable Portfolio Standards (RPS) programs are the most common.

11. To some, renewable energy is equated with "soft path" energy, a concept that originated with Amory Lovins in the 1970's. Soft path technologies are those that minimize total social cost, those that are the most resource efficient. For many today, renewable energy is equated with "green energy", energy that is less harmful to humans or the natural environment.

12. American Wind Energy Ass'n, *Wind Energy Fact Sheets*, AWEA, Jan. 1, 2007, *available at* http://www.awea.org/pubs/factsheets.html [hereinafter AWEA *Fact Sheets*].

13. *See* American Wind Energy Ass'n, 3 NORTH AMERICAN WINDPOWER 3, at 6 (2006).

14. AWEA *Fact Sheets*, *supra* note 12.

15. The first generation wind turbines available in the early 1980's had up to 25 kilowatts of capacity and reached over 100 feet high. A 100 kilowatt turbine quickly became a common size.

16. Common wind turbines today are available in 1.0, 1.5, 2.0, and 2.5 megawatt sizes. They stand more than 300 above the ground.

17. Wind energy cost varies with the wind energy content of each site whereas fossil fuel powered energy cost varies with fuel costs. Both vary significantly based on location and time.

III. FEDERAL AND STATE LAWS PROTECTING WILDLIFE

The most problematic wildlife protection law for the wind industry is the MBTA. Other laws, however, are actually more aggressively enforced and applied to wind energy projects. Those other federal laws have viable compliance mechanisms in place that allow the wind industry to attempt to manage the development process while dealing with the law. In some cases, however, even compliance mechanisms fail to resolve impact issues. Similarly, state laws often have regulatory mechanisms allowing projects to deal with impacts they may cause. As applied to wind projects, however, the MBTA, lacks compliance mechanisms, making the MBTA much like a sword of Damocles that could come swooping down at any time. As wind energy grows and moves into ever more regions and habitats, and as wind energy projects grow in scale, even routine wildlife protection laws have become more difficult to navigate.

A. Endangered Species Act

The Endangered Species Act (ESA)[18] is perhaps the most recognized federal wildlife law.[19] For avian issues, the ESA is enforced by the United States Fish and Wildlife Services (USFWS).[20] The ESA prohibits the unauthorized take of a listed species.[21] Take is broadly defined to include not only injury or death to a bird, but also can include destruction of an essential habitat.[22] Where a project can anticipate the taking of species, an incidental take permit can be obtained allowing the take to occur as authorized.[23] The USFWS can be required to consult regarding a project's compliance with the ESA where a project requires other federal agency approvals.[24] For projects lacking federal involvement, project owners can request USFWS consultation. Violations of the ESA can lead to criminal prison sentences and penalties. Civil penalties can be as much as $25,000 per violation where as criminal penalties can reach $50,000 and up to one year in prison per violation.[25]

Several bats are listed as endangered or threatened species under the ESA.[26] As discussed further below, bat kills can present a significant problem for wind projects operating in an environment containing bats listed under the ESA.[27]

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18. 16 U.S.C. §§ 1531-43 (2000).

19. For an overview of the ESA, *see generally* THE STANFORD ENVIRONMENTAL LAW SOCIETY, The Endangered Species Act (2001).

20. The USFWS is a division of the Department of the Interior. The ESA assigns the Secretary of the Interior to enforce the ESA. *See also,* 16 U.S.C. § 1533(a) (2000).

21. 16 U.S.C. § 1531 (2000).

22. *Id*. at § 1532.

23. 16 U.S.C. § 1539 (2000).

24. Referred to as a "Section 7 consultation."

25. 16 U.S.C. § 1540 (2000).

26. Six bats found in the continental United States are listed as endangered: the lesser long nosed bat, the Mexican long nosed bat, the gray bat, the Indiana bat, the Ozark big-eared bat, and the Virginia big-eared bat.

27. Besides ESA-listed bats, non-listed bats, if killed in sufficient numbers can also invoke regulatory scrutiny under the general environmental harm prevention statutes, both state and federal. *See infra*, discussion of National Environmental Policy Act, Section IV.D.

The ESA allows private citizen suits alleging violations of the ESA. The potential for citizen suits is often the reason why a wind project might seek USFWS consultation and seek an incidental take permit. Some wind developers choose consultation as a matter of policy and as a protective measure. Wind projects can result in an ESA-take when built in or near essential habitat that will be harmed by construction activities. Wind projects can also cause ESA-take operationally, if a listed species of bird is killed during operation. This latter ESA-take must be predicted based on the presence of endangered species and the probability of those species impacting the turbine tower or blades. An incidental take permit would resolve these potential ESA-takes and is the primary reason why it is sought.

Where take is possible, private individuals and organizations can seek an Incidental Take Permit. This is accomplished by submitting a proposed Habitat Conservation Plan to the USFWS along with an application for an Incidental Take Permit. The process can be as short as three months from application and as long as several years, depending on the complexity of the impacts involved and the availability of resources within the local USFWS office.[28] Generally, the Habitat Conservation Plan must minimize impacts and taking of species and provide mitigation for expected take.[29]

Incidental take permits, however, are not without their own uncertainty. A project owner must initiate the incidental take permit process without certainty as to what the USFWS will require in the form of operational constraints or mitigation costs.[30] The process itself can take several years. For the Incidental Take Permit to be effective, it must accurately predict impacts. Assisting in this regard, the USFWS enacted an assurances rule called the "no surprises rule," which provides assurances that holders of Incidental Take Permits will not have ESA enforcement actions brought against them as long as the species taken was included in the Habitat Conservation Plan, and the requirements of the plan and permit are being followed.[31]

B. Bald and Golden Eagle Protection Act

The Bald and Golden Eagle Protection Act (BGEPA)[32] provides specific protections to Bald and Golden eagles. Like the ESA, the BGEPA is enforced by the USFWS. The BGEPA declares that no person shall take a Bald or Golden eagle and defines take to include the acts of "pursu[ing], shoot[ing], shoot[ing] at, poison[ing], wound[ing], kill[ing], captur[ing], trapp[ing], collect[ing], molest[ing], or disturb[ing]."[33] The meaning of the word "disturbing" in the

28. Notice of Availability of Final Handbook for Habitat Conservation Planning and Incidental Take Permitting Process, 61 Fed. Reg. 63,857 (Dec. 2, 1996).

29. *See generally* United States Fish And Wildlife Service, Habitat Conservation Plans: Section 10 of the Endangered Species Act (Dec. 2006), http://www.fws.gov/Endangered/hcp/HCP_Incidental_Take.pdf.

30. Most areas have "thumb rules" that specialists in that area can provide in advance to developers. Unfortunately, most thumb rules relate to habitat damage, which is not the issue with operational harm such as with avian wind turbine impacts. Still, these thumb rules can translate over if the covered ground surface area is added up and used to compute equivalent acreage requiring offsets.

31. 7 C.F.R. § 222 (1998).

32. Bald and Golden Eagle Protection Act, 16 U.S.C. §§ 668-68d (2000).

33. *Id.* at § 668c.

BGEPA is currently being reviewed by the USFWS for possible regulation clarification or change.[34] The BGEPA differs from the ESA in the fact that its "take" definition does not include damage to habitat. The BGEPA provides for civil penalties regardless of intent, but applies criminal penalties only for "knowingly" causing the death of an eagle or acting with "wanton disregard" of the consequences.[35] The BGEPA provides both criminal and civil penalties.

The BGEPA allows only certain take permits for the express take of eagles and does not contain an incidental take permit program as the ESA does.[36] Thus, as with the ESA, there are means of complying with the law for land use or development projects that risk harm to Bald and Golden eagles.

C. Migratory Bird Treaty Act

The MBTA is, in many ways, a bird of a different feather from the ESA and the BGEPA. It is a much older law, having been enacted in 1918, well before the advent of the environmental protection movement of the sixties and seventies. The MBTA uses very broad language in its prohibition: "[I]t shall be unlawful at any time, by any means or in any manner, to pursue, hunt, take, capture, kill . . . any migratory bird . . . ."[37] The scope of prohibited conduct has been addressed numerous times. Scienter is not required,[38] and the use of the word "any" several times in that prohibition has been interpreted several times to mean that conduct not expressly cited can be included as prohibited conduct.[39] The USFWS is responsible for enforcing the MBTA.

Unlike the ESA, the MBTA has no incidental take permit or its equivalent. Instead, there are only some very specific take permits allowed for specific purposes, such as falconry and scientific collecting.[40] The MBTA itself authorizes take permits for numerous intentional acts including hunting, and there is actually a set of regulations specifically for the hunting of migratory birds.[41] The MBTA reaches a tremendous number of species of birds, currently more than 800.[42] The unauthorized killing of any one of those species constitutes a violation of the MBTA.

The MBTA provides criminal penalties for its violations. Unknowing violations of the MBTA can receive fines up to $15,000 per violation and prison terms up to six months. Knowing violations are felonies and receive fines of $250,000 to $500,000 per violation and up to two years in prison.[43] Several cases have allowed strict liability for the take of migratory birds, even where the

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34. Protection of Bald Eagles; Definition of "Disturb", 71 Fed. Reg. 74,483 (Dec. 12, 2006) (to be codified at 50 C.F.R. pt. 22).

35. Bald and Golden Eagle Protection Act § 668(a).

36. *Id.*

37. Bald and Golden Eagle Protection Act, 16 U.S.C. § 703 (2000).

38. *See generally* United States v. FMC Corp., 572 F.2d 902 (2d Cir. 1978); United States v. Catlett, 747 F.2d 1102, 1104 (6th Cir. 1984).

39. *See generally* United States v. Corbin Farm Serv., 444 F. Supp. 510 (E.D. Cal. 1978).

40. 50 CFR § 10.13 (2005).

41. Migratory Bird Treaty Act, 16 U.S.C. § 705 (2000); 50 C.F.R. § 20 (2006).

42. 50 CFR § 10.13 (2005).

43. Migratory Bird Treaty Act § 707. It is clearly possible that wind turbine avian kills could be considered "knowing violations."

take appears incidental to other conduct. Two cases, *United States v. Corbin Farm Services*,[44] and *United States v. FMC Corporation*,[45] involved criminal sentences for pesticide use that resulted in the killing of migratory birds. In a recent case, *United States v. Moon Lake Electrical Association*,[46] that reaches the electrical power industry, an electrical utility that refused to install bird guards for power lines was found criminally liable for the unintended killing of migratory birds from electrocution.

More realistically, for wind turbine operators, it is fair to expect a punishment commensurate with the crime. Thus, where a wind energy facility has evaluated and taken measures to reduce avian collisions, and where a wind energy facility has engaged federal and state wildlife authorities such as the USFWS, enforcement of the MBTA should be expected to result in lesser or minimal punishments. This might be little consolation to the individual manager or executive facing criminal charges for MBTA violations.

The MBTA is mostly accommodated in the United States by being ignored, or more euphemistically, by "selective enforcement." The doctrine of selective enforcement as a means to comply with the MBTA was expressly stated in a USFWS memorandum.[47] Because the MBTA contains no private right of action, individuals and non-governmental organizations dedicated to the protection of wildlife cannot use the MBTA directly. This lack of a private right of action is what gives the selective enforcement rule its value: if the USFWS does not enforce then there will be no enforcement of the MBTA, since no other agency can enforce it.

Because the MBTA's scope is so expansive, its authority reaches probably every wind energy project. The wind energy industry is not alone. The MBTA's protected birds are killed through collisions with cars and buildings. Electrocution of the MBTA's protected birds has long been a problem in the electric utility industry when birds perch in location that provides a path to ground for power. High voltage power lines can electrocute without a grounding path. As discussed further below, the history of MBTA enforcement against the utility industry and the industry's efforts to establish methods of reducing avian impacts provide insight into the potential problems that the MBTA may present the wind energy industry and also into possible solutions. Mostly, however, the entire industrial sector, including wind energy, depends upon the USFWS's selective enforcement history and the lack of a private cause of action for protection from MBTA liability.

In recent years, there have been several attempts to enforce the MBTA through the Administrative Procedures Act (APA).[48] The theory underlying these attempts argues that when a federal agency fails to comply with a statute when performing an act subject to the APA, then that failure is a violation of the APA. Thus, when the USFWS takes an action related to a wind project—for

44. United States v. Corbin Farm Serv., 444 F. Supp. 510 (E.D. Cal. 1978).

45. United States v. FMC Corp., 572 F.2d 902 (2nd Cir. 1978).

46. United States v. Moon Lake Elec. Assoc., 45 F. Supp. 2d 1070 (D. Colo. 1999).

47. Memorandum from U.S. Dep't of the Interior, Fish and Wildlife Service on Service Interim Guidance on Avoiding and Mitigating Wildlife Impacts from Wind Turbines (May 13, 2003), http://www.fws.gov/habitatconservation/wind.pdf [hereinafter Fish and Wildlife Service].

48. Administrative Procedures Act, 5 U.S.C. § 500-706 (2000).

example issuing an Incidental Take Permit—then USFWS' failure to enforce the MBTA would be actionable under the APA. The two cases addressing this approach on the merits involved challenges to governmental decisions allowing governmental action, not challenges to actions of private individuals. Even then, the first case failed on appeal,[49] and the second case became moot while on appeal because Congress intervened with regulations granting an incidental take permit for the activity.[50] This latter case foreshadows a primary recommendation of this article—that Congress should intervene in the wind energy avian situation and grant an incidental take permit for wind energy impacts.

D. National Environmental Policy Act

The National Environmental Policy Act (NEPA)[51] requires that federal agencies assess the environmental consequences of proposed governmental actions and alternatives available to avoid those consequences.[52] Federal agencies must also prepare detailed documents that detail the environmental analysis.[53] Many states have adopted laws substantially identical or similar to NEPA.[54] NEPA and the state-equivalent NEPA laws present a slightly different type of a wildlife issue than the wildlife-focused laws. While the ESA, the BGEPA, and the MBTA are focused on specific impacts to specific classes or species of wildlife that can be as few as a single animal being harmed or killed, NEPA and NEPA-equivalent laws look at impacts as a whole. The killing of otherwise unprotected birds could still be a forbidden impact to an ecosystem if 100,000 of those birds were killed. As wind energy projects have grown in scale, so to have the scale of their impacts. Thus, modern wind energy projects are much more likely to trigger NEPA level reviews.

When conducting NEPA-style impact assessments for wind energy avian impacts, guidance is needed regarding the method of assessing impacts. Generally, literature studies followed by on-site field inspections are relied upon to generate data from which an assessment of the potential for birds to strike a wind turbine blade is made. The newness of the scale of the wind industry projects and their turbine size has forced recent development of new ideas and standards for assessing avian impacts. For instance, the USFWS issued "Interim Guidance" on avian impact avoidance in 2003.[55] Not only was this guidance "interim" but it also lacked specificity, prompting many in the wind industry to dismiss its value. Similarly, a joint effort is underway by the Wildlife

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49. Sierra Club v. Martin, 110 F.3d 1551 (11th Cir. 1997).

50. Ctr. for Biological Diversity v. Pirie, 201 F. Supp. 2d 113 (D.C. Cir. 2002), *appeal dismissed sub nom*., Ctr. for Biological Diversity v. England, 02-5163, 2003 U.S. App. Lexis 1110 (D.C. Cir. Jan. 23, 2003).

51. National Environmental Policy Act of 1969, 42 U.S.C. §§ 4321-75 (2000).

52. *Id.* at § 4332; NICHOLAS C. YOST & SONNENSCHEIN NATH ROSENTHAL, THE NEPA DESKBOOK (Envtl. Law Inst. 3rd ed. 2003).

53. National Environmental Policy Act § 4332; 40 C.F.R. §§ 1500-05 (2005).

54. According to the Council on Environmental Quality the following states have NEPA-equivalent laws: California, Connecticut, Georgia, Hawaii, Indiana, Maryland, Massachusetts, Minnesota, North Carolina, South Dakota, Montana, New Jersey, New York, Virgina, Washington, and Wisconsin. State Environmental Planning Information (2006), *available at* http://ceq.eh.doe.gov/nepa/states.html.

55. Fish and Wildlife Service, *supra* note 47.

Workgroup Core Group of the National Wind Coordinating Collaborative (NWCC),[56] a voluntary coalition of government, industry, and representatives, to develop and promote consistent standards relating to the avian impacts. This group, however, is still advancing towards such standards.[57]

Lacking clear standards, each federal agency tasked with implementing NEPA must rely upon dueling experts to determine what an effective methodology for assessing avian impacts is. The same problem applies to states having NEPA-equivalent laws. This ad hoc approach breeds controversy and litigation, and, ultimately, increases uncertainty at the expense of project funding viability. Uncertainty is addressed below.

IV. CONFRONTATION

The laws that regulate impacts to avian wildlife in the United States are colliding with renewable energy policy and promotion in the United States. In particular, wind energy systems and the industry as a whole have grown to a scale that wildlife impact issues, long in background, have come to the forefront. Chief among them are avian impacts. Yet the very problem of avian impacts is complicated, if not created, by other federal and state policies and laws that have not been adjusted to reflect current energy policy favoring renewable energy. In short, to continue to sustain the renewable energy boom led by wind energy, Congress and federal agencies and, in some instances, state government, may need to revise existing wildlife protection law and policy.

A. Wind Industry Role in Renewable Energy

Renewable energy has generally been a component of United States energy policy for several decades. Various investigations, rulemaking, and enticements have been required to encourage the development of renewable energy sources. EPAct 2005 extended the wind energy tax credit and had other supportive provisions for renewable energy and wind energy.[58] RPS laws, implemented in a limited form in EPAct 2005 and in broad form by many states, are also encouraging the development of renewable energy.[59] Under an RPS, the governmental unit requires that a certain percentage of electricity be obtained from renewable sources.[60] While the definitions of renewable sources differ from state to state, wind and solar are consistent components. State RPS programs, however, are burgeoning. Currently, seventeen states have adopted

56. *See* The National Wind Coordinating Collaborative, http://www.nationalwind.org [hereinafter NWCC]. The NWCC is a voluntary organization including representatives of the USFWS, utilities, wind energy companies, scientists, and environmental organizations. *Id.*

57. *See generally* NWCC, *Wind Turbine Interactions With Birds and Bats: A Summary of Research Results and Remaining Questions*, Nov. 2004, http://www.nationalwind.org/publications/wildlife/wildlife_factsheet.pdf.

58. Energy Policy Act of 2005, Pub. L. No. 109-58, § 211, 119 Stat. 594.

59. *Id.* § 203.

60. To some, the RPS in EPAct 2005 is not actually an RPS, but rather a purchasing requirement the federal government has imposed upon itself. Under EPAct 2005, the federal government must purchase 7.5% of its energy from renewable sources by 2013. A federal RPS, to some, would be a federal mandate to utilities to achieve minimum portfolio percentages of renewable energy procurement.

RPS standards including California, Colorado, and New York.[61] Typically, an RPS requires around ten to twenty percent of renewable energy procured by a utility to be certified or approved as renewable by a date within seven to fifteen years.

As the call for increasing the reliance upon renewable energy has been growing, it has mostly been answered by wind energy. In part, this is because wind energy had a head start. It does not require the steam power plant of a geothermal project or bio-mass generating station. Likewise it does not rely upon the very new and technical concept of photo-voltaic cells that convert sunlight to electricity as solar does. It does not even require elaborate efforts to collect and harness natural resources like water, as hydroelectricity does. Instead, it harnesses wind in its natural form and converts it to rotational mechanical energy, which is in turn converted to electricity. The idea of harnessing wind to do mechanical work has of course been around since pre-Don Quixote days.[62] Wind is also pervasive across the face of the earth. For all these reasons, wind turbines have proliferated. As the scale of wind turbine projects have grown, allowing better economies of scale, which in turn has led to lower costs per unit of electrical energy, wind energy has dominated the development of renewable electricity sources.

The modern wind generating facility is tremendous in scale. One megawatt to two megawatt turbines are common. The blade tip can reach more than 400 feet in the air on common large sizes. Turbine blade diameters reach more than 250 feet. These large structures are placed in locations according to precise modeling to determine the ideal configuration of locations for a given parcel or set of parcels of land to maximize total generation potential. Wind energy projects are supported by teams of consultants that model, measure, map, evaluate, advise, and predict. Wind energy, however, remains grounded to several basic tenets. First, the location has to be windy on a relatively regular basis. The United States has been publicly and privately mapped numerous times to show the windiest locations in the country. Second, transmission has to be available or feasible to allow the generated electricity to reach the national grid and, in turn, reach users. Those criteria have historically driven wind project locations.

B. Predicting and Assessing Avian Impacts

It is intuitive that flying birds or bats could, and probably will, collide with rotating wind turbine blades. Avian collisions with both moving objects, such as vehicles, and stationary objects, such as buildings, have long been witnessed by humans and generally accepted as a toll the human environment takes on

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61. American Wind Energy Assoc., *State-Level Renewable Energy Portfolio Standards (RPS) Fact Sheet* (Jan. 30, 2005), http://www.awea.org/legislative/pdf/RPS_Fact_Sheet.pdf.

62. Annoying to most wind energy industry members, many journalists cannot resist the temptation to talk of "tilting at windmills" when writing of wind energy news, referring of course to the fictional character, Don Quixote and his mad quest to joust windmills in Miguel de Cervantes Saavedra's DON QUIXOTE DE LA MANCHA. Most annoying about the reference to windmills is that wind-generated electricity does not use a "windmill" but instead a "wind turbine generator" or often just "wind turbine."

wildlife.[63] What is not as well understood is how many birds or bats collide with wind turbines. Even less understood is how many birds or bats *will* collide with a *future* wind project that exists only on paper. Avian impacts, moreover, have not traditionally been a criteria used for site selection. Instead, avian collision issues are mostly dealt with in the permitting phase of a project or perhaps not until actual operation occurs. As the industry has matured, and as the scale of wind projects has grown, environmental laws such as NEPA and NEPA-equivalent laws are increasingly forcing pre-project evaluations of avian and bat impacts and post-project studies of actual impacts. These surveys can also be required to satisfy ESA and BGEPA consultations and incidental take permit process applications.

1. Pre-project Surveys

Pre-project surveys attempt to predict what the impacts *will* be. Thus, pre-project surveys are rooted in prediction science. This science, however, is new and methodologies vary across the country and even within states themselves. The industry and involved agencies are making varied, sometimes conflicting efforts to establish standards for the assessment of avian impacts.

Most commonly, potential avian impact studies include literature research and on-site observations to determine the species and quantities of species that will be present or will pass-through a wind project. Then, an analysis is conducted to determine the specific, probable number of birds that will be injured by the turbine blades. The significance of these injuries is assessed in the context of the applicable laws. For the ESA and BGEPA, each "take" of a protected species requires address. Under the MBTA, in theory, the same should be true for every protected bird, though as discussed, the MBTA largely goes un-enforced in wind projects. Finally, and perhaps most complexly, the effect on bird populations might need to be assessed if a significant quantity of birds will be harmed relative to the population as a whole. This last assessment can involve very subjective and conflicting opinions of ornithologists and other avian experts.

The science and standards of studying avian impacts is evolving. A time tested method is to conduct ground surveys at appropriate times of the year, use the bird counts from those surveys to calculate a theoretical total number of birds, and then apply formulas to predict what percentage of those birds will be killed. The appropriate process for conducting the ground survey is ever changing and is often controversial. For instance, is mere observation enough, or should nets be used to capture ground occupying birds for counting? What time of day should ground surveys be conducted? How many days? What months or seasons should be surveyed? Finally, the biggest question, what about nocturnal birds and, of course, bats?

Nighttime surveys, of course cannot be visual.[64] Auditory surveys are useful for species that make noises, some owls for instance. Otherwise, predicting nighttime bird and bat impacts requires either the use of radar surveys

63. It is worth noting that avian collisions with wind turbines are usually considered to be less than auto and building collisions by an order of magnitude.

64. Though one theoretical method involves shining bright lights briefly to count illuminated birds.

or daytime habitat evaluation. The use of radar is relatively new and at an early stage in its evolution. Birds and bats appear as blips and lines on a radar screen. Each blip and line must be interpreted. Fast moving blips are often bats or small hunting birds. Slow moving ones are often soaring owls. Higher altitude contacts are probably nighttime migrating birds.

2. Operational Studies

Once operational, wind projects are increasingly being required to conduct studies of *actual* impacts. These often require site inspections to count bird carcasses. Bird carcass numbers are manipulated through formulas to assess actual total impacts. Bird carcass counting, while sounding accurate and adequate on paper, is not always supported by interest groups as being accurate or adequate. An injured, mortally or otherwise, but not immediately killed bird or bat might fly some distance before landing. Killed birds and bats might be carried off during the night by predators or scavengers.[65]

Depending on the status of the species killed and the scale of the impacts, operational studies can force projects to obtain additional permits, reduce or stop the operation of some turbines during some periods of the year, or provide off-site mitigation or restoration. Post-operational surveys thus, while allowing certainty after-the-fact to the extent that the study process is generally accepted, creates uncertainty before operations, during permitting and construction. This uncertainty may present problems for project financing. This problem is discussed further below.

An avian impact assessment industry is evolving right along with the wind energy industry. Companies exist that are nearly exclusively studying avian impacts for wind projects. Businesses have started up solely to provide radar survey services for wind projects. Evaluating avian impact risk has become an accepted practice in developing wind energy projects. Such efforts can be very expensive, depending in part on what level of effort is required. In general, avian impact risk evaluation is people-intensive. The various activities all involve individuals watching, catching, and/or counting birds or inspecting the ground for clues as to what birds or bats might utilize the project location. Night time surveys are also costly. Radar surveys alone, must factor in the cost of radar equipment as well as the operator or operators. The biggest problem of all, however, may be that impact standard.

3. Efforts to Standardize Impact Assessment

Standardized avian and bat impact study requirements would be of great value to the wind energy industry. Many efforts have been made or are being made to accomplish that. In 2005, USFWS issued interim guidelines for the wind energy industry.[66] Met with much fanfare, the guidelines were not well received and ultimately were withdrawn. Critics pointed out that the guidelines lacked specificity, the one key component they needed to be effective at

65. Unconfirmed stories circulate of vulture deaths caused by the scavenger bird's efforts to reach killed birds lying on the ground beneath wind turbines.

66. Fish and Wildlife Service, *supra* note 47.

standardizing the prediction and assessment of avian impacts.[67] USFWS probably struggled with the core problem of standardization efforts: not all locations and projects have the same species or the same survey needs. A survey methodology needed at one site might be superfluous at another. Likewise, fall surveys needed at one site might be pointless at another.

Another problem inherent in the USFWS effort lies in the multiple jurisdictional nature of many wind projects. Many wind projects do not involve federal land, making the USFWS and the laws it enforces only part of the regulation of avian impacts at best, and minor involved laws at worst. For many wind projects, state laws also loom large. Thus, a coordinated national effort would be advantageous. Such an effort might lie in the NWCC's efforts to provide sound practices for developing wind resources in the United States.[68]

While standardized assessment methodology might resolve the issues over predicting or measuring avian and bat impacts caused by wind projects, they will not eliminate the other core issue: establishing what impacts will be allowable under what circumstances. This latter problem is creating barriers and uncertainty of its own. A collaboration of utility industry and conservation representatives recently released updates for power line electrocution avoidance. The Avian Power Line Interaction Committee (APLIC) released its 2006 Suggested Practices Manual in November of 2006, which provides comprehensive guidelines for the siting, design, construction, and operation of power lines to reduce avian electrocution.[69] This APLIC effort highlights the concern the electrical industry has over avian impacts and also the industry's need to turn to private cooperative efforts to reduce both avian impacts and liability. Similarly, the wind energy industry is also striving to reduce avian impacts.

C. Mitigating and Reducing Avian and Bat Impacts with Wind Turbines

As wind energy projects began emerging in the late 1970's and early 1980's, it quickly became obvious that avian impacts might require extensive efforts to reduce them by design or practice. What has followed has been a long quest to test various ideas that held promise towards reducing avian impacts. Generally speaking, the methods can be divided into four categories: deterrence through equipment design, project location, and operation, and offsetting mitigation. The science and practice of reducing impacts has found various practices that have reduced avian impacts, but there is growing indications that further progress may be long in coming as few new progressive ideas are emerging.

Early on it was clear that the design of wind turbines and their towers could be improved. One simple solution was to reduce equipment that offered perching opportunities for hunting birds such as hawks and eagles. Single pole towers quickly became preferred over multi-leg lattice towers. Today, as wind

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67. A common criticism was that the guidelines suggested parameters, or a range of parameters, without specifying when a particular parameter should apply and when it should not.

68. NWCC, *supra* note 56.

69. AVIAN POWER LINE INTERACTION COMM., SUGGESTED PRACTICES FOR AVIAN PROTECTION ON POWER LINES: THE STATE OF THE ART IN 2006, *available at* http://www.aplic.org.

turbines have grown in size, single pole towers are the norm. But this may not be for avian impact reduction reasons. In fact, one study evaluating the benefits of eliminating lattice style wind turbine support structures found little or no benefit.[70] Other design ideas have been implemented or are being tested. For instance, experiments have been done and are being done to test various painting schemes on turbine blades, with the idea of making turbine blades more visible and noticeable to birds.[71] There is a theory that newer and larger wind turbines, with their slower more visible motions, might reduce collisions. Still more studies and ideas have involved using radar to steer off birds or placing lights at selected locations to avoid impacts.[72] Bats present a curious problem in regard to deterrence ideas. With their radar, one would presume that bats would be easily able to avoid impacts, yet the high bat-kill rates at some project's plants belie this assumption.[73]

Another approach to avian impact reduction involves location and operation of wind turbines. As the industry has matured, the initial project location decision is increasingly involving evaluation of the potential for avian impacts. Thus, the ultimate way to avoid avian and bat impacts, not building the project, is becoming increasingly viable. High value wind resource areas, however, attract developers so this strategy may only work to deter more risk adverse developers from the major wind resource areas.

D. Wind Energy Confrontations

Some interest groups have risen to challenge established and proposed wind projects in recent years. To date, there have not been any successful defeats or court-ordered shutdowns of wind projects, but the potential for such outcomes appears increasingly possible as opponents gain sophistication and wind projects grow in scale and number. Three example wind project confrontations provide a good overview of the varying types of issues, interests, and laws that are being increasingly fought over.

1. Altamont Pass

A legacy wind resource area, the story of the Altamont Pass, east of the San Francisco Bay area, provides an excellent overview of past and present avian impact issues. Altamont Pass was developed in the early 1980's during the first wind energy boom. These early turbines, often called "first generation" wind turbines, were small in stature and varied tremendously in their design. The blades on most designs were propeller style and spun quickly, often seen as a blur. Altamont Pass, it turned out, while an excellent wind resource area, was also a challenging location to avoid avian impacts. Worse, this area of rolling hills was a primary hunting ground for large birds of prey, raptors. The end

70. *See* CAL. ENERGY COMM'N., A ROADMAP FOR PIER RESEARCH ON AVIAN COLLISIONS WITH WIND TURBINES IN CALIFORNIA (2002), *available at* http://www.energy.ca.gov/reports [hereinafter Cal. Energy Comm'n].

71. *Id.*

72. Cal. Energy Comm'n., *supra* note 70.

73. Bats continue to puzzle researchers. Some projects have a very large bat kill whereas others have minimal bat kill.

result was numerous dead raptors. Actual numbers have never been agreed upon by the various sides in the Altamont Pass confrontations, but a significant number of study efforts have taken place. Estimates often claim that more than 1000 eagles, hawks, and owls are killed each year.[74]

Several legal efforts have been made to stop the operation of the wind turbines in the Altamont Pass or force lengthy detailed environmental studies. Though no lawsuits have prevailed, the responsible permitting agency, the County of Alameda, has ordered an extensive study of avian impacts for the region as part of the gradual retrofitting of the region to new, larger wind turbines. The main challenge to the wind projects there has involved the compliance with the California Environmental Quality Act (CEQA),[75] the NEPA-equivalent law in California. The current operators,[76] meanwhile have been undertaking efforts to assess and reduce, avoid, or mitigate impacts.[77] The transition from the first generation small wind turbines to large, modern generation turbines has also provided an opportunity to compare the generations of wind turbines to determine if modern wind turbines have a lesser impact on a power produced or acreage affected basis.

If Altamont Pass were to be considered for wind development today, the permitting process would certainly be a different story. Whereas in the 1980's, project location selection focused on the wind resource primarily, while today developers must look carefully at the environmental issues a wind resource area presents. Initial studies would readily reveal the high frequency of raptor hunting and that would, in turn, caution development before the scope and cost of liability and remediation could be assessed.

2. Flint Hills

Flint Hills[78] is a tallgrass prairie area in Kansas. Like many of the windy prairie areas of the Midwest it offers sustained high winds that have attracted wind development during the current boom. In some ways, the Flint Hills habitat presents issues similar to those of Altamont Pass. The Flint Hills confrontation, however, differs primarily by its involvement with the MBTA and also by the fact that it is entirely a new project with no history of first generation wind turbine use such as with Altamont Pass

Whereas in Altamont Pass, it was the ESA and NEPA-equivalent CEQA statute that was applied, the challenge in Flint Hills involved an attempt to assert that the project in question would violate the MBTA because it would kill

74. Many opponents came to call the wind turbines in Altamont Pass "bird blenders" a term that has hung on the wind industry like an albatross tied around its neck.

75. CAL. PUB. RES. CODE §§ 21000-177 (West 2005).

76. Originally the wind turbines were owned by many small operators. Gradually these smaller operators were bought out resulting in several wind energy companies owning the vast bulk of the turbines, led by Florida Power and Light which operates more than 2000 of the approximately 5000 wind turbines in the region.

77. *See also* Dale Strickland & Wallace Erickson, Study Plan For Testing Effectiveness of Management Measures for Avian Fatality Risk Reduction at Altamont Pass Wind Resource Area (Nov. 2004) (last visited Jan. 20, 2006), http://www.nationalwind.org/events/wildlife/2004-2/presentations/Strickland_Altamont.pdf.

78. The author's law firm represented the defendants in the Flint Hills cases. This article reflects views solely of the author and not any of the defendants.

migratory birds protected under the Act.[79] The values driving the challenge were mostly the same. Plaintiffs feared the killing of owls, hawks, and eagles along with general damage to the tallgrass prairie habitat by virtue of the project and its impacts on raptors.

The plaintiffs failed. The Tenth Circuit affirmed the District Court's holding that the court lacked jurisdiction under the MBTA for lack of a private cause of action. Going unspoken, in the dismissal of the case, was the answer to the question whether the project would violate the MBTA. In fact, given the broad scope of the MBTA and lack of any permit or exemption allowing take, many felt that it was clear that the project, like nearly all, if not every wind project, would have take of birds protected by the MBTA. Thus, the protection afforded Flint Hills was the same protection relied upon by all wind projects as to the MBTA: lack of a private right of action and the tolerance of the USFWS of the take occurring at wind facilities. Stated another way, wind facility operators avoided the sword of the MBTA at the good grace of the USFWS.

3. Pine Tree

The Pine Tree[80] confrontation illustrates the very complex issue involved when the concerned avian mortality involves an abundant population that is alleged to be threatened with some significant level or injury. The Pine Tree Wind Energy Project is proposed in a rocky canyon area of Southern California receiving little annual rainfall. Thus, its habitat differs significantly from those habitats sustaining large year round bird populations. In Pine Tree, the issue was the impacts to migrating songbirds that might have potentially used the project area for rest and foraging in the spring or fall. Two chapters of the Audubon Society challenged the adequacy of the CEQA Environmental Impact Report[81] as to its assessment of songbird impacts. Specifically, the Audubon chapters claimed that little or no adequate on-site observations or surveys were completed. They thus argued that Songbird impacts had not been properly assessed. The challenge in the Superior Court of California failed and the Audubon chapters appealed. The appeal was pending at the time this article was written.

Pine Tree, while sharing the same underlying statute as Altamont Pass, namely CEQA, involved the fundamental issue of what the legal standard is or should be applied to assess avian impacts to a large population of birds that might migrate through an area. It reflects the current questions of how many years of on-survey data is necessary and how many different months or seasons must be involved in those years. Actual on-site survey methodologies were also questioned. Were mere observations sufficient, or are capture-and-count methods such as mist-netting necessary? Finally, time-of-day or better stated, time-of-night, issues presented themselves. Are nighttime surveys needed? If so, how must they be conducted? Is the use of radar necessary for nighttime

79. Flint Hills Tallgrass Prairie Heritage Foundation v. Scottish Power, 147 Fed. App'x 785 (2005).

80. The author represented the developer of the project in the Pine Tree case in the subject litigation. This article reflects views solely of the author and not those of any party to the litigation.

81. An Environmental Impact Report under CEQA is the functional equivalent of an Environmental Impact Statement under NEPA.

surveys? All these questions remain lurking in the background of most wind projects today. Currently, there is no consensus or legal standard on these issues.

Altamont Pass, Flint Hills, and Pine Tree collectively illustrate the myriad of controversial avian issues and laws facing wind projects today. One notable and consistent feature of these three example confrontations is the mostly local character of the opposition. Most national environmental protection organizations are supportive of wind energy, and many have made such policy declarations. These three projects demonstrate, however, that such mainstream, national leadership has not been able to deter local groups, concerned over local impacts from opposing local projects. In Pine Tree, it was two local Audubon chapters opposing the project, not the national Audubon organization. In Flint Hills, it was a local environmental organization dedicated to protecting the local prairie habitat. The environmental opposition to wind has much more of a NIMBY-ist character than a national environmental organization character. The local character of opposition both helps and hurts. While local opposition can often lack expertise and resources, local opposition can be harder to predict and deal with.

While all three of these projects have not been prevented from continuing towards or sustaining operation, the uncertainty these issues create certainly threatened and perhaps continue to threaten these projects as well as many others.

F. The Development Problem: Uncertainty

The development of a modern wind project costs tens of millions, and often hundreds of millions of dollars.[82] Thus, the source of funds and the willingness of banks or holders of capital to support a project are critical factors in the success of a modern wind project. Traditionally, lenders balance risk with rate of return. For large electrical generating projects, the limits on rate of return, driven by a mostly regulated or competitive market, require limited risk before funding will be released to allow construction. Thus, there is low tolerance for uncertainty in wind energy projects.

Unfortunately, there are multiple sources of uncertainty in wind energy projects. Wind energy faces its own inherent uncertainty as to how much energy will actually be produced.[83] Uncertainty of the ability of the project to obtain permits can, and often does, prevent funding. Uncertainty on costs can be a problem.

The uncertainty brought on by unknown avian impacts, unknown possible consequences to the ability of the project to operate, and unknown mitigation costs can reach all these categories of uncertainty in a wind energy project and can be an unbearable burden on project financing. Avian impacts thus present several distinct challenges to wind energy developers, all related to assessing and

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82. A current rough pricing, based on public data, puts wind projects in the area of $1.5 million per megawatt. Robert Thresher, *Wind Power Today*, EJOURNAL USA, June 2005, *available at* http://usinfo.state.gov/journals/itgic/0605/ijge/thresher.htm.

83. Wind strength varies with time, and projections of the future wind energy production are modeled guesses founded upon wind data from the recent past. Thus nearly all wind projects present production risk.

managing avian and bat impacts: for instance pre-project permitting uncertainty and post-operation risk of reduced operation, shutdown, or fines for avian impacts.

The uncertainty brought on by reliance on selective enforcement of the MBTA is perhaps the most difficult risk to precisely assess. For the time being, resolution of MBTA issues is a fine balancing act, capable of being upset by perhaps just one catastrophic case where a wind energy facility is forced to grapple with take under the MBTA.[84] One can look towards a sister industry, the general electrical utility industry and its history of impact issue and enforcement regarding power line interaction, for an example of the vulnerability of an industry to MBTA attacks.

The lack of clear standards in the assessment of avian impacts not only has created some of the wind energy opposition or concern but is also a source of uncertainty. Unclear standards for assessing impacts make it more questionable that a project will receive a permit and also raise questions regarding how well that permit will sustain a legal challenge. That uncertainty must also be overcome. Fortunately, the passage of time frequently alleviates these sources of uncertainty. Once a statute of limitations on a legal challenge has passed, uncertainty regarding the legitimacy of the studies and impact assessment can become moot. Delays, however, can be devastating to projects. Other permits might expire while the lead permit is undergoing legal challenge. Funding can be made available for only a period of time. Further, some permits have no statute of limitations, leaving the uncertainty in place for all time.[85]

The uncertainty created by the MBTA and the lack of standards in the assessment of avian and bat impacts are problems that require redress if the United States is going to rely on wind energy to meet renewable energy goals. While efforts are underway to perhaps partly resolve the impact assessment problems, the MBTA, ESA, BGEPA, and NEPA still can present problems to a project as to how to resolve its impacts even when known. The MBTA's lack of a compliance mechanism further exacerbates these problems. At the core of these problems, is a fundamental shortcoming in the current energy policy: while EPAct 2005 promotes renewable energy and thus ostensibly raises its value, older laws, with now outdated value systems, have been left as barriers to renewable energy.

V. THE POLICY VALUE GAME: HOW MUCH ENERGY IS A BIRD WORTH?

Allowing effective development of the wind energy resources of the United States will require revising or supplementing now antiquated environmental laws that were not revised to reflect current energy policy. EPAct 2005 promotes renewable energy development as sound policy for the United States in the 21st Century. The question remains, however, whether that policy has been fully implemented at all the required levels and in all the needed locations.

84. As explained above, MBTA compliance for probably all wind energy projects is accomplished through selective enforcement, or more accurately, by the USFWS not enforcing MBTA.

85. *See, e.g.*, Endangered Species Act of 1973, 16 U.S.C. § 1531 (for example, private right of action for violations).

A. Policy Questions

As the United States shifts its energy policy towards renewable energy, reliance upon the vast wind resources of the country is weakened by lack of supporting environmental protection policy. It will not suffice to merely declare renewable energy as being valued and provide incentives for wind energy. The wind energy industry would argue that the United States must also clear the barriers it has presented to energy infrastructure development in the past where those barriers are out of balance with the harm protected against. The wind energy industry would emphasize that a bird killed for a megawatt-hour of renewable, non-foreign wind energy is much more acceptable than a bird killed for a unit of foreign-purchased[86] or non-renewable energy. EPAct 2005 certainly expresses a policy that values new, renewable energy more than fossil-fueled energy.

Detractors to those arguments would hold that renewable energy is only better to the extent that it is compared on an equal playing field. They would argue that a bird is a bird, and a megawatt-hour a megawatt-hour, regardless of whether the energy fit a convenient, popular definition of being "renewable." They would argue that all environmental values should stand for themselves and treat all others, including various sources of energy, equally.

In essence then, the policy question is one of how much energy a bird is worth, and whether it is worth more renewable energy than non-renewable energy. Certainly, all species are not equal in the eyes of environmental law. But the ESA and BGEPA, two laws that treat threatened birds differently than other birds, both have compliance mechanisms. It is the archaic, ancient MBTA that lacks compliance tools. It is the same MBTA that is being resolved by not being enforced. It is the same MBTA that protects a very broad scope of birds. Thus, the true policy problem facing the wind industry is one of a new value clashing with an old value. The MBTA is increasingly coming into focus as a problem for the wind energy industry. It was not a particular problem for other types of electricity generation and thus has not historically stood in the way of energy infrastructure development.

Resolution to this conflict is perhaps stymied by the failure of an important ally to renewable energy, the environmental protection collective, to consider softening any environmental law. The fear is, of course, that allowing any modification might open the floodgates and allow tremendous trimming of environmental protection that would reach beyond renewable energy. Consider the common lobbying on each side of the ESA. Farmers and industry press for changes to the ESA while non-governmental environmental protection organizations maintain a staunch fight against such relaxation. Wind energy thus is hurt by the very relationship it has relied upon to advance in United States energy policy. Organizations that historically fight development of energy

86. The foreign versus non-foreign comparison, though frequently made regarding renewable electricity, is not as sound as when comparing renewable transportation fuels with foreign oil. While significant quantities of transportation fuel come from foreign sources, electricity mainly comes from domestic sources of coal, water, nuclear fuel, and from mostly continental sources of natural gas. It is still legitimate to promote renewable electricity as being non-foreign because it is non-foreign and because it could reduce demands on natural gas and coal, allowing those fuels to increasingly provide thermal heating and, in some cases, transportation fuel.

industry facilities need to understand how they can help and how they can hurt the development of wind energy. To the extent that they too still hold onto older policy values with regard to avian impacts, environmental organizations also need to refresh their policy think.

B. Call for Action

Congress, in advancing an incomplete policy, has to bear the primary responsibility to correct the problem. Logically, Congress should either withdraw its support of renewable energy values or complete its promotion and clear the left over environmental policy of the MBTA. There are several specific actions mostly involving Congress or the USFWS that would significantly reduce the undue hurdles the wind industry must currently clear.

1. Statutory Redefinition of MBTA Take

The simplest and quickest single action Congress could take would be to redefine illegal take under the MBTA to be a killing resulting from an act intended to kill the bird, such as shooting a gun.[87] This would relieve not only wind turbine operators, but also building owners, vehicle drivers, and even household cats, all of whom kill migratory birds on a regular basis.[88] The earlier explained take definition in the MBTA[89] could be changed by the insertion of the phrase "excepting therein incidental harm or death to birds occurring from birds striking structures, including rotating or stationary wind energy turbine blades, reasonably designed to minimize such collisions" as shown below:

> [I]t shall be unlawful at any time, by any means or in any manner, excepting therein incidental harm or death to birds occurring from birds striking structures, including rotating or stationary wind energy turbine blades reasonably designed to minimize such collisions, to pursue, hunt, take, capture, kill . . . any migratory bird . . . .

2. Statutory MBTA Take Permit

An alternative solution involving the MBTA would be for Congress to statutorily authorize a take permit under the MBTA for wind energy facilities. Given the broad willingness of the USFWS to let the MBTA go un-enforced in the face of rapidly rising wind energy development, the USFWS should prove more than willing to support such a take permit for wind energy needs. Creation of a take permit under the MBTA may not require Congressional action. Section 704 of the MBTA authorizes the Secretary of the Interior to allow "taking" of migratory birds.[90] By Congress establishing a statutory take permit, however, there would be no ambiguity about it legitimacy. Congress can probably accomplish this much faster than the regulatory process can be completed.

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87. Recall the discussion above, regarding the question of whether the blade kills the bird or the bird kills itself by striking the blade.

88. Buildings, cars, and domestic cats are commonly believed to be the greatest killers of birds migratory and non-migratory alike.

89. 16 U.S.C. § 703 (2000).

90. *Id.* at § 704 provides: **"[**T]he Secretary of the Interior is authorized and directed, from time to time . . . to determine when, to what extent, if at all, and by what means . . . to allow hunting, *taking*, capture, killing . . . of any such bird . . . and to adopt suitable regulations permitting and governing the same . . . ." (emphasis added).

3. Development of Avian and Bat Impact Assessment Standards

Consistent standards for the assessment of the probable or actual avian impacts of a wind energy project are needed. Because federal law (the MBTA, ESA, BGEPA, and NEPA) create avian impact issues for all wind energy projects, a federal standard that reaches across all of those laws is necessary for it to have value. This logically suggests that the USFWS should accomplish this, or be involved since it enforces, or is key in the application of all of those laws.

The standards need to provide a clear and specific minimum methodology necessary for satisfactorily estimating avian impacts from wind energy. Congress could greatly aid the creation of an avian impact assessment standard by ordering the USFWS to develop a single standard, set of guidelines, or a safe harbor that covers the MBTA, the ESA, the BGEPA, and the USFWS's role in implementation of the NEPA.

A safe harbor or assessment standard should include design and location criteria, acceptable avian impact assessment methodologies, and an impact threshold standard below which a wind project would be deemed compliant with the MBTA. It would need to address the question of the duration and frequency needed for pre-operation studies and present that in the context of varying site conditions.

Alternatively, consultation with the USFWS for ESA, and possibly BGEPA, issues could be deemed a safe harbor for the MBTA. Lacking Congressional mandates, or perhaps in concert with them, cooperative efforts including those of the NWCC should also focus on production of a clear assessment standard. Because the USFWS participates in the NWCC, the effect of such standards would go towards reducing the threat and uncertainty created under the current regime. It would also aid in the quest to standardize assessment methodologies across the states. It would not be as valuable, however, as a USFWS enacted assessment standard for the federal wildlife and environmental laws.

VI. CONCLUSION

The success and growth of wind energy in the United States is leading it into conflict with laws and values in several disciplines. Recent cases show that organized opposition groups have formed and, for various reasons, are fighting against wind energy projects. Besides aesthetic values, a chief issue is avian impacts. Even without successful opposition, the ancient MBTA leaves nearly every wind energy project in a world of uncertainty that could threaten to further challenge the wind energy industry. With the passage of EPAct 2005, the United States has further declared its promotion of the value of renewable energy. That would suggest that it is time to clear the land of laws and regulations founded on old, out-of-date policy that conflict with renewable energy. Congress should act to provide an MBTA exemption for properly designed and permitted wind energy projects. Further, the federal government should help establish clear standards for the assessment of avian impacts that states can or will want to adopt as well. That, coupled with environmental laws reflecting renewable energy values, should allow the wind industry to better move towards utilizing the vast resource of wind energy in the United States.

MODIFIED PROPOSED TEXT AMENDMENTS
MARIN COUNTY DEVELOPMENT CODE (TITLE 22)

SHOWING TRACK CHANGES FROM THE
PLANNING COMMISSION HEARING OF NOVEMBER 23, 2009

22.32.180 – Wind Energy Conversion Systems (WECS)

This Section establishes permit requirements for planned district and non-planned district zones and standards for the development and operation of Wind Energy Conversion Systems (WECS) in compliance with Marin County policies and State and Federal laws and allows and encourages the safe, effective, and efficient use of WECS in order to reduce consumption of utility supplied electricity.

A. **Permit requirements.** Wind Energy Conversion Systems (WECS) are allowed in all zoning districts, except the RF (Floating Home Marina) zoning district, subject to the following permit requirements.

1. **Planned Districts.** Large WECS located in planned district zones shall require the approval of a Master Plan, Precise Development Plan, and Use Permit subject to the development standards outlined in Subsection 22.32.180.B unless the Master Plan and Precise Development Plan requirements are waived in compliance with Section 22.44.040 (Waiver of Master Plan/Precise Development Plan Review) and a Use Permit and Design Review are instead required. Small WECS located in planned district zones shall require Design Review approval, subject to the development standards in Subsection 22.32.180.Bunless exempt in accordance with the development standards in Table 3-8.

2. **Other zoning districts.** Large WECS located in zoning districts other than a planned district shall require Use Permit and Design Review approval, subject to the development standards outlined in Subsection 22.32.180.B. Small WECS shall require Design Review approval, subject to the development standards outlined in Subsection 22.32.180.B unless exempt in accordance with the development standards in Table 3-8.

3. **Time limits.** The approval for a Large WECS shall be granted for a term of no less than 10 years unless it has been inoperative or abandoned for a one-year period. The approval for a Small WECS shall be for an indefinite period unless it has been inoperative or abandoned for a one-year period.

B. **Development standards.**

1. **Small WECS.**

a. All small WECS shall be subject to the development standards in Table 3-8.

b. All Small WECS shall avoid significant impacts to birds and bats as verified by a Bird and Bat Study, using the "California Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development", (California Energy Commission and California Department of Fish and Game,) prepared by a qualified consultant approved by the Marin County Environmental Coordinator.

c. Small-Ministerial WECS shall not result in noise levels that exceed 55 dbA at the property line in residential zoning districts or 60 dbA at the property line of all other zoning districts, except during short-term events such as utility outages and severe wind storms, as verified by specifications provided by the manufacturer.

d. Exceptions to the standards in Table 3-8 for Small-Ministerial WECS shall be considered through the Design Review process pursuant to Chapter 22.42 (Design Review). Exceptions to the standards in Table 3-8 for Small-Discretionary WECS shall be considered through the Use Permit process pursuant to Chapter 22.48 (Use Permits).

e. All Small-Discretionary WECS shall comply with the development standards contained in Sections 22.32.180.C through 22.32.180.H.

TABLE 3-8
SMALL WECS DEVELOPMENT STANDARDS

	Small Discretionary			Small Discretionary		
	Roof-Mounted	Non-Grid -Tied Agricultural Uses	Freestanding	Freestanding		
Min. Parcel Size (acres)	N/A	> 10	N/A	N/A	N/A	N/A
Max. Total Height	10 feet (Above Roof Line)	≤100 feet	≤ 40 feet	>40 - ≤ 100 feet	>100 - ≤ 150 feet	>150 - ≤ 200 feet
Max. Rotor Blade Radius/ Max. Rotor Diameter	7.5 feet/ 5 feet	0.5 x tower height	0.5 x tower height 5 feet	0.5 x tower height	0.5 x tower height	0.5 x tower height
Min. Setback from property line	0.5 x tower height	0.5 x tower height	0.5 x total height	1 x total height	1.5 x total height	2 x total height
Max. Units/Parcel	1	1	1	2	2	2
Min.Unit Separation	N/A	N/A	N/A	1 x tower height	1 x tower height	1 x tower height
Min. Setback from Habitable Structures	N/A	1 x total height	1 x total height	1 x total height	1 x total height	1 x total height

2. Large WECS.

a. Large WECS are allowed only in agricultural zoning districts (A3-A60, ARP, APZ) with a minimum lot size of 20 acres.

b. The minimum setback from property lines shall be a minimum of two times the total height. The minimum setback from habitable structures shall be two times the total height.

c. Large WECS are subject to submittal of a comprehensive environmental assessment prepared by a qualified consultant approved by the Marin County Environmental Coordinator in consultation with the County to determine the development capability and physical and policy constraints of the property The environmental assessment shall include a Bird and Bat Study, using the "California Guidelines for Reducing Impacts to

Birds and Bats from Wind Energy Development", (California Energy Commission and California Department of Fish and Game). Based upon the findings, conclusions and recommendations of the environmental assessment, specific regulations for siting and design on the site can be identified.

d. Exceptions to the standards in Table 3-9 for Large WECS shall be considered through the Use Permit process pursuant to Chapter 22.48 (Use Permits).

e. Large WECS shall comply with the development standards contained in Sections 22.32.180.C through 22.32.180.H.

f. The maximum number of Large WECS that is allowed per parcel shall be established through the permit process.

C. Public notice. Where required, a Notice of the required application(s) shall be provided in compliance with Section 22.118.020 (Notice of Hearing).

Notice of a discretionary permit application for any WECS within five miles of Federal, State, and regional park property shall be provided to the superintendent of the appropriate park.

D. Site and design requirements:

1. General standards. No WECS or supporting infrastructure shall be allowed:

a. Within five times the height or 300 feet, whichever is greater, of a known nest or roost of a listed State or Federal threatened or endangered species or California Department of Fish and Game designated bird or bat 'species of special concern' (unless siting of the WECS preceded nest or roost establishment) based on information in the California Natural Diversity Database, California Partners in Flight Database or a Bird and Bat Study, prepared by a qualified consultant approved by the Marin County Environmental Coordinator.

b. Within five times the height or 300 feet, whichever is greater, of a known or suspected avian migratory concentration point (ridge, valley, peninsula, water body or course, habitat island, concentrated food source) based on a Bird and Bat Study prepared by a qualified consultant approved by the Marin County Environmental Coordinator.

c. Within 1.5 times the height or 100 feet, whichever is greater, of a Stream Conservation Area (SCA), a Wetlands Conservation Area (WCA), a State or Federal listed special status species, a designated archaeological or historical site, or a water course, wetland, pond, lake, bayfront area habitat island, or other significant water body with suitable avian habitat based on a Bird and Bat Study prepared by a qualified consultant approved by the Marin County Environmental Coordinator.

d. Where prohibited by any of the following:

1) The Alquist-Priolo Earthquake Fault Zoning Act.
2) The terms of any conservation easement or Williamson Act contract.
3) The listing of the proposed site in the National Register of Historic Places or the California Register of Historical Resources.

E. **Appearance and visibility:**

In addition to any conditions which may be required by Master Plan/Precise Development Plan or Design Review/Use Permit approvals, all WECS shall comply with the following design standards:

1. All WECS, other than roof-mounted WECS, shall be located downslope a minimum of 300 feet horizontally from a visually prominent ridgeline, unless it can be demonstrated through submittal of a Wind Measurement Study that no other suitable locations are available on the site.

2. WECS shall be designed and located to minimize adverse visual impacts from public viewing places, such as roads, trails, scenic vistas, or parklands.

3. Brand names or advertising associated with any WECS installation shall not be visible from any public access. Only signs warning of the WECS installation are allowed.

4. Colors and surface treatments, materials and finishes of the WECS and supporting structures shall minimize visual disruption. Exterior materials, surfaces, and finishes shall be non-reflective to reduce visual impacts.

5. Exterior lighting on any WECS or associated structure shall not be allowed except that which is specifically required in accordance with Federal Aviation Association (FAA) regulations.

6. Large WECS shall be located in a manner which minimizes their visibility from any existing Federal wilderness area.

7. All new electrical wires and transmission lines associated with WECS shall be placed underground except for connection points to a public utility company infrastructure. This standard may be modified by the Director if the project area is determined to be unsuitable for undergrounding of infrastructure due to reasons of excessive grading, biological impacts, or similar factors.

8. Construction of on-site access routes, staging areas, excavation, and grading shall be minimized. Excluding the access roadway, areas disturbed due to construction shall be re-graded and re-vegetated to as natural a condition as feasibly possible after completion of installation.

9. All permanent WECS related equipment shall be weather-proof and tamper-proof.

10. If a climbing apparatus is present on a WECS tower, access control to the tower shall be provided by one of the following means:

    a. Tower-climbing apparatus located no closer than 12 feet from the ground;

    b. A locked anti-climb device installed on the tower; or

c. A locked, protective fence at least six feet in height that encloses the tower.

11. All WECS shall be equipped with manual and automatic over-speed controls. The conformance of rotor and over-speed control design and fabrication with good engineering practices shall be certified by the manufacturer.

12. Latticed towers shall be designed to prevent birds from perching or nesting on the tower and to not exceed the wind loading forces the tower was designed to withstand. Measures to prevent the nesting and perching of birds on external tower climbing devices and other possible perching and nesting areas shall also be implemented.

13. aThe use of guy wires shall be avoided whenever feasible. If guy wires are necessary, they shall be marked with bird deterrent devices as recommended by USFWS or CDFG.

F. Noise. The noise level of the WECS shall not exceed 55 dbA at the property line in residential zoning districts or 60 dbA at the property line of all other zoning districts, except during short-term events such as utility outages and severe wind storms, as verified by specifications provided by the manufacturer.

G. Application submittal requirements. Except for Small-Ministerial WECS, all WECS permit applications shall include, but may not be limited to, the following information:

1. A plot plan of the proposed development drawn to scale showing:

   a. Acreage and boundaries of the property;

   b. Location of all existing structures, their use and dimensions within five times the height of the proposed WECS;

   c. Location within a distance of five times the total height of the proposed WECS of all wetlands, ponds, lakes, water bodies, watercourses, listed State or Federal special status species habitats, habitat islands, and designated archaeological or historical sites. ;

   d. Location of all proposed WECS and associated structures, and their designated use, dimensions, and setback distances;

   e. Location of all areas to be disturbed by the construction of the proposed WECS project including access routes, trenches, grading and staging areas; and

   f. The height of all trees taller than 15 feet within five times the height of the proposed WECS.

2. Elevations of the components of the proposed WECS.

3. A description of the measures taken to minimize adverse noise, transmission interference, and visual and safety impacts to adjacent land uses including, but not limited to, over-speed protection devices and methods to prevent public access to the structure.

4. A post-installation erosion control, revegetation, and landscaping plan.

5. Standard drawings and an engineering analysis of the system's tower, showing compliance with the Uniform Building Code (UBC), the International Building Code (IBC) or the California Building Code and certification by a professional mechanical, structural, or civil engineer licensed by this state. However, a wet stamp shall not be required, provided that the application demonstrates that the system is designed to meet the UBC or IBC requirements for wind exposure D, the UBC or IBC requirements for Seismic Zone 4, and the requirements for a soil strength of not more than 1,000 pounds per square foot, or other relevant conditions normally required by a local agency.

6. A line drawing of the electrical components of the system in sufficient detail to allow for a determination that the manner of installation conforms to the National Electric Code.

7. Written evidence that the electric utility service provider that serves the proposed site has been informed of the owner's intent to install an interconnected customer-owned electricity generator, unless the owner does not plan, and so states so in the application, to connect the system to the electricity grid.

8. Wind Measurement Study. A wind resource assessment study, prepared by a qualified consultant approved by the Marin County Environmental Coordinator, may be required to be submitted. The study shall be performed for a minimum five-month prime wind period from May to September at the proposed site prior to the acceptance of an application. The study may require the installation of a meteorological tower, erected primarily to measure wind speed and directions plus other data relevant to appropriate siting. The study shall include any potential impacts on existing WECS within a minimum of two miles of the proposed WECS site.

9. Biological Study. All WECS projects before issuance of County building or planning permit approvals shall require the submittal of a biological study, consisting of a Bird and Bat Study using the "California Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development", (California Energy Commission and California Department of Fish and Game), prepared by a qualified consultant approved by the Marin County Environmental Coordinator. The Bird and Bat Study shall identify any listed State or Federal threatened or endangered species or California Department of Fish and Game designated bird or bat 'species of special concern' found to nest or roost in the area of the proposed WECS site. The study shall identify periods of migration and roosting and assess pre-construction site conditions and proposed tree removal of potential roosting sites and, if necessary, provide mitigation measures.

-10. Visual Simulations. Visual simulations taken from a minimum of four off-site views shall be submitted showing the site location with the proposed WECS installed on the proposed site.

-11 Project-Specific Acoustical Analysis. A project-specific acoustical analysis may be required that would simulate the proposed WECS installation to assure acceptable noise levels and, if necessary, provide measures to comply with applicable County noise standards.

H. Post approval.

1. A post-construction avian and bat monitoring program may be required of the owner during periods of nesting and roosting. The application of this requirement shall be in accordance with criteria established by a governmental agency, such as the U. S. Fish and Wildlife Service (USFWS) or the California Department of Fish and Game (CDFG), or the PRBO Conservation Science (PRBO). The required monitoring program shall be conducted by a professional biologist or an ornithologist approved by the Marin County Environmental Coordinator. Monitoring protocol shall be utilized as set forth in the "California Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development", (California Energy Commission and California Department of Fish and Game). Operation of a WEC determined to be detrimental to avian and bat wildlife may be required to cease operation for a specific period of time or may be required to be decommissioned.

2. Before issuance of a building permit, the owner/operator of any WEC shall enter into a "WECS Decommission and Reclamation Plan Agreement" with the County, outlining the anticipated means and cost of removing the WECS at the end of its serviceable life or upon becoming a discontinued use. The owner/operator shall post suitable financial security as determined by the County in order to guarantee removal of any WECS that is non-operational or abandoned. The plan must include in reasonable detail how the WECS will be dismantled and removed. The WECS must be dismantled and removed from the premises if it has been inoperative or abandoned for a one-year period. Decommissioning shall include removal of all equipment, and may require removal of all foundations and other features such as fencing and access roads to the satisfaction of the Director. The owner/operator, at his/her expense shall complete the removal within 90 days following the one-year period of non-operation, useful life, or abandonment, unless an extension for cause is granted by the Director or a plan is submitted outlining the steps and schedule for returning the WECS to service to the satisfaction of the Director. The "WECS Decommission and Reclamation Plan Agreement" shall be recorded by the Community Development Agency against the title of the property.

3. Any encumbrances placed on a parcel or parcels due to the installation of a WECS system shall remain in effect for as long as the WECS is on the site, and these encumbrances shall hold equal weight and be cumulative with respect to other limitations on the development of the parcel or parcels. Such encumbrances may not be the basis for granting variances or any other exception to the Marin County Development Code or Marin Countywide Plan regardless of any other additional development constraints imposed on the parcel or parcels. It is the owner's due diligence responsibility to ensure the siting of the WECS will not impose future development restrictions that are unacceptable to the owner.

4. Construction monitoring of individual projects may be required to include, but not be limited to, surveys and/or inspections as needed, to ensure on-site compliance with all permit requirements, until implementation of requirements is complete.

5. Upon the completion of construction and before final inspection, solid and hazardous wastes, including, but not necessarily limited to, packaging materials, debris, oils and lubricants, shall be removed promptly from the site and disposed of in accordance with all applicable County, State and Federal regulations. No hazardous materials shall be stored on the WECS site.

22.130.030 – Definitions of Specialized Terms and Phrases.

W. Definitions, "W."

Wind Energy Conversion System (WECS) (land use). This land use is defined as any machine that converts the kinetic energy in the wind into a usable form of mechanical or electrical energy. The WECS consists of all parts of the system, including the tower, wind turbine, generator, rotor, blades, supports, and transmission equipment. Additional WECS definitions include:

Small Wind Energy Conversion System. Small WECS are comprised of Small-Ministerial and Small-Discretionary WECS systems, as defined below.

Small-Ministerial Wind Energy Conversion System. This land use is defined as: (1) any small free-standing WECS up to 40 feet in total height above grade; (2) a roofmounted WECS utilizing a horizontal-axis wind turbine (HAWT) or a vertical-axis wind turbine (VAWT) and not exceeding 10 feet in height above the roof line of the structure; or (3) a non-grid-tied WECS used solely to pump water for agricultural uses and not exceeding 100 feet in height.

Small-Discretionary Wind Energy Conversion System. This land use is defined as any WECS project up to 200 feet in total height above grade.

Large Wind Energy Conversion System. This land use is defined as any WECS project greater than 200 feet in total height above grade..

Guy Wires. Wires used to secure wind turbines or towers that are not self-supporting.

Rotor Blade. The part of a wind turbine that interacts with wind to produce energy. It consists of the turbine's blades and the hub to which the blades attach.

Tower. The tower is the support structure, including guyed monopole and lattice types, upon which a wind turbine or other mechanical device is mounted as part of a wind energy system.

Tower Height (WECS). The tower height is the height from natural grade of the upper-most fixed portion of the tower excluding the length of any vertical axial-rotating turbine blade.

Total Height. The total WECS height is the height from natural grade of the fixed portion of the tower and includes the highest vertical length of any extensions such as the rotor blades of the wind turbine.

Wind Turbine. A wind turbine is a rotating machine which converts the kinetic energy in wind into mechanical energy, which is then converted to electricity.

Wind Turbine Generator. A wind turbine generator converts mechanical energy into electrical energy by means of attaching a generator to a rotating part of a wind turbine.

22.20.060 – Height Measurement and Height Limit Exceptions.

E. Exceptions to height limits:

4. **Spires, towers, water tanks, etc.** Chimneys, cupolas, flag poles, gables, monuments, spires, towers (e.g., transmission, utility, etc.), water tanks, similar structures and necessary mechanical appurtenances may be allowed to exceed the height limit established for the applicable zoning district, subject to the following standards.

   a. The structure shall not cover more than fifteen percent of the lot area at any level.

   b. The area of the base of the structure shall not exceed thousand six hundred square feet.

   c. No gable, spire, tower or similar structure shall be used for sleeping or eating quarters or for any commercial purpose other than that which is incidental to the allowed uses of the primary structure.

   d. No structure shall exceed a maximum height of one hundred fifty feet above grade, except for parcels in the A2 or IP zoning districts.

LAND USE (1)	PERMIT REQUIREMENT BY DISTRICT				See Standards in Section:
	R2 Residential Two Family	RMP Residential Multiple Planned	RX Residential Mobile Home Park	RF Floating Home Marina	
AGRICULTURAL, RESOURCE AND OPEN SPACE USES					
Agricultural accessory structures	P	MP(4)	--	--	22.32.030
Commercial gardening	P	MP(4)	--	--	
Dairy operations	--	MU(4)	--	--	22.32.030
Fish hatcheries and game reserves	--	MU(4)	--	--	
Livestock operations, grazing	--	MU(4,5)	--	--	22.32.030
Livestock operations, large animals	--	MU(4,5)	--		22.32.030
Livestock operations, sales/feed lots, stockyards	--	MU(4,5)	--	--	22.32.030
Livestock operations, small animals	(5)	MP(5)	--	--	22.32.030
Mariculture/aquaculture	--	MU(4)	--	--	
Nature preserves	--	MU	--	--	
Plant nurseries, with on-site sales	U	MU	--	--	
Plant nurseries, without on-site sales	P	MP	--	--	
Small WECS	P	MP	MP	--	22.32.180
Large WECS	U	MU	MU	--	22.32.180

Indirect Effects of Development on the Flat-tailed Horned Lizard

Final Report Submitted to Arizona Game and Fish Department, Yuma
February 2005

Prepared by

Kevin V. Young and April T. Young

ABSTRACT

We assessed indirect effects of human activity on adjacent populations of flat-tailed horned lizards by sampling plots at increasing distances from agricultural or urban development that abutted undeveloped flat-tailed horned lizard habitat. Surveys consisted of one-hour presence-absence searches on one-hectare plots centered at 50, 250, 450, and 650 meters from disturbance. Detection rates were low, and horned lizard scats were used to indicate presence when lizards were not found. The data were analyzed using logistic regression analysis. Distance to disturbance was found to be a highly significant factor in whether or not flat-tailed horned lizards were present. Probability of presence increased significantly with increasing distance from disturbance, indicating a negative indirect effect to at least 450 m away from agricultural or urban areas. We suspect the impact is mainly due to increased predator density near human activity. Harvester ants, the main prey of flat-tailed horned lizards, were not diminished near agriculture. We did not evaluate presence of invasive species but discuss this as another risk associated with human development.

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INTRODUCTION

Habitat loss through human activities is considered the leading agent of species declines, followed by threats from non-native species (Czech and Krausman 1997, Wilcove *et al.* 1998). Habitat destruction comes from a variety of human activities, with agricultural and urban development topping the list (Wilcove *et al.* 1998). While it is understood that either activity makes former habitat completely unusable for the flat-tailed horned lizard (FTHL), *Phrynosoma mcallii*, the extent to which negative indirect effects impact adjoining populations has not been established (FTHL ICC 2003).

The FTHL has the most limited range of any of the 14 species of horned lizards (Sherbrooke 2003). It is found only in the extreme southwestern corner of Arizona, the southeastern corner of California, and adjoining portions of Sonora and Baja California, Mexico (Stebbins 2003, FTHL ICC 2003). While a variety of human activities have modified or destroyed habitat throughout the Sonoran Desert (Lovich and Bainbridge 1999), agricultural and urban development have been the primary causes of habitat loss within the range of the FTHL. As of 1997 approximately 24,000 acres of FTHL habitat had been converted to agricultural and urban use in Arizona and 877,000 acres in California (Hodges 1997). While it has been suspected that the impact to FTHL populations is greater than the total acreage directly converted to human use (FTHL ICC 2003), no data to measure indirect effects have previously been available.

In May 2004 we conducted a series of time and area-constrained presence-absence searches for FTHL near Yuma, Arizona. We surveyed plots beginning at places of human activity (agricultural or urban development) and extending into adjacent undeveloped desert land, with a goal of assessing whether or not human activities have a measurable indirect effect on FTHL populations.

METHODS

We surveyed 4 plots along a 650 m transect at each of 27 sites, selected randomly from a pool of all possible sites (provided by Fred Wong, Bureau of Land Management, Yuma) that met the following criteria: 1) a sharp edge between agricultural or urban development and undeveloped desert, 2) development was at least one year old, 3) no major road within 200 m, 4) no additional disturbances or other transects within 500 m, and 5) no protruding or recessed edges of the disturbance within 200 m on either side of the transect. We avoided areas close to heavily-traveled roads in order to limit our study to the effects of agricultural and urban development, but a few sites close to roads were included to increase sample size. We conducted some additional surveys away from disturbance to test the methodology, but did not include these in analyses (Fig. 1).

At each of the 27 sites we placed four one-hectare plots in a line going perpendicular to the edge of human activity, for a total of 108 total sample plots. The center of the first plot was placed 50 m from the disturbance (so that one edge of the plot touched the human disturbance), and other plots were placed 250 m, 450 m, and 650 m away from the edge of disturbance.

Each plot was surveyed by a single person. Two observers worked together at a site to survey all 4 plots between sunrise and 9:30 AM. In the case of evening surveys we sampled two plots one evening and the remaining plots the following evening. To survey a plot an observer navigated to the coordinates of the plot center using a handheld GPS unit and flagged the center point with a pin flag. The approximate edges of the plot were delineated by pacing from the center point, and searches were constrained to within these boundaries for one hour. We randomly chose which plots to survey first, with the constraint that a near plot (50 m or 250 m) and a far plot (450 m or 650 m) were always surveyed simultaneously.

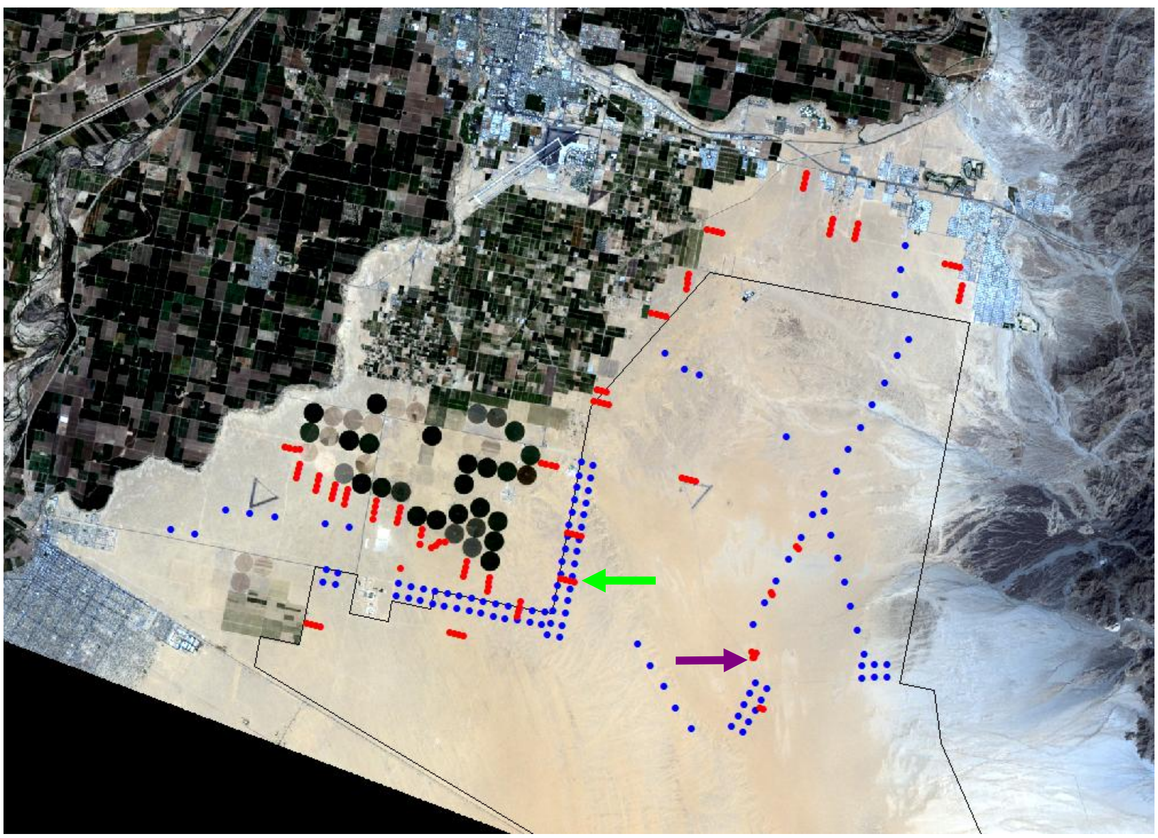
Data that were collected include date, time, location in UTMs, type of disturbance (agricultural, urban, or both), tracking conditions, percentages of different substrate components (fine sand, coarse sand, gravel, rock), number of scat, tracks, and FTHLs found, roundtail ground squirrel (*Spermophilus tereticaudus*) density (high, medium, or low based on tracks, burrows, and vocalizations), number of black harvester ant mounds (*Messor pergandei*) observed, and a density estimate of FTHLs. In short the methodology was similar to the presence-absence surveys conducted in 2003 by Young *et al.* (2004) except that we surveyed each plot for a full hour regardless of whether or not a FTHL was caught because we wanted to estimate FTHL density instead of just determining presence or absence. Factors that we considered for the density estimate included number of FTHLs found, number of tracks, number of scat, distribution of tracks and scat throughout the plot, freshness of tracks and scat, tracking conditions, and overall habitat quality. Tracking conditions were relatively poor this year due to dense annual vegetation and high rodent activity (in response to winter rainfall), so we had to rely more heavily on indirect measures of FTHL presence.

Primarily because of the difficult tracking conditions, we lacked confidence in the density estimates and chose to not present any summary data on these estimates or use them for estimating effects of disturbance. Since 75% of the estimates were either 0 or 1 anyway it seemed prudent to base analyses simply on presence or absence and do a logistic regression analysis instead of a linear regression. We counted presence for any plot where a FTHL was captured, but also for any plot (outside the range of desert horned lizards) with at least 3 scats found, or at least one definite track plus a scat. If we were near where desert horned lizards were known to occur we only counted FTHL captures as presence. During the 2003 presence-absence surveys we only counted presence when we found a FTHL, thus avoiding any false presences but risking false absences. The change in protocol this year is because our ability to find FTHLs was so much lower than last year (due to tracking conditions). We would have created too many false absences if we had relied solely on captures.

We performed a logistic regression analysis using stepwise selection (SAS 2004). Stepwise selection begins with no independent variables in the model. It adds variables one at a time by comparing the *P*-values for the F statistics of the possible independent variables (the variable with the lowest *P*-value is added first). Unlike forward selection, in stepwise selection a variable that has already been added to the model does not necessarily stay there (if the F statistic changes too much in presence of other variables then it is dropped from the model). The stepwise selection process ends when no variable outside the model has an F statistic that is significant at the specified entry level (we used $P < 0.05$ as the entry criteria). The independent variables that were available for selection by the model were distance from disturbance, northing coordinate, easting coordinate, percentages of fine sand, coarse sand, and gravel, tracking rating, type of disturbance, observer, and probability of presence values (from the model of predicted distribution that was created with 2003 presence/absence survey data) (Young *et al*. 2004).

After running the logistic regression model we plotted predicted presence at each sampling distance and compared mean values of these predictions with t-tests. We ran a separate logistic regression analysis that forced type of disturbance (agricultural, urban, or both) to stay in the model to evaluate differences between disturbance types. Data for ground squirrel density and density of active black harvester ant mounds were summarized but not statistically analyzed.

Figure 1. Sample plots for 2004 indicated by red dots. Blue dots indicate 2003 presence-absence samples used to create a model of predicted distribution. Some samples (such as indicated by the green arrow) are adjacent to disturbance that is new since the time of this satellite image in the year 2000. Other samples (such as indicated by the purple arrow) are not adjacent to disturbance and were not included in any analyses. A black line shows the boundaries of the Yuma Desert Management Area



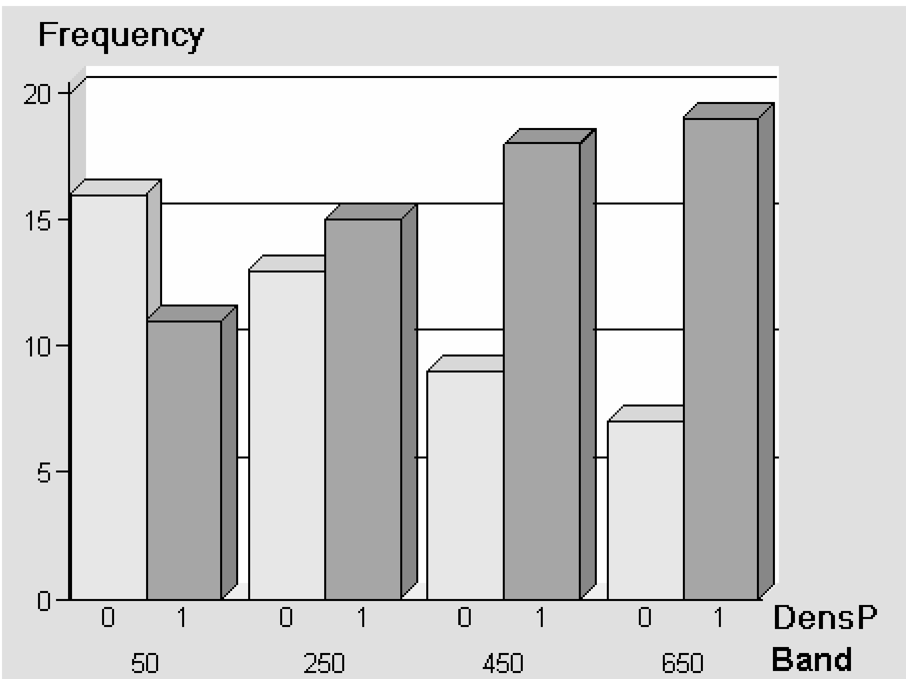
RESULTS

We surveyed 27 sites, with 4 plots per site, for a total of 108 plots sampled as 27 replicates per distance treatment. Of the 27 different sites that interfaced between human disturbance and desert, 18 were adjacent to agriculture, 5 next to urban development, and 4 were a mixture of agricultural and urban impacts. FTHL presence was counted at 1 or more plots at 22 of the 27 sites, while 5 sites had absence at all 4 plots. Presence was confirmed by capture of at least one

FTHL at only 27 of the 108 plots (25%), but we noted presence based on tracks, scat, habitat suitability, and captures at 63 plots (58%). Scat was the most common indicator of presence, with an average of 4 scats found per plot (35 maximum), compared to an average of 0.66 tracks (5 maximum) and 0.23 FTHLs (3 maximum) found per plot.

A bar graph showing how many plots had presence or absence at each of the distances from disturbance (50 m, 250 m, 450 m, and 650 m) shows a clear increase in frequency of FTHL presence with increasing distance from agricultural or urban development (Figure 2).

Figure 2. Bar chart of frequency of absence (0) or presence (1) of flat-tailed horned lizards at plots of increasing distances (in meters) from human disturbance.



The step-wise selection criteria only included the 2003 model predictions (P = 0.0133) and the distance from disturbance (P = 0.0148) as effects in the model. The predictions from the logistic regression analysis were plotted to visualize probability of presence at each of the four distances from disturbance (Figure 3). The mean predicted value at each distance was statistically different from the values at all other distances ($P < 0.05$).

When type of disturbance was forced into the logistic regression analysis along with the 2003 model predictions and distance from disturbance, type of disturbance did not have any measurable effect on probability of FTHL presence (P = 0.4363).

Ground squirrel densities were considered high at eight of the nearest plots, but at only one plot at each of the other distances (Table 1). Number of active black harvester mounds was higher at the two nearest plots than the two farthest plots (Table 1). Because ground squirrel data were subjective and ant data were not collected systematically, we did not statistically test for differences between distances for these variables.

Figure 3. A box plot indicating a positive relationship between the probability of occurrence of flat-tailed horned lizards and distance (in meters) from human disturbance. Predicted probability of occurrence at each sample plot was output from the logistic regression analysis that used output from a predictive model of distribution and distance from disturbance as predictive variables. The box encloses the middle 50% of the predicted values for each distance, the horizontal line within the box represents the median value, and the line extending beyond the box represents the range of values.

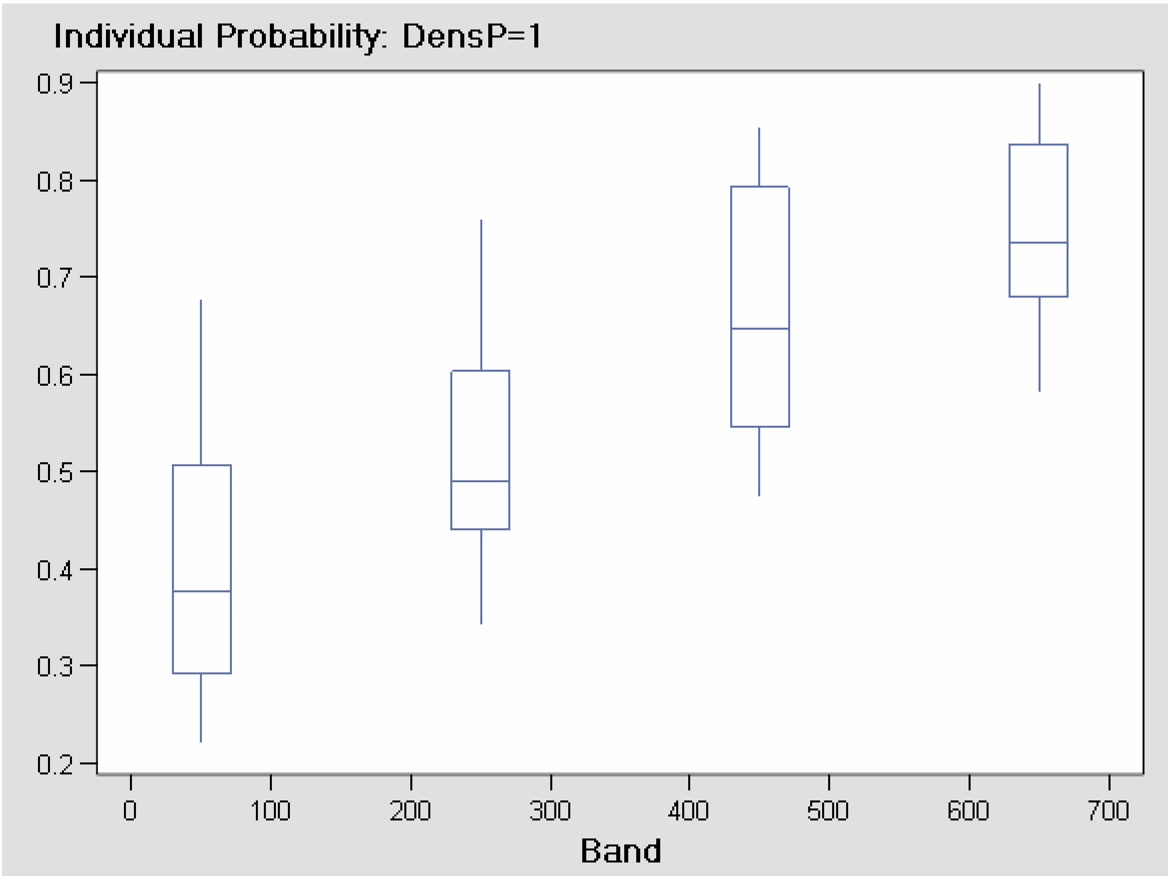


Table 1. Comparison of ground squirrel (*Spermophilus tereticaudus*) density categories and mean number of black harvester ant mounds (*Messor pergandei*) at increasing distances from human activity.

		Distance From Disturbance			
		50 m	**250 m**	**450 m**	**650 m**
Number of plots with different ground squirrel densities	Low	12	16	17	16
	Med	4	7	5	3
	High	8	1	1	1
Mean *Messor* mounds per plot		10.3	12.9	7.8	7.3

DISCUSSION

The data are very clear in any form—there is a negative effect on FTHLs that extends beyond the margins of human activity. While the main predictor of presence in the logistic regression model was the 2003 model of predicted distribution (which is a reflection of habitat suitability), the only other significant predictor of FTHL presence was distance from disturbance. There is a clear negative impact on FTHL presence to at least 450 m away from disturbance. We did not sample far enough away from disturbance to verify that we had reached the edge of the disturbance effect since predicted density did not reach an asymptote. However, our subjective opinion is that the rates of presence at the most distant plots were similar to those at areas far removed from disturbance. A measurable edge effect of 450 m is similar to other studies where it was found that most edge effects typically extend a few hundred meters into natural areas (Murcia 1995, Laurance 2000). We found no difference between agricultural and urban development, but it should be noted that our sample size from urban development was low (not surprising since agriculture commonly adjoins undisturbed habitat but urban areas generally do not).

We have documented that development along an edge of a management area impacts adjacent habitat, thus diminishing the overall reserve size. For example, a 40-acre field (1/4 mile square) that borders FTHL habitat on one edge (1/4 mile = 402 m) negatively impacts at least 45 acres of undisturbed FTHL habitat (402 m * 450 m = 180,900 m^2 = 18.1 ha = 44.7 acres). Management agencies need to consider that they will experience FTHL losses within their management areas on at least 180 acres per mile of edge that borders agricultural or urban development. Impacts from human activities are a leading cause of mortality within protected areas (Woodroffe and Ginsberg 1998). A visual estimate of the perimeter of the Yuma Desert Management Area shows at least 20 miles that border land that has been or may be converted to agricultural or urban development, for a potential indirect negative impact on FTHL populations on 3,600 acres of protected land. Because the habitat is still intact FTHL will continue to move into these areas, creating a population sink that will have a negative impact on the overall population on an ongoing basis. Such sinks would have the greatest impact on population dynamics in small habitat fragments with a high perimeter:area ratio and on species that range widely (Woodroffe and Ginsberg 1998). Fortunately, the Yuma Desert Management Area and other FTHL Management Areas are quite large relative to the movements of the FTHL, thus reducing the risk of extinction from edge effects within these reserves.

With the FTHL Management Areas already established, one additional way to conserve FTHL populations would be to minimize edge effects on border areas (Woodroffe and Ginsberg 1998). This can be difficult, but in the case of the proposed Area Service Highway, the planned horned lizard-proof fence along the border of the Management Area should mitigate much of the impact. FTHL habitat occurs on both sides of the proposed highway along some stretches, but the fence will only be on the side that borders the Management Area. The success of minimizing impacts of the road could be studied by comparing plots on either side of the road at increasing distances from it. This would indicate both the effect of a road in FTHL habitat and also the effectiveness of horned lizard-proof fencing.

Artificially increased predator densities may be an important contributor to the negative correlation between FTHL presence and proximity to human development. As stated in the Rangewide Management Strategy (FTHL ICC 2003), "Predators, such as common ravens, American kestrels, and domestic dogs and cats, also increase in urban areas, resulting in increased predation rates on FTHLs in adjacent wildlands (Bolster and Nicol 1989; Cameron Barrows, CNLM, pers. comm.)." Although we cannot attribute the reduced presence of FTHLs near development to specific causes with certainty, the density of a major FTHL predator, the roundtail ground squirrel, was highest in the plots closest to human activity. Young and Young (2000) found that the roundtail ground squirrel killed a higher proportion of FTHLs carrying transmitters in the Yuma Desert Management Area than all other predators combined. Shrikes are almost certainly more common around agricultural fields, but we made no attempts to measure their density.

While we think increased predator density is the most likely cause for the observed decline in FTHLs near development, invasive species may also contribute. Biological invasions can spread far into a reserve, thus decreasing its effective area (Suarez and Case 2002). We did not evaluate presence or density of alien species, but they are known to be problems for other horned lizards. Argentine ants (*Linepithema humile*) invade coastal horned lizard (*Phrynosoma coronatum*) habitat much more readily in disturbed areas or adjacent to development (Suarez *et al.* 1998). These ants displace native ants and are not, themselves, eaten by horned lizards (Suarez *et al.* 2000). This "bottom-up" effect is different than the "top-down" effect of increased predator abundance, but can be just as threatening to a rare species, particularly when that species is a dietary specialist (Suarez and Case 2002). Fire ants (*Solenopsis invicta*), which have had adverse effects on the Texas horned lizard (*P. cornutum*), were found in Yuma on one occasion but have apparently been eradicated (L. Piest pers. comm.). We did not look for fire ants at the sites we sampled. We did count active mounds of *Messor pergandei*, which is a native harvester ant and an important food source of FTHLs (Young and Young 2000). Since we found more of these harvester ants closer to development, we suspect that fire ants had not invaded any of the areas that we sampled. We know invasive plants occur over wide areas of the Yuma Desert MA and suspect that they are more common closer to development. Invasive plants may negatively affect FTHLs but the actual impacts are unknown (FTHL ICC 2003) and we did not attempt to measure their presence or density in this study. Another factor that may cause decline in prey abundance is pesticide drift. Although harvester ants were more abundant closer to fields, we do not know which, if any, of these fields had been sprayed with pesticides applied by plane. Either there was no pesticide drift, or if there was there was no measurable negative impact on black harvester ants.

Presence-absence data yields less information than actual counts, but due to low detection rates this year we were limited to using only presence-absence data in the analyses. Because we did not resample sites and create a history of detection/non-detection for each site, it was not possible for us to estimate detection rates or true occupancy rates (MacKenzie *et al.* 2002). These estimates would be helpful for establishing differences in detection rates in different years, and we recommend including site resampling in future designs. If enough sites are resampled enough times, it is even possible to deduce abundance estimates from presence-absence samples (Royle and Nichols 2003). Since FTHL are easy to capture if detected, mark-recapture data can be collected during repeated site visits, which will yield better abundance estimates when combined with presence-absence data than the presence-absence data alone (Royle, pers. comm. 2005). If samples are repeated across years it is also possible to estimate extinction and recolonization rates (MacKenzie *et al.* 2003), which would be particularly valuable in areas where new disturbance occurs.

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APPENDIX

A CD containing the following has been deposited at AZGFD and BLM offices in Yuma

- Capture data (Excel file)
- Survey data (Excel file)
- Digital photos of captures
- Digital photos of habitat

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Title:

Boundary processes between a desert sand dune community and an encroaching suburban landscape

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edge effect, anthropogenic boundary processes, desert aeolian sand community, flat-tailed horned lizard, loggerhead shrike : predation

Abstract:

In contrast to the body of work in more mesic habitats, few studies have examined boundary processes between natural and anthropogenic desert landscapes. Our research examined processes occurring at boundaries between a desert sand dune community and an encroaching suburban habitat. We measured responses to an anthropogenic boundary by species from multiple trophic levels, and incorporated measures of habitat suitability, and temporal variation, at multiple spatial scales. At an edge versus core habitat scale the only aeolian sand species that demonstrated an unambiguous negative response to the anthropogenic habitat edges was the flat-tailed homed lizard (Phrynosoma mcallii). Conversely loggerhead shrikes (Lanius ludovicianus) demonstrated a positive response to that edge. At a finer scale, species that exhibited a response to a habitat edge within the first 250 m included the horned lizards along with desert kangaroo rats (Dipodomys deserti). The latter species' response was confined to 25 In from the edge. For the flat-tailed horned lizard, edge effects were measured up to 150 m from the habitat boundary. Three potential causal hypotheses were explored to explain the edge effect on horned lizards: (1) invasions of exotic ant species reducing potential prey for the lizards; (2) road avoidance and road associated mortalities; and (3) predation from a suite of avian predators whose occurrence and abundance may be augmented by resources available in the suburban habitat. We rejected the exotic ant hypothesis due to the absence of exotic ants within the boundary region, and because native ant species (prey for horned lizards) did not show an edge effect. Our data supported the predation and road mortality hypotheses. Mechanisms for regulating population dynamics of desert species are often "bottom-up," stochastic processes driven by precipitation. The juxtaposition of an anthropogenic edge appears to have created a shift to a "top-down," predator-mediated dynamic for these lizards. (c) 2006 Elsevier Ltd. All rights reserved.

Boundary processes between a desert sand dune community and an encroaching suburban landscape

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Abstract

In contrast to the body of work in more mesic habitats, few studies have examined boundary processes between natural and anthropogenic desert landscapes. Our research examined processes occurring at boundaries between a desert sand dune community and an encroaching suburban habitat. We measured responses to an anthropogenic boundary by species from multiple trophic levels, and incorporated measures of habitat suitability, temporal variation, and spatial scales. At an edge versus core habitat scale the only aeolian sand species that demonstrated an unambiguous negative response to the anthropogenic habitat edges was the flat-tailed horned lizard (*Phrynosoma mcallii*). Conversely loggerhead shrikes (*Lanius ludovicianus*) demonstrated a positive response to that edge. At a finer scale, species that exhibited a response to a habitat edge within the first 250 m included the horned lizards along with desert kangaroo rats (*Dipodomys deserti*). The latter species' response was confined to 25 m from the edge. For the flat-tailed horned lizard, edge effects were measured up to 150 m from the habitat boundary. Three potential causal hypotheses were explored for explaining the edge effect on horned lizards: 1) potential invasions of exotic ant species reducing potential prey for the lizards; 2) road avoidance and road associated mortalities; and, 3) predation from a suite of avian predators whose occurrence and abundance may be augmented by resources available in the suburban habitat. We rejected exotic ant hypothesis due to the absence of exotic ants within the boundary region, and because native ant species (prey for horned lizards) did not show an edge effect. Our data supported the predation hypothesis and road mortality hypotheses. Mechanisms for regulating population dynamics of desert species are often “bottom-up,” stochastic processes driven by precipitation. The juxtaposition of an anthropogenic edge appears to have created a shift to a “top-down,” predator mediated dynamic for these lizards.

Keywords: Edge Effect; Anthropogenic boundary processes; Desert aeolian sand community; Flat-tailed horned lizard; Loggerhead shrike: Predation

1. Introduction

Primary mechanisms that distinguish processes at habitat boundaries include: 1) abiotic gradients unique to those boundaries, 2) access to spatially separated resources, and 3) species interactions (Wiens et al. 1985, Murcia 1995, Laurance et al. 2002, Ries et al. 2004). Collectively these mechanisms create a conceptual framework for understanding ecological boundary responses. Additionally, understanding factors that control the occurrence and dynamics of populations in relatively unfragmented habitat patches provide a context from which to evaluate how those drivers are impacted at boundaries. In arid ecosystems highly variable and unpredictable precipitation often regulates biological processes (Noy-Meir, 1973). Support for this axiom can be found across a broad range of taxa and regions (Mayhew 1965, 1966; Pianka 1970; Ballinger 1977; Whitford and Creusere 1977; Seely and Louw 1980; Dunham 1981; Abts 1987; Robinson 1990; Brown and Ernest 2002; Germano and Williams 2005). Population dynamics of desert species are thus often characterized as being regulated from the bottom-up, by resource availability mediated by annual rainfall (Brown and Ernest 2002). In contrast, Faeth et al. (2005) described a shift in the processes controlling population dynamics in a suburban desert environment. There irrigated landscapes regulated productivity and resulted in a predation controlled, top-down community. These different population regulating processes meet at the boundary between natural desert and anthropogenic habitats. The extent to which processes generated by anthropogenic habitats encroach on the natural desert and impact components of that community is the subject of this paper.

In contrast to the body of work in more mesic habitats, few studies have examined boundary processes between natural and anthropogenic desert landscapes (e.g., Germaine et al. 1998, Germaine and Wakeling 2001, Boal et al. 2003, Gutzwiller and Barrow 2003). Here we examined processes and species occurring at boundaries between an aeolian sand landscape and encroaching suburban and abandoned agricultural field habitats. Distinguishing between variance in abundance imposed by the heterogeneity of the available habitats and what if any effects the proximity of an edge has on the distribution of native species is critical in determining the ecological importance of those edges (Bolger et al. 1997, Fagan et al. 2003). We incorporated measures of habitat suitability, temporal variation, and spatial scales to identify whether components of an aeolian sand community have altered their distributions in response to the presence of anthropogenic habitat edges.

Much of the previous research on edges has focused on temperate and tropical habitats (Janzen 1983, Wilcove 1985, Laurance 1991, Murcia 1995, Laurance et al. 2002, Watson et al. 2004) where boundary-mediated ecological flow processes extend from 10-400 m into interior habitats (i.e., Kapos 1989, Camargo and Kapos 1995, Laurance et al. 2001). Fewer studies have investigated edge effects in semi-arid environments, with much of that work focusing on coastal sage scrub in southern California (Bolger et al. 1991, Bolger et al. 1997, Kristan et al. 2003). In this habitat, moisture gradients at suburban-natural community boundaries have limited the invasion of non-native ants to 100 m or more into the natural communities from mesic refuges in the suburban landscape, with a corresponding negative cascade affecting overall native species richness (Suarez et al. 1998). Increased predation is another factor identified at sage scrub boundaries (Bolger et al. 1991, Bolger et al. 1997, Crooks and Soulé 1999, Suarez et al. 2000, Suarez and Case 2002, Unfried 2003). Collectively these findings define the range of anthropogenic boundary impacts described to date. Our objective was to determine whether any of these impacts also influence the distribution and abundance of species in desert habitats.

2. Methods

2.1 Study Area

Aeolian sand habitats were studied within the Thousand Palms Preserve (33^{o} 47' N, 116^{o} 20' W*)* in the Coachella Valley near Palm Desert, Riverside County, California. The Preserve includes approximately 1,300 ha of contiguous sand dunes and hummocks.

The Coachella Valley is an extremely arid shrub desert with a mean annual rainfall of 79 to 125 mm (most recent 60 year means, Western Regional Climate Center, Palm Springs and Indio reporting stations). The lowest rainfall year occurred in 2002, with just 4 to 7 mm recorded across the valley floor. Temperatures range from a low approaching 0 ^{o}C in the winter to highs exceeding 45 ^{o}C commonly recorded during July and August.

Study plots were designed to enable analyses at both a coarse scale (edge versus interior plots) and at a finer scale along the habitat edges (within plot distance from the habitat edge). Additionally, study plots were established to identify effects from two separate edge types. Fourteen study plots were established within the Preserve: three were located along a 2.4 km boundary with a suburban golf course community, six were located along a 3.2 km boundary with an abandoned agricultural area and sparse rural housing (Figure 1), and five control plots were centrally located in "core" habitat, greater than 500 m from roads. There was a four-lane paved road separating the Preserve from the suburban habitat and a two-lane paved road separating the Preserve from an area of abandoned agriculture. All study plots were located in a stratified random manner. Plots were stratified so as to include both active sand dune and sand hummock habitat in a proportion corresponding to the aerial extent of those different habitat types. Edge plots were established adjacent to paved roads, but randomly located along the roadway.

Each of the 14 study plots consisted a cluster of 5-8, 10 m x 100 m belt transects. Edge plots included seven transects, with the first centered on a barbed wire boundary fence and running parallel to the fence and adjacent paved road. A second transect was established parallel to the first, but was 25 m interior from the edge. Additional parallel transects were placed at 50, 100, 150, 200, and 250 m from the edge. Core plots consisted of similar clusters of belt transects with the same dimensions as the edge sites. Core plots were >500 m from any roadway, residence, or habitat discontinuity and included five to eight parallel belt transects separated by 50-150 m. Each transect was marked with a short wooden stake at the beginning, middle, and end so that their position with respect to the boundaries of the belt transect could be readily determined. Each study plot covered approximately 2.5 ha. Surveys were repeated six times at each plot between June and July each year from 2002 through 2004. Data collected in 2002 focused on flat-tailed horned lizards, *Phrynosoma mcallii*. Data collected in 2003 and 2004 included all species encountered.

2.2 Survey Protocol

The fine aeolian sand of the Thousand Palms Preserve presented an opportunity unique to sand dunes to quantify the occurrence and abundance of all terrestrial species occurring along transects with more or less equal detectability. Each vertebrate species could be identified to species and age class by their diagnostic tracks left in the sand. Ground-based species left easily identifiable tracks, and so their ability to avoid detection by differences in activity times, cryptic coloration, or stealthy behavior was nullified. Because late afternoon and evening breezes would wipe the sand clean the next day's accumulation of tracks could not be confused with those from the previous day. On those days when the wind did not blow, tracks from the current day could be distinguished from those from previous days by whether or not the tracks of nocturnal arthropods crossed over the vertebrate's track. Lizard track identification criteria were developed by spending several weeks prior to surveys, following tracks until animals were located and the species and age class was confirmed. Tracks from other diurnal vertebrates were confirmed as they were encountered during pre-survey field work. Nocturnal or otherwise cryptic species' tracks were confirmed by comparisons with foot sizes and configurations from museum specimens

Surveys would begin after the sand surface temperature had risen sufficiently so that diurnal reptiles were observed to be active, usually ≥ 35^{o} C. Surveys continued until late morning when the high angle of the sun reduced the observer's ability to distinguish and identify tracks. One or two observers working in tandem completed a survey on a given study plot in 30-45 minutes, recording all fresh tracks observed within the 10 m wide belt of each 100 m transect. Tracks were followed off transect if it was necessary to confirm a species' identification and to insure that the same individual was not crossing the same transect repeatedly, thus avoiding an inflated count of the individuals active on that transect. Data for separate transects were considered independent for most species. In addition to tracks, we recorded any sightings of animals along transects and recorded any bird vocalizations heard during a survey. Wide ranging predators such as coyotes (*Canis latrans*), greater roadrunners (*Geococcyx californianus*), American kestrels (*Falco sparverius*), and loggerhead shrikes (*Lanius ludovicianus*), had ranges much larger than the transect dimensions, and so were recorded as present on a study plot, rather than on individual transects.

Harvester Ants (*Pogonomyrmex* sp.) were sampled using dry pitfall traps in April of each year. Previous arthropod sampling efforts (Barrows, unpublished data) have indicated that in most years ant numbers reached peak numbers in April. This was also the period when lizards eating ants would be consuming the resources necessary for egg production in the coming months. Three pitfall traps was placed on each transect; one at both ends and another at the transect middle. The traps were collected within 24 hrs of being set out to avoid any mortality of vertebrates that happened into the traps. Ant data were presented as the total count per transect.

2.3 Habitat Measures

Vegetation density and plant species composition were measured on each transect each year. All perennial shrubs were counted within the 10 m x 100 m belt transects. Annual plants were counted and cover estimated in a 1 m^2 sampling frame placed at 12 locations along the midline of the belt transect.

Sand compaction has been described as a key habitat variable for Coachella Valley fringe-toed lizards, *Uma inornata*, (Barrows 1997), and may be important for other psamnophilic species. Sand compaction was measured at 25 points, approximately four m apart, along the midline of each belt transect using a hand-held penetrometer with an adapter foot for loose soils (Ben Meadows Company, Janesville, WI, USA).

2.4 Data Analysis

A one-way analysis of variance (ANOVA) was employed to conduct coarser scale analyses, examining edge versus core differences, and to include wider ranging bird species. Here edge plots adjacent to the preserve edge (including transects ranging from 0

– 250 m from that edge) were compared with core plots (> 500 m from the preserve edge). A two-way ANOVA was conducted to partition finer scale variance in species abundance between the treatment (distance from the preserve edge) and variance associated with habitat heterogeneity between each of the edge plots.

For the nine edge plots, those species that showed statistically significant variation with respect to distance to edge (0-250 m) were then subjected to a linear regression to determine whether environmental variation coincident with the edge distance could explain that observed variance. All variables were tested for normality and transformed with natural logs when necessary. Dependent variables were means of the six surveys on each transect per year for each species. Independent variables included measures of sand compaction (kg / $cm^{2)}$ for each year, shrub density (shrubs / m^2), and linear distance from the Preserve edge. Total observations equaled 63 (seven transects / plot over nine plots), and just since one or two variables were included in the regression analyses, model over fitting was avoided. Linear regression analyses were performed using SYSTAT 10.0 (SYSTAT, Wilkinson, 1990). A threshold of $\alpha = 0.05$ for statistical significance was used throughout this paper.

3. Results

Of the nine species tested with ANOVAs at the edge versus core scale, only the flat-tailed horned lizard and the loggerhead shrike showed a statistically significant effect, although their responses were opposite (Table 1). Shrikes were more common along the edge whereas the horned lizards were more abundant in the core. At the finer scale, for those nine plots situated along the Preserve boundary, distance from the

Preserve edge was found to be a significant source of variance for the flat-tailed horned lizard, and the Desert kangaroo rat, *Dipodomys deserti* (Table 2).

These statistical results are corroborated by the patterns of temporal and spatial species' abundance for the seven sand dune occurring species included in our analysis (Figs. 2a-2g). There were no consistent responses to proximity of the habitat boundary for Coachella Valley round-tailed ground squirrels (*Spermophilus tereticaudus chlorus*), sidewinders (*Crotalus cerastes*), western shovel-nosed snakes (*Chionactis occipitalis*), and harvester ants (*Pogonomyrmex* spp., including *P. californicus* and *P. magnacanthus*). The abundance of both fringe-toed lizards and desert kangaroo rats appeared to be reduced along the immediate habitat edge in both 2003 and 2004, but not at distances ≥ 25 m from that boundary in either year. In contrast, flat-tailed horned lizards' abundance was reduced at distances from the habitat edge of 150 m in 2002, and 100 m in 2003 and 2004.

For the nine edge plots, Pearson's correlations were calculated for distance from the habitat edge and sand compaction and shrub density. Edge distance was not correlated with sand compaction (r = -0.001 to -0.135, all P = .0335 to 0.995), and was only moderately negatively correlated with shrub density (r = - 0.235, P = 0..043). However, sand was consistently more compacted along the immediate Preserve boundary than it was 25 m interior of that boundary (paired t-test, p = 0.048).

Regression models were run for the two species for which the within-plot ANOVAs indicated significant edge correlations (Table 3). Shrub density did not explain a significant amount of the variance in abundance for either species, and so was not included in the models. For each species, a single variate model using distance as the independent variable yielded statistically significant linear relationships. However, only the horned lizard's edge distance model yielded a R^2 above 0.100. A single variate model using sand compaction as the independent variable also yielded a significant relationship for the horned lizard.

Boundaries between the natural desert and anthropogenic landscapes evaluated here were of two types. One was adjacent to a suburban golf course community, but separated by a well used four-lane road with curbs. The other boundary was adjacent to abandoned agricultural fields with tree rows surrounding each parcel, and was separated by a low use, two-lane road without curbs. The abundance of flat-tailed horned lizards, round-tailed ground squirrels, desert kangaroo rats and harvester ants differed between habitats adjacent to the two boundary types (Table 2). For species other than horned lizards, abundances within boundary types were statistically invariant on transects within plots; no difference in their response to the edge was detected. For the horned lizards there were differences in abundance with respect to the Preserve edge. No horned lizards were located closer than 100 m from the boundary adjacent to the suburban landscape; here lizard abundance didn't reach an apparent asymptote until 200 m from the preserve edge (Fig. 3). Some horned lizards were located right to the edge of the boundary along the abandoned agricultural fields. Abundance appeared asymptotic 100 m from the preserve edge

4. Discussion

We identified negative responses to anthropogenic boundaries for flat-tailed horned lizards, and desert kangaroo rats. Data for the horned lizards were the most consistent from the standpoint of different scales (edge versus core plots and within-plot edge distances) and linear regression results. For the kangaroo rat, edge effects were apparent only at the finer scale, within-plot analyses and relatively weak regression results. This pattern may be explained by environmental variation associated with Preserve habitat boundary. Historic road grading created low berms along the road-Preserve boundaries. Rare flood events create pooled standing water and silt deposition along those berms, resulting in significantly more compacted sediments within 10-20 m of that boundary. The edge effect for desert kangaroo rats appeared to be confined to < 25 m from the Preserve boundary, coincident with the effects of roadside berms.

Flat-tailed horned lizards typically occupy sand compaction conditions found throughout the nine edge plots., Edge effects for this species were measured up to 150 m from the habitat boundary, well beyond the impact of the roadside berms. This lizard's range has been reduced and fragmented in recent years (Turner and Medica 1982) and this preserve may represent the only remaining habitat for flat-tails in the northern one-third of their original distribution. Deciphering causal factors for the flat-tail's absence along the preserve boundary may provide important directions for future management and preserve design strategies. Three non-exclusive hypotheses were evaluated to explain this edge effect.

1) Road Mortality – Road Avoidance Hypothesis - Like many reptiles, flat-tailed horned lizards will use the margins of paved roads, most likely for thermoregulation (Norris 1949, Turner and Medica 1982). Impacts of roads on wildlife populations include direct mortality and road avoidance (Forman and Alexander 1998). If there is a road impact here we would expect the response from the lizards to be stronger adjacent to

larger, busier roadways. In fact, we found consistent differences in lizard-edge relationships between edges adjacent to a busy four-lane road and a less used two-lane road. While edge effects were apparent along each road type, lizards adjacent to the four-lane road demonstrated a more pronounced and abrupt edge effect than those along the two-lane road, and so the data are consistent with a road effect hypothesis. No statistical difference in shrike abundance was found between plots along the two-land and four-lane roads, eliminating shrike predation as a confounding variable. The lack of a edge effect in any of the three nocturnal species included in our analysis may be in part a reflection of reduced vehicle traffic during the night.

2) Invasive Alien Ant Hypothesis - Flat-tailed horned lizards' prey is almost exclusively harvester ants (Pianka and Parker 1975, Turner and Medica 1982). The reduction in harvester ants from 2003 to 2004 in the aeolian sand habitat, which coincided with a similar reduction in flat-tails, supports a hypothesis that the population dynamics of these two taxa are linked.

Suarez and Case (2002) and Fisher et al. (2002) have identified the invasion of non-native Argentine ants (*Linepithema humile*) as a leading factor in the disappearance of coast horned lizards (*P. coronatum*) from fragmented habitats in coastal southern California. Suarez et al. (1998) described Argentine ants being able to invade up to 100 m into semi-arid natural habitats, greatly reducing native ant populations within that same 100 m belt. Coast horned lizards that were limited to Argentine ants for prey had negative or zero growth rates, and so could not maintain populations unless native ant populations were present (Suarez et al. 2000, Suarez and Case 2002).

Argentine ants were known to occur in adjacent suburban golf course communities. Similarly, introduced fire ants (Solenopsis invicta) have also been identified in the Coachella Valley and elsewhere are associated with roads, suburban development and edges (Forys et al. 2002), No non-native ant species were collected within any plots on the Thousand Palms Preserve.. The extreme aridity of this habitat may be a barrier to invasion of ant species otherwise problematic to more mesic habitats. These data, and the lack of any edge effect apparent in the native harvester ants, indicate that alien ant invasions are not a cause for the observed edge effect in the horned lizard population

3) Enhanced Predation Hypothesis - Increased predation along habitat edges is often identified as a causal factor for reducing nesting success for birds along forest edges (Andrén et al. 1985, Wilcove 1985, Angelstam 1986, Andrén and Angelstam 1988, Burkey 1993, Estrada et al. 2002, Maina and Jackson 2003, Aquilani and Brewer 2004). If increased levels of predation along the habitat margins are responsible for reduced flat-tail numbers there, then increased numbers of predators should be evident.

Comparing edge versus core plots, counts of loggerhead shrikes were consistently higher on edge of the aeolian sand habitat. The higher numbers of shrikes at edge plots versus core locations in our study area was consistent with an enhanced predator hypothesis. However, if predation rates are an important causal factor, then why were other species not similarly impacted? Of the six vertebrate species measured, three are primarily nocturnal and so would not be subjected to predation pressure from the diurnal shrikes; however Daley et al. (2000) did record shrike predation on four kangaroo rats. Of the diurnal potential prey species, the ground squirrel's large size puts them outside of the prey range of shrikes. The two lizards are within the shrikes' prey size, and flat-tailed horned lizards are regularly preyed on by shrikes (Young et al. 2004). Whereas both lizards are cryptically colored, flat-tailed horned lizards are slower moving and often respond to threats by remaining motionless (Norris 1949). Fringe-toed lizards respond to threats by running extremely fast or diving into the loose sand (Stebbins 1944).

Although predators were not quantified in 2002, flat-tailed horned lizards were commonly observed being preyed upon by American kestrels during site visits that year. Carcasses of marked horned lizards that had disappeared from study plots were located 0.7 km away in a palm tree planted on the edge of a golf course and frequented by kestrels. In 2003 and 2004 when predator occurrence was quantified, there were few observations of kestrels, but shrike observations were common. While kestrels and shrikes are native to the deserts of southern California, their abundance in the sand dune habitats of the Coachella Valley is likely enhanced by suburban development. In a pre-development landscape there were no trees growing in or around the Coachella Valley sand dunes. American kestrels are obligate hole or ledge nesters. Whereas there were once no nest sites for kestrels within 10 km of the dunes, today palm trees and other exotic vegetation planted in the neighboring suburban developments provide abundant nest sites on ledges formed by the large leaf petioles and in the thick “skirts” of dead palm leaves. While shrikes nest in native desert shrubs, trees in suburban areas as well as tree windbreaks planted at the margins agricultural fields provide more sheltered nest sites. Power poles bordering the preserve provide elevated perch sites for both the kestrels and shrikes to see prey and then launch their hunting sorties. Flat-tailed horned lizards may be subjected to levels of predation along edges that they would not likely have experienced in a pre-development landscape.

By collecting data on multiple species from multiple trophic levels we have rejected the alien ant hypothesis and found support for both the predation and road affect hypotheses. Dynamics of the flat-tailed horned lizard population occupying a 100-200 m boundary region of the available habitat appears to have shifted from a bottom-up process where the lizard numbers are regulated by native ant abundance, to a top-down process where the lizards are limited by predation, and possibly road mortality. This shift in regulatory processes may contribute to a habitat "sink" (Pulliam 1988) along the preserve boundary. For 2003 and 2004 combined, the horned lizards' mean reproductive success ranged from 0 – 0.2 hatchlings/adult at distances from 0 to 150 m from the habitat edge; at 200 m from the edge and in core plots, mean reproductive success averaged 0.8 hatchlings/adult (Barrows, unpubl. data). Without immigration from the preserve core, flat-tailed horned lizards may not be able to sustain populations in the boundary region.

These results demonstrate the utility of community based research designed to evaluate hypotheses regarding processes that regulate the abundance of species (Barrows et al. 2005). Rather than having broad impacts from indeterminate causes, boundary effects here were found to have a narrow scope and likely causes were identified. These findings can allow managers to focus adaptive management strategies aimed at reducing the boundary effect for flat-tailed horned lizards and so improve the viability of this remnant population. In the face of increasing suburban expansion into natural desert communities in the southwestern U. S. and elsewhere in arid regions of the world, managers otherwise face decisions with little or no baseline from which to predict species responses.

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Table 1. Analysis of variance (ANOVA) of the abundance of nine species at the larger, edge versus core, scale. The error term represents variation among plots. P-values ≤ 0.05 indicate a statistically significant amount of the variance in the distribution of that species is explained by that treatment (edge effect).

Species	Source of variation	SS	df	MS	F	P-value
Coachella Valley fringe-toed lizard	Edge effect	1.404	1	1.404	0.871	0.361
	Error	33.850	21	1.612		
Flat-tailed horned lizard	Edge effect	1.294	1	1.294	8.464	0.007
	Error	3.975	26	0.153		
Sidewinder	Edge effect	0.008	1	0.008	0.564	0.465
	Error	0.208	14	0.015		
Shovel-nosed snake	Edge effect	0.032	1	0.032	0.211	0.650
	Error	3.344	22	0.152		
Round-tailed ground squirrel	Edge effect	0.302	1	0.302	3.941	0.063
	Error	1.379	18	0.077		
Desert kangaroo rat	Edge effect	0.078	1	0.078	0.125	0.727
	Error	11.781	19	0.620		
Harvester ants	Edge effect	13.209	1	13.209	0.551	0.467
	Error	455.486	19	23.973		
Greater roadrunner	Edge effect	0.009	1	0.009	0.096	0.760
	Error	2.169	22	0.099		
Loggerhead shrike	Edge effect	1.131	1	1.131	18.871	0.0002
	Error	1.558	26	0.060		

Table 2. Two-way ANOVAs were employed to determine sources of variance at a smaller, within edge plot, scale. Here variance is partitioned between edge effects and between plots occurring along two boundary types. Coachella Valley fringe-toed lizards did not occur along the boundary that included the four-lane road, so only a one-way ANOVA was calculated for edge effect. P-values ≤ 0.05 indicate a statistically significant amount of the variance in the distribution of that species is explained by that treatment (edge effect or boundary type).

SPECIES	*SOURCE OF VARIATION*	*SS*	*df*	*MS*	*F*	*P-value*
Coachella Valley fringe-toed lizard						
	Edge Effect	11.569	6	1.928	1.629	0.150
	Within Group (Error)	91.107	77	1.183		
Flat-tailed horned lizard						
	Edge Effect	1.549	6	0.258	9.545	0.007
	Boundary Type	0.319	1	0.319	11.810	0.014
	Error	0.162	6	0.027		
Sidewinder						
	Edge Effect	0.008	6	0.001	0.585	0.735
	Boundary Type	< 0.0001	1	< 0.0001	0.010	0.923
	Error	0.014	6	0.002		
Shovel-nosed snake						
	Edge Effect	0.109	6	0.018	2.073	0.198
	Boundary Type	0.005	1	0.004	0.550	0.486
	Error	0.053	6	0.009		
Round-tailed ground squirrel						
	Edge Effect	0.075	6	0.013	1.345	0.364
	Boundary Type	0.197	1	0.197	21.085	0.004
	Error	0.056	6	0.009		
Desert kangaroo rat						
	Edge Effect	2.683	6	0.447	15.529	0.002
	Boundary Type	3.323	1	3.323	115.400	< 0.0001
	Error	0.173	6	0.029		
Harvester ants						
	Edge Effect	8.789	6	1.465	1.890	0.229
	Boundary Type	13.114	1	13.114	16.921	0.006
	Error	4.650	6	0.775		

Table 3. Results of linear regressions, with species abundance as the dependent variable and two habitat metrics as independent variables, included here as two separate one-variable models and together as a two-variable multiple regression model. Regression coefficients, R^2, and p-values are included.

Species		Edge distance	Sand compaction	Edge distance and sand compactio
Flat-tailed horned lizard				
	p	< 0.0001	< 0.0001	< 0.0001
	R^2	0.345	0.127	0.406
	Regression Coefficient	0.003	-0.241	.003/-0.16
Desert kangaroo rat				
	p	0.04	0.952	0.108
	R^2	0.038	< 0.0001	0.04
	Regression Coefficient	0.003	-0.669	0.001/- 0.643

Figure Captions

Figure 1. Satellite image depicting distribution of plots, extent of aeolian sand habitat, juxtaposition of suburban golf course development and abandoned agricultural fields, and roads

Figure 2a-2h. Mean counts and one standard error (indicated by the error bar) of species occurring on sand dunes and sand hummocks in the Coachella Valley at various distances from an anthropogenic habitat edge. Data for each year are the combined means for the plots on which the species occurred, with six repetitions per transect per plot. Data collected at >500 m represent the combined core plots.

Figure 3. Mean counts and one standard error (indicated by the error bar) of flat-tailed horned lizards at distances from two boundary types. Solid black bars represent data summarized from three plots adjacent to a four-lane road, with curbs, bounded by a suburban golf course community. Diagonally lined bars represent data summarized from five plots adjacent to a two-lane curbless road, bounded by abandoned agricultural fields and tree-row windbreaks. Both summaries include data combined from 2002 and 2003. Data for each year are the combined means for the plots on which the species occurred, with six repetitions per transect per plot.

Figure 1.

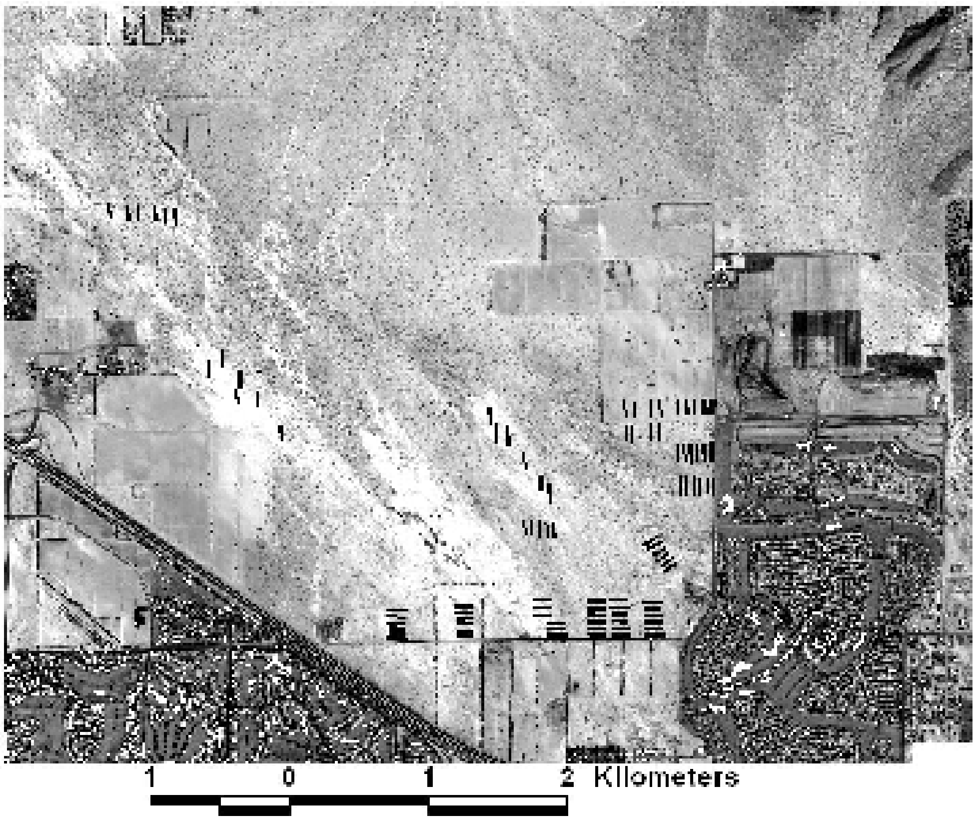


Figure 2a.

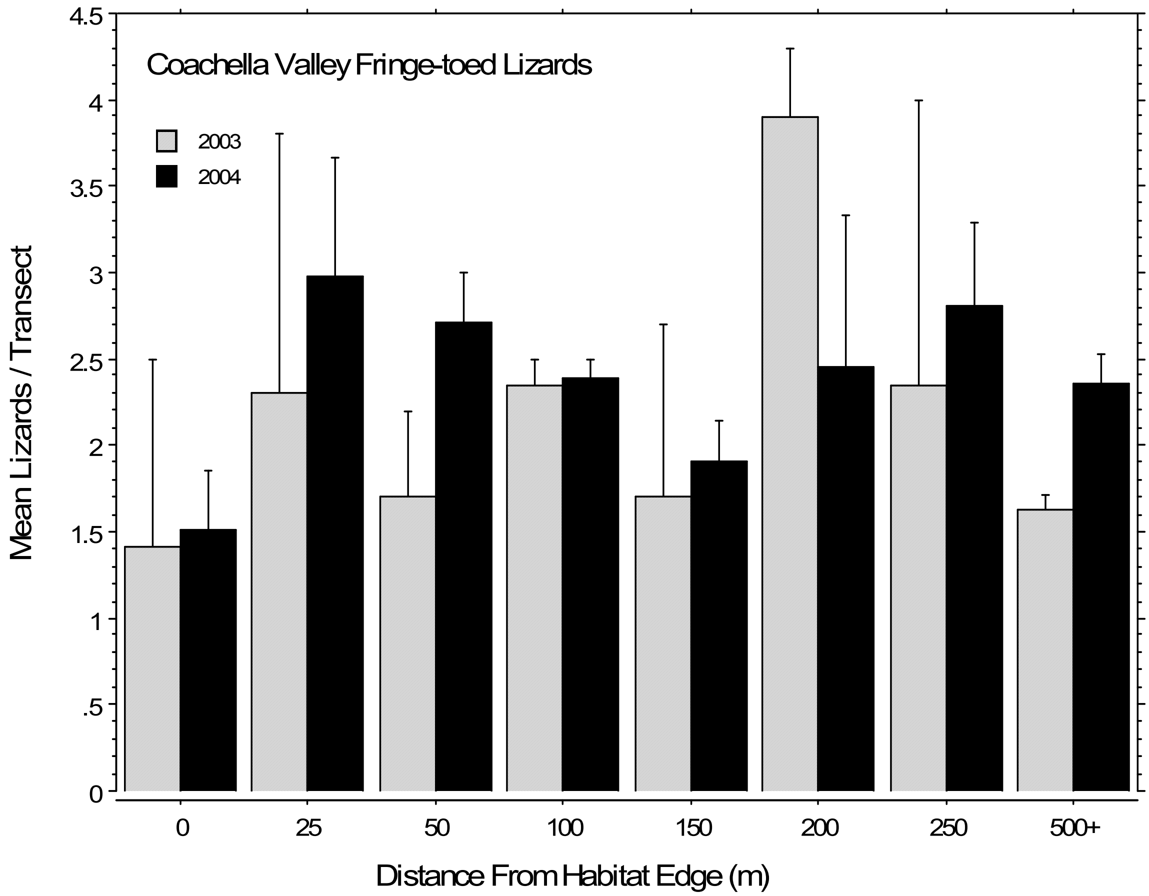


Figure 2b.

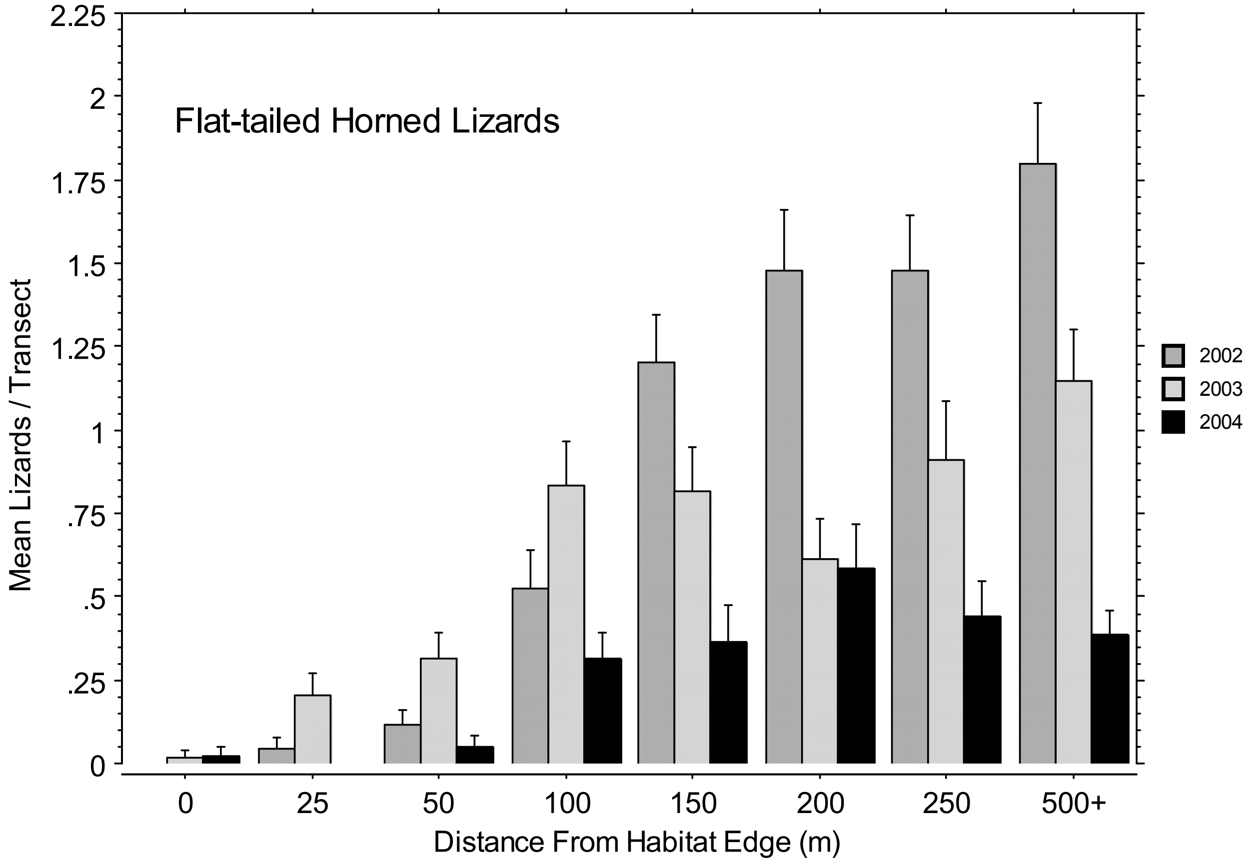

Flat-tailed Horned Lizards
Mean Lizards / Transect
2.25
2
1.75
1.5
1.25
1
.75
.5
.25
0
0
25
50
100
150
200
250
500+
Distance From Habitat Edge (m)
2002
2003
2004

Figure 2c.

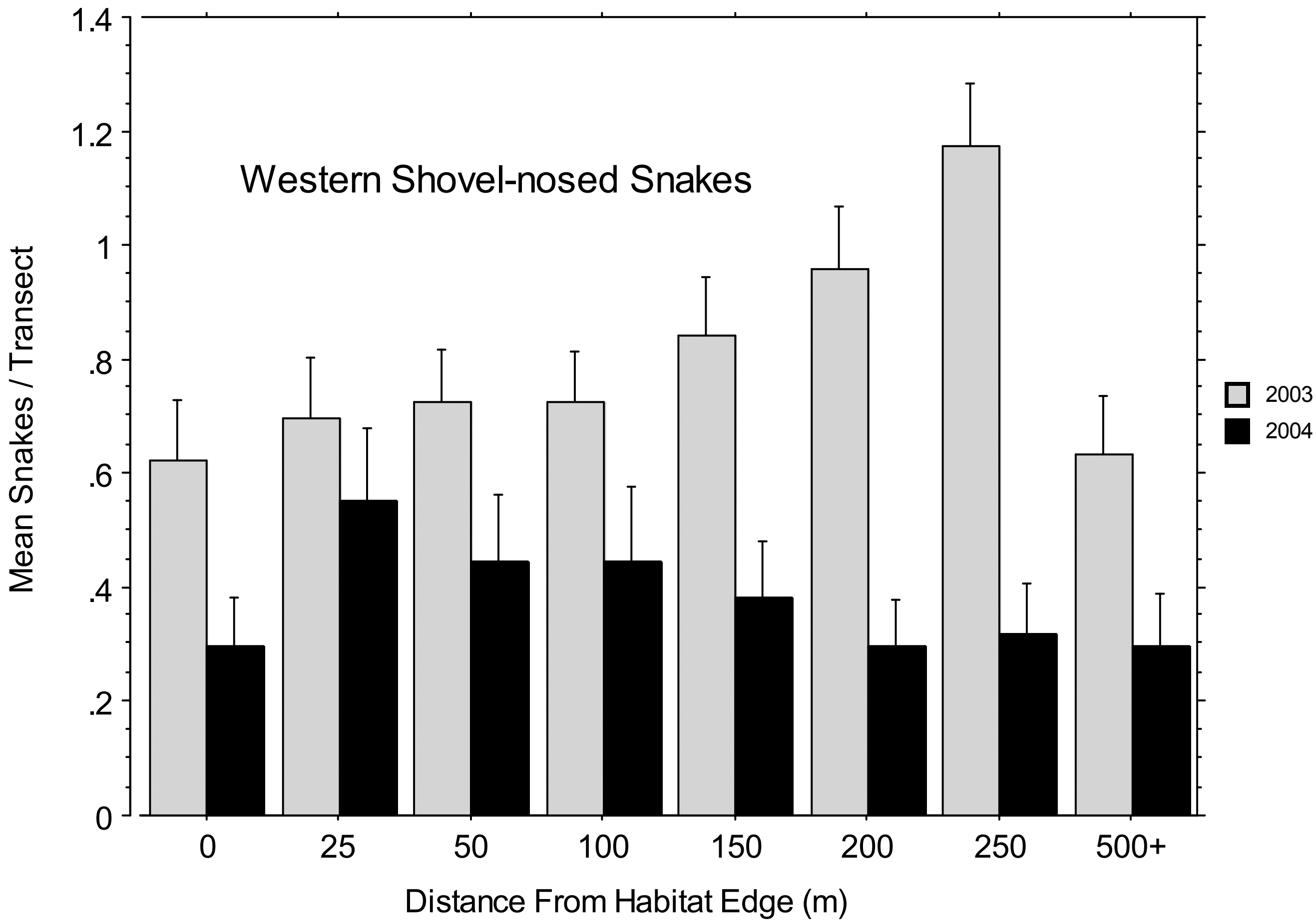

1.4
1.2
1
.8
.6
.4
.2
0
Western Shovel-nosed Snakes
Mean Snakes / Transect
2003
2004
0
25
50
100
150
200
250
500+
Distance From Habitat Edge (m)

Figure 2d.

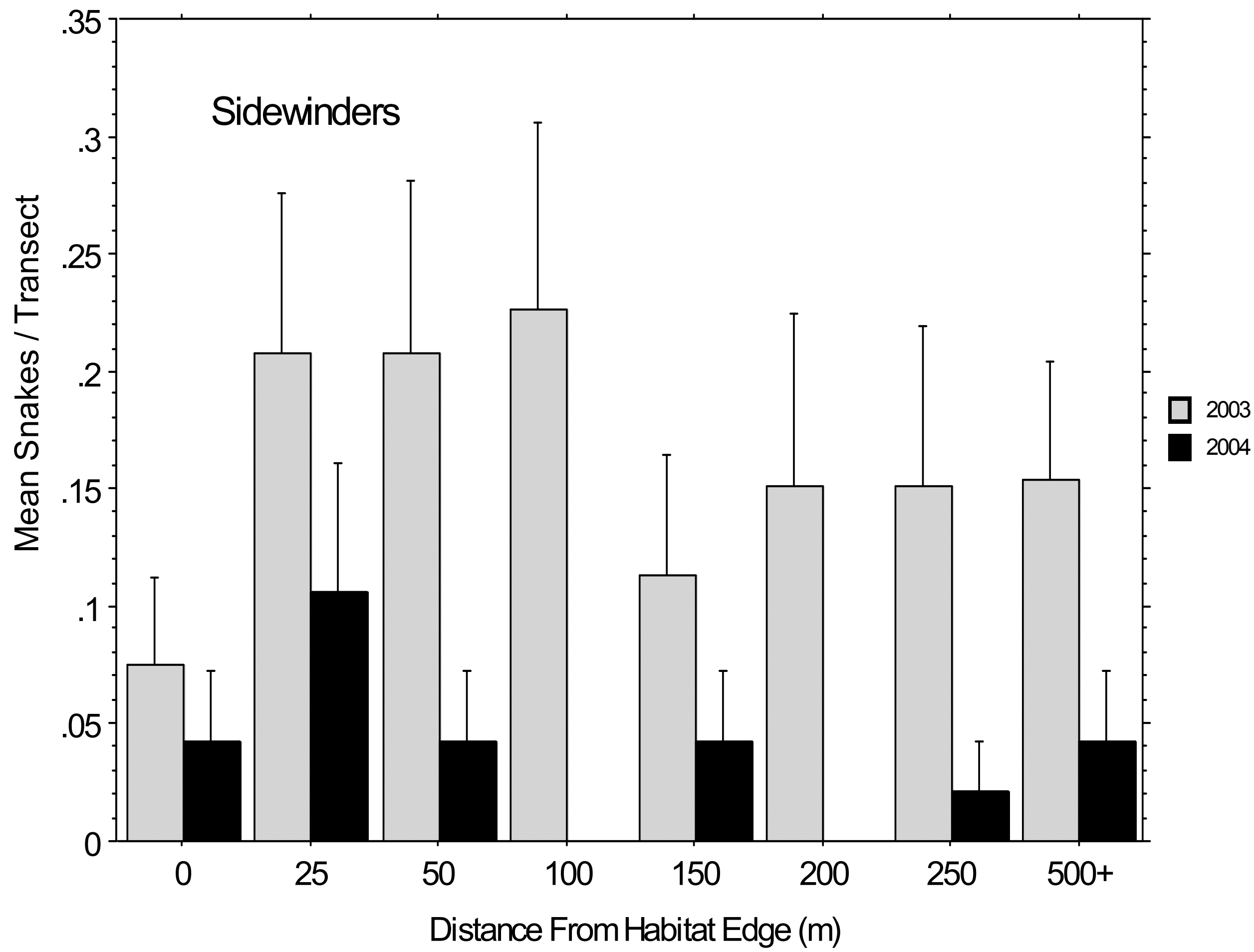
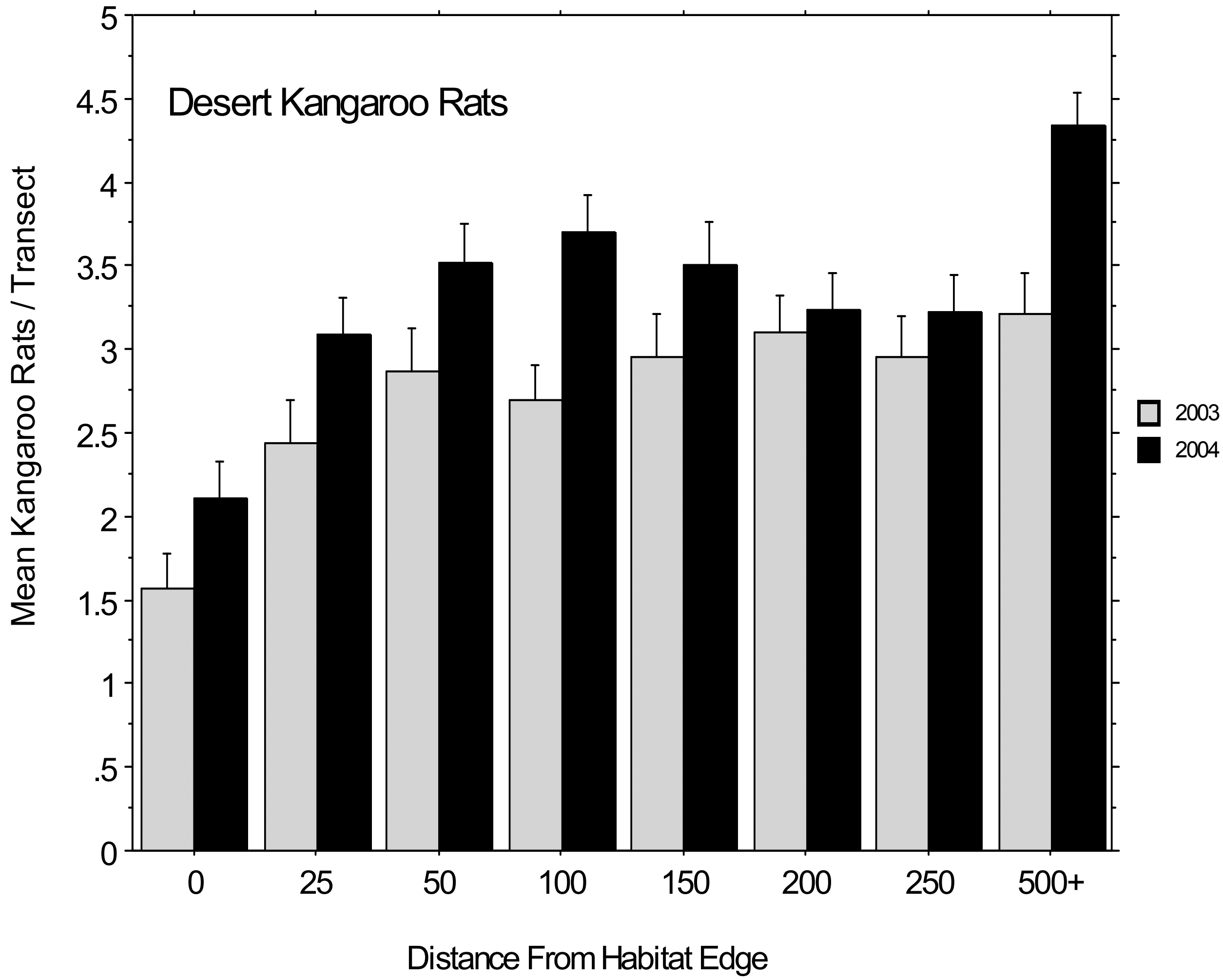


Figure 2e.



Desert Kangaroo Rats
Mean Kangaroo Rats / Transect
5
4.5
4
3.5
3
2.5
2
1.5
1
.5
0
0
25
50
100
150
200
250
500+
Distance From Habitat Edge
2003
2004

Figure 2f.

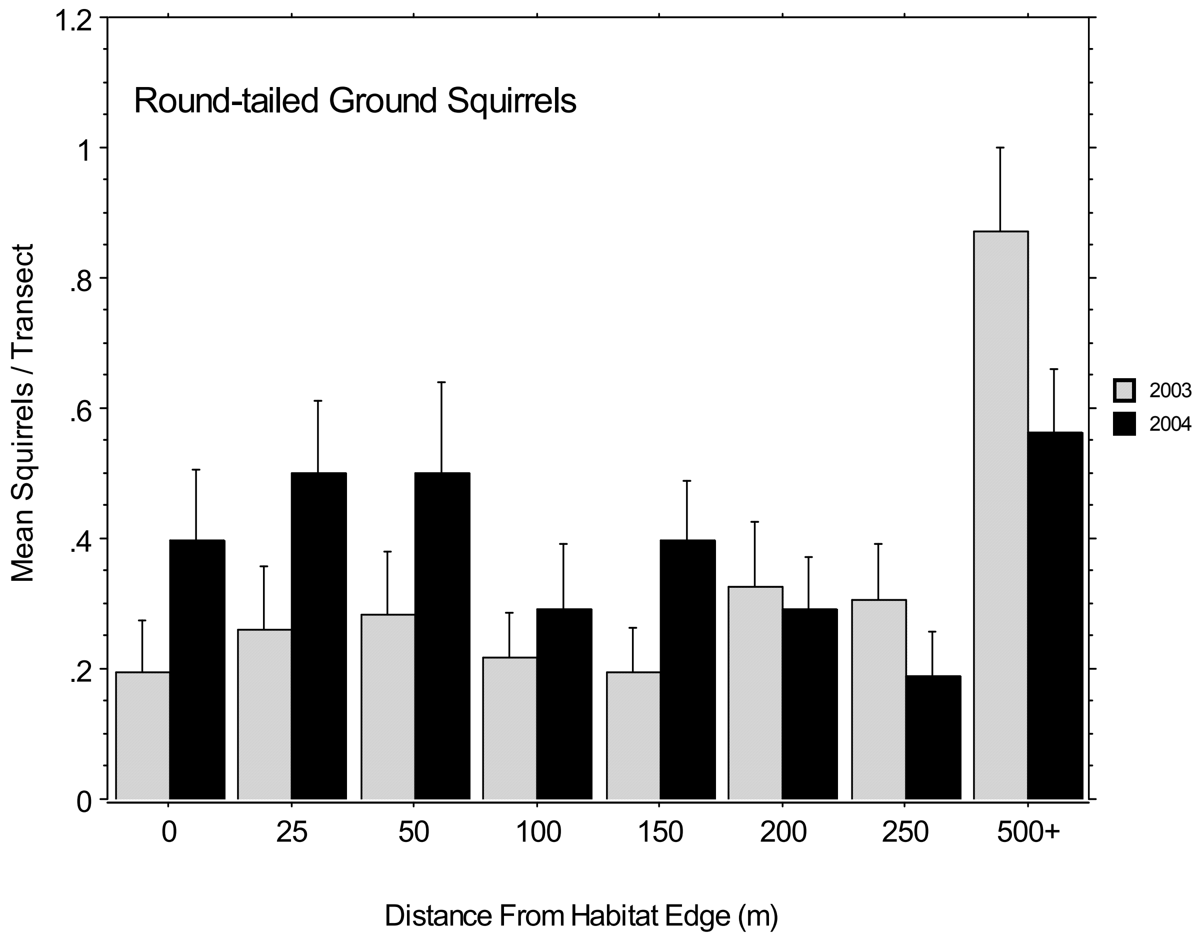

Round-tailed Ground Squirrels
Mean Squirrels / Transect
1.2
1
.8
.6
.4
.2
0
0
25
50
100
150
200
250
500+
Distance From Habitat Edge (m)
2003
2004

Figure 2g.

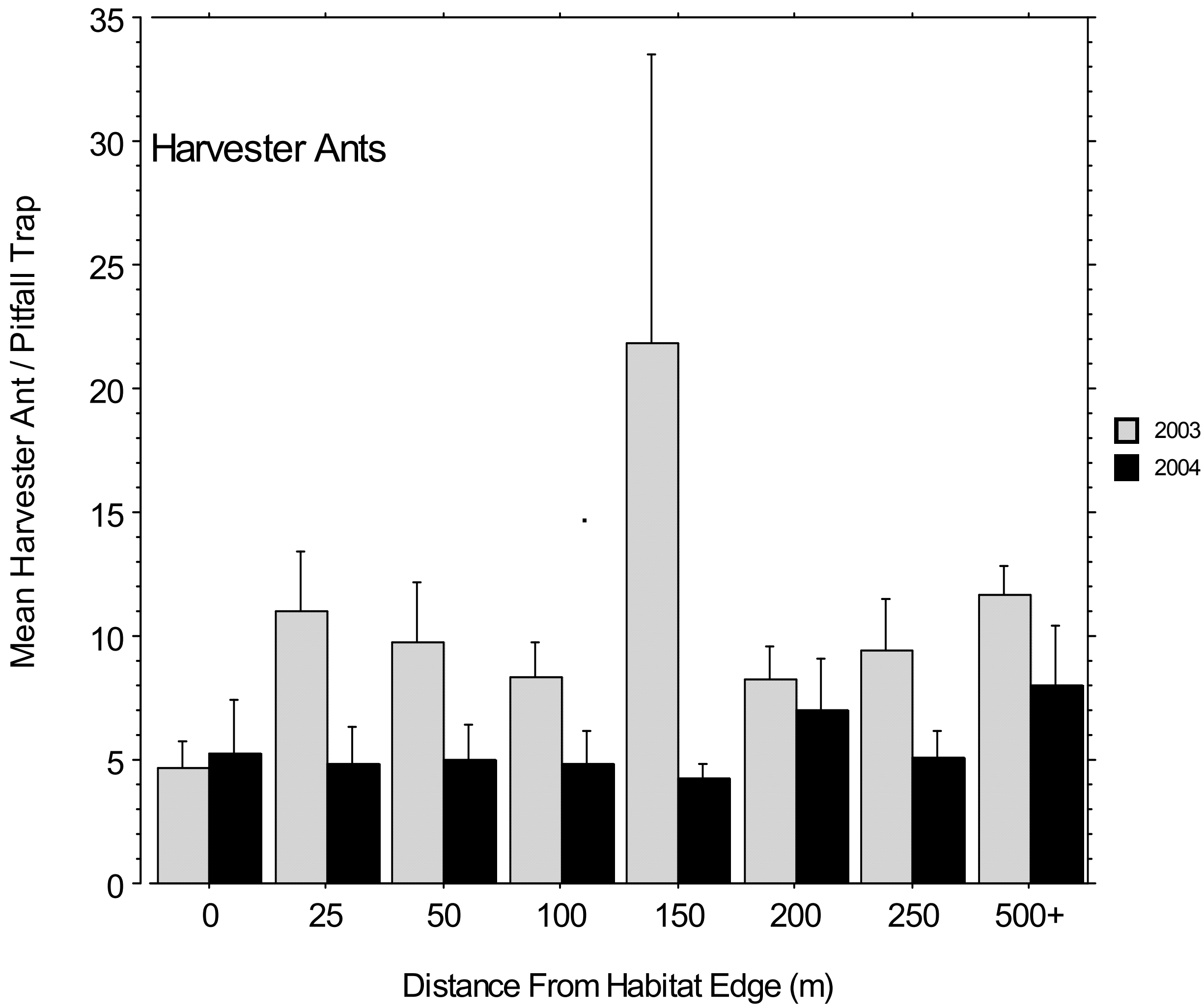
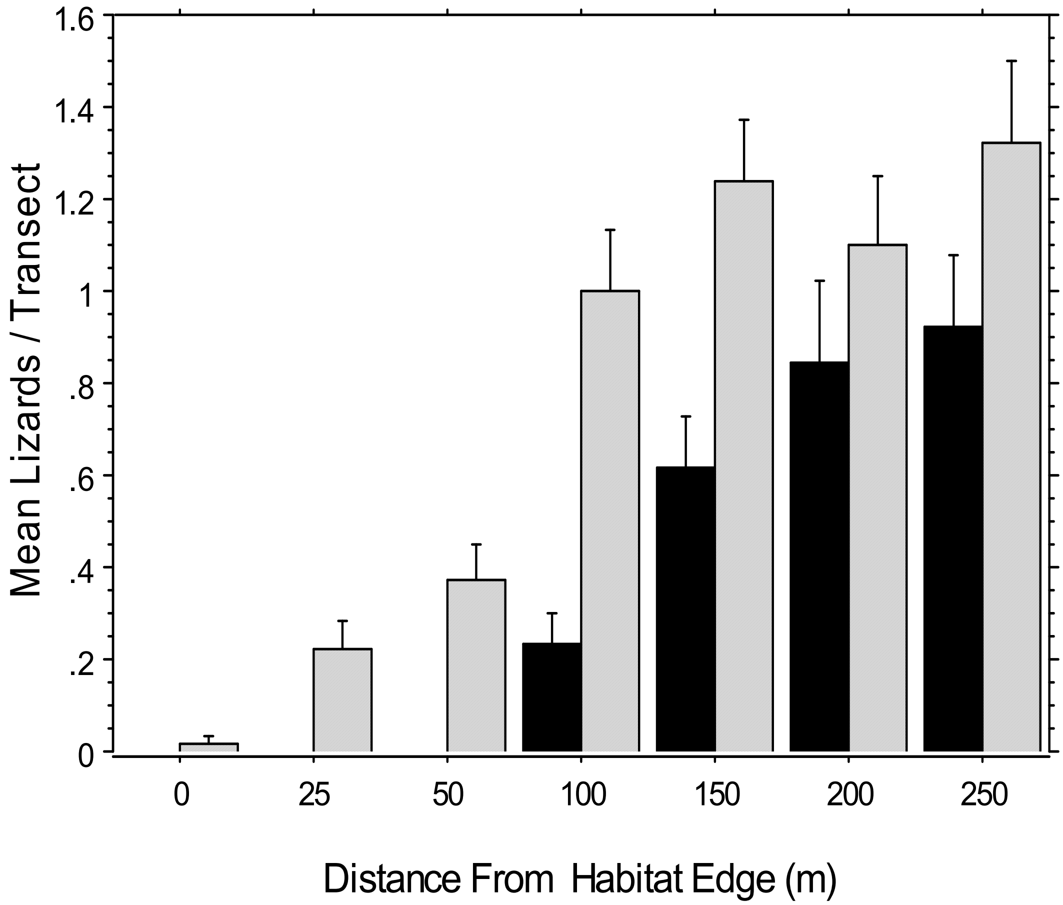

Harvester Ants
Mean Harvester Ant / Pitfall Trap
35
30
25
20
15
10
5
0
0
25
50
100
150
200
250
500+
Distance From Habitat Edge (m)
2003
2004

Figure 3.


1.6
1.4
1.2
1
.8
.6
.4
.2
0
Mean Lizards / Transect
0
25
50
100
150
200
250
Distance From Habitat Edge (m)

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Washington, D.C. 20240

IN REPLY REFER TO:

MAY 13 2003

FWS/DFPA/BFA

Memorandum

To: Regional Directors, Regions 1-7

From: Deputy Director

Subject: Service Interim Guidance on Avoiding and Minimizing Wildlife Impacts from Wind Turbines

Wind-generated electrical energy is renewable, produces no emissions, and is considered to be generally environmentally friendly technology. Development of wind energy is strongly endorsed by the Secretary of the Interior, as expressed in the Secretary's Renewable Energy on Public Lands Initiative (May 2002). However, wind energy facilities can adversely impact wildlife, especially birds and bats, and their habitats. As more facilities with larger turbines are built, the cumulative effects of this rapidly growing industry may initiate or contribute to the decline of some wildlife populations. The potential harm to these populations from an additional source of mortality makes careful evaluation of proposed facilities essential. Due to local differences in wildlife concentration and movement patterns, habitats, area topography, facility design, and weather, each proposed development site is unique and requires detailed, individual evaluation.

Service personnel may become involved in the review of potential wind energy developments on public lands through National Environmental Policy Act review (sections 1501.6, *opportunity as a cooperating agency,* and section 1503.4, *duty to comment on federally-licensed activities for agencies with jurisdiction by law*, i.e., the Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act); or because of special expertise. The National Wildlife Refuge System Improvement Act requires that any activity on Refuge lands be determined to be compatible with the Refuge system mission and Refuge purpose(s). In addition, the Service is required by the Endangered Species Act to assist other Federal agencies in ensuring that any action they authorize, implement, or fund will not jeopardize the continued existence of any federally endangered or threatened species. Service biologists have also received requests from industry for consultation on wildlife impacts of proposed wind energy developments on private lands.

The following guidance was prepared by the Service's Wind Turbine Siting Working Group. It is intended to assist Service staff in providing technical assistance to the wind energy industry to avoid or minimize impacts to wildlife and their habitats through: (1) proper evaluation of potential wind energy development sites; (2) proper location and design of turbines and associated structures within sites selected for development; and (3) pre- and post-construction research and monitoring to identify and/or assess impacts to wildlife. This guidance is intended for terrestrial applications only; guidelines for wind energy developments in marine environments and the Great Lakes will be provided at a future date. The interim guidelines are based on current science and will be updated as new information becomes available. They will be evaluated over a two-year period, and then modified as necessary based on their performance in the field and on the latest scientific and technical discoveries developed in coordination with industry, states, academic researchers, and other Federal agencies. A Notice of Availability and request for comments will be published in the Federal Register simultaneously with the release of this guidance to Service personnel. We encourage industry use of this guidance and solicit their feedback on its efficacy.

These guidelines are not intended nor shall they be construed to limit or preclude the Service from exercising its authority under any law, statute, or regulation, and to take enforcement action against any individual, company, industry or agency or to relieve any individual, company, industry, or agency of its obligations to comply with any applicable Federal, State, or local laws, statutes, or regulations.

Implementation of Service recommendations provided in accordance with these guidelines by the wind energy industry is voluntary. Field offices have discretion in the use of these guidelines on a case-by-case basis, and may also have additional recommendations to add which are specific to their geographic area.

The Migratory Bird Treaty Act (16 U.S.C. 703-712) prohibits the taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts, and nests, except when specifically authorized by the Department of the Interior. While the Act has no provision for allowing an unauthorized take, it must be recognized that some birds may be killed at structures such as wind turbines even if all reasonable measures to avoid it are implemented. The Service's Office of Law Enforcement carries out its mission to protect migratory birds not only through investigations and enforcement, but also through fostering relationships with individuals and industries that proactively seek to eliminate their impacts on migratory birds. While it is not possible under the Act to absolve individuals, companies, or agencies from liability if they follow these recommended guidelines, the Office of Law Enforcement and Department of Justice have used enforcement and prosecutorial discretion in the past regarding individuals, companies, or agencies who have made good faith efforts to avoid the take of migratory birds.

Please ensure that all field personnel involved in review of wind energy development proposals receive copies of this memorandum. Questions regarding this issue should be directed to Dr. Benjamin N. Tuggle, Chief, Division of Federal Program Activities, at (703) 358-2161, or Brian Millsap, Chief, Division of Migratory Bird Management, at (703) 358-1714.

Attachment

INTERIM GUIDELINES TO AVOID AND MINIMIZE WILDLIFE IMPACTS FROM WIND TURBINES

Introduction

Wind-generated electrical energy is renewable, produces no emissions, and is generally considered to be an environmentally friendly technology. Development of wind energy is strongly endorsed by the Secretary of the Interior, as expressed in the Secretary's Renewable Energy on Public Lands Initiative (May 2002). However, wind energy facilities can adversely impact wildlife, especially birds (e.g., Orloff and Flannery 1992, Leddy et al. 1999, Woodward et al. 2001, Braun et al. 2002, Hunt 2002) and bats (Keeley et al. 2001, Johnson et al. 2002, Johnson et al. 2003). As more facilities with larger turbines are built, the cumulative effects of this rapidly growing industry may initiate or contribute to the decline of some wildlife populations (Manes et al. 2002, Johnson et al. 2002, Manville 2003). The potential harm to these populations from an additional source of mortality or adverse habitat impacts makes careful evaluation of proposed facilities essential. Due to local differences in wildlife concentration and movement patterns, habitats, area topography, facility design, and weather, each proposed development site is unique and requires detailed, individual evaluation.

The following guidance was prepared by the U.S. Fish and Wildlife Service (Service). Like the Service's voluntary guidance addressing the siting, construction, operation, and decommissioning of communication towers (http://migratorybirds.fws.gov/issues/towers/comtow.html) and the voluntary guidance developed in cooperation with the electric utility industry to minimize bird strikes and electrocutions (APLIC 1994, APLIC 1996), this guidance is intended to assist the wind energy industry in avoiding or minimizing impacts to wildlife and their habitats. This is accomplished through: (1) proper evaluation of potential Wind Resource Areas (WRAs), (2) proper location and design of turbines and associated structures within WRAs selected for development, and (3) pre- and post-construction research and monitoring to identify and/or assess impacts to wildlife. These guidelines are based on current science and will be updated as new information becomes available. They are voluntary, and interim in nature. They will be evaluated over a two-year period, and then modified as necessary based on their performance in the field, on comments from the public, and on the latest scientific and technical discoveries developed in coordination with industry, states, academic researchers, and other Federal agencies. After this period, the Service plans to develop a complete operations manual for evaluation, site selection, design, construction, operation, and monitoring of wind energy facilities in both terrestrial and aquatic environments.

Data on wildlife use and mortality collected at one wind energy facility are not necessarily applicable to others; each site poses its own set of possibilities for negative effects on wildlife. In addition, the wind industry is rapidly expanding into habitats and regions that have not been well studied. The Service therefore suggests a precautionary approach to site selection and development, and will employ this approach in making recommendations and assessing impacts of wind energy developments. We encourage the wind energy industry to follow these guidelines and, in cooperation with the Service, to conduct scientific research to provide additional information on the impacts of wind energy development on wildlife. We further encourage the industry to look for opportunities to promote bird and other wildlife conservation when planning wind energy facilities (e.g., voluntary habitat acquisition or conservation easements).

The Service is guided by the Fish and Wildlife Service Mitigation Policy (Federal Register 46 (15), January 1981) in evaluating modifications to or loss of habitat caused by development. This policy follows the sequence of steps recommended in the Council on Environmental Quality's Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act (NEPA) in seeking to avoid, minimize, or compensate for negative impacts. Mitigation can involve (1) avoiding the impact of an activity by taking no action; (2) minimizing impacts by limiting the degree of activity; (3) rectifying an impact by repairing, rehabilitating, or restoring an affected environment; (4) reducing or eliminating an impact by conducting activities that preserve and maintain the resources; or (5) compensating for an impact by replacing or providing substitute resources or environments. Any mitigation recommended by the Service for wind energy development would be voluntary on the part of the developer unless made a condition of a Federal license or permit. Mitigation does not apply to “take” of species under the Migratory Bird Treaty Act, Bald and Golden Eagle Protection Act, or Endangered Species Act. The goal of the Service under these laws is the elimination of loss of migratory birds and endangered and threatened species due to wind energy development. The Service will actively expand partnerships with regional, national, and international organizations, States, tribes, industry, and environmental groups to meet this goal.

Projects with Federal involvement may require additional analysis under the National Environmental Policy Act (http://www.fws.gov/r9esnepa), Endangered Species Act (http://endangered.fws.gov), or National Wildlife Refuge System Administration Act (http://www.fws.gov/policyMakers/mandates/index.html#adminact). This includes projects on federally-owned lands (e.g., National Wildlife Refuges, National Forests), lands where a Federal permit is required for development (e.g., BLM-administered lands), or lands where Federal funds were used for purchase or improvement (some State Wildlife Management Areas).

These guidelines are not intended nor shall they be construed to limit or preclude the Service from exercising its authority under any law, statute, or regulation, and to take enforcement action against any individual, company, or agency, or to relieve any individual, company, or agency of its obligations to comply with any applicable Federal, State, or local laws, statutes, or regulations.

The guidelines contain a site evaluation process with checklists for pre-development evaluations of potential terrestrial wind energy development sites (Appendix 1). Use of this process allows comparison of one site with another with respect to the impacts that would occur to wildlife if the area were developed. The evaluation area for a potential development site should include the “footprint” encompassing all of the turbines and associated structures planned for that proposed facility, and the adjacent wildlife habitats which may be affected by the proximity of the structures, but excluding transmission lines extending outside the footprint. All potential development sites within a geographic area should be evaluated before a site is selected for development.

Pre-development evaluations should be conducted by a team that includes Federal and/or State agency wildlife professionals with no vested interest (e.g., monetary or personal business gain) in the sites selected. Teams may also include academic and industry wildlife professionals as available. Any site evaluations conducted by teams that do not include Federal and/or State agency wildlife professionals will not be considered valid evaluations by the Service.

The pre-development evaluation may also identify additional studies needed prior to and after development. Post-construction monitoring to identify any wildlife impacts is recommended at all developed sites. Pre- and post-development studies and monitoring may be conducted by any qualified wildlife biologist without regard to his/her affiliation or interest in the site.

Additional information relevant to these guidelines is appended as follows:

Appendix 2 – Definitions Related to Wind Energy Development and Evaluation
Appendix 3 – Wildlife Laws Relevant to Wind Power Development Projects
Appendix 4 - Research Needs on the Impacts of Wind Power Development on Wildlife
Appendix 5 – Procedures for Endangered Species Evaluations and Consultations
Appendix 6 – Guidelines for Considering Wind Turbine Siting on Easement Lands Administered as Part of the National Wildlife Refuge System in Region 6 (CO, KS, MT, NE, ND, SD, UT, WY)
Appendix 7 – Known and Suspected Impacts of Wind Turbines on Wildlife
Appendix 8 – Literature Cited

Site Evaluation

The site evaluation protocol presented in Appendix 1 was developed by a team of Federal, State, university, and wind energy industry biologists to rank potential terrestrial wind energy development sites by their potential impacts on wildlife. There are two steps to follow:

1. Identify and evaluate reference sites, preferably within the general geographic area of the proposed facility. Reference sites are high-quality wildlife areas where wind development would result in the maximum negative impact on wildlife (i.e., sites selected to have the highest possible rank using the protocol). Reference sites are used to determine the comparative risks of developing other potential sites.

2. Evaluate potential development sites to determine risk to wildlife and rank sites against each other using the highest-ranking reference site as a standard. Although high-ranking sites are generally less desirable for wind energy development, a high rank does not necessarily preclude development of a site, nor does a low rank automatically eliminate the need to conduct pre-development assessments of wildlife resources or post-development assessments of impacts.

Studies to Assess and Monitor Wildlife Impacts

While ranking potential development sites, the site evaluation team referenced above may identify pre-development studies that are needed to better assess potential negative impacts to wildlife. Ranking may also suggest the extent and duration of study required. Developers are encouraged to conduct any studies suggested by the team in coordination with Service and other agency wildlife biologists.

Post-development mortality studies should be a part of any site development plan in order to determine if or to what extent mortality occurs. As with pre-development studies, ranking may suggest the extent and duration of study needed. Studies should be designed in coordination with Federal and other agency biologists.

Site Development Recommendations

The following recommendations apply to locating turbines and associated structures within WRAs selected for development of wind energy facilities:

1. Avoid placing turbines in documented locations of any species of wildlife, fish, or plant protected under the Federal Endangered Species Act.

2. Avoid locating turbines in known local bird migration pathways or in areas where birds are highly concentrated, unless mortality risk is low (e.g., birds present rarely enter the rotor-swept area). Examples of high concentration areas for birds are wetlands, State or Federal refuges, private duck clubs, staging areas, rookeries, leks, roosts, riparian areas along streams, and landfills. Avoid known daily movement flyways (e.g., between roosting and feeding areas) and areas with a high incidence of fog, mist, low cloud ceilings, and low visibility.

3. Avoid placing turbines near known bat hibernation, breeding, and maternity/nursery colonies, in migration corridors, or in flight paths between colonies and feeding areas.

4. Configure turbine locations to avoid areas or features of the landscape known to attract raptors (hawks, falcons, eagles, owls). For example, Golden Eagles, hawks, and falcons use cliff/rim edges extensively; setbacks from these edges may reduce mortality. Other examples include not locating turbines in a dip or pass in a ridge, or in or near prairie dog colonies.

5. Configure turbine arrays to avoid potential avian mortality where feasible. For example, group turbines rather than spreading them widely, and orient rows of turbines parallel to known bird movements, thereby decreasing the potential for bird strikes. Implement appropriate storm water management practices that do not create attractions for birds, and maintain contiguous habitat for area-sensitive species (e.g., Sage Grouse).

6. Avoid fragmenting large, contiguous tracts of wildlife habitat. Where practical, place turbines on lands already altered or cultivated, and away from areas of intact and healthy native habitats. If not practical, select fragmented or degraded habitats over relatively intact areas.

7. Avoid placing turbines in habitat known to be occupied by prairie grouse or other species that exhibit extreme avoidance of vertical features and/or structural habitat fragmentation. In known prairie grouse habitat, avoid placing turbines within 5 miles of known leks (communal pair formation grounds).

8. Minimize roads, fences, and other infrastructure. All infrastructure should be capable of withstanding periodic burning of vegetation, as natural fires or controlled burns are necessary for maintaining most prairie habitats.

9. Develop a habitat restoration plan for the proposed site that avoids or minimizes negative impacts on vulnerable wildlife while maintaining or enhancing habitat values for other species. For example, avoid attracting high densities of prey animals (rodents, rabbits, etc.) used by raptors.

10. Reduce availability of carrion by practicing responsible animal husbandry (removing carcasses, fencing out cattle, etc.) to avoid attracting Golden Eagles and other raptors.

Turbine Design and Operation Recommendations

1. Use tubular supports with pointed tops rather than lattice supports to minimize bird perching and nesting opportunities. Avoid placing external ladders and platforms on tubular towers to minimize perching and nesting. Avoid use of guy wires for turbine or meteorological tower supports. All existing guy wires should be marked with recommended bird deterrent devices (Avian Power Line Interaction Committee 1994).

2. If taller turbines (top of the rotor-swept area is >199 feet above ground level) require lights for aviation safety, the minimum amount of pilot warning and obstruction avoidance lighting specified by the Federal Aviation Administration (FAA) should be used (FAA 2000). Unless otherwise requested by the FAA, only white strobe lights should be used at night, and these should be the minimum number, minimum intensity, and minimum number of flashes per minute (longest duration between flashes) allowable by the FAA. Solid red or pulsating red incandescent lights should not be used, as they appear to attract night-migrating birds at a much higher rate than white strobe lights.

3. Where the height of the rotor-swept area produces a high risk for wildlife, adjust tower height where feasible to reduce the risk of strikes.

4. Where feasible, place electric power lines underground or on the surface as insulated, shielded wire to avoid electrocution of birds. Use recommendations of the Avian Power Line Interaction Committee (1994, 1996) for any required above-ground lines, transformers, or conductors.

5. High seasonal concentrations of birds may cause problems in some areas. If, however, power generation is critical in these areas, an average of three years monitoring data (e.g., acoustic, radar, infrared, or observational) should be collected and used to determine peak use dates for specific sites. Where feasible, turbines should be shut down during periods when birds are highly concentrated at those sites.

6. When upgrading or retrofitting turbines, follow the above guidelines as closely as possible. If studies indicate high mortality at specific older turbines, retrofitting or relocating is highly recommended.

Appendix 1

PROTOCOL TO RANK POTENTIAL TERRESTRIAL WIND ENERGY DEVELOPMENT SITES BY IMPACTS ON WILDLIFE

This protocol was developed by a team of Federal, State, university, and industry biologists to rank potential wind development sites in Montana by their potential for impacts on wildlife (USFWS 2002). It has been modified to apply nationwide. The protocol allows the user to evaluate potential development sites and rank them against a reference site. Objectives are to: (1) assist developers in deciding whether to proceed with development; (2) provide a procedure to determine pre-construction study needs to verify use of potential sites by wildlife; and (3) provide recommendations for monitoring potential sites post-construction to identify, quantify, or verify actual impacts (or lack thereof).

Although this protocol focuses on impacts to wildlife, potential impacts to fish, other aquatic life, and plants should be considered as well. Surveys for rare, threatened, or endangered plants known or suspected to occur in the geographic area should be conducted at all proposed terrestrial development sites having suitable habitat.

This protocol is intended to provide a conceptual framework for initial steps in investigating a site. It is not intended to be all-inclusive relative to objectives, methods, and analysis nor to serve as the definitive reference or directive for any step in wind power related investigations. The Physical Attributes, Species Occurrence and Status, and Ecological Attractiveness groupings in this protocol should serve as a model framework; the terrain features, species, and conditions used in these groupings will be dictated by local conditions and should be developed by wildlife biologists familiar with the region in which this protocol is being used.

Potential Impact Index (PII)

The Potential Impact Index represents a “first cut” analysis of the suitability of a site proposed for development. It does so by estimating use of the site by selected wildlife species as an indicator of potential impact. Emphasis of the PII is on initial site evaluation and is intended to provide more objectivity than simple reconnaissance surveys.

There are two steps to follow in ranking sites by their potential impact on wildlife:

1. Identify and evaluate reference sites within the general geographic area of Wind Resource Areas (WRA’s) being considered for development of a facility. Reference sites are areas where wind development would result in the maximum negative impact on wildlife, resulting in a high PII score. Reference sites are used to determine the comparative risks of developing other potential sites.

2. Evaluate potential development sites to determine risk to wildlife, and rank sites against each other using the highest-ranking reference site as a standard. While high-ranking sites are generally less desirable for wind development, a high rank does not necessarily preclude development of a site, not does a low rank automatically eliminate the need to conduct pre-development assessments of wildlife use and impact potential.

The following assumptions are implicit in the PII process:

1. All WRA sites, regardless of turbine design, configuration, placement, or operation present some hazard and risk to wildlife from both an individual and population perspective.

2. Certain sites present less hazard and risk to wildlife than others.

3. No adequate and defensible information exists regarding the appropriateness of the proposed WRA site being evaluated relative to impacts to wildlife.

4. Evaluations will be conducted by qualified biologists without competitive interest in site selection, including those from State and Federal agencies who are familiar with local and regional wildlife.

The PII is designed primarily to evaluate potential impacts on aerial wildlife from collision with turbines and infrastructure. The PII is derived from the results of three checklists (forms are attached). These checklists should be developed and applied as follows:

A. The PHYSICAL ATTRIBUTE checklist considers topographic, meteorological, and site characteristics that may influence bird and bat occurrence and movements.

B. The SPECIES OCCURRENCE AND STATUS checklist includes: Birds of Conservation Concern at the Bird Conservation Region level (http://migratorybirds.fws.gov/reports/reports.html); all federally-listed Endangered, Threatened, and Candidate Species (http://endangered.fws.gov); bird species of high recreational or other value (e.g., waterfowl, prairie grouse); State Endangered, Threatened, and Species of Management Concern; and any additional species of concern listed by State Natural Heritage Programs.

C. The ECOLOGICAL ATTRACTIVENESS checklist evaluates the presence and influence of ecological magnets and other conditions that would draw birds or bats to the site or vicinity.

Each checklist has boxes to be checked for a particular attribute or species found at an evaluation site. The number of boxes in each checklist will vary from region to region due to variations in the number of physical attributes and species of concern in that region. Keep in mind that all boxes in a checklist are very unlikely to be checked at a single evaluation site, because all species and ecological physical conditions potentially occurring in the region would not exist at one site.

Each checklist should be assigned a divisor, which is developed by dividing the number of boxes in a checklist by the total number of boxes in all three checklists. This expands the spread of index values and more dramatically displays the magnitude of differences among sites. For example, if the PHYSICAL ATTRIBUTE checklist has 36 boxes and the total number of boxes in all three checklists is 144, divide 36 by 144 = 0.25, the divisor.

You can change the number of boxes in any of the checklists to fit your geographic area, habitat type, or other selected region (e.g., a state or portion of a state). Remember to recalculate the divisor if you change the number of boxes.

Boxes in a checklist are checked if the condition or species is known or strongly suspected to occur. Criteria for checklist conditions marked with an asterisk (*) are explained on the following page. Conditions that are self-explanatory are not included. Conditions are not weighted. Boxes are checked in the SPECIES OCCURRENCE AND STATUS checklist if presence of the species is unconfirmed but strongly suspected (i.e., WRA is within the range and habitat of the species). This permits more liberal assignment of potential impact, reduces the probability of missing impacts on specific species due to lack of empirical data, and focuses future study and monitoring effort. Totals for each checklist are simple column sums. The PII is calculated from the checklist totals. A completed example from Montana is provided at the end of this Appendix.

Determining Checklist Scores

Checklist scores are determined as follows:

1. Place a check in each box for which an attribute, species, or condition is present or strongly suspected.

2. After completing the three checklists for each site, add the total number of checks in a checklist for an ending sum (each box checked equals one).

Determining PII Score

The Potential Impact Index score is determined as follows:

1. Place the sums from each of the three checklists in the POTENTIAL IMPACT INDEX table sum boxes (Σ column) in the appropriate category.

2. Divide each checklist sum by the previously calculated divisor to adjust the sum for disproportionate numbers of conditions in each checklist, and place this adjusted sum in the Σ/p boxes for each checklist.

3. Add the adjusted checklist sums (Σ/p column) to produce the PII score.

Include any questions, statements, comments, or concerns regarding any checklist cell or category on the SITE SPECIFIC COMMENTS sheet. These comments are critical to determining pre-construction study needs. They will also help identify and refine questions and objectives to be addressed by follow-up study and monitoring. The nature of suspected Significant Ecological Events should be noted on the SITE SPECIFIC COMMENTS sheet.

Ranking PII Scores

PII of each site evaluated is assigned a ranking based on its proportional relationship to the reference site that has the maximum PII score, as shown in Figure 2 in the Montana example. Ranking categories (High, Low, etc.) in the example are arbitrarily set at intervals of 20 percent of maximum.

Rankings are intended as a guide to developers. They are designed to serve as indicators of relative risk to wildlife and thus provide an estimator of the level of impact that may be expected should a site be developed. A high rank does not preclude development, nor does a low rank automatically eliminate the need to conduct pre-development assessments of impacts on wildlife. More intensive pre-construction studies may be needed for both scenarios if development of the site is pursued. Rankings may also suggest the extent of additional study needed.

In the case of federally listed threatened, endangered, or candidate species of wildlife, fish, or plants, consultation with the Fish and Wildlife Service under the Endangered Species Act is required, and may preclude development of a site regardless of its PII score. See Appendix 5 for procedures for obtaining lists of these species that may be present, and for consulting with the Fish and Wildlife Service if species or their habitats are found.

Determining Pre-construction Study Needs

The goals of pre-construction studies are to estimate impacts of proposed wind power development on wildlife by addressing areas of concern identified during the PII process. Objectives, intensity, duration, and methods of pre-construction studies are likely to be site specific, but may be independent of ranking. Regardless of ranking, studies should be designed to address (1) verification of use of WRAs by all species recorded in the "SPECIES OCCURRENCE AND STATUS" checklist, (2) verification of natural conditions (e.g., under "Significant Ecological Events", the magnitude, timing, and location of suspected bird/bat migration), or (3) questions noted in the SITE SPECIFIC COMMENTS sheet for that site. The SITE SPECIFIC COMMENTS sheet may also indicate conditions that need not be investigated. As a result, a site with a low rank may require radar surveillance (e.g., important songbird migration site) while a site with a high rank may require only a single season visual survey (e.g., site potentially contains autumn Whooping Crane habitat). The process should involve a feedback mechanism within an adaptive management strategy (Figure 1). Timely review of study results will determine if data are

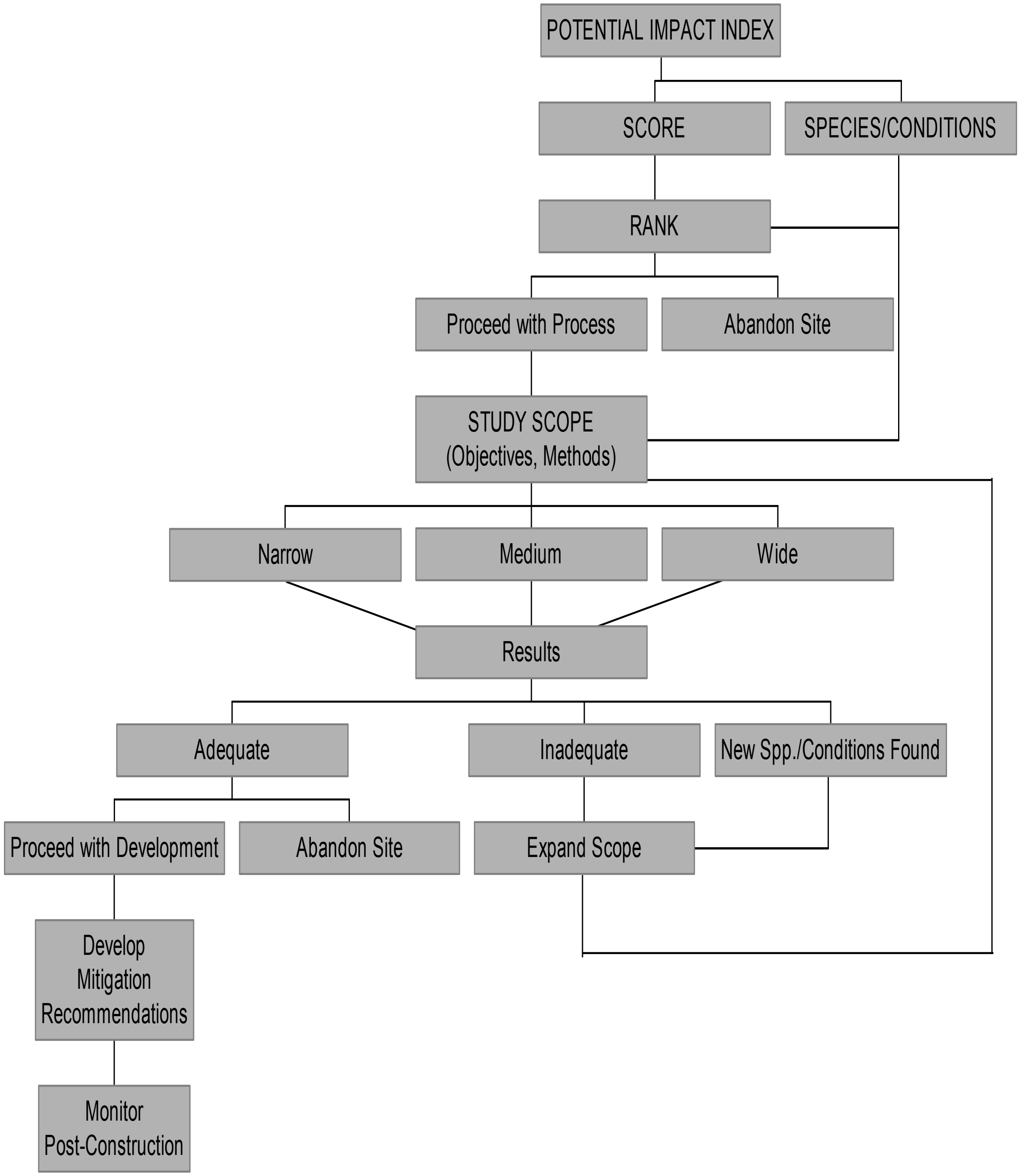


Figure 1. A suggested decision tree for assessing potential development sites. Begin by developing a PII score.

adequate, if conclusions are defensible (Anderson et al. 1999), and if additional investigational effort is required (e.g., if Black-footed Ferrets are found on Mountain Plover searches). Projects with Federal involvement may require additional analysis under the National Environmental Policy Act (http://www.fws.gov/r9esnepa), Endangered Species Act (http://endangered.fws.gov), or National Wildlife Refuge System Administration Act (http://www.fws.gov/policyMakers/mandates/index.html#adminact). Also, the mere existence of a pre-construction study, whether in progress or completed, does not imply Federal sanction for development of a site.

Post-construction Studies

The Service recommends that all sites be monitored for impacts on wildlife after construction is completed. Some sites may be so obviously benign that little more than simple reconnaissance study may be needed and any impact will be revealed during post-construction monitoring. Otherwise, pre-construction studies should be designed to explicitly consider post-construction monitoring that permits statistically valid evaluation of actual impacts. Accordingly, studies should be conducted as much as possible within a Before-After-Control-Impact (BACI) study design (Green 1979). Such design requires investigation of at least two sites (Impact [proposed site] and Control) simultaneously, both pre-construction (Before) and post-construction (After). Because true "Control" sites are seldom available, other sites may be substituted, including reference sites used in developing the PII ranking. In the case of radar surveillance studies, sites within the proposed WRA boundaries may be acceptable (e.g., Harmata et al. 1998). Structuring pre-construction studies within a hypotheses-testing framework will help identify appropriate metrics, focus effort, and permit comparisons with post-construction conditions or other WRAs.

Where feasible, post-construction studies should also be utilized to test measures that may eliminate or reduce impacts on wildlife. See Appendix 4, Research Needs on the Impacts of Wind Power Development on Wildlife.

Metrics and Methods

Metrics and methods are specific tools used to assess wildlife populations and their status (e.g., point counts, line transects, nest success studies, radar surveys, mortality rates, and risk). They can provide important information about birds, bats, and other wildlife at proposed development sites. Metrics and methods may be selected to collect seasonal, group, guild, or habitat specific information, based on data and comments in the SPECIES OCCURRENCE AND STATUS checklist and SITE SPECIFIC COMMENTS sheet. For example, a proposed WRA may be in a narrow north-south oriented valley of relatively monotypic habitat. These conditions suggest a heavy seasonal avian migration corridor but little avian breeding habitat. Accordingly, study emphasis should be on defining use and mortality of migratory birds during autumn or spring or both, with little effort directed at defining use and mortality of breeding birds. Conversely, a potential WRA on a flat plain in diverse habitat would indicate the exact opposite in study emphasis.

While metrics represent specific measurements, concepts, and relationships, methods refer to observational or manipulative study techniques that may be used to verify the location of birds and other wildlife, estimate their numbers, and document their use and behavior (Anderson et al. 1999). Table 1 depicts some commonly used metrics and methods for wildlife studies.

Table 1. Examples of metrics and methods associated with evaluating use and mortality of wildlife at proposed Wind Resource Areas in Montana.

Data Need	Metric	Methods
Use Profile	Individuals/Count	Point Counts (birds) Winter Raptor Surveys Lek Counts (grouse) Migration Counts Ungulate Surveys Spotlight Surveys

	Species/Count	Species/guild/group List Point Counts (birds) Raptor Nesting Surveys Raptor Migration Counts Winter Raptor Surveys Acoustic Surveillance (bats) Pellet Counts Bait Stations Track Boards
	Use per unit of time (e.g., hour, season)	Radar Migration Counts Raptors/watch Area Searches
	Individuals/capture effort	Various techniques for capture
	Productivity	Nests/area Raptor Nesting Surveys Nest Success Ungulate Surveys
	Events/height category (Altitude Profile)	Radar
	Events/distance category (Spatial Profile)	Radar
Mortality	Dead/injured individuals/unit	Transects Spot Searches Carcass Removal Study Observer Detection Efficiency Study

Studies should also strive to generate information to mitigate impacts by properly locating, configuring, or operating turbines (Johnson et al. 2000). Every effort should be made to choose metrics and methods that allow comparisons of pre-construction studies with post-construction studies, other WRAs, and other regions.

Interpreting Metrics

It may be difficult to establish empirically exactly what constitutes high use (i.e., potentially high impact). When looking at the distribution and movements, and local, regional, or range-wide population estimates for particular species, the relative proportions of species, groups, or guilds of wildlife using proposed WRAs may indicate degrees of risk. If baseline population data are unknown, consult with a qualified biologist who can recommend a specific metric.

It is likely that little or no evidence of mortality will be found during pre-construction study. If, however, post-construction mortality is found, and statistical evaluation is not possible, that mortality should be assessed in regard to the species status (e.g., ESA-listed species or Birds of Conservation Concern) or the effect of the loss of individuals of that species on a local, regional, or continental population.

Determining Post-construction Monitoring Needs

Post-construction monitoring is important to the Service, industry, and public because of the limited information available on impacts of wind turbines and WRAs on wildlife. Therefore, post-construction monitoring should be designed to detect major impacts. The intended time frame for post-construction monitoring is not expected to exceed three years, however. Major impacts may be considered as statistically significant decreases in use by species of concern, or limited to statistically significant increases in mortality rates of any wildlife. Monitoring effort may be intensive or cursory, depending on results of pre-construction use and mortality studies. Simple, infrequent mortality surveys on impact and control plots may be all that is needed at WRAs where recorded pre-construction use by wildlife is low. Documented high use of a proposed WRA may require monitoring methods identical to those employed in pre-construction studies. Anderson et al. (1999) provide specific, detailed direction in post-construction study design and monitoring. Manville (2002) developed a monitoring protocol for use by the U.S. Forest Service at three National Forests in Arizona to monitor the impact of cellular telecommunications towers on migratory birds that could be modified for use at land-based wind turbines.

POTENTIAL IMPACT INDEX CHECKLIST FORMS AND INSTRUCTIONS

PHYSICAL ATTRIBUTE CHECKLIST

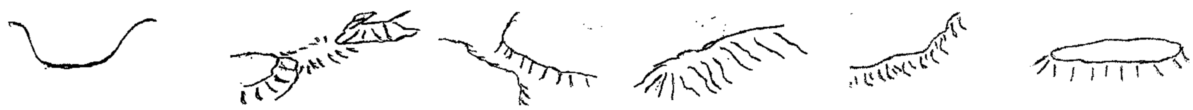
Physical Attribute				Site			
Topography	Mountain Aspect, if mountainous*	Side	W				
			E				
			N				
			S				
		Top					
		Foothill	W				
			E				
			N				
			S				
Wind* Direction	S						
	N						
	E						
	W						
	Updrafts*						
Migratory* Corridor Potential	Latitudinal (N ↔ S)						
	Longitudinal (E ↔ W)						
	Wide Approaches (>30 km)*						
	Funnel Effect	Horizontal					
		Vertical					
Site Size (acres) & Configuration*	<640						
	>640 <1000						
	>1000 <1500						
	Turbine Rows not Parallel to						
Infrastructure To Build	Transmission						
	Roads						
	Buildings*						
	Maintenance						
	Daily Activity						
	Substation						
Increased Activity*							
Totals							

* Criteria on following page

PHYSICAL ATTRIBUTE CRITERIA -   categories, max Σ =   , (p =   ).

Topography - Terrain characteristic within the ecological influence of the proposed wind development site, generally, but not restricted to ± 5 mi. Some examples are:

Valley Pass Gap Ridgetop Bluff Butte



Mountain Aspect - Aspect of topography for site of proposed development. Multiple categories may be checked.

Wind Direction - Compass direction *from* which prevailing winds approach. Multiple categories may be checked.

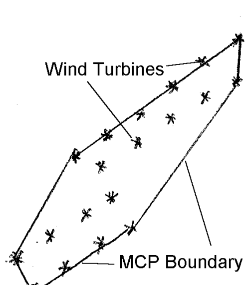
Updrafts - Do updrafts/upslope winds prevail?

Migratory Corridor Potential - Subjective estimate of area to be a potential avian/bat migratory corridor based strictly on topographical characteristics. Multiple categories may be checked.

Wide (>20 mi) - Terrain characteristics of approaches to site from each migratory direction, i.e., a large plain, river corridor, long valley. The larger the area that migrant birds/bats are drawn from, the more may be at risk

Funnel Effect - Is the site in or near an area where migrant birds/bats may be funneled (concentrated) into a smaller area, either altitudinally, laterally, or both?

Site Size & Configuration – Size is estimated as if a minimum convex polygon (MCP) were drawn around peripheral turbines.



Successive boxes are checked to convey relationship of larger size = increased impact to birds/bats, *e.g.*, a 700 acre site will have 2 categories checked while a 1,200 acre site will have all 3 categories checked.

Configuration of turbine rows is usually perpendicular to prevailing wind direction. Rows aligned perpendicular or oblique to route of migration intuitively presents more risk to birds than rows aligned parallel to movement.

Buildings – Building are categorized by relative size and visitation frequency, *i.e.,* structures that are visited daily are usually larger and present more impact than those that are not. If a “Daily Activity” building is required, all Building categories are checked. If a maintenance structure is required, Substation is also checked.

Increased Activity - Will any type of human activity increase? Sites in urban-suburban or otherwise developed areas (oil, gas, mines) will have less impact on wildlife than those in remote or undeveloped areas.

Avian Species of Concern Checklist
(Complete prior to SPECIES OCCURRENCE & STATUS Checklist)

Site

Birds (n =)												
Occurrence	B	M/W	Σ	B	M/W	Σ	B	M/W	Σ	B	M/W	Σ
Subtotals												
Total												

Avian Species of Concern Checklist (species, max Σ =)

Column totals of this list are added to appropriate cells in the SPECIES OCCURRENCE & STATUS checklist. Consult Birds of Conservation Concern (http://migratorybirds.fws.gov/reports/reports.html) and Threatened/Endangered Species list (http://endangered.fws.gov), and list other species of high value or management concern such as migratory waterfowl and prairie grouse. Appropriate avian field guides and species accounts should be consulted for confirmation of species distribution and habitat associations. State Natural Heritage Programs may also provide species accounts that include additional information useful in completing checklists.

In addition to species lists (rows), season of occurrence is also indicated (columns). "B" indicates breeding or summer occurrence and "M/W" indicates presence during migration or as wintering species. If occurrence within or in the vicinity of a proposed site is confirmed or suspected, an "X" is entered.

Bat Species Of Concern Checklist
(Complete prior to SPECIES OCCURRENCE & STATUS Checklist)

	Site											
Bats (n =)												
Occurrence	B	M/W	Σ	B	M/W	Σ	B	M/W	Σ	B	M/W	Σ
Subtotals												
Total												

Bat Species Of Concern Checklist (species, max Σ =).

Column totals of this list are added to appropriate cells in the SPECIES OCCURRENCE & STATUS checklist. Appropriate bat field guides and references (Barbour and Davis 1969) should be consulted for confirmation of species distribution and habitat associations. State Natural Heritage Programs may also provide species accounts that include additional information useful in completing checklists.

In addition to species lists (rows), season of occurrence is also indicated (columns). "B" indicates breeding or summer occurrence and "M/W" indicates presence during migration or as wintering species. If occurrence within or in the vicinity of a proposed site is confirmed or suspected, an "X" is entered.

SPECIES OCCURRENCE & STATUS CHECKLIST

		Site											
	Species												
	Occurrence	B	M/W	Σ	B	M/W	Σ	B	M/W	Σ	B	M/W	Σ
Threatened & Endangered (includes wildlife, fish, and plants)													
Candidate*													
Special Concern*	Birds (max Σ=)												
	Bats (max Σ=)												
	Subtotals												
	Total												

* Criteria on following page

SPECIES OCCURRENCE & STATUS Checklist (categories, max Σ = , (p =   ).

Checklist totals for each column in "Avian Species of Concern List" and "Bat Species of Concern List" are inserted in this checklist.

Threatened & Endangered Species - Species on the Federal List of Endangered and Threatened Species (http://endangered.fws.gov).

Candidate Species - Species being investigated for inclusion in the Federal List of Endangered and Threatened Species (http://endangered.fws.gov).

Species of Special Concern - Species listed in Birds of Conservation Concern; by Natural Heritage Programs that are known or suspected to be rare, endemic, disjunct, threatened or endangered; and species of high value such as migratory or other game birds.

Golden Eagles may be included in this checklist because of special protective status afforded under the Bald and Golden Eagle Protection Act (16 U.S.C. 668-668d). Other species (e.g., Sage Grouse) may be included because of recent concern over population declines range wide. Bats (other than bat Species of Special Concern) should be included due to generally unknown impacts of wind farms on individuals and populations.

ECOLOGICAL ATTRACTIVENESS CHECKLIST

Ecological Attractor			Site			
Migration Route*	Local					
	Continental*	N				
		S				
		E				
		W				
Ecological Magnets*	Lotic System					
	Lentic System					
	Wetlands					
	Native Grassland					
	Forest					
	Food Concentrated					
	Energetic Foraging					
	Vegetation/ Habitat	Unique				
		Diverse				
Significant Ecological Event*						
Site of Special Conservation Status*						
		Total				

* Criteria on following page

ECOLOGICAL ATTRACTIVENESS CRITERIA - categories, max Σ = , (p =).

Migration Route - Indicates predominate direction of movement of seasonal migrations. Multiple categories may be checked.

Local - Some avian populations move only altitudinally & direction may be East-West (Sage Grouse, owls, Bald Eagles).

Continental - Some migratory corridors experience mass movements in only one season/direction annually (e.g., Bridger Mountains autumn eagle migration).

Ecological Magnets - Special, unique, unusual, or super ordinary habitats or conditions within the vicinity of the site that may attract wildlife. Lotic systems include small perennial or seasonal creeks to major rivers. Lentic systems include stock ponds to lakes to marine environments. Multiple categories may be checked.

Vegetation/Habitat - Unique or exceptionally diverse vegetation or habitat in the vicinity may indicate exceptional diversity and abundance of avian species or bats.

Significant Ecological Event - Special, unique, unusual, or super ordinary events that occur or are suspected to occur in the vicinity of the site, e.g., up to one third of the Continental population of Trumpeter Swans visit Ennis Lake, < 2.5 miles from a proposed Wind Resource Area; the Continental migration of shorebirds passes over (many stop) at Benton Lake National Wildlife Refuge) and up to 2,000 Golden Eagles pass over the Bridger Mountains in autumn. If unknown but suspected a "?" is entered. Specifics regarding the cell are then addressed in the appropriate box of the SITE SPECIFIC COMMENTS sheet to focus follow-up investigation and assist in definition of study objectives.

Site of Special Conservation Status - Any existing or proposed covenants, conservation easements, or other land development limitations intended to conserve, protect, or enhance wildlife or habitat. This criterion is weighted (2 entered if true) because of previous financial or other investment in ecological values. Specifics regarding the easement are then addressed in the appropriate box of the SITE SPECIFIC COMMENTS sheet to focus follow-up attention.

POTENTIAL IMPACT INDEX

Checklist (p)[1]	Site							
	Σ	Σ/p	Σ	Σ/p	Σ	Σ/p	Σ	Σ/p
Physical ( )								
Species Occurrence & Status ( )								
Ecological ( )								
Totals								

[1]Proportion of total checklist categories.

Determining PII Score

A. Place the sums from each of the three checklists in the POTENTIAL IMPACT INDEX table sum boxes (Σ column) in the appropriate category.

B. Divide each checklist sum by the previously calculated divisor to adjust the sum for disproportionate numbers of conditions in each checklist, and place this adjusted sum in the Σ/p boxes for each checklist.

C. Add the Σ/p boxes for the three checklists to obtain a total score.

SITE SPECIFIC COMMENTS

Checklist	**Site**			
Physical				
Species Occurrence				
Ecological				

EXAMPLE SITE ASSESSMENT AND
CALCULATION OF POTENTIAL IMPACT INDEX (PII)
FROM MONTANA

POTENTIAL IMPACT INDEX CHECKLISTS

Calculating Divisors

A. Each checklist should be assigned a divisor, which is developed by dividing the number of boxes in a checklist by the total number of boxes in all three checklists. In this example, the total number of boxes in all three checklists is 143.

B. Physical Attribute checklist: 36 boxes ÷ 143 = 0.25; Species Occurrence and Status checklist: 91 boxes ÷ 143 = 0.63; Ecological Attractiveness checklist: 16 boxes ÷ 143 = 0.11.

Determining Checklist Scores

A. Place a check in each box for which an attribute, species, or condition is present or strongly suspected.

B. After completing the three checklists for each site, add the total number of checks in a checklist for an ending sum (each box checked equals 1).

PHYSICAL ATTRIBUTE CHECKLIST

Physical Attribute				Site: Snowy Mtn.Range			
Topography	Mountain Aspect	Side	W	X			
			E				
			N				
			S				
		Top					
		Foothill	W	X			
			E				
			N				
			S				
	Valley			X			
	Pass						
	Gap						
	Ridge			X			
	Bluff						
	Butte						
Wind Direction	S						
	N			X			
	E						
	W						
	Updrafts			X			
Migratory Corridor Potential	Latitudinal (N ↔ S)						
	Longitudinal (E ↔ W)			X			
	Wide Approaches (>30 km)						
	Funnel Effect	Horizontal		X			
		Vertical					
Site Size (acres) & Configuration	<640			X			
	>640 <1000			X			
	>1000 <1500			X			
	Turbine Rows not Parallel to						
Infrastructure To Build	Transmission			X			
	Roads			X			
	Buildings			X			
			Maintenance	X			
			Daily Activity	X			
	Substation			X			
Increased Activity				X			
			Totals	18			

Avian Species of Concern Checklist
(Complete prior to SPECIES OCCURRENCE & STATUS Checklist)

Site

Birds (n = 12)	Snowy Mtn. R.											
Occurrence	B	M/W	∑	B	M/W	Σ	B	M/W	Σ	B	M/W	Σ
Nelson's Sharptailed Sparrow	X	X	2									
LeConte's Sparrow	X	X	2									
Baird's Sparrow	X	X	2									
Dickcissel	X		1									
Cassion's Kingbird	X		1									
Blackbacked Woodpecker	X		1									
Yellow-billed Cuckoo	X		1									
Peregrine Falcon	X		1									
Northern Goshawk		X	1									
Ferruginous Hawk		X	1									
Clark's Grebe	X		1									
Common Loon	X		1									
Subtotals	10	5	15									
Total			15									

Bat Species Of Concern Checklist
(Complete prior to SPECIES OCCURRENCE & STATUS Checklist)

Bats (n = 2)	Site: Snowy Mtn. Range											
Occurrence	B	M/W	∑	B	M/W	Σ	B	M/W	Σ	B	M/W	Σ
Fringed Myotis	X		1									
Spotted Bat	X		1									
Subtotals	2		2									
Total			2									

SPECIES OCCURRENCE & STATUS CHECKLIST

		Site											
Species		Snow Mtn. R.											
	Occurrence	B	M/W	Σ	B	M/W	Σ	B	M/W	Σ	B	M/W	Σ
Threatened & Endangered	Bald Eagle		X	1									
Candidate	Columbian Sharp-tailed Grouse	X	X	2									
Special Concern	Birds (max Σ=)			15									
	Bats (max Σ=)			2									
	Subtotals			20									
	Total			20									

ECOLOGICAL ATTRACTIVENESS CHECKLIST

Ecological Attractor			Site: Snowy Mtn. Range			
Migration Route	Local					
	Continental	N	X			
		S	X			
		E				
		W				
Ecological Magnets	Lotic System					
	Lentic System					
	Wetlands		X			
	Native Grassland		X			
	Forest		X			
	Food Concentrated					
	Energetic Foraging		X			
	Vegetation/ Habitat	Unique				
		Diverse	X			
Significant Ecological Event						
Site of Special Conservation Status						
Total			7			

POTENTIAL IMPACT INDEX

Checklist (p)[1]	Site							
	Σ	Σ/p	Σ	Σ/p	Σ	Σ/p	Σ	Σ/p
Physical (0.25) 15÷.25=60	15	60						
Species Occurrence & Status (0.63) 20÷.63=32	20	32						
Ecological (0.11) 7÷.11=64	7	64						
Totals	42	**156**						

[1]Proportion of total checklist categories.

Score is 156, compared to the highest reference site score of 244 (Figure 2).

Determining PII Score

A. Place the sums from each of the three checklists in the POTENTIAL IMPACT INDEX table sum boxes (Σ column) in the appropriate category.

B. Divide each checklist sum by the previously calculated divisor to adjust the sum for disproportionate numbers of conditions in each checklist, and place this adjusted sum in the Σ/p boxes for each checklist.

C. Add the Σ/p boxes for the three checklists to obtain a total score.

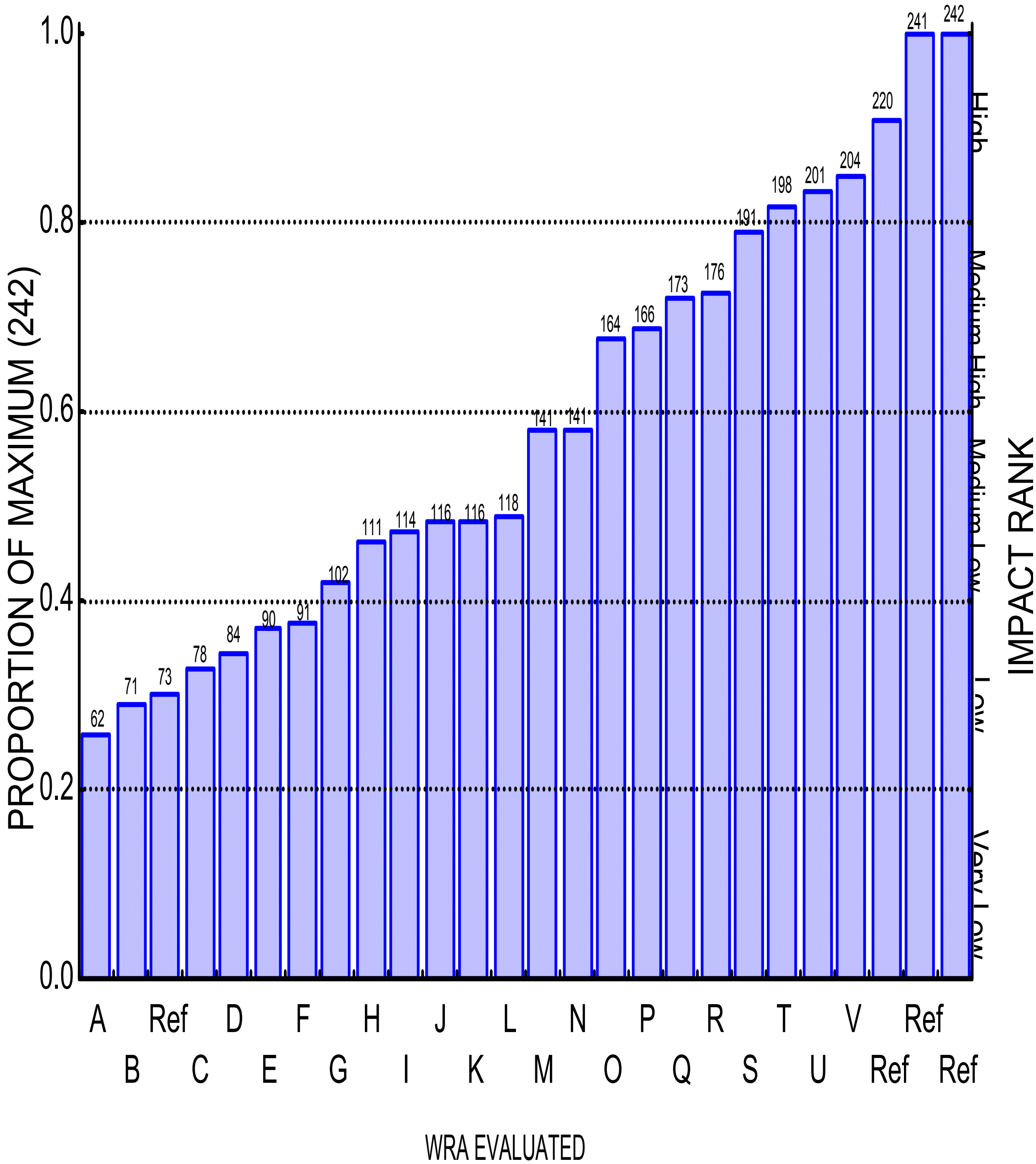


Figure 2. Impact ranks of proposed Wind Resource Areas in Montana. The number above each bar is the PII score. Rank is a function of the proportional relationship of proposed development sites to the maximum score of 4 Reference Sites evaluated.

Appendix 2

DEFINITIONS RELATED TO WIND ENERGY DEVELOPMENT AND EVALUATION

AGL: height above ground level in feet.

Breco Bird Scaring Buoy: a device developed to disperse seabirds at oil spills, which emits some 30 different sounds (including alert calls) up to 130 dB, generally effective in scaring birds at distances up to 200 yards, but may deter birds to 0.5 mile radius. The floating device can be used daytime or night, in fog, wind or storms.

Deterrent Devices: specific equipment, devices, or techniques which are intended to be seen or heard to alert and deter birds from contacting turbine towers, rotors, guy wires, or related equipment. These include diverters installed on turbine or meteorological tower guy wires, dark (e.g., black) paint on single turbine blades or portions of a blade, or noise-making devices that alert (e.g., infrasound) or frighten (e.g., Breco Buoys) birds.

Fish and Wildlife: any member of the animal kingdom, including any bird (including any migratory, non-migratory, or endangered bird for which protection is afforded), mammal, fish, amphibian, reptile, mollusk, crustacean, arthropod, or other invertebrate. Unless otherwise indicated, the Fish and Wildlife Service is particularly concerned about the impacts of wind turbines on birds and bats.

Flyway: a concentrated, predictable flight path of migratory bird species (e.g., particularly water birds such as ducks, geese, large waders, and shorebirds, but also raptors, and sometimes songbirds) from their breeding ground to wintering area. Except along coast lines, the flyway concept may not generally apply to songbirds because they tend to migrate in broad fronts rather than down specific flyways. The term “corridors” has sometimes been used. These frontal movements of songbirds can change within and between seasons and years – as can, for example, movements of waterfowl – making specific designations more difficult. The concept applies both biologically and administratively. For administrative purposes, for example, there are four waterfowl flyways (Atlantic, Pacific, Central, and Pacific and three shorebird flyways (East, Central, and Pacific). “Daily flyways” may also exist between roosting, breeding, and feeding areas.

Lek: A traditional site used year after year by males of certain species of birds (in North America, Greater and Lesser Prairie-chickens, Sage and Sharp-tailed grouse, and Buff-breasted Sandpiper), within which the males display communally to compete for female mates. Dominant males secure the majority of all the matings. Pair bonds are not formed; females leave to nest and raise the young, and males do not take part in parental care.

Passerines: a scientific term for the order of songbirds, many of which winter in tropical areas.

Precautionary Approach: a conservative, scientific approach to conserving and managing habitats and species. Absent definitive data, the approach suggests taking the best steps available to initiate appropriate conservation actions. Those actions should then be refined through the use of principles of adaptive management and sound science. The absence of complete or definitive scientific information should not be used as a reason for postponing or failing to take measures to conserve target species, associated or dependent species, or non-target species and their environments. Specifically, developers should apply a precautionary approach widely to conservation and management of birds, bats, other fauna, flora, and affected habitats. This will protect the resources and preserve Wind Resource Areas by taking account of the best scientific evidence available.

Reference Site: an area of high wildlife value which is used to evaluate the suitability of other areas for wind energy development. Reference sites are selected by biologists familiar with the wildlife in the geographic area and habitat types where wind energy development is contemplated, and evaluated using the Ranking Protocol in Appendix 1. The reference site having the highest score, i.e., the area where wind energy development would have the greatest negative impact on wildlife, is used as the standard against which potential wind energy development sites are ranked.

Riparian Area: The vegetation, habitats, or ecosystems that are associated with streams, rivers, or lakes, or are dependent upon the existence of perennial, intermittent, or ephemeral surface or subsurface water drainage. Relative to other habitats, riparian habitats have a disproportionately high wildlife value in the drier western states due to the presence of surface water and/or lush vegetation that is typically surrounded by harsher, arid or semi-arid environments.

Rookery: the breeding place of a colony of gregarious birds (e.g., herons) or mammals (e.g., bats).

Rotor-swept Area: generally the vertical airspace within which the turbine blades (usually 3) rotate on a pivot point or drive train rotor. The Area will vary in location depending on the direction of the prevailing wind. While "slower" turbines may operate at speeds less than 30 revolutions per minute (RPMs), turbine speeds at the blade tips can still exceed 220 miles per hour in stiff winds. Recent studies indicate that birds appear unable to recognize blade presence at rotor tips during high blade speed, referred to as the "smear effect."

Staging Area: a traditional site where migratory birds of one or more species congregate in spring and fall for varying periods of time to forage and build up fat reserves prior to launching migratory flights. The term may be used on both the breeding and wintering grounds, as well as at intermediate stopover sites used at any point along the migration route.

Turbine Position within a Row/String: the specific position of a turbine within a string or row of turbines. It may be designated as an end-row, mid-row, or lone row turbine (one not located within a row).

Wind Resource Area: the geographic area or footprint within which wind turbines are located and operated, such as the Altamont Pass, California, WRA, or where location and operation of turbines are anticipated. The term may be used to describe an existing facility, or a general area in which development of a facility is proposed. Existing facilities are known variously as "wind farms," "wind parks," or "energy parks." WRAs are selected based primarily on the reliability and availability of sufficient wind. These areas are designated by the *United States Wind Resource Map*, published by the National Renewable Energy Laboratory, Department of Energy (http://rredc.nrel.gov). The *Map* delineates wind power classifications from "marginal" to "superb" based on a Weibull wind speed index.

Appendix 3

WILDLIFE LAWS RELEVANT TO WIND POWER DEVELOPMENT PROJECTS

The Migratory Bird Treaty Act (16 U.S.C. 703-712; MBTA), which is administered by the Fish and Wildlife Service (FWS), is the cornerstone of migratory bird conservation and protection in the United States. The MBTA implements four treaties that provide for international protection of migratory birds. It is a strict liability statute wherein proof of intent is not an element of a taking violation. Wording is clear in that most actions that result in a "taking" or possession (permanent or temporary) of a protected species can be a violation. Specifically, the MBTA states:

"Unless and except as permitted by regulations … it shall be unlawful at any time, by any means, or in any manner to pursue, hunt, take, capture, kill … possess, offer for sale, sell … purchase … ship, export, import … transport or cause to be transported … any migratory bird, any part, nest, or eggs of any such bird … (The Act) prohibits the taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts, and nests, except when specifically authorized by the Department of the Interior." The word "take" is defined as "to pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to pursue, hunt, shoot, wound, kill, trap, capture, or collect."

A 1972 amendment to the MBTA resulted in inclusion of Bald Eagles and other birds of prey in the definition of a migratory bird. The MBTA provides criminal penalties for persons who, by any means or in any manner, pursue, hunt, take, capture, kill, attempt to take, capture, or kill, possess, offer for sale, sell, offer to barter, barter, offer to purchase, purchase, deliver for shipment, ship, export, import, cause to be shipped, exported, or imported, deliver for transportation, transport or cause to be transported, carry or cause to be carried, or receive for shipment, transportation, carriage, or export, any migratory bird (including Bald Eagles) as well as possessing Bald Eagles, their parts, nests, or eggs without a permit. A violation of the MBTA by an individual can result in a fine of up to $15,000, and/or imprisonment for up to 6 months, for a misdemeanor, and up to $250,000 and/or imprisonment for up to 2 years for a felony. Fines are doubled for organizations. Penalties increase greatly for offenses involving commercialization and/or the sale of migratory birds and/or their parts. Under authority of the Bald and Golden Eagle Protection Act (16 U.S.C. 668-668d; BGEPA), Bald and Golden Eagles are afforded additional legal protection. Penalties for violations of the BGEPA are up to $250,000 and/or 2 years imprisonment for a felony, with fines doubled for an organization.

While these Acts have no provision for allowing unauthorized take, the FWS realizes that some birds may be killed even if all reasonable measures to avoid the take are implemented. The FWS Office of Law Enforcement carries out its mission to protect migratory birds not only through investigations and enforcement, but also through fostering relationships with individuals, companies, and industries who seek to eliminate their impacts on migratory birds. Unless the activity is authorized, it is not possible to absolve individuals, companies, or agencies from liability even if they implement avian mortality avoidance or similar conservation measures. However, the Office of Law Enforcement focuses on those individuals, companies, or agencies that take migratory birds with disregard for their actions and the law, especially when conservation measures have been developed but are not properly implemented.

The Endangered Species Act (16 U.S.C. 1531-1544; ESA) was passed by Congress in 1973 in recognition that many of our Nation's native plants and animals were in danger of becoming extinct. The purposes of the Act are to protect these endangered and threatened species and to provide a means to conserve their ecosystems. To this end, Federal agencies are directed to utilize their authorities to conserve listed species, as well as "Candidate" species which may be listed in the near future, and make sure that their actions do not jeopardize the continued existence of these species. The law is administered by the Interior Department's FWS and the Commerce Department's National Marine Fisheries Service (NMFS). The FWS has primary responsibility for terrestrial and freshwater organisms, while the NMFS has responsibility for marine species such as whales and salmon. These two agencies work with other agencies to plan or modify Federal projects so that they will have minimal impact on listed species and their habitats. Protection of species is also achieved through partnerships with the States, with Federal financial assistance and a system of incentives available to encourage State participation. The FWS also works with private landowners, providing financial and technical assistance for management actions on their lands to benefit both listed and non-listed species.

Section 9 of the ESA makes it unlawful for a person to "take" a listed species. Take means ". . . to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct." The Secretary of the Interior, through regulations, defined the term "harm" as "an act which actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering." However, permits for "incidental take" can be obtained from the FWS for take which would occur as a result of an otherwise legal activity, such as construction of wind turbines, and which would not jeopardize the species.

Section 10 of the ESA allows for the development of "Habitat Conservation Plans" for endangered species on private lands. This provision is designed to assist private landowners in incorporating conservation measures for listed species with their land and/or water development plans. Private landowners who develop and implement an approved habitat conservation plan can receive an incidental take permit that allows their development to go forward.

The National Environmental Policy Act of 1969 (42 U.S.C. 4371 et seq.; NEPA) requires that Federal agencies prepare an environmental impact statement (EIS) for Federal actions significantly affecting the quality of the human environment. "Federal Actions" are those actions in which a Federal agency is conducting the activity, providing funding for the activity, or licensing or permitting the activity. An EIS must describe the proposed action, present detailed analyses of the impacts of the proposed action and alternatives to that action, and include public involvement in the decision making process on how to proceed to accomplish the purpose of the action. The purpose of NEPA is to allow better environmental decisions to be made. The Council on Environmental Quality, established by NEPA, has promulgated regulations in 40 CFR 1500-1508 that include provisions for 1) preparing EISs and Environmental Assessments, 2) considering categorical exclusions from NEPA documentation requirements for certain agency actions, and 3) developing cooperating agency agreements between Federal agencies.

Other Federal agencies may be required by NEPA to review and comment on proposed activities as a cooperating agency with the action agency under Section 1501.6, or because of a duty to comment on federally-licensed activities for which the agency has jurisdiction by law (Section 1503.4). For the FWS, this would be the MBTA and BGEPA. Other agencies may also be called on for review and comment because of special expertise.

The National Wildlife Refuge System Administration Act (16 U.S.C. 668dd), as amended, serves as the "organic act" for the National Wildlife Refuge System. It consolidates the various categories of lands administered by the Secretary of the Interior (Secretary) through the FWS into a single National Wildlife Refuge System. The Act establishes a unifying mission for the Refuge System, a process for determining compatible uses of refuges, and a requirement for preparing comprehensive conservation plans. The Act states first and foremost that the mission of the National Wildlife Refuge System will be focused singularly on wildlife conservation.

The Act identifies six priority wildlife-dependent recreation uses; clarifies the Secretary's authority to accept donations of money for land acquisition; and places restrictions on the transfer, exchange, or other disposal of lands within the Refuge System. Most importantly, the Act reinforces and expands the "compatibility standard" of the Refuge Recreation Act, authorizing the Secretary, under such regulations as he may prescribe, to "permit the use of any area within the System for any purpose, including but not limited to hunting, fishing, public recreation and accommodations, and access whenever he determines that such uses are compatible with the major purposes for which such areas were established." This section applies to any proposed development of wind energy on Refuge System lands; such development must be compatible with the major purpose for which that Refuge was established.

The National Historic Preservation Act of 1966 (16 U.S.C. 470-470b, 470c-470n) approved October 15, 1966 and repeatedly amended, provides for preservation of significant historical features (buildings, objects, and sites) through a grant-in-aid program to the States. It established a National Register of Historic Places and a program of matching grants under the existing National Trust for Historic Preservation (16 U.S.C. 468-468d). The Act also requires Federal agencies to take into account the effects of their actions on items or sites listed or eligible for listing in the National Register. Thus, the Act functions similarly to NEPA, requiring a determination of the presence of any such items or sites, and an evaluation of the effects of proposed developments (such as wind energy facilities) on them, if the facility would be built, funded, licensed or permitted by a Federal agency. This includes State lands purchased or improved with Federal Aid in Wildlife Restoration funds.

Appendix 4

RESEARCH NEEDS ON THE IMPACTS OF WIND POWER DEVELOPMENT ON WILDLIFE

Representatives of the Fish and Wildlife Service's Wind Turbine Siting Working Group have suggested the following research needs:

- Effects of inclement weather in attracting birds and bats to lighted turbines, e.g., drawing birds and bats to within rotor-swept area of turbines, particularly for passerines during spring and fall migrations.

- Localized effects of turbines on wildlife: habitat fragmentation and loss; effects of noise on both aquatic and terrestrial wildlife; habituation.

- Effects of wind turbine string configuration on mortality, e.g., end of row turbine effect, turbines in dips or passes or draws, setbacks from rim/cliff edges.

- Effectiveness of deterrents: alternating colors on blades (particularly, effect of black/white and UV gel coats on the smear effect); lights (e.g., color, duration, and intensity of pilot warning lights; lasers); infrasound (Breco Buoys, other noisemakers such as predator and distress calls if not irritating to humans, other wildlife, or domestic animals); visual markers on guy wires.

- Utility of acoustic, infrared, and radar technologies to detect bird species presence, abundance, location height, and movement.

- Accuracy of mortality counts: estimate of the number of carcasses (especially of passerines) lost because they have been fragmented and lost to collision momentum and the wind; size and shape of dead bird search areas; possibility of recording collisions acoustically or with radar or infrared monitoring.

- Annual variability (temporal and spatial) in migratory pathways; what is the utility of Geographic Information System to assess migratory pathways and stopovers, particularly for passerines and bats.

- Effectiveness of seasonal wind turbine shutdowns at preventing mortalities, including the feasibility of using "self-erecting" turbines that are easily erected and dismantled without cranes, and taking them down during critical periods such as migrations.

- Impacts of larger turbines versus smaller models.

- Changes in predator-prey relationships due to placing potential perching sites in prairie habitats.

Appendix 5

PROCEDURES FOR ENDANGERED SPECIES EVALUATIONS AND CONSULTATIONS

The Endangered Species Act (ESA) directs all Federal agencies to participate in endangered species conservation. Specifically, section 7(a)(1) of the ESA charges Federal agencies to aid in the conservation of listed species. Section 7 (a)(2) requires Federal agencies to consult with the Fish and Wildlife Service (FWS) to ensure that actions that they fund, authorize, permit, or otherwise carry out will not jeopardize the continued existence of any listed species or adversely modify designated critical habitats. The FWS has developed a handbook describing the consultation process in detail. It is available on the FWS web site at http://endangered.fws.gov/consultations. Consultation may be informal or formal, depending upon the presence of listed species and the potential for the proposed project to affect them.

Before initiating an action, the Federal action agency (the agency authorizing a specific action) or its non-Federal permit applicant, must ask the FWS to provide a list of threatened, endangered, proposed, and candidate species and designated critical habitats that may be present in the project area. This initiates the informal consultation process. If the FWS answers that no species or critical habitats are present, then the Federal action agency or permit applicant has no further ESA obligation under section 7(a)(2), and consultation is concluded. If listed species or critical habitats are present, then the action agency or applicant must determine whether the project may affect those species (known as a *may affect* determination), and informal consultation continues. If the action agency or applicant determines, and the FWS agrees, that the project does not adversely affect any listed species, then the consultation is concluded and the decision is put in writing.

If the action agency or applicant determines that a project *may adversely affect* a listed species or designated critical habitat, the action agency/applicant prepares a *Biological Assessment* and requests formal consultation. There is a designated period of time in which to consult (90 days), and beyond that, another set period of time for the FWS to prepare a *biological opinion* (45 days). An analysis of whether or not the proposed action would be likely to jeopardize the species or adversely modify its critical habitat is determined in the biological opinion. If a *jeopardy* or *adverse modification* determination is made, the biological opinion must identify any reasonable and prudent alternatives that could allow the project to move forward.

The biological opinion will contain an “incidental take statement.” “Take” is defined as harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting or attempting to engage in any such conduct. “Harm” is further defined to include significant habitat modification or degradation that results in death or injury to a listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering. “Incidental take” is defined as take that is incidental to, and not the purpose of, an otherwise lawful activity. If the FWS issues a *jeopardy* opinion, the incidental take statement will simply state that no take is authorized. If the FWS issues a nonjeopardy opinion, the FWS will anticipate the take that may result from the proposed project and describe that take in the incidental take statement. The statement will contain clear terms and conditions designed to reduce the impact of the anticipated take to the species; these terms are non-discretionary on the action agency or applicant.

When non-Federal activities will result in take of threatened or endangered species, an *incidental take permit* is required under section 10 of the ESA. A habitat conservation plan or “HCP” must accompany an application for an incidental take permit. The habitat conservation plan associated with the permit is to ensure that there are adequate conservation measures to avoid jeopardy to the species.

Examples:

1. **No Effect** – The appropriate conclusion when the action agency or applicant determines that its proposed action will not affect a listed species or designated critical habitat.

   Example: A permit applicant contacts the FWS to request information on listed species. The FWS provides a species list containing 3 plants, 1 fish, and 1 butterfly. The proposed project would be constructed at an upland site on clay soils. The 3 plants are found only on sandy soils. The butterfly’s habitat is one of the plants on sandy soil. The nearest sandy soils are 10 miles from the proposed project. The fish is in a stream 5 miles from the proposed project. Conclusion: No effects from the project, either direct or indirect. Justification: No construction is proposed in listed species habitat or in an area that may affect listed species. In addition, the project proponent has charted a route for heavy equipment moving onto the construction site that avoids listed species habitat.

2. **May Affect, but Not Likely to Adversely Affect** – The appropriate conclusion when effects on listed species are expected to be discountable, insignificant, or completely beneficial. Beneficial effects are contemporaneous positive effects without any adverse effects to the species. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Discountable effects are those extremely unlikely to occur. Based on best judgment, a person would not (a) be able to meaningfully measure, detect, or evaluate insignificant effects, or (b) expect discountable effects to occur.

   Example: The applicant contacts the FWS to request information on listed species. The FWS provides a species list containing 2 birds and 1 fish. The proposed project would be constructed at an upland site, 200 yards from the stream (fish habitat) and adjoining riparian vegetation (bird habitat). The migratory birds use the riparian vegetation to nest between April 15 and August 15. The uplands are highly erodible soils. The project proponent agrees not to construct during the nesting season. He flags the riparian vegetation to indicate an avoidance zone and installs silt fencing between the riparian vegetation and the construction site. He states that he will plant the disturbed soils surrounding the project with native vegetation after construction. He also agrees to monitor the vegetation planted for 3 years to assure that it establishes sufficiently to prevent any additional erosion in the project area caused by construction. Conclusion: Although the project proponent is working in very close proximity to listed species habitat, the action is not likely to adversely affect listed species. Justification: The proponent has incorporated sufficient avoidance and other mitigation measures into the project that any effects to listed species would be discountable. The project proponent prepares a Biological Assessment that includes a complete description of the project, all proposed avoidance and other mitigation measures, and the resulting effects of the project on the listed species. The Biological Assessment is sent to the FWS to request concurrence that the project is not likely to adversely affect listed species.

3. **May Affect, and Likely to Adversely Affect** – The appropriate finding in a Biological Assessment (or conclusion during informal consultation) if any adverse effect to listed species may occur as a direct or indirect result of the proposed action or its interrelated or interdependent actions, and the effect is not discountable, insignificant, or beneficial. In the event the overall effect of the proposed action is beneficial to the listed species, but is also likely to cause some adverse effects, then the proposed action "is likely to adversely affect" the listed species. If incidental take is anticipated to occur as a result of the proposed action, an "is likely to adversely affect" determination should be made. This determination requires the initiation of formal section 7 consultation.

   Example: The applicant contacts the FWS to request information on listed species. The FWS provides a species list containing 10 birds. The proposed project would be constructed at an upland site within a significant migratory bird corridor that is utilized by the 10 listed birds. Construction will permanently alter the character of the corridor and will likely cause take of listed birds every year during the migration periods. Conclusion: Formal consultation will be required. The project proponent prepares a Biological Assessment to submit to the action agency to accompany their request to initiate formal consultation. Justification: The project is likely to cause take of listed birds every year during their migration periods.

Appendix 6

GUIDELINES FOR CONSIDERING WIND TURBINE SITING ON EASEMENT LANDS ADMINISTERED AS PART OF THE NATIONAL WILDLIFE REFUGE SYSTEM IN REGION 6

Grassland easements are acquired to protect native and planted grasslands essential for grassland dependent migratory birds and other wildlife. Healthy grasslands provide both nesting and migration habitat necessary to maintain these important populations. Wind energy could severely impact this important program if not developed carefully with as little impact to migratory birds and their habitat as possible.

The following guidelines are to be used when making compatibility determinations for the siting of wind turbines and associated facilities on lands encumbered by U.S. Fish and Wildlife Service (Service) grassland easements and USDA conservation easements administered by the Service in Region 6, particularly in North Dakota, South Dakota, and Montana. These guidelines are intended to provide guidance for considering compatibility determinations during the period while the Service and the wind power industry monitor potential impacts to migratory birds as a result of turbine construction, maintenance, and operation. The following guidelines will be incorporated into rights-of-way permits issued for the construction of turbines, access roads, and other associated activities necessary to make the turbines operational. The intention of these guidelines is to minimize impacts to migratory birds and protect the habitat covered by the easement. The guidelines pertain only to permits issued for the alteration or destruction of grassland habitat as a result of turbine and other associated construction on lands encumbered by Service easements.

Refuge Managers and Wetland District Managers shall use these guidelines for site-by-site consideration of compatibility determinations for individual right-of-way requests for wind turbines on easement lands. These guidelines may be incorporated as needed as right-of-way or permit stipulations.

These guidelines may be revised and modified as a result of the findings of research and monitoring conducted in the future. Wind turbine rights-of-way applications will be reviewed according to these guidelines in conjunction with the Service's compatibility policy and in accordance with 50 CFR 29.21 and the Service Realty Manual. Future right-of-way applications will be reviewed using the guidelines in effect at the time of application. The Service will not make changes to previously issued rights-of-way or easement permits issued under these guidelines.

1) The Service may permit up to one turbine per 160 acres on an individual easement tract. No more than one turbine may be allowed on an individual easement tract of less than 160 acres. Current biological information (Attachment 2) indicates that this density of turbines would not have any significant impact to grassland habitat and its value to migratory birds or other wildlife. This is the upper limit for the density of turbines on easements. However, consideration may be given to clump or consolidate towers within an easement tract(s) to minimize the disturbance to the remaining habitat, i.e., two turbines may be clumped on a tract of 320 acres. Information available at this time indicates that turbine densities at this level will not materially interfere with or detract from the purposes of the easement (Attachment 2). Wind power industry turbine spacing recommendations are 2,000 feet between wind turbines and 2,000 feet from an occupied building. This constraint may limit the ability to clump turbines.

2) Turbines shall not be constructed in wetlands, including lakes, ponds, marshes, sloughs, swales, swamps, or potholes. Similarly, turbine locations should avoid obvious "duck passes" between large (20 acres or greater), semi-permanent (type 4, or cattail/bulrush) wetlands or sloughs. In addition, known migratory bird corridors or flight paths and environmentally sensitive areas such as colonial bird nesting areas or upland game bird leks, should be avoided.

3) Siting recommendations made by the Service for turbines and access roads and turbine lighting recommendations shall be consistent with all general siting and mitigating measures for tower and transmission line construction (Director's September 14, 2000 memorandum, attachment 3, APLIC 1996, and APLIC 1994).

4) Priority should be given to siting turbines on tame, planted, or seeded grasslands in preference to unbroken native prairie when such options are available on a given easement tract.

5) Spoil material from the excavated turbine pad shall not be deposited in wetlands and must be stored or deposited off easement lands using established roads to transport the material off site.

6) Turbines shall be sited as close to existing roads or the edge of the grassland tract as practical. Disturbance of grassland to construct and maintain a wind turbine shall be done in such a manner as to minimize the destruction or alteration of the habitat. Use of existing roads as a means of accessing a turbine within protected habitats is strongly encouraged. Conservation measures shall be used to avoid the impacts of erosion and sedimentation in order to protect grasslands and wetlands during the construction of the access road. Buried transmission lines, electric lines, and other cables shall be co-located on the access road when practical. Turbine construction should be encouraged to occur outside the breeding season for migratory birds when practical.

7) Regardless of a Service permit the developer is responsible for adhering to all local, state, and federal regulations in siting turbine location and construction. In the event that location and construction criteria conflict between the various levels of government, the criteria providing the maximum protection to the habitat shall be the criteria used during turbine location and construction.

8) In the event that a turbine is no longer utilized for power generation and has been abandoned for that purpose, the turbine owner shall remove the turbine at his/her own expense from the easement tract. The turbine site and associated facilities shall be reclaimed by the turbine owner by planting these areas to a grass mixture consistent with the surrounding grassland or such mixture as is mutually agreed upon by the Service and the turbine owner.

9) The turbine owner must update bird strike avoidance equipment on turbines and implement techniques that reduce the disturbance to nesting birds at turbine sites as future research and evaluation by the Service and the industry indicate.

These guidelines provide flexibility for the Service Refuge Manager in evaluating compatibility determinations and to negotiate with the energy company and the easement landowner to allow wind turbine development consistent with the purposes of the conservation easements. Where development is found to be compatible with easement purposes the guidelines will be used to negotiate siting, lighting, and other restrictions to grant rights-of-way and easement permits for wind turbines.

References:

Avian Power Line Interaction Committee (APLIC). 1994. Mitigating bird collisions with power lines: The state of the art in 1994.

Avian Power Line Interaction Committee (APLIC). 1996. Suggested practices for raptor protection on power lines: the state of the art in 1996.

Attachment 2

Potential Effect of Wind Turbine Presence on Numbers of Breeding Grassland Birds and Nesting Ducks on Grassland Easement Properties in North and South Dakota.

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Recently, companies that develop wind-powered electricity generation have begun operations in areas of South Dakota and North Dakota where the U.S. Fish and Wildlife Service has purchased or intends to purchase conservation easements on grasslands. Questions have been raised within the FWS as to whether the placement of wind towers on easement tracts would violate terms of the easement contract, and whether the Service would consider purchasing easements on lands after towers are in place. Before allowing turbines on easement lands, the Service must address the issue of whether placement of wind turbines on grassland easements is compatible with the goals and purpose of refuge lands as defined by the Refuge Improvement Act, which states that, "A Compatible use means . . . any other use of a National Wildlife Refuge that, based on sound professional judgment, will not materially interfere with or detract from the fulfillment of the National Wildlife Refuge System mission or the purposes(s) of the National Wildlife Refuge." If birds avoid the area surrounding wind turbines because of noise, disruption of habitat, or disturbance, the biological value of an easement may be compromised. At this time, we do not know if wind turbines are compatible with the purpose of grassland easements, because we do not know if turbines reduce the attractiveness of a site to birds or if turbines affect avian reproductive success. The issue is complicated partly because, if, the FWS restricts certain alternative uses on easements, this may reduce the willingness of landowners to offer to sell easements to the FWS in the future. For example, some landowners believe the potential income derived from wind generators will exceed the income from selling grass easements to the FWS or other conservation organizations. In this respect, the future success of the easement program could be compromised if these restrictions are unnecessary.

Little is known about bird avoidance of grasslands near wind turbines, as previous avian research at wind towers has focused primarily on bird strikes. In one study that did consider avoidance, density of grassland birds was reduced in the immediate vicinity of wind turbines at Buffalo Ridge, Minnesota, (Leddy et al. 1999), although at larger scales no differences were detected (Johnson et al. 2000). However, in the Buffalo Ridge study, wind turbines were placed primarily in Conservation Reserve Program fields with few wetlands and much higher densities of breeding birds than are typically found in native prairie where grassland easements are targeted in the Dakotas, and therefore results from Leddy et al. (1999) may not be applicable here. In the absence of specific data on the effect of wind turbines on birds in North and South Dakota, we used two approaches to assess the potential impact; 1) existing data (Igl and Johnson 1997, D. H. Johnson, unpublished data) was used to estimate the potential impact of wind turbine placement on grassland bird use in quarter-section (160 acre) parcels, and 2) a Mallard productivity model (Cowardin et al. 1988) was used to predict changes in nesting and recruitment rate of ducks on grassland areas with wind turbines in place.

Grassland birds. For the first assessment, abundance of grassland birds, standardized to 160 acres of grassland habitat, was estimated from data gathered on 128 quarter sections in North Dakota during summers of 1992 and 1993 (Igl and Johnson 1997, D. H. Johnson, unpublished data). We estimated the potential impact of wind turbines at two scales representing a five-acre and two-acre loss of habitat for each wind tower, with one wind tower per quarter section. We estimated the two-acre potential area of impact as approximately 4 times the area of road and tower pad (Appendix 1); the five-acre area of impact was estimated using the 80-m reported zone of reduced bird density surrounding towers at Buffalo Ridge (Leddy et al. 1999, Appendix 1). For purposes of our analysis, we assumed that no grassland birds would be present in the area immediately surrounding the tower, which is a worst-case scenario, because (Leddy et al. 1999) showed that birds are present immediately adjacent to turbines, but at reduced densities. Thus, our methods guaranteed we would predict a reduction in birds using easements, however, our intent was to put this change into perspective relative to bird use on the entire easement. Given the high variance associated with the grassland bird data we used, it would be impossible to detect a statistically significant decrease in grassland bird numbers, because the lower 95% confidence limit for population estimates was less than zero for each species (D. H. Johnson, unpublished data). Therefore, we estimated the impact of tower presence by calculating the density of each grassland bird species per 160-acre tract, and then calculating the mean reduction in the number of pairs if 2 acre and 5 acre areas of habitat were considered as unused (Table 1).

Expected reductions were estimated at approximately 1% and 3% of the number of individuals present for each species. As expected, greatest reductions in number of pairs occurred with common species such as the chestnut-collared longspur and horned lark; where, at the 5 acres level, a reduction of less than 1 pair per 160-acre tract would be expected. For all species combined, we estimated the expected maximum reduction would be about 2 pairs per 160 acre area, or about 3 percent of the total population. As mentioned previously, based on variation observed in the existing data set, these levels of change would not be statistically significant. Additionally, because we would expect some bird use of the area near the tower, the actual change would likely be less than the numbers presented in table 1.

Table 1. Mean number of breeding pairs of grassland birds found per 160 acres of grassland and expected reduction in pairs with loss of 5 acres and 2 acres of habitat. Data based on surveys of 128 160-acre parcels in North Dakota during summers of 1992 and 1993 (Igl and Johnson 1997, D. H. Johnson, unpublished data).

	Mean Number (pairs)		Mean Reduction (pairs)	
Species	1992	1993	5 acre	2 acre
Baird's Sparrow	1.424	2.464	0.06075	0.0243
Bobolink	0.336	0.784	0.0175	0.007

Brewer's Sparrow	0	0	0	0
Brown-headed Cowbird	2.88	3.632	0.10175	0.0407
Chestnut-collared Longspur	15.584	19.696	0.55125	0.2205
Clay-colored Sparrow	2.08	1.92	0.0625	0.025
Common Yellowthroat	0.144	0.112	0.004	0.0016
Dickcissel	0.304	0.32	0.00975	0.0039
Ferruginous Hawk	0.032	0.24	0.00425	0.0017
Field Sparrow	0.24	0	0.00375	0.0015
Grasshopper Sparrow	6.368	8.928	0.239	0.0956
Gray Catbird	0	0	0	0
Gray Partridge	0.16	0.128	0.0045	0.0018
Horned Lark	6.88	12.544	0.3035	0.1214
Killdeer	0.544	0.848	0.02175	0.0087
Lark Bunting	8.416	4.16	0.1965	0.0786
Lark Sparrow	0.448	0.128	0.009	0.0036
Le Conte's Sparrow	0	0.192	0.003	0.0012
Northern Harrier	0.304	0.512	0.01275	0.0051
Red-winged Blackbird	1.616	1.248	0.04475	0.0179
Ring-necked Pheasant	0.16	0.368	0.00825	0.0033
Savannah Sparrow	1.184	2.144	0.052	0.0208
Sedge Wren	0.16	0	0.0025	0.001
Sharp-tailed Grouse	0.432	0.464	0.014	0.0056
Sharp-tailed Sparrow	0.032	0	0.0005	0.0002
Short-eared Owl	0.032	0.032	0.001	0.0004
Sprague's Pipit	0.256	0.576	0.013	0.0052
Swainson's Hawk	0.032	0.16	0.003	0.0012
Upland Sandpiper	1.52	1.552	0.048	0.0192
Vesper Sparrow	1.312	0.976	0.03575	0.0143
Western Meadowlark	7.088	11.184	0.2855	0.1142
SUM	**59.97**	**75.31**	**2.11**	**0.85**

Ducks. To assess the impact of wind turbines on ducks, we used the Mallard Productivity Model (Cowardin et al. 1988). The Mallard Model is particularly useful for this exercise because it allowed us to predict any "net" change in nest site selection and recruitment that might occur as a result of simulating the reduction of grasslands available to nesting hens due to the placement of wind turbines. For example, if grassland availability is reduced as a result of disturbance, displaced hens may select other habitat types (e.g., cropland, hayland etc.) in the area for nesting, or they may elect to nest elsewhere in the grasslands protected by easement. If other habitats are selected, this could result in reduced recruitment because, most other habitats are characterized by lower nest success compared to grass habitats. However, if these hens select nest sites in the remaining grasslands outside the influence of the wind turbines, nest success will not change materially and recruitment rate will be the same with-or-without turbines. For this exercise, we selected six study areas from Four Square Mile plots used for breeding population and production surveys (Cowardin et al. 1995) in the Kulm Wetland Management District in North Dakota. Plots were selected that had ≥160 acres of grassland in one unit, and were accessible to ≥60 breeding duck pairs (≥12 mallard pairs) based on the "thunderstorm map" (HAPET 2000) for North Dakota. These criteria are consistent with those used by FWS Realty Office, Bismarck, ND for focusing grassland easements, and the Kulm WMD is representative of areas where the grassland easement program is being targeted. For the purpose of our assessment, all grasslands on study plots selected were treated as protected by easement. This was done to obtain sample acreage similar to easement acreage being purchased. We ran the model on plots with-and-without wind turbines in place and compared the response by mallard hens. The area of influence for turbines was set at 5 acres and was converted to barren habitat which simulated eliminating all nesting activity in that area. To reduce variability, and thus increase the precision of our estimates we conducted eight model runs (1000 hens each) and then scaled the average results to the estimated mallard population on each study plot.

Neither nests initiated or recruitment rates differed significantly between treatment and control model runs (Table 2). The variation shown in nests initiated and recruitment rate between treatment and control runs is due to variation inherent in the biological system being examined. The model predicts that hens displaced by the presence of wind turbines will select nesting sites in the remaining available grass habitat and that recruitment rates will not be influenced.

Summary. Using data collected in North Dakota and South Dakota for grassland birds and ducks, we were able to estimate the magnitude of change that would likely be observed if similar data were collected on grassland easement properties. For some species of grassland birds that have restricted distributions the changes predicted could be underestimated on some sites, but it is unlikely these would be of a different order of magnitude. For ducks, the changes predicted account for differences in geographic distribution. Based on our assessment, the expected impact of wind turbines on grassland nesting species would be negligible with the density of one turbine per 160 acre area.

Table 2. Mallard nests initiated and recruitment rate estimates on six study plots with-and-without wind turbines, based on Mallard Model predictions. ( ) standard errors.

		Without Wind Turbines				With Wind Turbines			
Study plot	Pop. Estimate	Grass Acres	Init. Nests	Recr. Rate	SE	No. Turbines	Init.Nests	Recr. Rate	SE
153	55	761	21	0.67	(.0115)	2	21	0.64	(.0090)
178	60	205	14	0.53	(.0094)	1	13	0.52	(.0064)
329	45	1496	59	0.57	(.0055)	3	59	0.59	(.0124)
330	35	1810	51	0.55	(.0163)	8	52	0.55	(.0118)
331	26	1310	18	0.62	(.0104)	2	18	0.59	(.0120)
332	70	1312	58	0.58	(.0166	2	60	0.58	(.0072)

LITERATURE CITED

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APPENDIX 1. Calculations of potential area of impact for wind towers on grassland easements in North Dakota and South Dakota.

Two-acre impact:

40 foot by 40 foot pad for tower		1,600 ft^2
16.5 foot by 1320 foot access road		21,780 ft^2
	total	23,380

Physical disruption of site is approximately 0.54 acre; we multiplied this by four to estimate a zone of potential impact.

Five-acre impact:
80-m zone of reduced density surrounding tower

80 m * 80 m * 3.14	2.0 ha
˜ 2.5 acres per ha	5.0 acres

Attachment 3

Memorandum

To: Regional Directors, Regions 1-7

From: Director

Subject: Service Guidance on the Siting, Construction, Operation and Decommissioning of Communications Towers

Construction of communications towers (including radio, television, cellular, and microwave) in the United States has been growing at an exponential rate, increasing at an estimated 6 percent to 8 percent annually. According to the Federal Communication Commission=s *2000 Antenna Structure Registry*, the number of lighted towers greater than 199 feet above ground level currently number over 45,000 and the total number of towers over 74,000. By 2003, all television stations must be digital, adding potentially 1,000 new towers exceeding 1,000 feet AGL.

The construction of new towers creates a potentially significant impact on migratory birds, especially some 350 species of night-migrating birds. Communications towers are estimated to kill 4-5 million birds per year, which violates the spirit and the intent of the Migratory Bird Treaty Act and the Code of Federal Regulations at Part 50 designed to implement the MBTA. Some of the species affected are also protected under the Endangered Species Act and Bald and Golden Eagle Act.

Service personnel may become involved in the review of proposed tower sitings and/or in the evaluation of tower impacts on migratory birds through National Environmental Policy Act review; specifically, sections 1501.6, opportunity to be a cooperating agency, and 1503.4, duty to comment on federally-licensed activities for agencies with jurisdiction by law, in this case the MBTA, or because of special expertise. Also, the National Wildlife Refuge System Improvement Act requires that any activity on Refuge lands be determined as compatible with the Refuge system mission and the Refuge purpose(s). In addition, the Service is required by the ESA to assist other Federal agencies in ensuring that any action they authorize, implement, or fund will not jeopardize the continued existence of any federally endangered or threatened species.

A Communication Tower Working Group composed of government agencies, industry, academic researchers and NGO=s has been formed to develop and implement a research protocol to determine the best ways to construct and operate towers to prevent bird strikes. Until the research study is completed, or until research efforts uncover significant new mitigation measures, all Service personnel involved in the review of proposed tower sitings and/or the evaluation of the impacts of towers on migratory birds should use the attached interim guidelines when making recommendations to all companies, license applicants, or licensees proposing new tower sitings. These guidelines were developed by Service personnel from research conducted in several eastern, midwestern, and southern States, and have been refined through Regional review. They are based on the best information available at this time, and are the most prudent and effective measures for avoiding bird strikes at towers. We believe that they will provide significant protection for migratory birds pending completion of the Working Group=s recommendations. As new information becomes available, the guidelines will be updated accordingly.

Implementation of these guidelines by the communications industry is voluntary, and our recommendations must be balanced with Federal Aviation Administration requirements and local community concerns where necessary. Field offices have discretion in the use of these guidelines on a case by case basis, and may also have additional recommendations to add which are specific to their geographic area.

Also attached is a Tower Site Evaluation Form which may prove useful in evaluating proposed towers and in streamlining the evaluation process. Copies may be provided to consultants or tower companies who regularly submit requests for consultation, as well as to those who submit individual requests that do not contain sufficient information to allow adequate evaluation. This form is for discretionary use, and may be modified as necessary.

The Migratory Bird Treaty Act (16 U.S.C. 703-712) prohibits the taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts, and nests, except when specifically authorized by the Department of the Interior. While the Act has no provision for allowing an unauthorized take, it must be recognized that some birds may be killed at structures such as communications towers even if all reasonable measures to avoid it are implemented. The Service=s Division of Law Enforcement carries out its mission to protect migratory birds not only through investigations and enforcement, but also through fostering relationships with individuals and industries that proactively seek to eliminate their impacts on migratory birds. While it is not possible under the Act to absolve individuals or companies from liability if they follow these recommended guidelines, the Division of Law Enforcement and Department of Justice have used enforcement and prosecutorial discretion in the past regarding individuals or companies who have made good faith efforts to avoid the take of migratory birds.

Please ensure that all field personnel involved in review of FCC licensed communications tower proposals receive copies of this memorandum. Questions regarding this issue should be directed to Dr. Benjamin N. Tuggle, Chief, Division of Habitat Conservation, at (703)358-2161, or

Jon Andrew, Chief, Division of Migratory Bird Management, at (703)358-1714. These guidelines will be incorporated in a Director=s Order and placed in the Fish and Wildlife Service Manual at a future date.

Attachment

cc: 3012-MIB-FWS/Directorate Reading File
3012-MIB-FWS/CCU Files
3245-MIB-FWS/AFHC Reading Files
840-ARLSQ-FWS/AF Files
400-ARLSQ-FWS/DHC Files
400-ARLSQ-FWS/DHC/BFA Files
400-ARLSQ-FWS/DHC/BFA Staff
520-ARLSQ-FWS/LE Files
634-ARLSQ-FWS/MBMO Files (Jon Andrew)

FWS/DHC/BFA/RWillis:bg:08/09/00:(703)358-2183
S:\DHC\BFA\WILLIS\COMTOW-2.POL

Service Interim Guidelines For Recommendations On Communications Tower Siting, Construction, Operation, and Decommissioning

1. Any company/applicant/licensee proposing to construct a new communications tower should be strongly encouraged to collocate the communications equipment on an existing communication tower or other structure (e.g., billboard, water tower, or building mount). Depending on tower load factors, from 6 to 10 providers may collocate on an existing tower.

2. If collocation is not feasible and a new tower or towers are to be constructed, communications service providers should be strongly encouraged to construct towers no more than 199 feet above ground level, using construction techniques which do not require guy wires (e.g., use a lattice structure, monopole, etc.). Such towers should be unlighted if Federal Aviation Administration regulations permit.

3. If constructing multiple towers, providers should consider the cumulative impacts of all of those towers to migratory birds and threatened and endangered species as well as the impacts of each individual tower.

4. If at all possible, new towers should be sited within existing "antenna farms" (clusters of towers). Towers should not be sited in or near wetlands, other known bird concentration areas (e.g., State or Federal refuges, staging areas, rookeries), in known migratory or daily movement flyways, or in habitat of threatened or endangered species. Towers should not be sited in areas with a high incidence of fog, mist, and low ceilings.

5. If taller (>199 feet AGL) towers requiring lights for aviation safety must be constructed, the minimum amount of pilot warning and obstruction avoidance lighting required by the FAA should be used. Unless otherwise required by the FAA, only white (preferable) or red strobe lights should be used at night, and these should be the minimum number, minimum intensity, and minimum number of flashes per minute (longest duration between flashes) allowable by the FAA. The use of solid red or pulsating red warning lights at night should be avoided. Current research indicates that solid or pulsating (beacon) red lights attract night-migrating birds at a much higher rate than white strobe lights. Red strobe lights have not yet been studied.

6. Tower designs using guy wires for support which are proposed to be located in known raptor or waterbird concentration areas or daily movement routes, or in major diurnal migratory bird movement routes or stopover sites, should have daytime visual markers on the wires to prevent collisions by these diurnally moving species. (For guidance on markers, see *Avian Power Line Interaction Committee (APLIC). 1994. Mitigating Bird Collisions with Power Lines: The State of the Art in 1994. Edison Electric Institute, Washington, D.C., 78 pp*, and *Avian Power Line Interaction Committee (APLIC). 1996. Suggested Practices for Raptor Protection on Power Lines. Edison Electric Institute/Raptor Research Foundation, Washington, D.C., 128 pp.* Copies can be obtained via the Internet at http://www.eei.org/resources/pubcat/enviro/, or by calling 1-800/334-5453).

7. Towers and appendant facilities should be sited, designed and constructed so as to avoid or minimize habitat loss within and adjacent to the tower "footprint"@ However, a larger tower footprint is preferable to the use of guy wires in construction. Road access and fencing should be minimized to reduce or prevent habitat fragmentation and disturbance, and to reduce above ground obstacles to birds in flight.

8. If significant numbers of breeding, feeding, or roosting birds are known to habitually use the proposed tower construction area, relocation to an alternate site should be recommended. If this is not an option, seasonal restrictions on construction may be advisable in order to avoid disturbance during periods of high bird activity.

9. In order to reduce the number of towers needed in the future, providers should be encouraged to design new towers structurally and electrically to accommodate the applicant/licensee's antennas and comparable antennas for at least two additional users (minimum of three users for each tower structure), unless this design would require the addition of lights or guy wires to an otherwise unlighted and/or unguyed tower.

10. Security lighting for on-ground facilities and equipment should be down-shielded to keep light within the boundaries of the site.

11. If a tower is constructed or proposed for construction, Service personnel or researchers from the Communication Tower Working Group should be allowed access to the site to evaluate bird use, conduct dead-bird searches, to place net catchments below the towers but above the ground, and to place radar, Global Positioning

System, infrared, thermal imagery, and acoustical monitoring equipment as necessary to assess and verify bird movements and to gain information on the impacts of various tower sizes, configurations, and lighting systems.

12. Towers no longer in use or determined to be obsolete should be removed within 12 months of cessation of use.

In order to obtain information on the extent to which these guidelines are being implemented, and to identify any recurring problems with their implementation which may necessitate modifications, letters provided in response to requests for evaluation of proposed towers should contain the following request:

> "In order to obtain information on the usefulness of these guidelines in preventing bird strikes, and to identify any recurring problems with their implementation which may necessitate modifications, please advise us of the final location and specifications of the proposed tower, and which of the measures recommended for the protection of migratory birds were implemented. If any of the recommended measures can not be implemented, please explain why they were not feasible."

Appendix 7

KNOWN AND SUSPECTED IMPACTS OF WIND TURBINES ON WILDLIFE

While wind-generated electrical energy is renewable, emission-free, and generally environmentally clean (American Wind Energy Association [AWEA] unpubl. data, <http://www.awea.org>), it does have one significant downside -- rotor blades kill birds, especially raptors (Hunt 2002) and bats. Birds can strike the towers; electrocutions can occur if designs are poor; and wind farms may impact bird movements, breeding, and habitat use.

Wind turbine technology is not new to the United States. In the 1800s, Cape Cod supported over 1,000 working wind turbines (Ferdinand 2002). In the late 1930s, Vermont boasted the world's then-largest turbine, which was likely disabled by high winds due to design flaws. But wind turbine 'farms' and their impacts to birds are a recent phenomenon compared to power lines and communication towers, where mortality has been documented for decades or longer (Boeker and Nickerson 1975, Olendorff et al. 1981, APLIC 1994, APLIC 1996, Harness 1997, Ainley et al. 2001, Manville 2001). The problem in the U.S. surfaced in the late 1980s and early 1990s at the Altamont Pass Wind Resource Area, a facility then containing some 6,500 turbines on 73 mi^2 of gently rolling hills just east of San Francisco Bay, California (Davis 1995). Orloff and Flannery (1992) estimated that several hundred raptors were killed each year due to turbine collisions, guy wire strikes, and electrocutions. The most common fatalities were those of Red-tailed Hawks (*Buteo jamaicensis*), American Kestrels (*Falco sparvarius*) and Golden Eagles (*Aquila chrysaetos*), with fewer mortalities of Turkey Vultures (*Cathartes aura*), Common Ravens (*Corvus corax*), and Barn Owls (*Tyto alba*). The impacts of this wind farm were of most concern to the population of Golden Eagles, which was showing a "disturbing source of mortality" to a disproportionately large segment of the population (Southern Niagara Escarpment [WI] Wind Resource Area unpubl. report). More recent studies indicate that a model previously used to assess Golden Eagle mortality was defective, and that nonbreeding Golden Eagles representing a "floater" population were likely suffering less mortality based on a new model (Hunt 2002). Research continues at this time to further assess the impacts of Altamont turbines on raptors. The Altamont turbines are still estimated to kill 40-60 subadult and adult Golden Eagles each year, as well as several hundred Red-tailed Hawks and American Kestrels – a continuing concern for the FWS. Of the variety of wind turbines at the site, the smaller, faster moving, Kenetech-built, lattice-supported turbines caused most of the mortality. As part of a re-powering effort, these turbines are now being replaced with slower moving, tubular-supported turbines. While Europeans have used tubular towers almost exclusively, the U.S. has almost solely used lattice support, at least until recently (Berg 1996).

Colson (1995) indicated that some 16,000 wind turbines operated in California, making the State the largest concentration of wind energy development in the world. Since 1995, that statistic has changed. While California still boasts the greatest number of turbines in the U.S., many smaller turbines are being replaced by fewer but larger models. Worldwide, an estimated 50,000 turbines are generating power (AWEA unpubl. data; Ferdinand 2002), of which over 15,000 are currently in 29 states in the U.S. Turbine numbers are often difficult to track since statistics are generally presented in megawatts (MW) of electricity produced rather than number of turbines present. The latter statistic is of greater concern to ornithologists. In 1998, for example, Germany was the greatest producer with 2,874 MW of electricity produced by turbines, followed by the U.S. (1,884), and Denmark (1,450); (AWEA unpubl. data). While some project that the number of wind turbines in the U.S. may increase by another 16,000 in the next 10 years, current trends indicate an even greater potential growth. Although the U.S. presently produces less than 1% of its electrical energy from turbines – compared, for example, to Norway's 15% – 2001 was a banner year for U.S. turbine technology, doubling the previous record for installed wind production. Companies installed 1,898 turbines in 26 states, which will produce nearly 1,700 MW, at a cost of $1.7 billion for the new equipment (J. Cadogan, U.S. Department of Energy, 2002, pers. comm.). Over the past decade, wind power has been the fastest growing energy industry in the world. By 2020, the AWEA (unpubl. data) predicts that wind will provide 6% of this nation's electricity, serving as many as 25 million households. Enron Wind Corporation constructed some 1,500 of the 1,898 turbines installed in the U.S. in 2001. Although Enron is now bankrupt, General Electric purchased the company and is now producing wind turbines.

In March 2002, President Bush signed the Job Creation and Worker Assistance Act, extending the production tax credit to the wind industry for another two years. There are presently attempts in Congress to amend the reauthorization of this legislation for five or more years. However, even with a bright future for growth, and with low speed tubular-constructed wind turbine technology now being stressed, larger and slower moving turbines still kill raptors, passerines, waterbirds, other avian species, and bats. Low wind speed turbine technology requires much larger rotors, blade tips often extending more than 420 ft. above ground, and blade tips can reach speeds in excess of 200 mph under windy conditions (J. Cadogan, U.S. Department of Energy, 2002, pers. comm.). When birds approach spinning turbine blades, "motion smear" – the inability of the bird's retina to process high speed motion stimulation – occurs primarily at the tips of the blades, making the blades deceptively transparent at high velocities. This increases the likelihood that a bird will fly through this arc, be struck by a blade, and be killed (Hodos et al. 2001).

What cumulative impact these larger turbines will have on birds and bats has yet to be determined. Johnson et al. 2002b raised some concerns about the impacts of newer, larger turbines on birds. Their data indicated that higher levels of mortality might be associated with the newer and larger turbines, and they indicated that wind power-related avian mortality would likely contribute to the cumulative impacts on birds. Since little research has been conducted on the impacts of large land-sited and offshore turbines on birds and bats, this newer technology is ripe for research.

Howell and Noone (1992) estimated U.S. avian mortality at 0.0 to 0.117 birds/turbine/yr., while in Europe, Winkelman (1992) estimated mortality at 0.1 to 37 birds/turbine/yr. Erickson et al. (2001) reassessed U.S. turbine impact, based on more than 15,000 turbines (some 11,500 in California), and estimated mortality in the range of 10,000 to 40,000 (mean = 33,000), with an average of 2.19 avian fatalities/turbine/yr. and 0.033 raptor fatalities/turbine/yr. This may be a considerable underestimate. As with other structural impacts, only a systematic turbine review will provide a more reliable estimate of mortality. While some have argued that turbine impacts are small (Berg 1996), especially when compared to those from communication towers and power lines, turbines can pose some unique problems, especially for birds of prey. Mortalities must be reduced, especially as turbine numbers increase. In addition to protections under the MBTA, Bald and Golden Eagles are afforded protections under the ESA for the former and the BGEPA for both raptors. As strict liability statutes, MBTA and BGEPA also provide no provisions for unauthorized "take." Wind farms can affect local populations of Golden Eagles and other raptors whose breeding and recruitment rates are naturally slow and whose populations tend to have smaller numbers of breeding adults (Davis 1995). Large raptors are also revered by Native Americans as well as by many others within the public. They are symbolic megafauna, and provide greater emotional appeal to many than do smaller avian species. Raptors also have a lower tolerance for additive mortality (Anderson et al. 1997). As with all other human-caused mortality, we have a responsibility to reverse mortality trends.

Until very recently, U.S. wind turbines have mostly been land-based. Perhaps following the European lead of siting wind turbines in estuarine and marine wetlands (van der Winden et al. 1999, van der Winden et al. 2000), and perhaps due to an assessment of a large number of potential offshore turbine locations in the U.S. (based on Weibull analyses of "good, excellent, outstanding, and superb" wind speed potentials [National Renewable Energy Laboratory 1987]), a new trend is evolving in North America. Several proposals for huge offshore sites are being submitted for locations on both Atlantic and Pacific coasts. These, at the very least, should require considerable research and monitoring to assess possible impacts to resident and migrating passerines, waterfowl, shorebirds, and seabirds. One site at Nantucket Shoals, offshore of Nantucket Island near Cape Cod, Massachusetts, is proposed by the Cape Wind Association to contain 170 turbines, many over 420 feet high, within a 25 mi^2 area (AWEA unpubl. data, Ferdinand 2002). What impacts this wind farm would have on wintering sea ducks and migrating terns, especially the Federally endangered Roseate Tern (*Sterna dougallii dougallii*), and on Northern Gannets (*Morus bassanus*), is unknown. The Long Island Power Authority is proposing a site offshore of Long Island, New York's south shore, covering as much as 314 mi^2. Other sites are being proposed for Portland, Maine, and Lake Erie. The largest proposed wind farm in North America is being planned for a 50 mi^2 area between Queen Charlotte Island, BC, and Alaska. It is being designed to contain 350 turbines, many exceeding 400 feet in height. The potential for significant offshore turbine impacts on waterbirds is great, virtually no research has been conducted in the United States to quell these concerns, and finding carcasses at sea is very challenging.

Europe presently has 10 offshore wind projects in operation, producing over 250 MW of electricity (British Wind Energy unpub. data, www.offshorewindfarms.co.uk). Many other projects are currently under review. To avoid citizen concerns regarding the "not in my backyard" complex, most European turbines are sited offshore or in estuaries, away from immediate human development (Larsen and Madsen 2000). While Europe is well ahead of the United States regarding turbine research, their study results are still generally inconclusive (T. Bowan, FWS, 2003 pers. comm.). Collision mortality, while generally unknown, is believed to be small because birds appear to avoid offshore wind farms. There are exceptions, including for Whooper Swans (*Cygnus Cygnus*; Larsen and Clausen 2002) that are susceptible to turbine strikes in the early mornings and evenings, especially in inclement weather. The collection of carcasses at offshore sites is more challenging than for land-based turbines since nets generally must be used to collect carcasses, tides and weather affect collection, and fog is a frequent problem. While habitat loss is not believed to be a serious concern, its impacts continue to be assessed. Disturbance may be problematic since some species such as Common Eiders avoid wind farms and may not return to a coastal area for several years (Guillemette and Larsen 2002). Disturbance may lead to displacement, and turbines may serve as barriers to seaduck movements. Only a few studies have been conducted in Denmark, the Netherlands, and Sweden, so further research is needed. Studies deal mostly with wintering species (Noer et al. 2000, Percival 2001, Langstron and Pullan 2002, Christensen et al. 2002, and Bruns et al. 2002).

In an attempt to begin addressing the bird mortality issue – and ancillary to this, the issue of ESA-listed bat strikes – the National Wind Coordinating Committee was created in 1994 as part of President Clinton's Global Climate Change Action Plan (Colson 1995). Shortly following the creation of the Committee, the Avian Subcommittee (now called the Wildlife Work Group) was formed, co-founded by the Service. In 1999, the Avian Subcommittee published a *Metrics and Methods* document to study turbine impacts on birds (Anderson et al. 1999). The document provides an excellent resource for conducting research on proposed and existing turbines and wind farms.

Appendix 8

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U.S. Fish and Wildlife Service
Land-Based Wind Energy Guidelines

Comment [UF&WS1]: Note to Reviewers:

Substantial differences from the July 12 draft have been highlighted in grey. Editorial changes were not highlighted.

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The U.S. Fish and Wildlife Service (Service) would like to recognize and thank the Wind Turbine Guidelines Federal Advisory Committee for its dedication and preparation of its Wind Turbine Recommendations. The Recommendations have served as the basis from which the Service's team worked to develop the Service's Guidelines for Land-Based Wind Energy Development. The Service also recognizes the tireless efforts of the Regional and Field Office staff that helped to review and update these Guidelines.

U.S. Fish and Wildlife Service

Land-Based Wind Energy Guidelines

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Comment [UF&WS2]: Will be updated in the Final Guidelines.

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Introduction

As the United States moves to expand wind energy production, it also must maintain and protect the Nation's fish, wildlife, and their habitats, which wind energy production can negatively affect. As with all responsible energy development, wind energy projects should adhere to high standards for environmental protection. With proper diligence paid to siting, operations, and management of projects, it is possible to mitigate for adverse effects to fish, wildlife, and their habitats. This is best accomplished when the developer coordinates as early as possible with the Service and other stakeholders. Such coordination allows for the greatest range of development and mitigation options.

In response to increasing wind energy development in the United States, the U.S. Fish and Wildlife Service (Service) released a set of voluntary, interim guidelines for reducing adverse effects to fish and wildlife resources from wind energy projects for public comment in July 2003. After the Service reviewed the public comments, the Secretary of the Interior (Secretary) established a Federal Advisory Committee to provide recommendations to revise the guidelines related to land-based wind energy facilities. In March 2007, the Service announced in the *Federal Register* the establishment of the Wind Turbine Guidelines Advisory Committee (the Committee). The Committee submitted its final Recommended Guidelines (Recommendations) to the Secretary on March 4, 2010. The Service used the Recommendations to develop its draft Land-Based Wind Energy Guidelines.

The Service's Land-based Wind Energy Guidelines are founded upon a "tiered approach" for assessing potential adverse effects to wildlife species of concern and their habitats. The tiered approach is an iterative decision making process for collecting information in increasing detail; quantifying the possible risks of proposed wind energy projects to wildlife species of concern and habitats; and evaluating those risks to make siting, construction, and operation decisions. Subsequent tiers refine and build upon issues raised and efforts undertaken in previous tiers. At each tier, a set of questions is provided to help the developer evaluate the potential risk associated with developing a project at the given location. The tiered approach guides a developer's decision process as to whether or not the selected location is appropriate for wind development. This decision is related to site-specific conditions regarding potential species and habitat effects.

Briefly, the tiers address:

- Tier 1 – Preliminary evaluation or screening of potential sites (landscape-scale screening of possible project sites)

- Tier 2 – Site characterization (broad characterization of one or more potential project sites)

- Tier 3 – Pre-construction monitoring and assessments (site-specific assessments at the proposed project site)

- Tier 4 – Post-construction fatality and habitat studies

- Tier 5 – Post-construction studies to further evaluate direct and indirect effects, and assess how they may be addressed

The Service urges voluntary adherence to the Guidelines (see page 12, *Service Expectations*) and frequent communication with the Service when planning and operating a facility.

The Guidelines are based on best available methods and metrics to help answer the questions posed at each tier. Research on wind energy effects on wildlife species of concern and their habitats is ongoing and new information is made available on a regular basis. Substantial variability can exist among project sites and as such, methods and metrics should be applied with the flexibility to address the varied issues that may occur on a site-by-site basis, while maintaining consistency in the overall tiered process. As research expands and provides new information, these methods and metrics will be updated to reflect current science.

Chapter 1

General Overview

The mission of the U.S. Fish and Wildlife Service is working with others to conserve, protect and enhance fish, wildlife, plants and their habitats for the continuing benefit of the American people. As part of this, the Service is charged with implementing statutes including the Endangered Species Act, Migratory Bird Treaty Act, and Bald and Golden Eagle Protection Act. These statutes prohibit taking of federally listed species, migratory birds and eagles unless otherwise authorized. These Guidelines are intended to:

(1) Promote compliance with relevant wildlife laws and regulations;

(2) Encourage scientifically rigorous survey, monitoring, assessment, and research designs proportionate to the risk to species of concern;

(3) Produce potentially comparable data across the Nation;

(4) Avoid, minimize, and, if appropriate, compensate for potential adverse effects on species of concern and their habitats; and,

(5) Improve the ability to predict and resolve effects locally, regionally, and nationally.

The Service encourages project proponents to use the process described in these voluntary Land-based Wind Energy Guidelines (Guidelines) to address risks to species of concern. The Service intends that these Guidelines, when used in concert with the appropriate regulatory tools, will be the best practical approach for conservation of species of concern.

Statutory Authorities

These draft Guidelines are not intended nor shall they be construed to limit or preclude the Service from exercising its authority under any law, statute, or regulation, or from conducting enforcement action against any individual, company, or agency. They are not meant to relieve any individual, company, or agency of its obligations to comply with any applicable federal, state, tribal, or local laws, statutes, or regulations.

Ultimately it is the responsibility of those involved with the planning, design, construction, operation, maintenance, and decommissioning of wind projects to conduct relevant fish, wildlife, and habitat evaluation (e.g., siting guidelines, risk assessment, etc.) and determine, which, if any, species may be affected. The results of these analyses will inform all efforts to achieve compliance with the appropriate jurisdictional statutes. Project proponents are responsible for complying with applicable state and local laws.

Migratory Bird Treaty Act

The Migratory Bird Treaty Act (MBTA) is the cornerstone of migratory bird conservation and protection in the United States. The MBTA implements four treaties that provide for international protection of migratory birds. It is a strict liability statute, meaning that proof of intent, knowledge, or negligence is not an element of an MBTA violation. The statute's language is clear that most actions resulting in a "taking" or possession (permanent or temporary) of a protected species, in the absence of regulatory authorization, are a violation of the MBTA.

The MBTA states, "Unless and except as permitted by regulations … it shall be unlawful at any time, by any means, or in any manner to pursue, hunt, take, capture, kill … possess, offer for sale, sell … purchase … ship, export, import … transport or cause to be transported … any migratory bird, any part, nest, or eggs of any such bird …. [The Act] prohibits the taking, killing, possession, transportation, import and export of migratory birds, their eggs, parts, and nests, except when specifically authorized by the Department of the Interior." 16 U.S.C. 703. The word "take" is defined by regulation as "to pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to pursue, hunt, shoot, wound, kill, trap, capture, or collect." 50 C.F.R. 10.12.

The MBTA provides criminal penalties for persons who commit any of the acts prohibited by the statute in section 703 on any of the species protected by the statute. *See* 16 U.S.C. 707. The Service maintains a list of all species protected by the MBTA at 50 C.F.R. 10.13. This list includes over one thousand species of migratory birds, including eagles and other raptors, waterfowl, shorebirds, seabirds, wading birds, and passerines. The MBTA does not protect introduced species such as the house (English) sparrow, European starling, rock dove (pigeon), Eurasian collared-dove, and non-migratory upland game birds. The Service maintains a list of introduced species not protected by the Act. *See* 70 Fed. Reg. 12,710 (Mar. 15, 2005).

Bald and Golden Eagle Protection Act

Under authority of the Bald and Golden Eagle Protection Act (BGEPA), 16 U.S.C. 668–668d, bald eagles and golden eagles are afforded additional legal protection. BGEPA prohibits the take, sale, purchase, barter, offer of sale, purchase, or barter, transport, export or import, at any time or in any manner , of any bald or golden eagle, alive or dead, or any part, nest, or egg thereof. 16 U.S.C. 668. BGEPA also defines take to include "pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest, or disturb," 16 U.S.C. 668c, and includes criminal and civil penalties for violating the statute. *See* 16 U.S.C. 668. The Service further defined the term "disturb" as agitating or bothering an eagle to a degree that causes, or is likely to cause, injury, or either a decrease in productivity or nest abandonment by substantially interfering with normal breeding, feeding, or sheltering behavior. 50 C.F.R. 22.3. BGEPA authorizes the Service to permit the take of eagles for certain purposes and under certain circumstances, including scientific or exhibition purposes, religious purposes of Indian tribes, and the protection of wildlife, agricultural, or other interests, so long as that take is compatible with the preservation of eagles. 16 U.S.C. 668a.

In 2009, the Service promulgated a final rule on two new permit regulations that, for the first time, specifically authorize the incidental take of eagles and eagle nests in certain situations under BGEPA. *See* 50 C.F.R. 22.26 & 22.27. The permits will authorize limited, non-purposeful (incidental) take of bald and golden eagles; authorizing individuals, companies, government agencies (including tribal governments), and other organizations to disturb or otherwise take eagles in the course of conducting lawful activities such as operating utilities and airports. Most permits issued under the new regulations would authorize disturbance. In limited cases, a permit may authorize the take of eagles that results in death or injury. Removal of active eagle nests would usually be allowed only when it is necessary to protect human safety or the eagles. Removal of inactive nests can be authorized when necessary to ensure public health and safety, when a nest is built on a human-engineered structure rendering it inoperable, and when removal is necessary to protect an interest in a particular locality, but only if the take or mitigation for the take will provide a clear and substantial benefit to eagles.

To facilitate issuance of permits under these new regulations, the Service has drafted Eagle Conservation Plan (ECP) Guidance. The ECP Guidance is intended to be compatible with these Land-Based Wind Energy Guidelines. The Guidelines guide developers through the process of project development and operation. If eagles are identified as a potential risk at a project site, developers are strongly encouraged to refer to the ECP Guidance. The ECP Guidance describes specific actions that are recommended to comply with the regulatory requirements in BGEPA for an eagle take permit as described in 50 CFR 22.26 and 22.27. The ECP Guidance is intended to provide a national framework for assessing and mitigating risk specific to eagles through development of ECPs. The final ECP Guidance will be made available to the public through the Service's website when it is finalized.

Endangered Species Act

The Endangered Species Act (16 U.S.C. 1531–1544; ESA) was enacted by Congress in 1973 in recognition that many of our Nation's native plants and animals were in danger of becoming extinct. The ESA directs the Service to identify and protect these endangered and threatened species and their critical habitat, and to provide a means to conserve their ecosystems. To this end, federal agencies are directed to utilize their authorities to conserve listed species, and ensure that their actions are not likely to jeopardize the continued existence of these species or destroy or adversely modify their critical habitat. Federal agencies are encouraged to do the same with respect to "candidate" species that may be listed in the near future. The law is administered by the Service and the Commerce Department's National Marine Fisheries Service (NMFS).

The Service has primary responsibility for terrestrial and freshwater organisms, while NMFS generally has responsibility for marine species. These two agencies work with other agencies to plan or modify federal projects so that they will have minimal impact on listed species and their habitats. Protection of species is also achieved through partnerships with the states, with federal financial assistance and a system of incentives available to encourage state participation. The Service also works with private landowners, providing financial and technical assistance for management actions on their lands to benefit both listed and non-listed species.

Section 9 of the ESA makes it unlawful for a person to "take" a listed species. Take is defined as "... to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct." 16 U.S.C. 1532(19). The terms harass and harm are further defined in our regulations. *See* 50 C.F.R. 17.3. However, the Service may authorize "incidental take" (take that occurs as a result of an otherwise legal activity) in two ways.

Take of federally listed species incidental to a lawful activity may be authorized through formal consultation under section 7(a)(2) of the ESA, whenever a federal agency, federal funding, or a federal permit is involved. Otherwise, a person may seek an incidental take permit under section 10(a)(1)(B) of the ESA upon completion of a satisfactory habitat conservation plan (HCP) for listed species. If threatened or endangered species are identified as a potential risk at a project site, developers are strongly encouraged to discuss with the Service whether an incidental take permit or other form of authorization may be appropriate. For more information regarding formal consultation and HCPs, please see the Endangered Species Consultation Handbook at http://www.fws.gov/endangered/esa-library/index.html#consultations and the Service's HCP website, http://www.fws.gov/endangered/what-we-do/hcp-overview.html.

Service Expectations

Consideration of the Guidelines in MBTA and BGEPA Enforcement

The Service urges voluntary adherence to the guidelines and communication with the Service when planning and operating a facility. These guidelines do not authorize take under MBTA or BGEPA. Violations of those statutes may result in prosecution. The Service will regard voluntary adherence and communication as evidence of due care with respect to avoiding, minimizing, and mitigating significant adverse impacts to species protected under the MBTA and BGEPA, and will take such adherence and communication fully into account when exercising its discretion with respect to any potential referral for prosecution related to the death of or injury to any such species. Each developer and operator will be responsible for maintaining internal records sufficient to demonstrate adherence to the guidelines, and responsiveness to communications from the Service. Examples of these records could include: studies performed in the implementation of the tiered approach; an internal or external review or audit process; an

Avian and Bat Protection Plan; or a wildlife management plan. ~~The Service retains its existing authority to inspect and assess the sufficiency of those records.~~

With regard to eagles, application of these considerations will not apply when take of eagles is anticipated. If Tiers 1, 2, and/or 3 identify a potential to take eagles, developers should consider also developing an ECP and, if necessary, apply for a take permit. If taking of eagles is not anticipated, adherence to the Guidelines would give rise to assurances regarding enforcement discretion if an unexpected taking occurs.

If a developer and operator are not the same entity, the Service expects the operator to maintain sufficient records to demonstrate adherence to the Guidelines.

Voluntary Adherence and Communication

For projects commencing after the effective date of the guidelines, "voluntary adherence and communication" means that the developer has applied the guidelines, including the tiered approach, through site selection, design, construction, operation and post-operation phases of the project, and has communicated with the Service and considered its advice. Table 1, Communications Protocol, provides guidance to the Service and developers in this regard. While the advice of the Service is not binding, neither can it simply be reviewed and rejected without a contemporaneously documented reasoned justification, at least if the developer seeks to have the benefit of the enforcement discretion provisions of these guidelines. Instead, proper consideration of the advice of the Service entails contemporaneous documentation of how the developer evaluated that advice and the reasons for any departures from it. Although the guidelines leave decisions up to the developer, the Service retains authority to evaluate whether developer efforts to avoid and mitigate impacts are sufficient, and to refer for prosecution any take of migratory birds that it believes to be reasonably related to lack of responsiveness to Service communications or insufficient compliance with the guidelines.

Table 1. Suggested Communications Protocol

This table provides examples of potential communication opportunities between a wind energy project developer and the Service. Not all projects will require all steps indicated below.

1

TIER	Project developer/operator Role	Service Role
Tier 1: Preliminary site evaluation	• Landscape level assessment of habitat for species of concern • Request data sources for existing information and literature	• Provide lists of data sources and references, if requested
Tier 2: Site characterization	• Assess potential presence of species of concern, including species of habitat fragmentation concern, likely to be on site • Assess potential presence of plant communities present on site that may provide habitat for species of concern • Assess potential presence of critical congregation areas for species of concern • One or more reconnaissance level site visit by biologist • Communicate results of site visits and other assessments with the Service • Provide general information about the size and location of the project to the Service	• Provide species lists, for species of concern, including species of habitat fragmentation concern, for general area, if available • Respond to information provided about findings of biologist from site visit • Identify initial concerns about site(s) based on available information
Tier 3: Field studies and impact prediction	• Discuss extent and design of field studies to conduct with the Service • Conduct biological studies • Communicate results of studies to Service field office • Evaluate risk to species of concern from project construction and operation • Identify ways to mitigate potential direct and indirect impacts of building and operating the project	• Respond to requests to discuss field studies • Advise project proponent about studies to conduct and methods for conducting them • Communicate with project proponent(s) about results of field studies and risk assessments • Communicate with project proponents(s) ways to mitigate potential impacts of building and operating the project
Tier 4: Post construction studies to estimate impacts	• Discuss extent and design of post-construction studies to conduct with the Service • Conduct post-construction studies to assess fatalities and habitat-related impacts • Communicate results of studies to Service field office • If necessary, discuss potential adaptive management and mitigation strategies with Service • Maintain appropriate records of data collected from studies	• Advise project operator on study design, including duration of studies to collect adequate information • Communicate with project operator about results of studies • Advise project operator of potential adaptive management/mitigation strategies, when appropriate
Tier 5: Other post-construction studies and research	• Communicate with the Service about the need for and design of other studies and research to conduct with the Service, when appropriate, particularly when impacts	• Advise project proponents as to need for Tier 5 studies to address specific topics based on information collected in Tiers 3 and 4

	exceed predicted levels • Communicate with the Service about ways to evaluate cumulative impacts on species of concern, particularly species of habitat fragmentation concern • Conduct appropriate studies as needed • Communicate results of studies with the Service • Identify potential adaptive management and mitigation strategies to reduce impacts and discuss them with the Service	• Advise project proponents of methods and metrics to use in Tier 5 studies • Communicate with project operator and consultants about results of Tier 5 studies • Advise project operator of potential adaptive management/mitigation strategies, when appropriate, based on Tier 5 studies

Implementation of the Guidelines

The Service recognizes that hundreds of wind energy projects exist and are being planned. The Service recommends that wind project developers and operators contact local Service offices to work with them regarding how to apply this tiered approach to operating projects and projects in various stages of planning. Tiers 1 through 5 should be applied at the appropriate tier based on the stage of development or construction of the project. The Service is aware that it will take time to train Service and other personnel, including wind project developers and their biologists, in the implementation of the Guidelines. However, the Guidelines will be implemented upon final publication. The Service will make every effort to begin training staff, users, and other interested parties as soon as possible, with a goal of beginning training no later than six months after publication of the final Guidelines.

The Service encourages use of the guidelines and adoption of the tiered approach by future projects, and, where feasible, existing projects. Accordingly, all projects that commence after the effective date should apply the tiered approach to all phases of the project. However, projects that are already under development or are in operation are not expected to start over or return to the beginning of a specific tier. Instead, these projects should implement those portions of the guidelines relevant to the continuing phases of the project. Projects that are operational prior to the effective date, should follow Tier 4, and, if applicable, Tier 5.

Scope and Project Scale of the Guidelines

The Guidelines are designed for "utility- scale" land-based wind energy projects to reduce potential impacts to species of concern, regardless of whether they are proposed for private or public lands. While these Guidelines are designed for utility- scale wind projects, the general principles may also apply to distributed and community-scale wind energy projects. Developers should contact the Service to determine applicability of the Guidelines to their particular project. Offshore wind energy projects may involve another suite of effects and analyses not addressed here.

The Service considers a "project" to include all phases of wind energy development, including, but not limited to, prospecting, site assessment, construction, operation, and decommissioning, as well as all associated infrastructure and interconnecting electrical lines. A "project site" is the land and airspace where development occurs or is proposed to occur, including the turbine pads, roads, power distribution and transmission lines on or immediately adjacent to the site; buildings and related infrastructure, ditches, grades, culverts; and any changes or modifications made to the original site before development occurs. Project evaluations should consider all potential effects to species of concern, which includes species (1) protected by the MBTA, BGEPA, and ESA, designated by law, regulation or other formal process for protection and/or management by the relevant agency or other authority, or that have been shown to be significantly adversely affected by wind energy development, and 2) determined to be possibly affected by the project. These draft Guidelines are not designed to address power transmission beyond the point of interconnection to the transmission system.

The tiered approach is designed to lead to the appropriate amount of evaluation in proportion to the anticipated level of risk that a project may pose to wildlife and their habitats. Study plans and the duration and intensity of study efforts should be tailored specifically to the unique characteristics of each site and the corresponding potential for significant adverse impacts on wildlife and their habitats as determined through the tiered approach. In particular, the risk of adverse impacts to wildlife and their habitats tends to be a function of site location, not necessarily the size of the project. A small project may pose greater risk to wildlife than a larger site in a less sensitive location, which may necessitate more pre- and post-construction studies than the larger site. This is why the tiered approach begins with an examination of the potential location of the project, not the size of the project. In all cases, study plans and selection of appropriate study methods and techniques may be tailored to the relative scale, location and potential for significant adverse impacts of the proposed site.

Service Review Period

The Service is committed to providing timely responses. The Service has determined that Field Offices have 60 calendar days to respond to a request by a wind energy developer to review and comment on proposed site locations, pre- and post-construction study designs, and proposed mitigation. The request should be in writing to the field office and copied to the Regional Office with information about the proposed project, location(s) under consideration, and point of contact. The request should contain a description of the information needed from the Service. The Service will provide a response, even if it is to notify a developer of additional review time, within the 60 day review period. If the Service does not respond within 60 days of receipt of the document, then the developer can proceed through Tier 3 without waiting for Service input. If the Service provides comments at a later time, the developer should incorporate the comments if feasible. It is particularly important, that if data from Tier 1-3 studies predict that the project is likely to produce significant adverse impacts on wildlife, the developer inform the Service of the actions it intends to implement to avoid or minimize those impacts. If the Service cannot respond within 60 days, this does not relieve developers from their MBTA, BGEPA, and ESA responsibilities.

The tiered approach allows a developer in certain limited circumstances to move directly from Tier 2 to construction (e.g., adequate survey data for the site exists). The developer should notify the Service of this decision and to give the Service 60 calendar days to comment on the proposed project prior to initiating construction activities.

Introduction to the Decision Framework Using a Tiered Approach

The tiered approach provides a decision framework for collecting information in increasing detail to evaluate risk and make siting and operational decisions. It provides the opportunity for evaluation and decision-making at each tier, enabling a developer to abandon or proceed with project development, or to collect additional information if necessary. This approach does not require that every tier, or every element within each tier, be implemented for every project. Instead, it allows efficient use of developer and wildlife agency resources with increasing levels of effort until sufficient information and the desired precision is acquired for the risk assessment.

Application of the Tiered Approach and Possible Outcomes

Figure 1 ("General Framework for Minimizing Impacts of Wind Development on Wildlife in the Context of the Siting and Development of Wind Energy Projects") illustrates the tiered approach, which consists of up to five iterative stages, or tiers:

Tier 1 – Preliminary evaluation or screening of potential sites

Tier 2 – Site characterization

Tier 3 – Field studies to document site wildlife conditions and predict project impacts

Tier 4 – Post-construction studies to estimate impacts[1]

Tier 5 – Other post-construction studies

At each tier, potential issues associated with developing or operating a project are identified and questions formulated to guide the decision process. Chapters Two through Six outline the questions to be posed at each tier, and describes recommended methods and metrics for gathering the data needed to answer those questions.

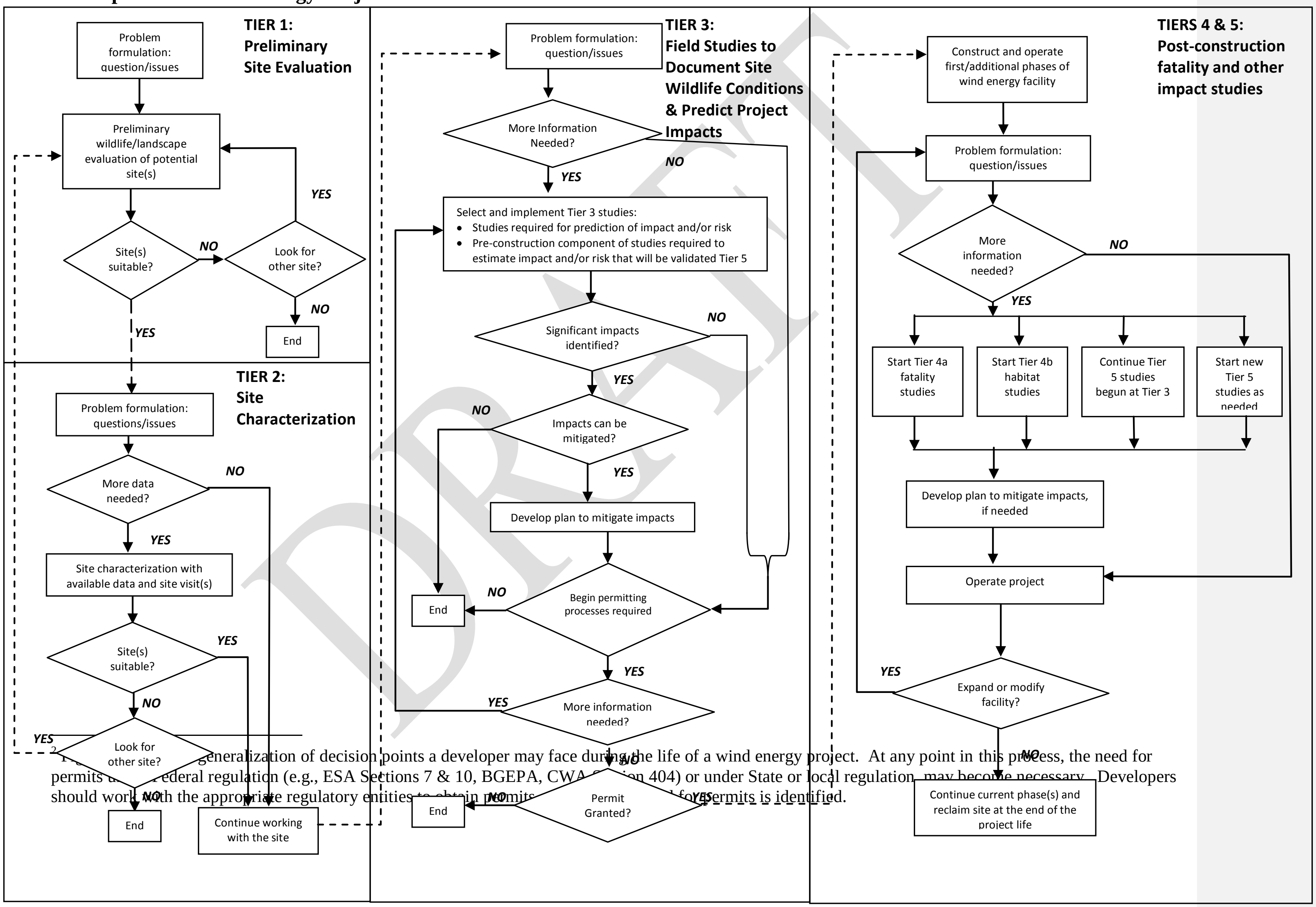
If sufficient data are available at a particular tier, the following outcomes are possible based on analysis of the information gathered:

1. The project site is abandoned because of the level of risk to species of concern.
2. The project proceeds to the next tier in the development process without additional data collection.
3. An action or combination of actions, such as project modification, mitigation, or specific post-construction monitoring, is indicated.

If data are deemed insufficient at a tier, more intensive study is conducted in the subsequent tier until sufficient data are available to make a decision to abandon the project, modify the project, or proceed with the project.

[1] The Service anticipates these studies will include fatality monitoring as well as studies to evaluate habitat impacts.

Figure 1. General Framework for Minimizing Impacts of Wind Development on Wildlife in the Context of the Siting and Development of Wind Energy Projects [2]



[2] [illegible] generalization of decision points a developer may face during the life of a wind energy project. At any point in this process, the need for permits [illegible] Federal regulation (e.g., ESA Sections 7 & 10, BGEPA, CWA [illegible] 404) or under State or local regulation may become necessary. Developers should work with the appropriate regulatory entities to obtain permits [illegible] for permits is identified.

Application of the Tiered Approach and Risk Assessment

Risk is the likelihood that adverse impacts will occur to individuals or populations of species of concern as a result of wind energy development and operation. Estimates of fatality risk can be used in a relative sense, allowing comparisons among projects, alternative development designs, and in the evaluation of potential risk to populations. Because there are relatively few methods available for direct estimation of risk, a weight-of-evidence approach is often used (Anderson et al. 1999). Until such time that reliable risk predictive models are developed, estimates of risk would typically be qualitative, but would be based upon quantitative site information.

Risk can also be defined in the context of populations, but the calculation is more complicated as it could involve estimating the reduction in population viability as indicated by demographic metrics such as growth rate, size of the population, or survivorship, either for local populations, metapopulations, or entire species. For most populations, risk cannot easily be reduced to a strict metric, especially in the absence of population viability models for most species. Consequently, estimating the quantitative risk to populations is usually beyond the scope of project studies due to the difficulties in evaluating these metrics, and therefore risk assessment will be qualitative. Risk to habitat is a component of the evaluation of population risk. In this context, the estimated loss of habitat is evaluated in terms of the potential for population level effects (e.g., reduced survival or reproduction).

The assessment of risk should synthesize sufficient data collected at a project to estimate exposure and predict impact for individuals and their habitats for the species of concern, with what is known about the population status of these species, and in communication with the relevant wildlife agency and industry wildlife experts. Predicted risk of these impacts could provide useful information for determining appropriate mitigation measures if determined to be necessary. In practice in the tiered approach, risk assessments conducted in Tiers 1 and 2 require less information to reach a risk-based decision than those conducted at higher tiers.

Cumulative Impacts of Project Development

Cumulative impacts are the comprehensive effect on the environment that results from the incremental impact of a project when added to other past, present, and reasonably foreseeable future actions. Consideration of cumulative impacts should be incorporated into the wind energy planning process as early as possible to improve decisions. To achieve that goal, it is important that agencies and organizations take the following actions to improve cumulative impacts analysis: review the range of development-related significant adverse impacts, determine which species of concern or their habitats within the landscape are most at risk of significant adverse impacts from wind development in conjunction with other reasonably foreseeable significant adverse impacts, and make that data available for regional or landscape level analysis. The magnitude and extent of the impact on a resource depend on whether the cumulative impacts exceed the capacity for resource sustainability and productivity.

Federal agencies are required to include a cumulative impacts analysis in their NEPA review, including any energy projects that require a federal permit or have any other federal nexus. The federal action agency coordinates with the developer to obtain the necessary information for the NEPA review and cumulative impacts analysis. To avoid project delays, federal and state agencies are encouraged to use existing wildlife data for the cumulative impacts analysis until improved data are available.

Where there is no federal nexus, individual developers are not expected to conduct their own cumulative impacts analysis. However, a cumulative impacts analysis would help developers and other stakeholders better understand the significance of potential impacts on wildlife and habitats. Developers are encouraged to coordinate with federal and state agencies early in the project planning process to access any existing information on the cumulative impacts of individual projects on species and habitats at risk, and to incorporate it into project development and any necessary wildlife studies.

Applicability of Adaptive Management

Adaptive management is an iterative learning process producing improved understanding and improved management over time (Williams et al 2007). The Department of the Interior determined that its resource agencies, and the natural resources they oversee, could benefit from adaptive management. Use of adaptive management in the DOI is guided by the DOI Policy on Adaptive Management. DOI adopted the National Research Council's 2004 definition of adaptive management, which states:

> Adaptive management [is a decision process that] promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a 'trial and error' process, but rather emphasizes learning while doing. Adaptive management does not represent an end in itself, but rather a means to more effective decisions and enhanced benefits. Its true measure is in how well it helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders.

This definition gives special emphasis to uncertainty about management effects, iterative learning to reduce uncertainty, and improved management as a result of learning.

When using adaptive management, project proponents will generally select several alternative management approaches to design, implement, and test. The alternatives are generally incorporated into sound experimental designs. Monitoring and evaluation of each alternative helps in deciding which alternative is more effective in meeting objectives, and informs adjustments to the next round of management decisions.

Adaptive management should not typically need to be applied to land-based wind energy projects because, in the majority of instances, when a developer follows the Guidelines, the impacts and the level of uncertainty should be low. Nevertheless, the tiered approach is designed to accommodate AM, when warranted. In the pre-construction environment, analysis and interpretation of information gathered at a particular tier influence the decision to proceed further with the project or the project assessment. If the project is constructed, information gathered in the pre-construction assessment will guide possible project modifications, mitigation or the need for and design of post-construction studies. Analysis of the results of post construction studies can test design modifications and operational activities to determine their effectiveness in avoiding or minimizing significant adverse impacts. When there is considerable uncertainty over the appropriate mitigation for a project, AM is typically the preferred approach to testing the effectiveness of alternative approaches.

Adaptive management should be reserved for situations where adverse impacts to species of concern are significant. This can be best determined by communication between the project operator, the Service field office, and the state wildlife agency, on a project-by-project basis. For adaptive management to be effective there must be agreement to adjust management and/or mitigation measures if monitoring indicates that anticipated impacts are being exceeded. Such agreement should include a timeline for periodic reviews and adjustments as well as a mechanism to consider and implement additional mitigation measures as necessary after the project is developed. The DOI Adaptive Management Technical Guide is located on the web at: www.doi.gov/initiatives/AdaptiveManagement/index.html.

Coordination with Other Federal Agencies

Other Federal agencies, such as the Bureau of Land Management, National Park Service, U.S. Department of Agriculture Forest Service and Rural Utility Service, and Department of Energy are often interested in and involved with wind project developments. These agencies have a variety of expertise and authorities they implement. State and local agencies and Tribes also have additional interests and knowledge. The Service recommends that wind project developers contact these agencies early in the tiered process and work closely with them throughout project planning and development to assure that projects address issues of concern to those agencies.

Relationship to Other Guidelines

These Guidelines replace the Service's 2003 interim voluntary guidelines. The Service intends that these Guidelines, when used in concert with the appropriate regulatory tools, will be the best practical approach for conservation of species of concern**.** For instance, when developers encounter an endangered or threatened species, they should comply with Section 7 or 10 of the ESA to obtain incidental take authorization. Other federal, state, tribal and local governments may use these Guidelines to complement their efforts to address wind energy development/fish and wildlife interactions. They are not intended to supplant existing regional or local guidance, or landscape-scale tools for conservation planning, but were developed to provide a means of improving consistency with the goals of the wildlife statutes that the Service is responsible for implementing. The Service will continue to work with states, tribes, and other local stakeholders on map-based tools, decision-support systems, and other products to help guide future development and conservation. Additionally, project proponents should utilize any relevant guidance of the appropriate jurisdictional entity, which will depend on the species and resources potentially affected by proposed development.

Chapter 2

Tiered Approach and Tier 1 – Preliminary Site Evaluation

This chapter briefly describes the tiered approach, with subsequent chapters outlining BMPs during site construction, retrofitting, repowering and decommissioning phases of a project. The five tiers are:

Tier 1 – Preliminary evaluation or screening of potential sites

Tier 2 – Site characterization

Tier 3 – Field studies to document site wildlife conditions and predict project impacts

Tier 4 – Post-construction studies to estimate impacts

Tier 5 – Other post-construction studies and research

The first three tiers correspond to the pre-construction evaluation phase of wind energy development. At each of the three tiers, the Guidelines provide a set of questions that developers attempt to answer, followed by recommended methods and metrics to use in answering the questions. Some questions are repeated at each tier, with successive tiers requiring a greater investment in data collection to answer certain questions. For example, while Tier 2 investigations may discover some existing information on federal or state-listed species and their use of the proposed development site, it may be necessary to collect empirical data in Tier 3 studies to determine the presence of federal or state-listed species.

Developers decide whether to proceed to the next tier. Timely communication will allow the opportunity for the Service to provide, and developers to consider, technical advice. A developer should base the decision on the information obtained from adequately answering the questions in this tier, whether the methods used were appropriate for the site selected, and the resulting assessment of risk posed to species of concern and their habitats.

Tier 1 - Preliminary Evaluation or Screening of Potential Sites

For developers taking a first look at a broad geographic area, a preliminary evaluation of the general ecological context of a potential site or sites can serve as useful preparation for coordination with the federal, state, tribal, and/or local agencies. The Service is available to assist wind energy project developers to identify potential wildlife and habitat issues and should be contacted as early as possible in the company's planning process. With this internal screening process, the developer can begin to identify broad geographic areas of high sensitivity due to the presence of: 1) large blocks of intact native landscapes, 2) intact ecological communities, 3) fragmentation-sensitive species' habitats, or 4) other important landscape-scale wildlife values. Tier 1 may be used in any of the following three ways:

1. To identify regions where wind energy development poses substantial risks to species of concern or their habitats, including the fragmentation of large-scale habitats and threats to regional populations of federal- or state-listed species.
2. To "screen" a landscape or set of multiple potential sites to avoid those with the highest habitat values.
3. To begin to determine if a single identified potential site poses serious risk to species of concern or their habitats.

Tier 1 can offer early guidance about the sensitivity of the site within a larger landscape context; it can help direct development away from sites that will be associated with additional study need, greater mitigation requirements, and uncertainty; or it can identify those sensitive resources that will need to be studied further to determine if the site can be developed without significant adverse impacts to the species of concern or local population(s). This may facilitate discussions with the federal, state, tribal, and/or local agencies in a region being considered for development. In some cases, Tier 1 studies could reveal serious concerns indicating that a site should not be developed.

Development in some areas may be precluded by federal law. This designation is separate from a determination through the tiered approach that an area is not appropriate for development due to feasibility, ecological reasons, or other issues. Developers are encouraged to visit Service databases or other available information during Tier 1 or Tier 2 to see if a potential wind energy area is precluded from development by federal law. Some areas may be protected from development through state or local laws or ordinances, and the appropriate agency should be contacted accordingly. The local Service office is available to answer questions regarding the designation and how it may apply to wind energy development.

Some areas may be inappropriate for large scale development because they have been recognized according to scientifically credible information as having high wildlife value, based solely on their ecological rarity and intactness (e.g., Audubon Important Bird Areas, The Nature Conservancy portfolio sites, state wildlife action plan priority habitats). It is important to identify such areas through the tiered approach, as reflected in Tier 1, Question 2 below. Many of North America's native landscapes are greatly diminished, with some existing at less than 10 percent of their pre-settlement occurrence. Herbaceous sub-shrub steppe in the Pacific Northwest and old growth forest in the Northeast are representative of such diminished native resources. Important remnants of these landscapes are identified and documented in various databases held by private conservation organizations, state wildlife agencies, and, in some cases, by the Service. Developers should collaborate with such entities specifically about such areas in the vicinity of a prospective project site.

Tier 1 Questions

Questions at each tier help determine potential environmental risks at the landscape scale for Tier 1 and project scale for Tiers 2 and 3. Suggested questions to be considered for Tier 1 include:

1. Are there species of concern present on the potential site(s), or is habitat (including designated critical habitat) present for these species?
2. Does the landscape contain areas where development is precluded by law or areas designated as sensitive according to scientifically credible information? Examples of designated areas include, but are not limited to: "areas of scientific importance;" "areas of significant value;" federally-designated critical habitat; high-priority conservation areas for non-government organizations (NGOs); or other local, state, regional, federal, tribal, or international categorizations.
3. Are there known critical areas of wildlife congregation, including, but not limited to: maternity roosts, hibernacula, staging areas, winter ranges, nesting sites, migration stopovers or corridors, leks, or other areas of seasonal importance?

Comment [UF&WS3]: ASK FAC – need citation/reference/definition

4. Are there large areas of intact habitat with the potential for fragmentation, with respect to species of habitat fragmentation concern needing large contiguous blocks of habitat?

Tier 1 Methods and Metrics

Developers who choose to conduct Tier 1 investigations would generally be able to utilize existing public or other readily available landscape-level maps and databases from sources such as federal, state, or tribal wildlife or natural heritage programs, the academic community, conservation organizations, or the developers' or consultants' own information. The Service recommends that developers conduct a review of the publicly available data. The analysis of available sites in the region of interest will be based on a blend of the information available in published and unpublished reports, wildlife range distribution maps, and other such sources. The developer should check with the Service Field Office for data specific to wind energy development and wildlife at the landscape scale in Tier 1.

Use of Tier 1 Information

The objective of the Tier 1 process is to help the developer identify a site or sites to consider further for wind energy development. Possible outcomes of this internal screening process include the following:

1. One or more sites are found within the area of investigation where the answer to each of the above Tier 1 questions is "no," indicating a low probability of significant adverse impact to wildlife. The developer proceeds to Tier 2 investigations and characterization of the site or sites, answering the Tier 2 questions with site-specific data to confirm the validity of the preliminary indications of low potential for significant adverse impact.
2. A "Yes" answer to one or more of the Tier 1 questions indicates a higher probability of significant adverse impacts to wildlife. Consideration of the area may be abandoned, or effort may be devoted to identifying possible means by which the project can be modified to avoid or minimize significant adverse impacts.
3. The data available in the sources described above are insufficient to answer one or more of the Tier 1 questions. The developer proceeds to Tier 2, with a specific emphasis on collecting the data necessary to answer the Tier 2 questions, which are inclusive of those asked at Tier 1.

Chapter 3

Tier 2 – Site Characterization

At this stage, the developer has narrowed consideration down to specific sites, and additional data may be necessary to systematically and comprehensively characterize a potential site in terms of the risk wind energy development would pose to species of concern and their habitats. In the case where a site or sites have been selected without the Tier 1 preliminary evaluation of the general ecological context, Tier 2 becomes the first stage in the site selection process. The developer will address the questions asked in Tier 1; if addressing the Tier 1 questions here, the developer will evaluate the site within a landscape context. However, a distinguishing feature of Tier 2 studies is that they focus on site-specific information and should include at least one visit to each of the prospective site(s). Because Tier 2 studies are preliminary, normally one reconnaissance level site visit will be adequate as a "ground-truth" of available information. Notwithstanding, if key issues are identified that relate to varying conditions and/or seasons, Tier 2 studies should include enough site visits during the appropriate times of the year to adequately assess these issues for the prospective site(s).

Tier 2 Questions

Questions suggested for Tier 2 can be answered using credible, publicly available information that includes published studies, technical reports, databases, and information from agencies, local conservation organizations, and/or local experts. Developers or consultants working on their behalf should contact the federal, state, tribal, and local agencies that have jurisdiction or management authority and responsibility over the potential project.

1. Are there known species of concern present on the proposed site, or is habitat (including designated critical habitat) present for these species?
2. Does the landscape contain areas where development is precluded by law or designated as sensitive according to scientifically credible information? Examples of designated areas include, but are not limited to: "areas of scientific importance;" "areas of significant value;" federally-designated critical habitat; high-priority conservation areas for NGOs; or other local, state, regional, federal, tribal, or international categorizations.

3. Are there plant communities of concern present or likely to be present at the site(s)?
4. Are there known critical areas of congregation of species of concern, including, but not limited to: maternity roosts, hibernacula, staging areas, winter ranges, nesting sites, migration stopovers or corridors, leks, or other areas of seasonal importance?
5. Using best available scientific information has the developer or relevant federal, state, tribal, and/or local agency identified the potential presence of a population of a species of habitat fragmentation concern?
6. Which species of birds and bats, especially those known to be at risk by wind energy facilities, are likely to use the proposed site based on an assessment of site attributes?

Tier 2 Methods and Metrics

Obtaining answers to Tier 2 questions will involve a more thorough review of the existing site-specific information than in Tier 1. Tier 2 site characterizations studies will generally contain three elements:

1. A review of existing information, including existing published or available literature and databases and maps of topography, land use and land cover, potential wetlands, wildlife, habitat, and sensitive plant distribution. If agencies have documented potential habitat for species of habitat fragmentation concern, this information can help with the analysis.
2. Contact with agencies and organizations that have relevant scientific information to further help identify if there are bird, bat or other wildlife issues. The Service recommends that the developer make contact with federal, state, tribal, and local agencies that have jurisdiction or management authority over the project or information about the potentially affected resources. In addition, because key NGOs and relevant local groups are often valuable sources of relevant local environmental information, the Service recommends that developers contact key NGOs, even if confidentiality concerns preclude the developer from identifying specific project location information at this stage. These contacts also provide an opportunity to identify other potential issues and data not already identified by the developer.

3. One or more reconnaissance level site visits by a wildlife biologist to evaluate current vegetation/habitat coverage and land management/use. Current habitat and land use practices will be noted to help in determining the baseline against which potential impacts from the project would be evaluated. The vegetation/habitat will be used for identifying potential bird and bat resources occurring at the site and the potential presence of, or suitable habitat for, species of concern. Vegetation types or habitats will be noted and evaluated against available information such as land use/land cover mapping. Any sensitive resources located during the site visit will be noted and mapped or digital location data recorded for future reference. Any individuals or signs of species of concern observed during the site visit will be noted. If land access agreements are not in place, access to the site will be limited to public roads.

Specific resources that can help answer each Tier 2 question include:

1. **Are there known species of concern present on the proposed site, or is habitat (including designated critical habitat) present for these species?**

   Information review and agency contact: locations of state and federally listed, proposed and candidate species and species of concern are frequently documented in state and federal wildlife databases. Examples include published literature such as: Natural Heritage Databases, State Wildlife Action Plans, NGOs publications, and developer and consultant information, or can be obtained by contacting these entities.

   Site Visit: to the extent practicable, the site visit(s) should evaluate the suitability of habitat at the site for species identified and the likelihood of the project to adversely affect the species of concern that may be present.

2. **Does the landscape contain areas where development is precluded by law or designated as sensitive according to scientifically credible information?** Examples of designated areas include, but are not limited to: "areas of scientific importance;" "areas of significant value;" federally-designated critical habitat; high-priority conservation areas for NGOs; or other local, state, regional, federal, tribal, or international categorizations.

Information review and agency contact such as: maps of political and administrative boundaries; National Wetland Inventory data files; USGS National Land Cover data maps; state, federal and tribal agency data on areas that have been designated to preclude development, including wind energy development; State Wildlife Action Plans; State Land and Water Resource Plans; Natural Heritage databases; scientifically credible information provided by NGO and local resources; and the additional resources listed in Appendix C of this document, or through contact of agencies and NGOs, to determine the presence of high priority habitats for species of concern or conservation areas.

Site Visit: to the extent practicable, the site visit(s) should characterize and evaluate the uniqueness of the site vegetation relative to surrounding areas.

3. Are plant communities of concern present or likely to be present at the site(s)?

Information review and agency contact such as: Natural Heritage Data of state rankings (S1, S2, S3) or globally (G1, G2, G3) ranked rare plant communities, such as tall grass prairies.

Site Visit: to the extent practicable, the site visit should evaluate the topography, physiographic features and uniqueness of the site vegetation in relation to the surrounding region.

4. Are there known critical areas of wildlife congregation, including, but not limited to, maternity roosts, hibernacula, staging areas, winter ranges, nesting sites, migration stopovers or corridors, leks, or other areas of seasonal importance?

Information review and agency contact such as: existing databases, State Wildlife Action Plan, Natural Heritage Data, and NGO and agency information regarding the presence of Important Bird Areas, migration corridors or stopovers, leks, bat hibernacula or maternity roosts, or game winter ranges at the site and in the surrounding area.

Site Visit: to the extent practicable, the site visit should evaluate the topography, physiographic features and uniqueness of the site in relation to the surrounding region to assess the potential for the project area to concentrate resident or migratory birds and bats.

5. **Using best available scientific information, has the developer or relevant federal, state, tribal, and/or local agency independently identified the potential presence of a population of a species of habitat fragmentation concern?** If not, the developer need not assess impacts of the proposed project on habitat fragmentation.

Habitat fragmentation is defined as the separation of a block of habitat for a species into segments, such that the genetic or demographic viability of the populations surviving in the remaining habitat segments is reduced; and risk, in this case, is defined as the probability that this fragmentation will occur as a result of the project. Site clearing, access roads, transmission lines and turbine tower arrays remove habitat and displace some species of wildlife, and may fragment continuous habitat areas into smaller, isolated tracts. Habitat fragmentation is of particular concern when species require large expanses of habitat for activities such as breeding and foraging.

Consequences of isolating local populations of some species include decreased reproductive success, reduced genetic diversity, and increased susceptibility to chance events (e.g. disease and natural disasters), which may lead to extirpation or local extinctions. In addition to displacement, development of wind energy infrastructure may result in additional loss of habitat for some species due to "edge effects" resulting from the break-up of continuous stands of similar vegetation resulting in an interface (edge) between two or more types of vegetation. The extent of edge effects will vary by species and may result in adverse impacts from such effects as a greater susceptibility to colonization by invasive species, increased risk of predation, and competing species favoring landscapes with a mosaic of vegetation.

If the answer to Tier 2 Question 5 is yes, developers should use the general framework for evaluating habitat fragmentation at a project site in Tier 2 outlined below. Developers and the Service may use this method to analyze the impacts of habitat fragmentation at wind development project sites on species of habitat fragmentation concern. Service field offices may be able to provide the available information on habitat types, quality and intactness. Developers may use this information in combination with site-specific information on the potential habitats to be impacted by a potential development and how they will be impacted.

General Framework for Evaluating Habitat Fragmentation at a Project Site (Tier 2)

A. The developer should define the study area. The study area should include the Project Site (see Glossary) for the proposed project. The extent of the study area should be based on the distribution of habitat for the local population of the species of habitat fragmentation concern.

B. The developer should analyze the current habitat quality and spatial configuration of the study area for the species of habitat fragmentation concern.

i. Use recent aerial and remote imagery to determine distinct habitat patches, or boundaries, within the study area, and the extent of existing habitat fragmenting features (e.g., highways).

ii. Assess the level of fragmentation of the existing habitat for the species of habitat fragmentation concern and categorize into three classes:

- High quality: little or no apparent fragmentation of intact habitat
- Medium quality: intact habitat exhibiting some recent disturbance activity (e.g., off-road vehicle (ORV) trails, roadways)
- Low quality: Extensive fragmentation of habitat (e.g., row-cropped agricultural lands, active surface mining areas)

C. The developer should determine potential changes in quality and spatial configuration of the habitat in the study area if development were to proceed as proposed using existing site information.

D. The developer should provide the collective information from steps A-C for all potential developments to the Service for use in assessing whether the habitat impacts, including habitat fragmentation, are likely to affect population viability of the potentially affected species of habitat fragmentation concern.

6. Which species of birds and bats, especially those known to be at risk by wind energy facilities, are likely to use the proposed site based on an assessment of site attributes?

Information review and agency contact: existing published information and databases from NGOs and federal and state resource agencies regarding the potential presence of:

- Raptors: species potentially present by season
- Prairie grouse and sage grouse: species potentially present by season and location of known leks
- Other birds: species potentially present by season that may be at risk of collision or adverse impacts to habitat, including loss, displacement and fragmentation
- Bats: species likely to be impacted by wind energy facilities and likely to occur on or migrate through the site

Site Visit: To the extent practicable, the site visit(s) should identify landscape features or habitats that could be important to raptors, prairie grouse, and other birds that may be at risk of adverse impacts, and bats, including nesting and brood-rearing habitats, areas of high prey density, movement corridors and features such as ridges that may concentrate raptors. Raptors, prairie grouse, and other presence or sign of species of concern seen during the site visit should be noted, with species identification if possible.

Tier 2 Decision Process

Possible outcomes of Tier 2 include the following:

1. If the results of the site assessment indicate that one or more species of concern are present, a developer should consider applicable regulatory or other agency processes for addressing them. For instance, if migratory birds and bats are likely to experience significant adverse impacts by a wind project at the proposed site, a developer should identify and document possible actions that will avoid those impacts on birds and bats (e.g., in documents such as operational plans or an Avian and Bat Protection Plan). Such actions might include, but not be limited to, altering locations of turbines or turbine arrays, operational modifications, or compensatory mitigation. If bald or golden eagles are present and likely to be affected by a wind project located there, a developer should consider preparing an ECP and, if necessary, apply for a programmatic take permit. If

endangered or threatened species are present and likely to be affected by a wind project located there, a federal agency should consult with the Service under Section 7(a)(2) of the ESA if the project has a federal nexus or the developer should apply for a section 10(a)(1)(B) incidental take permit if there is not a federal nexus, and incidental take of listed wildlife is anticipated. State, tribal, and local jurisdictions may have additional permitting requirements.

2. The most likely outcome of Tier 2 is that the answer to one or more Tier 2 questions is inconclusive to address wildlife risk, either due to insufficient data to answer the question or because of uncertainty about what the answers indicate (for example, Tier 2 site characterization may capture the presence of features indicating wildlife congregation, but may not capture seasonality and spatial variation of wildlife use). The developer proceeds to Tier 3, formulating questions, methods, and assessment of potential mitigation measures based on issues raised in Tier 2 results.

3. Sufficient information is available to answer all Tier 2 questions, and the answer to each Tier 2 question indicates a low probability of significant adverse impact to wildlife (for example, infill or expansion of an existing facility where impacts have been low and Tier 2 results indicate that conditions are similar, therefore wildlife risk is low). The developer may then decide to proceed to obtain state and local permit (if required), design, and construction following best management practices (see Chapter 7).

4. The answers to one or more Tier 2 questions indicate a high probability of significant adverse impacts to species of concern or their habitats, or plant communities of concern, that cannot be adequately mitigated. The proposed site should be abandoned.

Chapter 4
Tier 3 – Field Studies to Document Site Wildlife Conditions and Predict Project Impacts

Tier 3 is the first tier in which a developer would conduct quantitative and scientifically rigorous studies to assess the potential risk of the proposed project. Specifically, these studies provide pre-construction information to:

- Further evaluate a site for determining whether the wind energy project should be developed or abandoned
- Design and operate a site to avoid or minimize significant adverse impacts if a decision is made to develop
- Design compensatory mitigation measures if significant adverse habitat impacts cannot acceptably be avoided or minimized
- Determine duration and level of effort of post-construction monitoring. If warranted, provide the pre-construction component of post-construction studies necessary to estimate and evaluate impacts

At the beginning of Tier 3, a developer should communicate with the Service on the pre-construction studies. At the end of Tier 3, developers should coordinate with the Service to complete the Tier 3 decision process. The Service will provide written comments to a developer on study and project development plans that identify concerns and recommendations to resolve the concerns.

Not all Tier 3 studies will continue into Tiers 4 or 5. For example, surveys conducted in Tier 3 for species of concern may indicate one or more species are not present at the proposed project site, or siting decisions could be made in Tier 3 that remove identified concerns, thus removing the need for continued efforts in later tiers. Additional detail on the design issues for post-construction studies that begin in Tier 3 is provided in the discussion of methods and metrics in Tier 3.

Tier 3 Questions

Tier 3 begins as the other tiers begin, with problem formulation: what additional studies are necessary to enable a decision as to whether the proposed project can proceed to construction or operation or should be abandoned? This step includes an evaluation of data gaps identified by Tier 2 studies as well as the gathering of data necessary to:

- Design a project to avoid or minimize predicted risk
- Evaluate predictions of impact and risk through post-construction comparisons of estimated impacts
- Identify compensatory mitigation measures, if appropriate, to offset unavoidable significant adverse impacts

The problem formulation stage for Tier 3 also will include an assessment of which species identified in Tier 1 and/or Tier 2 will be studied further in the site risk assessment. This determination is based on analysis of existing data from Tier 1 and existing site-specific data and Project Site (see Glossary) visit(s) in Tier 2, and on the likelihood of presence and the degree of adverse impact to species or their habitat. If the habitat is suitable for a species needing further study and the site occurs within the historical range of the species, or is near the existing range of the species but presence has not been documented, additional field studies may be appropriate. Additional analyses should not be necessary if a species is unlikely to be present or is present but adverse impact is unlikely or of minor significance.

Tier 3 studies address many of the questions identified for Tiers 1 and 2, but Tier 3 studies differ because they attempt to quantify the distribution, relative abundance, behavior, and site use of species of concern. Tier 3 data also attempt to estimate the extent that these factors expose these species to risk from the proposed wind energy facility. Therefore, in answering Tier 3 questions 1-3, developers should collect data sufficient to analyze and answer Tier 3 questions 4-6.

If Tier 3 studies identify species of concern or important habitats, e.g., wetlands, which have specific regulatory processes and requirements, developers should work with appropriate state, tribal, or federal agencies to obtain required authorizations or permits.

Tier 3 studies should be designed to answer the following questions:

1. Do field studies indicate that species of concern are present on or likely to use the proposed site?
2. Do field studies indicate the potential for significant adverse impacts on affected population of species of habitat fragmentation concern?
3. What is the distribution, relative abundance, behavior, and site use of species of concern identified in Tiers 1 or 2, and to what extent do these factors expose these species to risk from the proposed wind energy project?
4. What are the potential risks of adverse impacts of the proposed wind energy project to individuals and local populations of species of concern and their habitats? (In the case of rare or endangered species, what are the possible impacts to such species and their habitats?)
5. How can developers mitigate identified significant adverse impacts?
6. Are there studies that should be initiated at this stage that would be continued in post-construction?

Tier 3 Methods and Metrics[3]

The Service encourages the use of common methods and metrics in Tier 3 assessments for measuring wildlife activity and habitat features. Common methods and metrics provide great benefit over the long-term, allowing for comparisons among projects and for greater certainty regarding what will be asked of the developer for a specific project. Deviation from commonly used methods should be carefully considered, scientifically justifiable and discussed with federal, tribal, or state natural resource agencies, or other credible experts, as appropriate. It may be

[3] The references cited herein were provided by the Wind Turbine Guidelines Advisory Committee. Additional information is available in Appendix C.

useful to consult other scientifically credible information sources. A list of references citing common methods and metrics is provided in Appendix C, including the National Wind Coordinating Collaborative's Studying Wind Energy/Wildlife Interactions: A Guidance Document (2011).

Tier 3 studies will be designed to accommodate local and regional characteristics. The specific protocols by which common methods and metrics are implemented in Tier 3 studies depend on the question being addressed, the species or ecological communities being studied and the characteristics of the study sites. Federally-listed threatened and endangered species, eagles, and some other species of concern and their habitats, may have specific protocols required by local, state or federal agencies. The need for special surveys and mapping that address these species and situations should be discussed with the appropriate stakeholders.

In some instances, a single method will not adequately assess potential collision risk or habitat impact. For example, when there is concern about moderate or high risk to nocturnally active species, such as migrating passerines and local and migrating bats, a combination of remote sensing tools such as radar, and acoustic monitoring for bats and indirect inference from diurnal bird surveys during the migration period may be necessary. Answering questions about habitat use by songbirds may be accomplished by relatively small-scale observational studies, while answering the same question related to wide-ranging species such as prairie grouse and sage grouse may require more time-consuming surveys, perhaps including telemetry.

Because of the points raised above and the need for flexibility in application, the Guidelines do not make specific recommendations on protocol elements for Tier 3 studies. The peer-reviewed scientific literature (such as the articles cited throughout this section) contains numerous recently published reviews of methods for assessing bird and bat activity, and tools for assessing habitat and landscape level risk. Details on specific methods and protocols for recommended studies are or will be widely available and should be consulted by industry and agency professionals.

Many methods for assessing risk are components of active research involving collaborative efforts of public-private research partnerships with federal, state and tribal agencies, wind energy developers and NGOs interested in wind energy-wildlife interactions (e.g., Bats and Wind Energy Cooperative and the Grassland Shrub Steppe Species Cooperative). It is important to recognize the need to integrate the results of research that improves existing methods or describes new methodological developments, while acknowledging the value of utilizing common methods that are currently available.

The remainder of this section outlines the methods and metrics that may be appropriate for gathering data to answer Tier 3 questions. These are not meant to be all inclusive and other methods and metrics are available, such as the NWCC Methods & Metrics document (Strickland et al. 2011).

Elements to Consider When Determining What to Study

Several factors can be considered to assess the potential effects to various species. Not all of these may be considered at all locations. First, the potential for presence of the species in the project area during the life of the project should be considered. Assessing species use from databases and site characteristics is a potential first step; however, it can be difficult to assess potential use by certain species from site characteristics alone. Various species in different locations may require developers to use specific survey protocols or make certain assumptions regarding presence. Seek local wildlife expertise, such as Service Field Office staff, in using the proper procedures and making assumptions.

Species that are rare or cryptic; that migrate, conduct other daily movements, or use areas for short periods of time; that are small in size or nocturnal; or that have become extirpated in parts of their historical range will present particular challenges when trying to determine potential presence. One of these challenges is “migration,” broadly defined as the act of moving from one spatial unit to another (Baker 1978), or as a periodic movement of animals from one location to another. Migration is species-specific, and for birds and bats occurs throughout the year. Such movements should be considered for all potentially affected species, including flying insects and species that migrate on the ground.

Developers should conduct monitoring of potential sites to determine the types of migratory species present, what type of spatial and temporal use these species make of the site (e.g., chronology of migration or other use), and the ecological function the site may provide in terms of the migration cycle of these species. Wind developers need to determine not only what species may migrate through a proposed development site and when, but also whether a site may function as a staging area or stopover habitat for wildlife on their migration pathway.

For some species, movements between foraging and breeding habitat, or between sheltering and feeding habitats, occur on a daily basis. Consideration of daily movements (morning and evening; coming and going) is a critical factor when considering project development.

Once likely presence has been determined or assumed, determine level of exposure regarding various risk factors, including abundance, frequency of use, habitat use patterns, and behavior. Finally, consider and/or determine the consequences to the "populations" and species. Below is a brief discussion of several types of risk factors that can be considered. This does not include all potential risk factors for all species, but addresses the most common ones.

a. <u>Collision and Barotrauma</u>

Collision likelihood for individual birds and bats at a particular wind energy facility may be the result of complex interactions among species distribution, "relative abundance," behavior, visibility, weather conditions, and site characteristics. Collision likelihood for an individual may be low regardless of abundance if its behavior does not place it within the "rotor-swept zone." Individuals that frequently occupy the rotor-swept zone but effectively avoid collisions are also at low likelihood of collision with a turbine.

Alternatively, if the behavior of individuals frequently places them in the rotor-swept zone, and they do not actively avoid turbine blade strikes, they are at higher likelihood of collisions with turbines regardless of abundance. Some species, even at lower abundance, may have a higher collision rate than similar species due to subtle differences in their ecology and behavior. At many projects, the numbers of bat fatalities are higher than the numbers of bird fatalities, but the exposure risk of bats at these facilities is not fully understood. Researchers (Horn et al. 2008 and Cryan 2008) hypothesize that some bats may be attracted to turbines, which, if true, would further complicate estimation of exposure. Further research is required to determine whether bats are attracted to turbines and if so, whether this increased individual risk translates into higher population-scale effects.

b. <u>Habitat Loss and Degradation</u>

Wind project development results in direct habitat loss and habitat modification, especially at sites previously undeveloped. Many of North America's native landscapes are greatly diminished or degraded from multiple causes unrelated to wind energy. Important remnants of these landscapes are identified and documented in various databases held by private conservation organizations, state wildlife agencies, and, in some cases, by the Service. Species that depend on these landscapes are susceptible to further loss of habitat, which will affect their ability to reproduce and survive. While habitat lost due to footprints of turbines, roads, and other infrastructure is obvious, less obvious is the potential reduction of habitat quality.

c. <u>Habitat Fragmentation</u>

Habitat fragmentation separates blocks of habitat for some species into segments, such that the individuals in the remaining habitat segments may suffer from effects such as decreased survival, reproduction, distribution, or use of the area. Site clearing, access roads, transmission lines, and arrays of turbine towers may displace some species or fragment continuous habitat areas into smaller, isolated tracts. Habitat fragmentation is of particular concern when species require large expanses of habitat for activities such as breeding, foraging, and sheltering.

Habitat fragmentation can result in increases in "edge" resulting in direct effects of barriers and displacement as well as indirect effects of nest parasitism and predation. Sensitivity to fragmentation effects varies among species. Habitat fragmentation and site modification are important issues that should be assessed at the landscape scale early in the siting process. Identify areas of high sensitivity due to the presence of blocks of native habitats, paying particular attention to known or suspected "species sensitive to habitat fragmentation."

d. Displacement and Behavioral Changes

Estimating displacement risk requires an understanding of animal behavior in response to a project and its infrastructure and activities, and a pre-construction estimate of presence/absence of species whose behavior would cause them to avoid or seek areas in proximity to turbines, roads, and other components of the project. Displacement is a function of the sensitivity of individuals to the project and activity levels associated with operations.

e. Indirect Effects

Wind development can also have indirect effects to wildlife and habitats. Indirect effects include reduced nesting and breeding densities and the social ramifications of those reductions; loss or modification of foraging habitat; loss of population vigor and overall population density; increased isolation between habitat patches, loss of habitat refugia; attraction to modified habitats; effects on behavior, physiological disturbance, and habitat unsuitability. Indirect effects can result from introduction of invasive plants; increased predator populations or facilitated predation; alterations in the natural fire regime; or other effects, and can manifest themselves later in time than the causing action.

Each question should be considered in turn, followed by a discussion of the methods and their applicability.

1. Do field studies indicate that species of concern are present on or likely to use the proposed site?

In many situations, this question can be answered based on information accumulated in Tier 2. Specific presence/absence studies may not be necessary, and protocol development should focus on answering the remaining Tier 3 questions. Nevertheless, it may be necessary to conduct field studies to determine the presence, or likelihood of presence, when little information is available for a particular site. The level of effort normally contemplated for Tier 3 studies should detect common species and species that are relatively rare, but which visit a site regularly (e.g., every year). In the event a species of concern is very rare and only occasionally visits a site, a determination of “likely to occur” would be inferred from the habitat at the site and historical records of occurrence on or near the site.

State, federal and tribal agencies often require specific protocols be followed when species of concern are potentially present on a site. The methods and protocols for determining presence of species of concern at a site are normally established for each species and required by federal, state and tribal resource agencies. Surveys should sample the wind turbine sites and applicable disturbance area during seasons when species are most likely present. Normally, the methods and protocols by which they are applied also will include an estimate of relative abundance. Most presence/absence surveys should be done following a probabilistic sampling protocol to allow statistical extrapolation to the area and time of interest.

Acoustic monitoring can be a practical method for determining the presence of threatened, endangered or otherwise rare species of bats throughout a proposed project (Kunz et al. 2007). There are two general types of acoustic detectors used for collection of information on bat activity and species identification: the full-spectrum, time-expansion and the zero-crossing techniques for ultrasound bat detection (see Kunz et al. 2007 for detailed discussion). Full-spectrum time expansion detectors provide nearly complete species discrimination, while zero-crossing detectors provide reliable and cost-effective estimates of total bat use at a site and some species discrimination. *Myotis* species can be especially difficult to discriminate with zero-crossing detectors (Kunz et al. 2007). Kunz et al. (2007) describe the strengths and weaknesses of each technique for ultrasonic bat detection, and either type of detector may be useful in most situations except where species identification is especially important and zero-crossing methods are inadequate to provide the necessary data. Bat acoustics technology is evolving rapidly and study objectives are an important consideration when selecting detectors. When rare or endangered species of bats are suspected, sampling should occur during different seasons and at multiple sampling stations to account for temporal and spatial variability.

Mist-netting for bats is required in some situations by state agencies, Tribes, and the Service to determine the presence of threatened, endangered or otherwise rare species. Mist-netting is best used in combination with acoustic monitoring to inventory the species of bats present at a site, especially to detect the presence of threatened or endangered species. Efforts should concentrate on potential commuting, foraging, drinking, and roosting sites (Kuenzi and Morrison 1998, O'Farrell et al. 1999). Mist-netting and other activities that involve capturing and handling threatened or endangered species of bats will require permits from state and/or federal agencies.

Determining the presence of diurnally or nocturnally active mammals, reptiles, amphibians, and other species of concern will typically be accomplished by following agency-required protocols. Most listed species have required protocols for detection (e.g., the black-footed ferret). State, tribal and federal agencies should be contacted regarding survey protocols for those species of concern. See Corn and Bury 1990, Olson et al. 1997, Bailey et al. 2004, Graeter et al. 2008 for examples of reptile and amphibian protocols, survey and analytical methods.

2. Do field studies indicate the potential for significant adverse impacts on affected populations of species of habitat fragmentation concern?

If Tier 2 studies indicate the presence of species of habitat fragmentation concern, but existing information did not allow for a complete analysis of potential impacts and decision-making, then additional studies and analyses should take place in Tier 3.

As in Tier 2, the particulars of the analysis will depend on the species of habitat fragmentation concern and how habitat block size and fragmentation are defined for the life cycles of that species, the likelihood that the project will adversely affect a local population of the species and the significance of these impacts to the viability of that population.

To assess habitat fragmentation in the project vicinity, developers should evaluate landscape characteristics of the proposed site prior to construction and determine the degree to which habitat for species of habitat fragmentation concern will be significantly altered by the presence of a wind energy facility.

A general framework for evaluating habitat fragmentation at a project site, following that described in Tier 2, is outlined below. This framework should be used in those circumstances when the developer, or a relevant federal, state, tribal and/or other local agency demonstrates the potential presence of a population of a species of habitat fragmentation concern that may be adversely affected by the project. Otherwise, the developer need not assess the impacts of the proposed project on habitat fragmentation. This method for analysis of habitat fragmentation at project sites must be adapted to the local population of the species of habitat fragmentation concern potentially affected by the proposed development.

The developer should:

1. Define the study area. The study area for the site should include the "footprint" for the proposed facility plus an appropriate surrounding area. The extent of the study area should be based on the area where there is potential for significant adverse habitat impacts, including indirect impacts, within the distribution of habitat for the species of habitat fragmentation concern.

2. Determine the potential for occupancy of the study area based on the guidance provided for the species of habitat fragmentation concern described above in Question 1.

3. Analyze current habitat quality and spatial configuration of the study area for the species of habitat fragmentation concern.
    a. Use recent aerial or remote imagery to determine distinct habitat patches or boundaries within the study area, and the extent of existing habitat fragmenting features.
        i. Assess the level of fragmentation of the existing habitat for the species of habitat fragmentation concern and categorize into three classes:
            - High quality: little or no apparent fragmentation of intact habitat
            - Medium quality: intact habitat exhibiting some recent disturbance activity (e.g., timber clearing, ORV trails, roadways)

- Low quality: extensive fragmentation of habitat (e.g., row-cropped agricultural lands, active surface mining areas)

ii. Determine edge and interior habitat metrics of the study area:

- Identify habitat, non-habitat landscape features and existing fragmenting features relative to the species of habitat fragmentation concern, to estimate existing edge
- Calculate area and acres of edge
- Calculate area of intact patches of habitat and compare to needs of species of habitat fragmentation concern

b. Determine potential changes in quality and spatial configuration of the habitat in the study area if development proceeds as proposed using existing site information and the best available spatial data regarding placement of wind turbines and ancillary infrastructure:

i. Identify, delineate and classify all additional features added by the development that potentially fragment habitat for the species of habitat fragmentation concern (e.g., roads, transmission lines, maintenance structures, etc.)

ii. Assess the expected future size and quality of habitat patches for the species of habitat fragmentation concern and the additional fragmenting features, and categorize into three classes as described above

iii. Determine expected future acreages of edge and interior habitats

iv. Calculate the area of the remaining patches of intact habitat

c. Compare pre-construction and expected post-construction fragmentation metrics:

i. Determine the area of intact habitat lost (to the displacement footprint or by alteration due to the edge effect)

ii. Identify habitat patches that are expected to be moved to a lower habitat quality classification as a result of the development

4. Assess the likelihood of a significant reduction in the demographic and genetic viability of the local population of the species of habitat fragmentation concern using the habitat fragmentation information collected under item 3 above and any currently available demographic and genetic data. Based on this assessment, the developer makes the finding whether or not there is significant reduction. The developer should share the finding with the relevant agencies. If the developer finds the likelihood of a significant reduction, the developer should consider items a, b or c below:

    a. Consider alternative locations and development configurations to minimize fragmentation of habitat in communication with species experts, for all species of habitat fragmentation concern in the area of interest.

    b. Identify high quality habitat parcels that may be protected as part of a plan to limit future loss of habitat for the impacted population of the species of habitat fragmentation concern in the area.

    c. Identify areas of medium or low quality habitat within the range of the impacted population that may be restored or improved to compensate for losses of habitat that result from the project (e.g., management of unpaved roads and ORV trails).

This protocol for analysis of habitat fragmentation at project sites should be adapted to the species of habitat fragmentation concern as identified in response to Question 5 in Tier 2 and to the landscape in which development is contemplated.

3. What is the distribution, relative abundance, behavior, and site use of species of concern identified in Tiers 1 or 2, and to what extent do these factors expose these species to risk from the proposed wind energy project?

For those species of concern that are considered at risk of collisions or habitat impacts, the questions to be answered in Tier 3 include: where are they likely to occur (i.e., where is their habitat) within a project site or vicinity, when might they occur, and in what abundance. The spatial distribution of species at risk of collision can influence how a site is developed. This distribution should include the airspace for flying species with respect to the rotor-swept zone. The abundance of a species and the spatial distribution of its habitat can be used to determine the relative risk of impact to species using the sites, and the absolute risk when compared to existing projects where similar information exists. Species abundance and habitat distribution can also be used in modeling risk factors.

Surveys for spatial distribution and relative abundance require coverage of the wind turbine sites and applicable site disturbance area, or a sample of the area using observational methods for the species of concern during the seasons of interest. As with presence/absence (see Tier 3, question 1, above) the methods used to determine distribution, abundance, and behavior may vary with the species and its ecology. Spatial distribution is determined by applying presence/absence or using surveys in a probabilistic manner over the entire area of interest.

Bird distribution, abundance, behavior and site use

Diurnal Avian Activity Surveys

The commonly used data collection methods for estimating the spatial distribution and relative abundance of diurnal birds includes counts of birds seen or heard at specific survey points (point count), along transects (transect surveys), and observational studies. Both methods result in estimates of bird use, which are assumed to be indices of abundance in the area surveyed. Absolute abundance is difficult to determine for most species and is not necessary to evaluate species risk. Depending on the characteristics of the area of interest and the bird species potentially affected by the project, additional pre-construction study methods may be necessary. Point counts or line transects should collect vertical as well as horizontal data to identify levels of activity within the rotor-swept zone.

Avian point counts should follow the general methodology described by Reynolds et al. (1980) for point counts within a fixed area, or the line transect survey similar to Schaffer and Johnson (2008), where all birds seen within a fixed distance of a line are counted. These methods are most useful for pre- and post-construction studies to quantify avian use of the project site by habitat, determine the presence of species of concern, and to provide a baseline for assessing displacement effects and habitat loss. Point counts for large birds (e.g., raptors) follow the same point count method described by Reynolds et al. (1980).

Point count plots, transects, and observational studies should allow for statistical extrapolation of data and be distributed throughout the area of interest using a probability sampling approach (e.g., systematic sample with a random start). For most projects, the area of interest is the area where wind turbines and permanent meteorological (met) towers are proposed or expected to be sited. Alternatively, the centers of the larger plots can be located at vantage points throughout the potential area being considered with the objective of covering most of the area of interest. Flight height should also be collected to focus estimates of use on activity occurring in the rotor-swept zone.

Sampling duration and frequency will be determined on a project-by-project basis and by the questions being addressed. The most important consideration for sampling frequency when estimating abundance is the amount of variation expected among survey dates and locations and the species of concern.

The use of comparable methods and metrics should allow data comparison from plot to plot within the area of interest and from site to site where similar data exist. The data should be collected so that avian activity can be estimated within the rotor-swept zone. Relating use to site characteristics requires that samples of use also measure site characteristics thought to influence use (i.e., covariates such as vegetation and topography) in relation to the location of use. The statistical relationship of use to these covariates can be used to predict occurrence in unsurveyed areas during the survey period and for the same areas in the future.

Surveys should be conducted at different intervals during the year to account for variation in expected bird activity with lower frequency during winter months if avian activity is low. Sampling frequency should also consider the episodic nature of activity during fall and spring migration. Standardized protocols for estimating avian abundance are well-established and should be consulted (e.g., Dettmers et al. 1999). If a more precise estimate of density is required for a particular species (e.g., when the goal is to determine densities of a special-status breeding bird species), the researcher will need more sophisticated sampling procedures, including estimates of detection probability.

Raptor Nest Searches

An estimate of raptor use of the project site is obtained through appropriate surveys, but if potential impacts to breeding raptors are a concern on a project, raptor nest searches are also recommended. These surveys provide information to predict risk to the local breeding population of raptors, for micro-siting decisions, and for developing an appropriate-sized non-disturbance buffer around nests. Surveys also provide baseline data for estimating impacts and determining mitigation requirements. A good source of information for raptor surveys and monitoring is Bird and Bildstein (2007).

Searches for raptor nests or raptor breeding territories on projects with potential for impacts to raptors should be conducted in suitable habitat during the breeding season. While there is no consensus on the recommended buffer zones around nest sites to avoid disturbance of most species (Sutter and Jones 1981), a nest search within at least one mile of the wind turbines and transmission lines, and other infrastructure should be conducted. However, larger nest search areas are needed for eagles, as explained in the Service's ECP Guidance.

Methods for these surveys are fairly common and will vary with the species, terrain, and vegetation within the survey area. The Service recommends that draft protocols be discussed with biologists from the lead agency, Service, state wildlife agency, and Tribes where they have jurisdiction. It may be useful to consult other scientifically credible information sources. At minimum, the protocols should contain the list of target raptor species for nest surveys and the appropriate search protocol for each site, including timing and number of surveys needed, search area, and search techniques.

Prairie Grouse and Sage Grouse Population Assessments

Sage grouse and prairie grouse merit special attention in this context for three reasons:

1. The scale and biotic nature of their habitat requirements uniquely position them as reliable indicators of impacts on, and needs of, a suite of species that depend on sage and

grassland habitats, which are among the nation's most diminished ecological communities (Vodehnal and Haufler 2007).

2. Their ranges and habitats are highly congruent with the nation's richest inland wind resources.
3. They are species for which some known impacts of anthropogenic features (e.g., tall structures, buildings, roads, transmission lines, wind energy facilities, etc.) have been documented.

Populations of prairie grouse and sage grouse generally are assessed by either lek counts (a count of the maximum number of males attending a lek) or lek surveys (classification of known leks as active or inactive) during the breeding season (e.g., Connelly et al. 2000). Methods for lek counts vary slightly by species but in general require repeated visits to known sites and a systematic search of all suitable habitat for leks, followed by repeated visits to active leks to estimate the number of grouse using them.

Recent research indicates that viable prairie grouse and sage grouse populations are dependent on suitable nesting and brood-rearing habitat (Connelly et al. 2000, Hagen et al. 2009). These habitats generally are associated with leks. Leks are the approximate centers of nesting and brood-rearing habitats (Connelly et al. 2000, but see Connelly et al. 1988; Becker et al. 2009,). High quality nesting and brood rearing habitats surrounding leks are critical to sustaining viable prairie grouse and sage grouse populations (Giesen and Connelly 1993, Hagen et al. 2004, Connelly et al. 2000). A population assessment study area should include nesting and brood rearing habitats that may extend several miles from leks. For example, greater and lesser prairie-chickens generally nest in suitable habitats within one to two miles of active leks (Hagen et al. 2004), whereas the average distances from nests to active leks of non-migratory sage grouse range from 0.7 to four miles (Connelly et al. 2000), and potentially much more for migratory populations (Connelly et al. 1988).

While surveying leks during the spring breeding season is the most common and convenient tool for monitoring population trends of prairie grouse and sage grouse, documenting available nesting and brood rearing habitat within and adjacent to the potentially affected area is recommended. Suitable nesting and brood rearing habitats can be mapped based on habitat requirements of individual species. The distribution and abundance of nesting and brood rearing habitats can be used to help in the assessment of adverse impacts of the proposed project to prairie grouse and sage grouse.

Mist-Netting for Birds

Mist-netting is not recommended as a method for assessing risk of wind development for birds. Mist-netting cannot generally be used to develop indices of relative bird abundance, nor does it provide an estimate of collision risk as mist-netting is not feasible at the heights of the rotor-swept zone and captures below that zone may not adequately reflect risk. Operating mist-nets requires considerable experience, as well as state and federal permits.

Occasionally mist-netting can help confirm the presence of rare species at documented fallout or migrant stopover sites near a proposed project. If mist-netting is to be used, the Service recommends that procedures for operating nets and collecting data be followed in accordance with Ralph et al. (1993).

Nocturnal and Crepuscular Bird Survey Methods

Additional studies using different methods should be conducted if characteristics of the project site and surrounding areas potentially pose a high risk of collision to night migrating songbirds and other nocturnal or crepuscular species. For most of their flight, songbirds and other nocturnal migrants are above the reach of wind turbines, but they pass through the altitudinal range of wind turbines during ascents and descents and may also fly closer to the ground during inclement weather (Able, 1970; Richardson, 2000). Factors affecting flight path, behavior, and “fall-out” locations of nocturnal migrants are reviewed elsewhere (e.g., Williams et al., 2001; Gauthreaux and Belser, 2003; Richardson, 2000; Mabee et al., 2006).

In general, pre-construction nocturnal studies are not recommended unless the site has features that might strongly concentrate nocturnal birds, such as along coastlines that are known to be migratory songbird corridors. Biologists knowledgeable about nocturnal bird migration and familiar with patterns of migratory stopovers in the region should assess the potential risks to nocturnal migrants at a proposed project site. No single method can adequately assess the spatial and temporal variation in nocturnal bird populations or the potential collision risk. Following nocturnal study methods in Kunz et al. (2007) is recommended to determine relative abundance, flight direction and flight altitude for assessing risk to migrating birds, if warranted. If areas of interest are within the range of nocturnal species of concern (e.g., marbled murrelet, northern spotted owl, Hawaiian petrel, Newell's shearwater), surveyors should use species-specific protocols recommended by state wildlife agencies, Tribes or Service to assess the species' potential presence in the area of interest.

In contrast to the diurnal avian survey techniques previously described, considerable variation and uncertainty exist on the optimal protocols for using acoustic monitoring devices, radar, and other techniques to evaluate species composition, relative abundance, flight height, and trajectory of nocturnal migrating birds. While an active area of research, the use of radar for determining passage rates, flight heights and flight directions of nocturnal migrating animals has yet to be shown as a good indicator of collision risk. Pre- and post-construction studies comparing radar monitoring results to estimates of bird and bat fatalities will be necessary to evaluate radar as a tool for predicting collision risk. Additional studies are also needed before making recommendations on the number of nights per season or the number of hours per night that are appropriate for radar studies of nocturnal bird migration (Mabee et al., 2006).

<u>*Bat survey methods*</u>

The Service recommends that all techniques discussed below be conducted by biologists trained in bat identification, equipment use, and the analysis and interpretation of data resulting from the design and conduct of the studies. Activities that involve capturing and handling bats may require permits from state and/or federal agencies.

Acoustic Monitoring

Acoustic monitoring provides information about bat presence and activity, as well as seasonal changes in species occurrence and use, but does not measure the number of individual bats or population density. The goal of acoustic monitoring is to provide a prediction of the potential risk of bat fatalities resulting from the construction and operation of a project. Our current state of knowledge about bat-wind turbine interactions, however, does not allow a quantitative link between pre-construction acoustic assessments of bat activity and operations fatalities. Discussions with experts, state wildlife trustee agencies, Tribes, and Service will be needed to determine whether acoustic monitoring is warranted at a proposed project site.

The predominance of bat fatalities detected to date are migratory species and acoustic monitoring should adequately cover periods of migration and periods of known high activity for other (i.e., non-migratory) species. Monitoring for a full year is recommended in areas where there is year round bat activity. Data on environmental variables such as temperature and wind speed should be collected concurrently with acoustic monitoring so these weather data can be used in the analysis of bat activity levels.

The number and distribution of sampling stations necessary to adequately estimate bat activity have not been well established but will depend, at least in part, on the size of the project area, variability within the project area, and a Tier 2 assessment of potential bat occurrence.

The number of detectors needed to achieve the desired level of precision will vary depending on the within-site variation (e.g., Arnett et al. 2006, Weller 2007, E.B. Arnett, Bat Conservation International, unpublished data). One frequently used method is to place acoustic detectors on existing met towers, approximately every two kilometers across the site where turbines are expected to be sited. Acoustic detectors should be placed at high positions (as high as practicable, based on tower height) on each met tower included in the sample to record bat activity at or near the rotor swept zone, the area of presumed greatest risk for bats. Developers should evaluate whether it would be cost effective to install detectors when met towers are first established on a site. Doing so might reduce the cost of installation later and might alleviate time delays to conduct such studies.

If sampling at met towers does not adequately cover the study area or provide sufficient replication, additional sampling stations can be established at low positions (~1.5-2 meters) at a sample of existing met towers and one or more mobile units (i.e., units that are moved to different locations throughout the study period) to increase coverage of the proposed project area. When practical and based on information from Tier 2, it may be appropriate to conduct some acoustic monitoring of features identified as potentially high bat use areas within the study area (e.g., bat roosts and caves) to determine use of such features.

There is growing interest in determining whether "low" position samples (~1.5-2 meters) can provide equal or greater correlation with bat fatalities than "high" position samples (described above) because this would substantially lower cost of this work. Developers could then install a greater number of detectors at lower cost resulting in improved estimates of bat activity and, potentially, improved qualitative estimates of risk to bats. This is a research question that is not expected to be addressed at a project.

Other bat survey techniques

Occasionally, other techniques may be needed to answer Tier 3 questions and complement the information from acoustic surveys. Kunz et al. (2007), NAS (2007), Kunz and Parsons (2009) provide comprehensive descriptions of bat survey techniques, including those identified below that are relevant for Tier 3 studies at wind energy facilities.

Roost Searches and Exit Counts

Pre-construction survey efforts may be recommended to determine whether known or likely bat roosts in mines, caves, bridges, buildings, or other potential roost sites occur within the project vicinity, and to confirm whether known or likely bat roosts are present and occupied by bats. If active roosts are detected, it may be appropriate to address questions about colony size and species composition of roosts. Exit counts and roost searches are two approaches to answering these questions, and Rainey (1995), Kunz and Parsons (2009), and Sherwin et al. (2009) are resources that describe options and approaches for these techniques. Roost searches should be performed cautiously because roosting bats are sensitive to human disturbance (Kunz et al. 1996). Known maternity and hibernation roosts should not be entered or otherwise disturbed unless authorized by state and/or federal wildlife agencies. Internal searches of abandoned mines or caves can be dangerous and should only be conducted by trained researchers. For mine survey protocol and guidelines for protection of bat roosts, see the appendices in Pierson et al. (1999). Exit surveys at known roosts generally should be limited to non-invasive observation using low-light binoculars and infrared video cameras.

Multiple surveys should be conducted to determine the presence or absence of bats in caves and mines, and the number of surveys needed will vary by species of bats, sex (maternity or bachelor colony) of bats, seasonality of use, and type of roost structure (e.g., caves or mines). For example, Sherwin et al. (2003) demonstrated that a minimum of three surveys are needed to determine the absence of large hibernating colonies of Townsend's big-eared bats (*Corynorhinus townsendii*) in mines (90 percent probability), while a minimum of nine surveys (during a single warm season) are necessary before a mine could be eliminated as a bachelor roost for this species (90 percent probability). An average of three surveys was needed before surveyed caves could be eliminated as bachelor roosts (90 percent probability). The Service recommends that decisions on level of effort follow discussion with relevant agencies and bat experts.

Activity Patterns

If active roosts are detected, it may be necessary to answer questions about behavior, movement patterns, and patterns of roost use for bat species of concern, or to further investigate habitat features that might attract bats and pose fatality risk. For some bat species, typically threatened, endangered, or state-listed species, radio telemetry or radar may be recommended to assess both the direction of movement as bats leave roosts, and the bats' use of the area being considered for development. Kunz et al. (2007) describe the use of telemetry, radar and other tools to evaluate use of roosts, activity patterns, and flight direction from roosts.

Mist-Netting for Bats

While mist-netting for bats is required in some situations by state agencies, Tribes, and the Service to determine the presence of threatened, endangered or other bat species of concern, mist-netting is not generally recommended for determining levels of activity or assessing risk of wind energy development to bats for the following reasons: 1) not all proposed or operational wind energy facilities offer conditions conducive to capturing bats, and often the number of suitable sampling points is minimal or not closely associated with the project location; 2) capture efforts often occur at water sources offsite or at nearby roosts and the results may not reflect species presence or use on the site where turbines are to be erected; and 3) mist-netting isn't feasible at the height of the rotor-swept zone, and captures below that zone may not adequately reflect risk of fatality. If mist-netting is employed, it is best used in combination with acoustic monitoring to inventory the species of bats present at a site.

White-Nose Syndrome

White-nose syndrome is a disease affecting hibernating bats. Named for the white fungus that appears on the muzzle and other body parts of hibernating bats, WNS is associated with extensive mortality of bats in eastern North America. All contractors and consultants hired by developers should employ the most current version of survey and handling protocols to avoid transmitting white-nose syndrome between bats.

Other wildlife

While the above guidance emphasizes the evaluation of potential impacts to birds and bats, Tier 1 and 2 evaluations may identify other species of concern. Developers are encouraged to assess adverse impacts potentially caused by development for those species most likely to be negatively affected by such development. Impacts to other species are primarily derived from potential habitat loss or displacement. The general guidance on the study design and methods for estimation of the distribution, relative abundance, and habitat use for birds is applicable to the study of other wildlife. References regarding monitoring for other wildlife are available in Appendix C. Nevertheless, most methods and metrics will be species-specific and developers are advised to work with the state, tribal, or federal agencies, or other credible experts, as appropriate, during problem formulation for Tier 3.

4. What are the potential risks of adverse impacts of the proposed wind energy project to individuals and local populations of species of concern and their habitats, and to limited plant communities or ecosystems? (In the case of rare or endangered species, what are the possible impacts to such species and their habitats?)

Methods used for estimating risk will vary with the species of concern. For example, estimating potential bird fatalities in Tier 3 may be accomplished by comparing exposure estimates (described earlier in estimates of bird use) at the proposed site with exposure estimates and fatalities at existing projects with similar characteristics (e.g., similar technology, landscape, and weather conditions). If models are used, they may provide an additional tool for estimating fatalities, and have been used in Australia (Organ and Meredith 2004), Europe (Chamberlin et al. 2006), and the United States (Madders and Whitfield 2006). As with other prediction tools, model predictions should be evaluated and compared with post-construction fatality data to validate the models. Models should be used as a subcomponent of a risk assessment based on the best available empirical data. A statistical model based on the relationship of pre-construction estimates of raptor abundance and post-construction raptor fatalities is described in Strickland et al. (in review) and promises to be a useful tool for risk assessment.

Collision risk to individual birds and bats at a particular wind energy facility may be the result of complex interactions among species distribution, relative abundance, behavior, weather conditions (e.g., wind, temperature) and site characteristics. Collision risk for an individual may be low regardless of abundance if its behavior does not place it within the rotor-swept zone. If individuals frequently occupy the rotor-swept zone but effectively avoid collisions, they are also at low risk of collision with a turbine (e.g., ravens). Alternatively, if the behavior of individuals frequently places them in the rotor-swept zone, and they do not actively avoid turbine blade strikes, they are at higher risk of collisions with turbines regardless of abundance. For a given species (e.g., red-tailed hawk), increased abundance increases the likelihood that individuals will be killed by turbine strikes, although the risk to individuals will remain about the same. The risk to a population increases as the proportion of individuals in the population at risk to collision increases.

At some projects, bat fatalities are higher than bird fatalities, but the exposure risk of bats at these facilities is not fully understood (National Research Council (NRC) 2007). Horn et al. (2008) and Cryan (2008) hypothesize that bats are attracted to turbines, which, if true, would further complicate estimation of exposure. Further research is required to determine if bats are attracted to turbines and if so, to evaluate 1) the influence on Tier 2 methods and predictions, and 2) if this increased individual risk translates into higher population-level impacts for bats.

The estimation of indirect impact risk requires an understanding of animal behavior in response to a project and its infrastructure, and a pre-construction estimate of presence/absence of species whose behavior would cause them to avoid areas in proximity to turbines, roads and other components of the project. The amount of habitat that is lost to indirect impacts will be a function of the sensitivity of individuals to the project and to the activity levels associated with the project's operations. The population-level significance of this indirect impact will depend on the amount of habitat available to the affected population. If the indirect impacts result in habitat fragmentation, then the risk to the demographic and genetic viability of the isolated animals is increased. Quantifying cause and effect may be very difficult, however.

5. How can developers mitigate identified significant adverse impacts?

Results of Tier 3 studies should provide a basis for identifying measures to mitigate significant adverse impacts predicted for species of concern. Information on wildlife use of the proposed area is most useful when designing a project to avoid or minimize significant adverse impacts. In cases of uncertainty with regard to impacts to species of concern, additional studies may be necessary to quantify significant adverse impacts and determine the need for mitigation of those impacts.

Chapter 7, Best Management Practices, and Chapter 8, Mitigation, outline measures that can be taken to mitigate impacts throughout all phases of a project.

The following discussion of prairie grouse and sage grouse as species of concern illustrates the uncertainty mentioned above by describing the present state of scientific knowledge relative to these species, which should be considered when designing mitigation measures. The extent of the impact of wind energy development on prairie grouse and sage grouse lekking activity (e.g., social structure, mating success, persistence) and the associated impacts on productivity (e.g., nesting, nest success, chick survival) is poorly understood (Arnett et al. 2007, NRC 2007, Manville 2004). However, recent published research documents that anthropogenic features (e.g., tall structures, buildings, roads, transmission lines) can adversely impact vital rates (e.g., nesting, nest success, lekking behavior) of lesser prairie-chickens (Pruett et al. 2009, Pitman et al. 2005, Hagen et al. 2009, Hagen et al. 2011) and greater prairie-chickens over long distances. Pitman et al. (2005) found that transmission lines reduced nesting of lesser prairie chicken by 90 percent out to a distance of 0.25 miles, improved roads at a distance of 0.25 miles, a house at 0.3 miles, and a power plant at >0.6 miles. Reduced nesting activity of lesser prairie chickens may extend farther, but Pitman et al. (2005) did not analyze their data for lower impacts (less than 90 percent reduction in nesting) of those anthropogenic features on lesser prairie chicken nesting activities at greater distances. Hagen et al. (2011) suggested that development within 1 to 1 ½ miles of active leks of prairie grouse may have significant adverse impacts on the affected grouse population. It is not unreasonable to infer that impacts from wind energy facilities may be similar to those from these other anthropogenic structures. Kansas State University, as part of the NWCC GS3C, is undertaking a multi-year telemetry study to evaluate the effects of a proposed wind-energy facility on displacement and demographic parameters (e.g., survival, nest success, brood success, fecundity) of greater prairie-chickens in Kansas.[4]

The distances over which anthropogenic activities impact sage grouse are greater than for prairie grouse. Based primarily on data documenting reduced fecundity (a combination of nesting, clutch size, nest success, juvenile survival, and other factors) in sage grouse populations near roads, transmissions lines, and areas of oil and gas development/production (Holloran 2005, Connelly et al. 2000), development within three to five miles (or more) of active sage grouse leks may have significant adverse impacts on the affected grouse population. Lyon and Anderson (2003) found that in habitats fragmented by natural gas development, only 26 percent of hens captured on disturbed leks nested within 1.8 miles of the lek of capture, whereas 91 percent of hens from undisturbed areas nested within the same area. Holloran (2005) found that active drilling within 3.1 miles of sage grouse lek reduced the number of breeding males by displacing adult males and reducing recruitment of juvenile males. The magnitudes and proximal causes (e.g., noise, height of structures, movement, human activity, etc.) of those impacts on vital rates in grouse populations are areas of much needed research (Becker et al. 2009). Data accumulated

[4] www.nationalwind.org

through such research may improve our understanding of the buffer distances necessary to avoid or minimize significant adverse impacts to prairie grouse and sage grouse populations.

When significant adverse impacts cannot be fully avoided or adequately minimized, some form of compensatory mitigation may be appropriate to address the loss of habitat value. For example, it may be possible to mitigate habitat loss or degradation for a species of concern by enhancing or restoring nearby habitat value comparable to that potentially influenced by the project.

6. Are there studies that should be initiated at this stage that would be continued in post-construction?

During Tier 3 problem formulation, it is necessary to identify the studies needed to address the Tier 3 questions. Consideration of how the resulting data may be used in conjunction with post-construction Tier 4 and 5 studies is also recommended. The design of post-construction impact or mitigation assessment studies will depend on the specific impact questions being addressed. Tier 3 predictions ~~of fatalities~~ will be evaluated using data from Tier 4 studies designed to estimate fatalities for species of concern and impacts to their habitat, including species of habitat fragmentation concern. Tier 3 studies may demonstrate the need for compensatory mitigation of significant adverse habitat impacts or for measures to avoid or minimize fatalities. Where Tier 3 studies indicate the potential for significant adverse direct and indirect impacts to habitat, Tier 4 studies will provide data that evaluate predictions of those impacts, and Tier 5 studies, if necessary, will provide data to evaluate the effect of those impacts on populations and the effectiveness of avoidance, minimization and mitigation measures. Evaluations of the impacts of a project on demographic parameters of local populations, habitat use, or some other parameter(s) are considered Tier 5 studies, and typically will require data on these parameters prior to as well as after construction of the project.

Study Design Issues

Specific study designs will vary from site to site and should be adjusted to the circumstances of individual projects. Study designs will depend on the types of questions, the specific project, and practical considerations. The most common practical considerations include the area being studied, the period of interest, the species of concern, potentially confounding variables, time available to conduct studies, project budget, and the magnitude of the anticipated impacts.

When collection of both pre- and post-construction data in the areas of interest and reference areas is possible, then the Before-After-Control-Impact (BACI) is the most statistically robust design. The BACI design is most like the classic manipulative experiment.[5] In the absence of a suitable reference area, the design is reduced to a Before-After (BA) analysis of effect where the differences between pre- and post-construction parameters of interest are assumed to be the result of the project, independent of other potential factors affecting the assessment area. With respect to BA studies, the key question is whether the observations taken immediately after the incident can reasonably be expected within the expected range for the system (Manly 2009). Reliable quantification of impact usually will include additional study components to limit variation and the confounding effects of natural factors that may change with time.

The developer's timeline for the development of a wind energy facility often does not allow for the collection of sufficient pre-construction data and/or identification of suitable reference areas to complete a BACI or BA study. Furthermore, alterations in land use or disturbance over the course of a multi-year BACI or BA study may complicate the analysis of study results. These design issues are discussed more fully under Tier 5 design considerations.

Tier 3 Decision Point

At the end of Tier 3, developers should coordinate with the Service to complete the Tier 3 decision process. The Service will provide written comments to a developer on study and project development plans that identify concerns and recommendations to resolve the concerns.

[5] In this context, such designs are not true experiments in that the treatments (project development and control) are not randomly assigned to an experimental unit, and there is often no true replication. Such constraints are not fatal flaws, but do limit statistical inferences of the results.

The developer and, when applicable, the permitting authority will make a decision regarding whether and how to develop the project. The decision point at the end of Tier 3 involves three potential outcomes:

1. Development of the site has a low probability of significant adverse impact based on existing and new information.

   There is little uncertainty regarding when and how development should proceed, and adequate information exists to satisfy any required permitting. The decision process proceeds to permitting, when required, and/or development, and post-construction monitoring.

2. Development of the site has a moderate to high probability of significant adverse impacts without proper measures being taken to mitigate those impacts. This outcome may be subdivided into two possible scenarios:

   a. There is certainty regarding how to develop the site to adequately mitigate significant adverse impacts. A decision to develop the site is made, conditional on the proper mitigation measures being adopted, with appropriate post-construction fatality and habitat studies (Tier 4).

   b. There is uncertainty regarding how to develop the site to adequately mitigate significant adverse impacts, or a permitting process requires additional information on potential significant adverse wildlife impacts before permitting future phases of the project. A decision to develop the site is made conditional on the proper mitigation measures being taken and with appropriate follow up post-construction studies (Tier 4 and 5).

3. Development of the site has a high probability of significant impact that cannot be satisfactorily mitigated.

Site development should be delayed until plans can be developed that satisfactorily avoid, minimize or provide compensatory mitigation for the significant adverse impacts. Alternatively, the site should be abandoned in favor of known sites with less potential for environmental impact, or the developer begins an evaluation of other sites or landscapes for more acceptable sites to develop.

Where pre-construction assessments are warranted to help assess risk to wildlife, the studies should be of sufficient duration and intensity to ensure adequate data are collected to accurately characterize wildlife use of the area. In ecological systems, resource quality and quantity can fluctuate rapidly. These fluctuations occur naturally, but human actions can significantly affect (i.e., increase or decrease) natural oscillations. Pre-construction monitoring and assessment of proposed wind energy sites are "snapshots in time," showing occurrence or no occurrence of a species or habitat at the specific time surveyed. Often due to prohibitive costs, assessments and surveys are conducted for very low percentages (e.g., less than 5 percent) of the available sample time in a given year, however, these data are used to support risk analyses over the projected life of a project (e.g., 30 years of operations).

To establish a trend in site use and conditions that incorporates annual and seasonal variation in meteorological conditions, biological factors, and other variables, pre-construction studies may need to occur over multiple years. However, the level of risk and the question of data requirements will be based on site sensitivity, affected species, and the availability of data from other sources. Accordingly, decisions regarding the studies recommended should consider information gathered during the previous tiers, variability within and between seasons, and years where variability is likely to substantially affect answers to the Tier 3 questions. These studies should also be designed to collect data during relevant breeding, feeding, sheltering, staging, or migration periods for each species being studied. Additionally, consideration for the frequency and intensity of pre-construction monitoring should be site-specific and determined through consultation with an expert authority based on their knowledge of the specific species, level of risk and other variables present at each individual site. Some tools have been developed for existing guidance to evaluate sites based on risk criteria.

Chapter 5

Tier 4 – Post-construction Studies to Estimate Impacts

Comment [UF&WS4]: FWS has significantly revised this Chapter. It now includes post-construction fatality monitoring and habitat studies.

Following the tiered decision process, the outcome of studies in Tiers 1, 2, and 3 will determine the duration and level of effort of post-construction studies.

Tier 4 post-construction studies are designed to assess whether predictions of fatality risk and direct and indirect impacts to habitat of species concern were correct. Fatality studies involve searching for bird and bat carcasses beneath turbines to estimate the number and species composition of fatalities (Tier 4a). Habitat studies involve application of GIS and use data collected in Tier 3 and Tier 4b and/or published information. Post-construction studies on direct and indirect impacts to habitat of species of concern, including species of habitat fragmentation concern need only be conducted if Tier 3 studies indicate the potential for significant adverse impacts.

1. Tier 4a – Fatality Studies

At this time, all projects should conduct at least one year of fatality studies. As data collected with consistent methods and metrics increases (see discussion below), it is possible that some future projects will not warrant fatality monitoring, but such a situation is rare with the present state of knowledge.

~~Fatality monitoring should be conducted at all wind energy projects.~~ Fatality monitoring should occur over all seasons of occupancy for the species being monitored, based on information produced in previous tiers. The number of seasons and total length of the monitoring may be determined separately for bats and birds, depending on the pre-construction risk assessment, results of Tier 3 studies and Tier 4 monitoring from comparable sites (see Glossary), and the results of first year fatality monitoring**.** Guidance on the relationship between these variables and monitoring for fatalities is provided in Table 2.

It may be appropriate to conduct monitoring using different durations and intervals depending on the species of concern. For example, if raptors occupy an area year-round, it may be appropriate to monitor for raptors throughout the year (12 months). It may be warranted to monitor for bats when they are active (spring, summer and fall or approximately eight months). It may be appropriate to increase the search frequency during the months bats are active and decrease the frequency during periods of inactivity. All fatality monitoring should include estimates of carcass removal and carcass detection bias likely to influence those rates.

Tier 4a Questions

Post-construction fatality monitoring should be designed to answer the following questions as appropriate for the individual project:

1. What are the bird and bat fatality rates for the project?
2. What are the fatality rates of species of concern?
3. How do the estimated fatality rates compare to the predicted fatality rates?
4. Do bird and bat fatalities vary within the project site in relation to site characteristics?
5. How do the fatality rates compare to the fatality rates from existing projects in similar landscapes with similar species composition and use?
6. What is the composition of fatalities in relation to migrating and resident birds and bats at the site?
7. Do fatality data suggest the need for measures to reduce impacts?

Tier 4a studies should be of sufficient statistical validity to address Tier 4a questions and enable determination of whether Tier 3 fatality predictions were correct. Fatality monitoring results also should allow comparisons with other sites, and provide a basis for determining if operational changes or mitigation measures at the site are appropriate. The Service encourages project operators to discuss Tier 4 studies with local, state, federal, and tribal wildlife agencies. The number of years of monitoring is based on outcomes of Tier 3 and Tier 4 studies and analysis of comparable Tier 4 data from other projects as indicated in Table 2. The Service may recommend multiple years of monitoring for projects located near a listed species or bald or golden eagle, or other situations, as appropriate.

Table 2. Decision Matrix for Post-construction Tier 4a Fatality Monitoring of Species of Concern.[6]

Risk as identified in Tier 3	Recommended Fatality Monitoring Duration and Effort	Possible outcomes of monitoring results
Tier 3 Studies indicate LOW risk	**Duration**: At least one year of fatality monitoring to estimate fatalities of birds and bats. Field assessments should be sufficient to confirm that risk to birds and/or bats is indeed "low."	1) Documented fatalities are approximately equal to or lower than predicted risk. No further fatality monitoring or mitigation is needed. 2) Fatalities are greater than predicted, but are not likely to be significant (i.e., unlikely to affect the long-term status of the population). If comparable fatality data at similar sites also supports that impacts are not likely to be high enough to affect population status, no further monitoring or mitigation is needed. If no comparable fatality data are available or such data indicates high risk, one additional year of fatality monitoring is recommended. If two years of fatality monitoring indicate levels of impacts that are not significant, no further fatality monitoring or mitigation is recommended. 3) Fatalities are greater than predicted and are likely to be significant OR Federally Endangered Species or BGEPA species are affected. Communication with the Service is recommended. Further efforts to address impacts to BGEPA or ESA species may be warranted, unless otherwise addressed in an ESA or BGEPA take permit.
Tier 3 studies indicate MODERATE risk	**Duration**: Two or more years of fatality monitoring may be necessary. Field assessments should be sufficient to confirm that risk to birds and/or bats is indeed "moderate." Closely compare estimated effects to species to those determined from the risk assessment protocol(s).	1) Documented fatalities after the first two years are lower or not different than predicted and are not significant and no Federally Endangered Species or BGEPA species are affected - no further fatality monitoring or mitigation is needed. 2) Fatalities are greater than predicted and are likely to be significant OR Federally Endangered Species or BGEPA species are affected, communication with the Service is recommended. Further efforts to address impacts to BGEPA or ESA species may be warranted, unless otherwise addressed in an ESA or BGEPA take permit.

[6] Ensure that survey protocols, and searcher efficiency and scavenger removal bias correction factors are the most reliable, robust, and up to date (after Huso 2009).

Tier 3 studies indicate HIGH risk	**Duration**: Three or more years of fatality monitoring may be necessary.	1) Documented fatalities during each year of fatality monitoring are less than predicted and are not likely to be significant, and no Federally Endangered Species or BGEPA species are affected – no further fatality monitoring or mitigation is needed. 2) Fatalities are equal to or greater than predicted and are likely to be significant - further efforts to reduce impacts are necessary; communication with the Service are recommended. Further efforts to address impacts to BGEPA or ESA species may be warranted, unless otherwise addressed in an ESA or BGEPA take permit.

Tier 4a Protocol Design Issues

The basic method of measuring fatality rates is the carcass search. Search protocols should be standardized to the greatest extent possible, especially for common objectives and species of concern, and they should include methods for adequately accounting for sampling biases (searcher efficiency and scavenger removal). However, some situations warrant exceptions to standardized protocol, and the responsibility of demonstrating that an exception is appropriate and applicable should be on the stakeholder attempting to justify increasing or decreasing the duration or intensity of operations monitoring.

Some general guidance is given below with regard to the following fatality search protocol design issues:

- Duration and frequency of monitoring
- Number of turbines to monitor
- Delineation of carcass search plots, transects, and habitat mapping
- General search protocol
- Field bias and error assessment
- Estimators of fatality

- More detailed descriptions and methods of fatality search protocols can be found in the California (California Energy Commission 2007) and Pennsylvania (Pennsylvania Game Commission 2007) state guidelines and in Kunz et al. (2007) and Smallwood (2007).
- Frequency of carcass searches

Frequency of carcass searches (search interval) may vary for birds and bats, and will vary depending on the questions to be answered, the species of concern, and their seasonal abundance at the project site. The carcass searching protocol should be adequate to answer applicable Tier 4 questions at an appropriate level of precision to make general conclusions about the project, and is not intended to provide highly precise measurements of fatalities. Except during low use times (e.g. winter months in northern states), the Service recommends that protocols be designed such that carcass searches occur at some turbines within the project area most days each week of the study.

The search interval is the interval between carcass searches at individual turbines, and this interval may be lengthened or shortened depending on the carcass removal rates. If the primary focus is on fatalities of large raptors, where carcass removal is typically low, then a longer interval between searches (e.g., 14-28 days) is sufficient. However, if the focus is on fatalities of bats and small birds and carcass removal is high, then a shorter search interval will be necessary.

There are situations in which studies of higher intensity (e.g., daily searches at individual turbines within the sample) may be appropriate. These would be considered only in Tier 5 studies or in research programs because the greater complexity and level of effort goes beyond that recommended for typical Tier 4 post construction monitoring. Tier 5 and research studies could include evaluation of specific measures that have been implemented to mitigate potential significant adverse impacts to species of concern identified during pre-construction studies.

<u>*Number of turbines to monitor*</u>

If available, data on variability among turbines from existing projects in similar conditions within the same region are recommended as a basis for determining needed sample size (see Morrison et al., 2008). If data are not available, the Service recommends that a sufficient number of turbines be selected via a systematic sample with a random start point. Sampling plans can be varied (e.g., rotating panels [McDonald 2003, Fuller 1999, Breidt and Fuller 1999, and Urquhart et al. 1998]) to increase efficiency as long as a probability sampling approach is used. If the project contains fewer than 10 turbines, the Service recommends that all turbines in the area of interest be searched unless otherwise agreed to by the permitting or wildlife resource agencies. When selecting turbines, the Service recommends that a systematic sample with a random start be used when selecting search plots to ensure interspersion among turbines. Stratification among different habitat types also is recommended to account for differences in fatality rates among different habitats (e.g., grass versus cropland or forest); a sufficient number of turbines should be sampled in each strata.

<u>*Delineation of carcass search plots, transects, and habitat mapping*</u>

Evidence suggests that greater than 80 percent of bat fatalities fall within half the maximum distance of turbine height to ground (Erickson 2003 a, b), and a minimum plot width of 120 meters from the turbine should be established at sample turbines. Plots will need to be larger for birds, with a width twice the turbine height to ground. Decisions regarding search plot size should be made in discussions with the Service, state wildlife agency, permitting agency and Tribes. It may be useful to consult other scientifically credible information sources.

The Service recommends that each search plot should be divided into oblong subplots or belt transects and that each subplot be searched. The objective is to find as many carcasses as possible so the width of the belt will vary depending on the ground cover and its influence on carcass visibility. In most situations, a search width of 6 meters should be adequate, but this may vary from 3-10 meters depending on ground cover.

Searchable area within the theoretical maximum plot size varies, and heavily vegetated areas (e.g., eastern mountains) often do not allow surveys to consistently extend to the maximum plot width. In other cases it may be preferable to search a portion of the maximum plot instead of the entire plot. For example, in some landscapes it may be impractical to search the entire plot because of the time required to do an effective search, even if it is accessible (e.g., croplands), and data from a probability sample of subplots within the maximum plot size can provide a reasonable estimate of fatalities. It is important to accurately delineate and map the area searched for each turbine to adjust fatality estimates based on the actual area searched. It may be advisable to establish habitat visibility classes in each plot to account for differential detectability, and to develop visibility classes for different landscapes (e.g., rocks, vegetation) within each search plot. For example, the Pennsylvania Game Commission (2007) identified four classes based on the percentage of bare ground.

The use of visibility classes requires that detection and removal biases be estimated for each class. Fatality estimates should be made for each class and summed for the total area sampled. Global positioning systems (GPS) are useful for accurately mapping the actual total area searched and area searched in each habitat visibility class, which can be used to adjust fatality estimates. The width of the belt or subplot searched may vary depending on the habitat and species of concern; the key is to determine actual searched area and area searched in each visibility class regardless of transect width. An adjustment may also be needed to take into account the density of fatalities as a function of the width of the search plot.

<u>General search protocol guidance</u>

Personnel trained in proper search techniques should look for bird and bat carcasses along transects or subplots within each plot and record and collect all carcasses located in the searchable areas. A developer should obtain a Special Purpose Salvage for Utilities-Wind permit to collect and possess bird carcasses. A complete search of the area should be accomplished and subplot size (e.g., transect width) should be adjusted to compensate for detectability differences in the search area. Subplots should be smaller when vegetation makes it difficult to detect carcasses; subplots can be wider in open terrain. Subplot width also can vary depending on the size of the species being looked for. For example, small species such as bats may require smaller subplots than larger species such as raptors.

Data to be recorded include date, start time, end time, observer, which turbine area was searched (including GPS coordinates) and weather data for each search. When a dead bat or bird is found, the searcher should place a flag near the carcass and continue the search. After searching the entire plot, the searcher returns to each carcass and records information on a fatality data sheet, including date, species, sex and age (when possible), observer name, turbine number, distance from turbine, azimuth from turbine (including GPS coordinates), habitat surrounding carcass, condition of carcass (entire, partial, scavenged), and estimated time of death (e.g., ≤1 day, 2 days). The recorded data will ultimately be housed in the FWS Office of Law Enforcement Bird Mortality Reporting System. A digital photograph of the carcass should be taken. Rubber gloves should be used to handle all carcasses to eliminate possible transmission of rabies or other diseases and to reduce possible human scent bias for carcasses later used in scavenger removal trials. Carcasses should be placed in a plastic bag and labeled. Fresh carcasses (those determined to have been killed the night immediately before a search) should be redistributed at random points on the same day for scavenging trials.

Field bias and error assessment

It has long been recognized that during searches conducted at wind turbines, actual fatalities are incompletely observed and that therefore carcass counts must be adjusted by some factor that accounts for imperfect detectability (Huso 2011). Important sources of bias and error include: 1) fatalities that occur on a highly periodic basis; 2) carcass removal by scavengers; 3) differences in searcher efficiency; 4) failure to account for the influence of site (e.g. vegetation) conditions in relation to carcass removal and searcher efficiency; and 5) fatalities or injured birds and bats that may land or move outside search plots.

Some fatalities may occur on a highly periodic basis creating a potential sampling error (number 1 above). The Service recommends that sampling be scheduled so that some turbines are searched most days and episodic events are more likely detected, regardless of the search interval. To address bias sources 2-4 above, it is strongly recommended that all fatality studies conduct carcass removal and searcher efficiency trials using accepted methods (Anderson 1999, Kunz et al. 2007, Arnett et al. 2007, NRC 2007, Strickland et al. 2011). Bias trials should be conducted throughout the entire study period and searchers should be unaware of which turbines are to be used or the number of carcasses placed beneath those turbines during trials. Carcasses or injured individuals may land or move outside the search plots (number 5 above). With respect to Tier 4a fatality estimates, this potential sampling error is considered to be small and can be assumed insignificant (Strickland et al. 2011).

Prior to a study's inception, a list of random turbine numbers and random azimuths and distances (in meters) from turbines should be generated for placement of each bat or bird used in bias trials. Data recorded for each trial carcass prior to placement should include date of placement, species, turbine number, distance and direction from turbine, and visibility class surrounding the carcass. Trial carcasses should be distributed as equally as possible among the different visibility classes throughout the study period and study area. Studies should attempt to avoid "over-seeding" any one turbine with carcasses by placing no more than one or two carcasses at any one time at a given turbine. Before placement, each carcass must be uniquely marked in a manner that does not cause additional attraction, and its location should be recorded. There is no agreed upon sample size for bias trials, though some state guidelines recommend from 50 - 200 carcasses (e.g., PGC 2007).

Estimators of fatality

If there were a direct relationship between the number of carcasses observed and the number killed, there would be no need to develop a complex estimator that adjusts observed counts for detectability, and observed counts could be used as a simple index of fatality (Huso 2011). But the relationship is not direct and raw carcass counts recorded using different search intervals and under different carcass removal rates and searcher efficiency rates are not directly comparable. It is strongly recommended that only the most contemporary equations for estimating fatality be used, as some original versions are now known to be extremely biased under many commonly encountered field conditions (Erickson et al. 2000b, Erickson et al. 2004, Johnson et al. 2003, Kerns and Kerlinger 2004, Fiedler et al. 2007, Kronner et al. 2007, Smallwood 2007, Huso 2011, Strickland et al. 2011).

Tier 4a Methods and Metrics

In addition to the monitoring protocol, the metrics used to estimate fatality rates must be selected with the Tier 4a questions and objectives in mind. Metrics considerations for each of the Tier 4a questions are discussed briefly below. Not all questions will be relevant for each project, and which questions apply would depend on Tier 3 outcomes.

1. What are the bird and bat fatality rates for the project?

The primary objective of fatality searches is to determine the overall estimated fatality rates for birds and bats for the project. These rates serve as the fundamental basis for all comparisons of fatalities, and if studies are designed appropriately they allow researchers to relate fatalities to site characteristics and environmental variables, and to evaluate mitigation measures. Several metrics are available for expressing fatality rates. Early studies reported fatality rates per turbine. However, this metric is somewhat misleading as turbine sizes and their risks to birds vary significantly (NRC 2007). Fatalities are frequently reported per nameplate capacity (i.e. MW), a metric that is easily calculated and better for comparing fatality rates among different sized turbines. Even with turbines of the same name plate capacity, the size of the rotor swept area may vary among manufacturers, and turbines at various sites may operate for different lengths of time and during different times of the day and seasons. With these considerations in mind, the Service recommends that fatality rates be expressed on a per turbine and per nameplate MW basis until a better metric becomes available.

2. What are the fatality rates of species of concern?

This analysis simply involves calculating fatalities per turbine of all species of concern at a site when sample sizes are sufficient to do so. These fatalities should be expressed on a per nameplate MW basis if comparing species fatality rates among projects.

3. How do the estimated fatality rates compare to the predicted fatality rates?

There are several ways that predictions can be assigned and later evaluated with actual fatality data. During the planning stages in Tier 2, predicted fatalities may be based on existing data at similar facilities in similar landscapes used by similar species. In this case, the assumption is that use is similar, and therefore that fatalities may be similar at the proposed facility. Alternatively, metrics derived from pre-construction assessments for an individual species or group of species – usually an index of activity or abundance at a proposed project – could be used in conjunction with use and fatality estimates from existing projects to develop a model for predicting fatalities at the proposed project site. Finally, physical models can be used to predict the probability of a bird of a particular size striking a turbine, and this probability, in conjunction with estimates of use and avoidance behavior, can be used to predict fatalities.

The most current equations for estimating fatality should be used to evaluate fatality predictions. Several statistical methods can be found in the revised Strickland et al. 2011 and used to evaluate fatality predictions. Metrics derived from Tier 3 pre-construction assessments may be correlated with fatality rates, and (using the project as the experimental unit), in Tier 5 studies it should be possible to determine if different preconstruction metrics can in fact accurately predict fatalities and, thus, risk.

4. Do bird and bat fatalities vary within the project site in relation to site characteristics?

Comparing fatality rates among facilities with similar characteristics is useful to determine patterns and broader landscape relationships, as is discussed in some detail above for predicting fatalities at a proposed project site. Fatality rates should be expressed on a per nameplate MW or some other standardized metric basis for comparison with other projects, and may be correlated with site characteristics – such as proximity to wetlands, riparian corridors, mountain-foothill interface, or other broader landscape features – using regression analysis. Comparing fatality rates from one project to fatality rates of other projects provides insight into whether a project has relatively high, moderate or low fatalities.

5. How do the fatality rates compare to the fatality rates from existing facilities in similar landscapes with similar species composition and use?

Turbine-specific fatality rates may be related to site characteristics such as proximity to water, forest edge, staging and roosting sites, known stop-over sites, or other key resources, and this relationship may be estimated using regression analysis. This information is particularly useful for evaluating micro-siting options when planning a future facility or, on a broader scale, in determining the location of the entire project.

6. What is the composition of fatalities in relation to migrating and resident birds and bats at the site?

The simplest way to address this question is to separate fatalities per turbine of known resident species (e.g., big brown bat, prairie horned lark) and those known to migrate long distances (e.g. hoary bat, red-eyed vireo). These data are useful in determining patterns of species composition of fatalities and possible mitigation measures directed at residents, migrants, or perhaps both, and can be used in assessing potential population effects.

7. Do fatality data suggest the need for measures to reduce impacts?

The Service recommends that the wind project operator[7] and the relevant agencies discuss the results from Tier 4 studies to determine whether these impacts are significant. If fatalities are considered significant, the wind project operator and the relevant agencies should develop a plan to mitigate the impacts.

2. Tier 4b – Assessing direct and indirect impacts of habitat loss, degradation, and fragmentation

Comment [UF&WS5]: This section on habitat impacts is new.

The purpose of Tier 4b studies is to **evaluate Tier 3 predictions of direct and indirect impacts to habitat and the potential for significant adverse impacts on species of concern as a result of these impacts**. Tier 4b studies should be conducted if Tier 3 studies indicate the presence of species of habitat fragmentation concern, or if Tier 3 studies indicate significant direct and indirect impacts to species of concern (see discussion below). Tier 4b studies should also inform project operators and the Service as to whether adaptive management and/or additional mitigation are necessary.

[7] In situations where a project operator was not the developer, the Service expects that obligations of the developer for adhering to the Guidelines transfer with the project.

Tier 4b studies should evaluate the following questions:

1. What are the effects of habitat loss, degradation, and fragmentation on species of concern, including species of habitat fragmentation concern?

2. Were any behavioral modifications or indirect impacts noted in regard to species of concern?

3. If significant adverse impacts were not predicted in Tier 3 because of loss, degradation, or fragmentation of habitat, but Tier 4b studies indicate such impacts may be occurring, a) can these impacts be mitigated and b) are Tier 5 studies necessary to evaluate the biological significance of these impacts?

The answers to these questions will be based on information estimating habitat loss, degradation, and fragmentation information collected in Tier 3, currently available demographic and genetic data, and studies initiated in Tier 3. As in the case of Tier 4a, the answers to these questions will determine the need to conduct Tier 5 studies.

Protocol Design Issues

Impacts to a species of concern resulting from the direct and indirect loss of habitat are important and must be considered when a wind project is being considered for development. Some species of concern are likely to occur at every proposed wind energy facility. This occurrence may range from a breeding population, to seasonal occupancy, such as a brief occurrence while migrating through the area. Consequently the level of concern regarding impacts due to direct and indirect loss of habitat will vary depending on the species and the impacts that occur.

If a breeding population of a species of habitat fragmentation concern occurs in the project area and Tier 3 studies indicate that fragmentation of their habitat is possible, these predictions should be evaluated following the guidance indicated in Table 3 using the protocols described in Tier 3. If the analysis of post-construction GIS data on direct and indirect habitat loss suggests that fragmentation is likely, then additional displacement studies and mitigation may be necessary. These studies would typically begin immediately and would be considered Tier 5 studies using design considerations illustrated by examples in Tier 5 below and from guidance in the scientific literature (e.g. Strickland et al. 2011).

Significant direct or indirect loss of habitat for a species of concern may occur without habitat fragmentation if project impacts result in the reduction of a habitat resource that potentially is limiting to the affected population. Impacts of this type include loss of use of breeding habitat or loss of a significant portion of the habitat of a Federally protected species. This would be evaluated by determining the amount of the resource that is lost and determining if this loss would potentially result in significant impacts to the affected population. Evaluation of potential significant impacts would occur in Tier 5 studies that measure the demographic response of the affected population.

The intention of the Guidelines is to focus industry and agency resources on the direct and indirect loss of habitat and limiting resources that potentially reduce the viability of a species of concern. Not all direct and indirect loss of a species' habitat will affect limiting resources for that species, and when habitat losses are minor or non-existent no further study is necessary.

1. What are the effects of habitat loss, degradation, and fragmentation on species of concern, including species of habitat fragmentation concern?

Predictions of impacts to species of concern from habitat loss, degradation, and fragmentation are made using GIS and demographic data collected in Tier 3 and/or published information under development assumptions provided by the developer. These assumptions should be evaluated in light of the actual development using GIS data collected during Tier 3 and updated after construction. Additional post-construction studies on impacts to species of concern due to direct and indirect impacts to habitat should only be conducted if Tier 4 studies indicate the potential for significant adverse impacts.

2. Were any behavioral modifications or indirect impacts noted in regard to affected species?

Evaluation of this question is based on the analysis of observed use of the area by species of concern prior to construction in comparison with observed use during operation. Observations and demographic data collected during Tier 3, and assessment of published information about the potential for displacement and demographic responses to habit impacts could be the basis for this analysis. If this analysis suggests that direct and/or indirect loss of habitat for a species of concern leads to behavioral modifications or displacement that are significant, further studies of these impacts in Tier 5 may be appropriate.

3. If significant adverse impacts were not predicted in Tier 3 because of loss, degradation, or fragmentation of habitat, but Tier 4b studies indicate such impacts may be occurring, a) can these impacts be mitigated and b) are Tier 5 studies necessary to evaluate the biological significance of these impacts?

When Tier 4b studies indicate significant impacts may be occurring, the developer may need to conduct an assessment of these impacts and what opportunities exist for additional mitigation. Evaluation of the effectiveness of mitigation is a Tier 5 study and should follow design considerations discussed in Tier 5 and from guidance in the scientific literature (e.g. Strickland et al. 2011).

Table 3. Decision framework to guide studies for minimizing impacts to habitat and species of habitat fragmentation (HF) concern. Level of effort for studies should be sufficient to answer all questions of interest. Refer to the relevant methods sections for Tier 2 Question 5 and Tier 3 Question 2 in the text for specific guidance on study protocols.

Outcomes of Tier 2	Outcomes of Tier 3	Outcomes of Tier 4b	Suggested Study/Mitigation Requirements
• No species of HF concern potentially present	• No further studies needed	• n/a	• n/a
• Species of HF concern potentially present	• No species of HF concern confirmed to be present	• No further studies needed	• n/a

	• Species of HF concern demonstrated to be present, but no significant impacts predicted	• Tier 4b studies confirm Tier 3 predictions	• No further studies or mitigation needed
		• Tier 4b studies indicate potentially significant impacts	• Tier 5 studies and mitigation may be needed
• Species of HF concern potentially present	• Species of HF concern demonstrated to be present; significant impacts predicted • Mitigation plan developed and implemented	• Tier 4b studies determine mitigation plan is effective; no significant impacts demonstrated	• No further studies or mitigation needed
		• Tier 4b studies determine mitigation plan is NOT effective; impacts potentially significant	• Further mitigation and, where appropriate, Tier 5 studies
• Plant community of concern is present	• Plant community of concern is present and adequate mitigation is possible	• Tier 4b studies determine mitigation plan is effective	• No further mitigation needed • Further mitigation is needed
	• Plant community of concern is present and cannot be adequately mitigated; project should be abandoned.	• Tier 4b studies determine mitigation plan is NOT effective; impacts potentially significant	

Chapter 6

Tier 5 – Other Post-construction Studies

Tier 5 studies will not be necessary for most wind energy projects. Tier 5 studies can be complex and time consuming. The Service anticipates that the tiered approach will steer projects away from sites where Tier 5 studies would be necessary.

When Tier 5 studies are conducted, they should be site-specific and intended to: 1) analyze factors associated with impacts in those cases in which Tier 4 analyses indicate they are potentially significant; 2) identify additional actions as warranted when mitigation measures implemented for a project are not adequate; and 3) assess demographic effects on local populations of species of concern including species of habitat fragmentation concern.

Tier 5 Questions

Tier 5 studies are intended to answer questions that fall in three major categories; answering yes to any of these questions might indicate a Tier 5 study is needed:

1. To the extent that the observed fatalities exceed anticipated fatalities, are those fatalities potentially having a significant adverse impact on local populations? Are observed direct and indirect impacts to habitat having a significant adverse impact on local populations?

For example, in the Tier 3 risk assessment, predictions of collision fatalities and habitat impacts (direct and indirect) are developed. Post-construction studies in Tier 4 evaluate the accuracy of those predictions by estimating impacts. If post-construction studies demonstrate potentially significant adverse impacts, Tier 5 studies may also be warranted and should be designed to understand observed versus predicted impacts.

2. Were habitat mitigation measures implemented in Tier 3(other than fee in lieu) not effective? If habitat restoration is conducted, it may be desirable to monitor the restoration efforts to determine if there is replacement of habitat conditions. Have measures undertaken to reduce collision fatalities been significantly less effective than anticipated?

Tier 4b studies can assess the effectiveness of measures taken to reduce direct and indirect habitat impacts as part of the project and to identify such alternative or additional measures as are necessary. For example, the project layout may be modified to avoid disturbance of grouse during the breeding season. Tier 4b studies would be designed to determine the effectiveness of these measures by evaluating prairie grouse behavior before and after construction. If these studies indicate that adverse direct and indirect impacts to habitat are higher than predicted, additional or alternative mitigation measures may need to be explored. The effectiveness of these additional measures would be evaluated using Tier 5 studies.

3. Are the estimated impacts of the proposed project likely to lead to population declines in the species of concern (other than federally-listed species)?

   Impacts of a project will have population level effects if the project causes a population decline in the species of concern.

   For non-listed species, this assessment will apply only to the local population.

Tier 5 studies may need to be conducted when:

1) Realized fatality levels for individual species of concern reach a level at which they are considered significant adverse impacts by the relevant agencies.

   For example, if Tier 4 fatality studies document that a particular turbine or set of turbines exhibits bird or bat collision fatality higher than predicted, adaptive management (as defined in Chapter 1) may be useful in evaluating alternative measures to avoid or minimize future fatalities at that turbine/turbine string.

2) There is the potential for significant fatality impacts or significant adverse impacts to habitat for species of concern, there is a need to assess the impacts more closely, and there is uncertainty over how these impacts will be mitigated.

3) Fatality and/or significant adverse habitat impacts suggest the potential for a reduction in the viability of an affected population, in which case studies on the potential for population impacts may be warranted.

4) A developer evaluates the effectiveness of a risk reduction measure before deciding to continue the measure permanently or whether to use the measure when implementing future phases of a project.

In the event additional turbines are proposed as an expansion of an existing project, results from Tier 4 and Tier 5 studies and the decision-making framework contained in the tiered approach can be used to determine whether the project should be expanded and whether additional information should be collected. It may also be necessary to evaluate whether additional measures are warranted to reduce significant adverse impacts to species.

Tier 5 Study Design Issues

As discussed in Chapter 4 Tier 3, Tier 5 studies will be highly variable and unique to the circumstances of the individual project, and therefore these Guidelines do not provide specific guidance on all potential approaches, but make some general statements about study design. Specific Tier 5 study designs will depend on the types of questions, the specific project, and practical considerations. The most common practical considerations include the area being studied, the time period of interest, the species of concern, potentially confounding variables, time available to conduct studies, project budget, and the magnitude of the anticipated impacts. When possible it is usually desirable to collect data before construction to address Tier 5 questions. Design considerations for these studies are including in Tier 3.

When pre-construction data are unavailable and/or a suitable reference area is lacking, the reference Control Impact Design (Morrison et al. 2008) is the recommended design. The lack of a suitable reference area also can be addressed using the Impact Gradient Design, when habitat and species use are homogenous in the assessment area prior to development. When applied both pre- and post-construction, the Impact Gradient Design is a suitable replacement for the classic BACI (Morrison et al. 2008).

In the study of habitat impacts, the resource selection function (RSF) study design (see Anderson et al 1999; Morrison et al. 2008; Manly et al. 2002) is a statistically robust design, either with or without pre-construction and reference data. Habitat selection is modeled as a function of characteristics measured on resource units and the use of those units by the animals of interest. The RSF allows the estimation of the probability of use as a function of the distance to various environmental features, including wind energy facilities, and thus provides a direct quantification of the magnitude of the displacement effect. RSF could be improved with pre-construction and reference area data. Nevertheless, it is a relatively powerful approach to documenting displacement or the effect of mitigation measures designed to reduce displacement even without those additional data.

Tier 5 Examples

As described earlier, Tier 5 studies will not be conducted at most projects, and the specific Tier 5 questions and methods for addressing these questions will depend on the individual project and the concerns raised during pre-construction studies and during operational phases. Rather than provide specific guidance on all potential approaches, these Guidelines offer the following case studies as examples of studies that have attempted to answer Tier 5 questions.

1. Habitat impacts - displacement and demographic impact studies

Studies to assess impacts may include quantifying species' habitat loss (e.g., acres of lost grassland habitat for grassland songbirds) and habitat modification. For example, an increase in edge may result in greater nest parasitism and nest predation. Assessing indirect impacts may include two important components: 1) indirect effects on wildlife resulting from displacement, due to disturbance, habitat fragmentation, loss, and alteration and 2) demographic effects that may occur at the local, regional or population-wide levels due to reduced nesting and breeding densities, increased isolation between habitat patches, and effects on behavior (e.g., stress, interruption, and modification). These factors can individually or cumulatively affect wildlife, although some species may be able to habituate to some or perhaps all habitat changes. Indirect impacts may be difficult to quantify but their effects may be significant (e.g., Stewart et al. 2007, Pearce-Higgins et al. 2008, Bright et al. 2008, Drewitt and Langston 2006, Robel et al. 2004, Pruett et al. 2009).

Example: in southwestern Pennsylvania, development of a project is proceeding at a site located within the range of a state-listed terrestrial species. Surveys were performed at habitat locations appropriate for use by the animal, including at control sites. Post-construction studies are planned at all locations to demonstrate any displacement effects resulting from the construction and operation of the project.

The Service recognizes that indirect impact studies may not be appropriate for most individual projects. Consideration should be given to developing collaborative research efforts with industry, government agencies, and NGOs to conduct studies to address indirect impacts.

Indirect impacts are considered potentially significant adverse threats to species such as prairie grouse (prairie chickens, sharp-tailed grouse), and sage grouse, and demographic studies may be necessary to determine the extent of these impacts and the need for mitigation.

Displacement studies may use any of the study designs describe earlier. The most scientifically robust study designs to estimate displacement effects are BACI, RSF, and impact gradient. RSF and impact gradient designs may not require specialized data gathering during Tier 3.

Telemetry studies that measure impacts of the project development on displacement, nesting, nest success, and survival of prairie grouse and sage grouse in different environments (e.g., tall grass, mixed grass, sandsage, sagebrush) will require spatial and temporal replication, undisturbed reference sites, and large sample sizes covering large areas. Examples of study designs and analyses used in the studies of other forms of energy development are presented in Holloran et al. (2005), Pitman et al. (2005), Robel et al. (2004), and Hagen et al. (2011). Anderson et al. (1999) provides a thorough discussion of the design, implementation, and analysis of these kinds of field studies and should be consulted when designing the BACI study.

Studies are being initiated to evaluate effects of wind energy development on greater sage grouse in Wyoming. In addition to measuring demographic patterns, these studies will use the RSF study design (see Sawyer et al. 2006) to estimate the probability of sage grouse use as a function of the distance to environmental features, including an existing and a proposed project.

In certain situations, such as for a proposed project site that is relatively small and in a more or less homogeneous landscape, an impact gradient design may be an appropriate means to assess avoidance of the wind energy facility by resident populations (Strickland et al., 2002). For example, Leddy et al. 1999 used the impact gradient design to evaluate grassland bird density as a function of the distance from wind turbines. Data were collected at various distances from turbines along transects.

This approach provides information on whether there is an effect, and may allow quantification of the gradient of the effect and the distance at which the displacement effect no longer exists – the assumption being that the data collected at distances beyond the influence of turbines are the reference data (Erickson et al., 2007). An impact gradient analysis could also involve measuring the number of breeding grassland birds counted at point count plots as a function of distance from the wind turbines (Johnson et al. 2000).

<u>Sound and Wildlife</u>

Turbine blades at normal operating speeds can generate levels of sound beyond ambient background levels. Construction and maintenance activities can also contribute to sound levels by affecting communication distance, an animal's ability to detect calls or danger, or to forage. Sound associated with developments can also cause behavioral and/or physiological effects, damage to hearing from acoustic over-exposure, and masking of communication signals and other biologically relevant sounds (Dooling and Popper 2007). Some birds are able to shift their vocalizations to reduce the masking effects of noise. However, when shifts don't occur or are insignificant, masking may prove detrimental to the health and survival of wildlife (Barber et al. 2010). Data suggest noise increases of 3 dB to 10 dB correspond to 30 percent to 90 percent reductions in alerting distances for wildlife, respectively (Barber et al. 2010).

The National Park Service has been investigating potential impacts to wildlife due to alterations in sound level and type. However, further research is needed to better understand this potential impact. Research may include: how wind facilities affect background sound levels; whether masking, disturbance, and acoustical fragmentation occur; and how turbine, construction, and maintenance sound levels can vary by topographic area.

2. Levels of fatality beyond those predicted

More intensive post-construction fatality studies may be used to determine relationships between fatalities and weather, wind speed or other covariates, which usually require daily carcass searches. Fatalities determined to have occurred the previous night can be correlated with that night's weather or turbine characteristics to establish important relationships that can then be used to evaluate the most effective times and conditions to implement measures to reduce collision fatality at the project.

3. Measures to address fatalities

The efficacy of operational modifications (e.g. changing turbine cut-in speed) of a project to reduce collision fatalities has only recently been evaluated (Arnett et al. 2009, Baerwald et al 2009). Operational modifications and other measures to address fatalities should be applied only at sites where collision fatalities are predicted or demonstrated to be high.

Tier 5 Studies and Research

The Service makes a distinction between Tier 5 studies focused on project-specific impacts and research (which is discussed earlier in the Guidelines). For example, developers may be encouraged to participate in collaborative studies (see earlier discussion of Research) or asked to conduct a study on an experimental mitigation technique, such as differences in turbine cut-in speed to reduce bat fatalities. Such techniques may show promise in mitigating the impacts of wind energy development to wildlife, but their broad applicability for mitigation purposes has not been demonstrated. Such techniques should not be routinely applied to projects, but application at appropriate sites will contribute to the breadth of knowledge regarding the efficacy of such measures in addressing collision fatalities. In addition, studies involving multiple sites and academic researchers can provide more robust research results, and such studies take more time and resources than are appropriately carried out by one developer at a single site. Examples below demonstrate collaborative research efforts to address displacement, operational modifications, and population level impacts.

1. Displacement Studies

The Service provides two examples below of ongoing studies to assess the effects of displacement related to wind energy facilities.

Kansas State University, as part of the NWCC Grassland Shrub-steppe Species Collaborative, is undertaking a multi-year research project to assess the effects of wind energy facilities on populations of greater prairie-chickens (GPCH) in Kansas. Initially the research was based on a Before/After Control/Impact (BACI) experimental design involving three replicated study sites in the Flint Hills and Smoky Hills of eastern Kansas. Each study site consisted of an impact area where a wind energy facility was proposed to be developed and a nearby reference area with similar rangeland characteristics where no development was planned. The research project is a coordinated field/laboratory effort, i.e., collecting telemetry and observational data from adult and juvenile GPCH in the field, and determining population genetic attributes of GPCH in the laboratory from blood samples of birds and the impact and reference areas. Detailed data on GPCH movements, demography, and population genetics were gathered from all three sites from 2007 to 2010. By late 2008, only one of the proposed wind energy facilities was developed (the Meridian Way Wind Farm in the Smoky Hills of Cloud County), and on-going research efforts are focused on that site. The revised BACI study design now will produce two years of pre-construction data (2007 and 2008), and three years of post-construction data (2009, 2010, and 2011) from a single wind energy facility site (impact area) and its reference area. Several hypotheses were formulated for testing to determine if wind energy facilities impacted GPCH populations, including but not limited to addressing issues relating to: lek attendance, avoidance of turbines and associated features, nest success and chick survival, habitat usage, adult mortality and survival, breeding behavior, and natal dispersal. A myriad of additional significant avenues are being pursued as a result of the rich database that has been developed for the GPCH during this research effort. GPCH reproductive data will be collected through the summer of 2011 whereas collection of data from transmitter-equipped GPCH will extend through the lekking season of 2012 to allow estimates of survival of GPCH over the 2011-2012 winter. At the conclusion of the study, the two years of pre-construction data and three years of post-construction data will be analyzed and submitted to peer-reviewed journals for publication.

Erickson et al. (2004) evaluated the displacement effect of a large wind energy facility in the Pacific Northwest. The study was conducted in a relatively homogeneous grassland landscape. Erickson et al. (2004) conducted surveys of breeding grassland birds along 300 meter transects perpendicular to strings of wind turbines. Surveys were conducted prior to construction and after commercial operation. The basic study design follows the Impact Gradient Design (Morrison et al. 2008) and in this application, conformed to a special case of BACI where areas at the distal end of each transect were considered controls (i.e., beyond the influence of the turbines). In this study, there is no attempt to census birds in the area, and observations per survey are used as an index of abundance. Additionally, the impact-gradient study design resulted in less effort than a BACI design with offsite control areas. Erickson et al. (2004) found that grassland passerines as a group, as well as grasshopper sparrows and western meadowlarks, showed reduced use in the first 50 meter segment nearest the turbine string. About half of the area within that segment, however, had disturbed vegetation and separation of behavior avoidance from physical loss of habitat in this portion of the area was impossible. Horned larks and savannah sparrows (*Passerculus sandwichensis*) appeared unaffected. The impact gradient design is best used when the study area is relatively small and homogeneous.

2. Operational Modifications to Reduce Collision Fatality

Arnett et al. (2009) conducted studies on the effectiveness of changing turbine cut-in speed on reducing bat fatality at wind turbines at the Casselman Wind Project in Somerset County, Pennsylvania. Their objectives were to: 1) determine the difference in bat fatalities at turbines with different cut-in-speeds relative to fully operational turbines, and 2) determine the economic costs of the experiment and estimated costs for the entire area of interest under different curtailment prescriptions and timeframes. Arnett et al. (2009) reported substantial reductions in bat fatalities with relatively modest power losses.

In Kenedy County, Texas, investigators are refining and testing a real-time curtailment protocol. The projects use an avian profiling radar system to detect approaching "flying vertebrates" (birds and bats), primarily during spring and fall bird and bat migrations. The blades automatically idle when risk reaches a certain level and weather conditions are particularly risky. Based on estimates of the number and timing of migrating raptors, feathering (real-time curtailment) experiments are underway in Tehuantepec, Mexico, where raptor migration through a mountain pass is extensive.

Other tools, such as thermal imaging (Horn et al. 2008) or acoustic detectors (Kunz et al. 2007), have been used to quantify post-construction bat activity in relation to weather and turbine characteristics for improving operational mitigation efforts. For example, at the Mountaineer project in 2003, Tier 4 studies (weekly searches at every turbine) demonstrated unanticipated and high levels of bat fatalities (Kerns and Kerlinger 2004). Daily searches were instituted in 2004 and revealed that fatalities were strongly associated with low-average-wind-speed nights, thus providing a basis for testing operational modifications (Arnett 2005, Arnett et al. 2008). The program also included behavioral observations using thermal imaging that demonstrated higher bat activity at lower wind speeds (Horn et al. 2008).

Studies are currently underway to design and test the efficacy of an acoustic deterrent device to reduce bat fatalities at wind facilities (E.B. Arnett, Bat Conservation International, under the auspices of BWEC). Prototypes of the device have been tested in the laboratory and in the field with some success. Spanjer (2006) tested the response of big brown bats (*Eptesicus fuscus*) to a prototype eight speaker deterrent emitting broadband white noise at frequencies from 12.5–112.5 kHz and found that during non-feeding trials, bats landed in the quadrant containing the device significantly less when it was broadcasting broadband noise. Spanjer (2006) also reported that during feeding trials, bats never successfully took a tethered mealworm when the device broadcast sound, but captured mealworms near the device in about 1/3 of trials when it was silent. Szewczak and Arnett (2006, 2007) tested the same acoustic deterrent in the field and found that when placed by the edge of a small pond where nightly bat activity was consistent, activity dropped significantly on nights when the deterrent was activated. Horn et al. (2007) tested the effectiveness of a larger, more powerful version of this deterrent device on reducing nightly bat activity and found mixed results. In 2009, a new prototype device was developed and tested at a project in Pennsylvania. Ten turbines were fitted with deterrent devices, daily fatality searches were conducted, and fatality estimates were compared with those from 15 turbines without deterrents (i.e., controls) to determine if bat fatalities were reduced. This experiment found that estimated bat fatalities per turbine were 20 to 53 percent lower at treatment turbines compared to controls. More experimentation is required. At the present time, there is not an operational deterrent available that has demonstrated effective reductions in bat kills (E. B. Arnett, Bat Conservation International, unpublished data).

3. Assessment of Population-level Impacts

The Altamont Pass Wind Resource Area (APWRA) has been the subject of intensive scrutiny because of avian fatalities, especially for raptors, in an area encompassing more than 5,000 wind turbines (e.g., Orloff and Flannery 1992; Smallwood and Thelander 2004, 2005). To assess population-level effects of long lived raptors, Hunt (2002) completed a four-year telemetry study of golden eagles at the APWRA and concluded that although all territories remain occupied, collision fatalities may reduce population productivity such that filling territories that become vacant may depend on floaters from the local population and/or immigration of eagles from other subpopulations to fill vacant territories. Hunt conducted follow-up surveys in 2005 (Hunt and Hunt 2006) and determined that all 58 territories occupied by eagle pairs in 2000 were occupied in 2005.

Chapter 7

Best Management Practices

Site Construction: Site Development and Construction Best Management Practices

During site planning and development, careful attention to reducing risk of adverse impacts to species of concern from wind energy projects, through careful site selection and facility design, is recommended. The following BMPs can assist a developer in the planning process to reduce potential impacts to species of concern. Use of these BMPs should ensure that the potentially adverse impacts to most species of concern and their habitats present at many project sites would be reduced, although compensatory mitigation may be appropriate at a project level to address significant site-specific concerns and pre-construction study results.

These BMPs will evolve over time as additional experience, learning, monitoring and research becomes available on how to best minimize wildlife and habitat impacts from wind energy projects. Service should work with the industry, stakeholders and states to evaluate, revise and update these BMPs on a periodic basis, and the Service should maintain a readily available publication of recommended, generally accepted best practices.

1. Minimize, to the extent practicable, the area disturbed by pre-construction site monitoring and testing activities and installations.
2. Avoid locating wind energy facilities in areas identified as having a demonstrated and unmitigatable high risk to birds and bats.
3. Use available data from state and federal agencies, and other sources (which could include maps or databases), that show the location of sensitive resources and the results of Tier 2 and/or 3 studies to establish the layout of roads, power lines, fences, and other infrastructure.
4. Minimize, to the maximum extent practicable, roads, power lines, fences, and other infrastructure associated with a wind development project. When fencing is necessary, construction should use wildlife compatible design standards.

5. Use native species when seeding or planting during restoration. Consult with appropriate state and federal agencies regarding native species to use for restoration.

6. To reduce avian collisions, place low and medium voltage connecting power lines associated with the wind energy development underground to the extent possible, unless burial of the lines is prohibitively expensive (e.g., where shallow bedrock exists) or where greater adverse impacts to biological resources would result:

    a. Overhead lines may be acceptable if sited away from high bird crossing locations, to the extent practicable, such as between roosting and feeding areas or between lakes, rivers, prairie grouse and sage grouse leks, and nesting habitats. To the extent practicable, the lines should be marked in accordance with Avian Power Line Interaction Committee (APLIC) collision guidelines.

    b. Overhead lines may be used when the lines parallel tree lines, employ bird flight diverters, or are otherwise screened so that collision risk is reduced.

    c. Above-ground low and medium voltage lines, transformers and conductors should follow the 2006 or most recent APLIC "Suggested Practices for Avian Protection on Power Lines."

7. Avoid guyed communication towers and permanent met towers at wind energy project sites. If guy wires are necessary, bird flight diverters or high visibility marking devices should be used.

8. Where permanent meteorological towers must be maintained on a project site, use the minimum number necessary.

9. Use construction and management practices to minimize activities that may attract prey and predators to the wind energy facility.

10. Employ only red, or dual red and white strobe, strobe-like, or flashing lights, not steady burning lights, to meet Federal Aviation Administration (FAA) requirements for visibility lighting of wind turbines, permanent met towers, and communication towers. Only a portion of the turbines within the wind project should be lighted, and all pilot warning lights should fire synchronously.

11. Keep lighting at both operation and maintenance facilities and substations located within half a mile of the turbines to the minimum required:
    a. Use lights with motion or heat sensors and switches to keep lights off when not required.
    b. Lights should be hooded downward and directed to minimize horizontal and skyward illumination.
    c. Minimize use of high-intensity lighting, steady-burning, or bright lights such as sodium vapor, quartz, halogen, or other bright spotlights.
12. Establish non-disturbance buffer zones to protect sensitive habitats or areas of high risk for species of concern identified in pre-construction studies. Determine the extent of the buffer zone in consultation with the Service and state, local and tribal wildlife biologists, and land management agencies (e.g., U.S. Bureau of Land Management (BLM) and U.S. Forest Service (USFS)), or other credible experts as appropriate.
13. Locate turbines to avoid separating bird and bat species of concern from their daily roosting, feeding, or nesting sites if documented that the turbines' presence poses a risk to species.
14. Avoid impacts to hydrology and stream morphology, especially where federal or state-listed aquatic or riparian species may be involved. Use appropriate erosion control measures in construction and operation to eliminate or minimize runoff into water bodies.
15. When practical use tubular towers or best available technology to reduce ability of birds to perch and to reduce risk of collision.
16. After project construction, close roads not needed for site operations and restore these roadbeds to native vegetation.
17. Minimize the number and length of access roads; use existing roads when feasible.
18. Minimize impacts to wetlands and water resources by following all applicable provisions of the Clean Water Act (33 USC 1251-1387) and the Rivers and Harbors Act (33 USC 301 et seq.); for instance, by developing and implementing a storm water management plan and taking measures to reduce erosion and avoid delivery of road-generated sediment into streams and waters.

19. Reduce vehicle collision risk to wildlife by instructing project personnel to drive at appropriate speeds, be alert for wildlife, and use additional caution in low visibility conditions.

20. Instruct employees, contractors, and site visitors to avoid harassing or disturbing wildlife, particularly during reproductive seasons.

21. Reduce fire hazard from vehicles and human activities (instruct employees to use spark arrestors on power equipment, ensure that no metal parts are dragging from vehicles, use caution with open flame, cigarettes, etc.). Site development and operation plans should specifically address the risk of wildfire and provide appropriate cautions and measures to be taken in the event of a wildfire.

22. Follow federal and state measures for handling toxic substances to minimize danger to water and wildlife resources from spills. Facility operators should maintain Hazardous Materials Spill Kits on site and train personnel in the use of these.

23. Reduce the introduction and spread of invasive species by following applicable local policies for noxious weed control, cleaning vehicles and equipment arriving from areas with known invasive species issues, using locally sourced topsoil, and monitoring for and rapidly removing noxious weeds at least annually.

24. Use pest and weed control measures as specified by county or state requirements, or by applicable federal agency requirements (such as Integrated Pest Management) when federal policies apply.

25. Properly manage garbage and waste disposal on project sites to avoid creating attractive nuisances for wildlife by providing them with supplemental food. In some circumstances removing large animal carcasses (e.g., big game, domestic livestock, or feral animal) should also be considered.

Retrofitting, Repowering, and Decommissioning: Best Management Practices

As with project construction, these Guidelines offer BMPs for the retrofitting, repowering, and decommissioning phases of wind energy projects.

Retrofitting

Retrofitting is defined as replacing portions of existing wind turbines or project facilities so that at least part of the original turbine, tower, electrical infrastructure or foundation is being utilized. Retrofitting BMPs include:

1. Retrofitting of turbines should use installation techniques that minimize new site disturbance, soil erosion, and removal of vegetation of habitat value.
2. Retrofits should employ shielded, separated or insulated electrical conductors that minimize electrocution risk to avian wildlife per APLIC (2006).
3. Retrofit designs should prevent nests or bird perches from being established in or on the wind turbine or tower.
4. FAA visibility lighting of wind turbines should employ only red, or dual red and white strobe, strobe-like, or flashing lights, not steady burning lights.
5. Lighting at both operation and maintenance facilities and substations located within half a mile of the turbines should be kept to the minimum required:
    a. Use lights with motion or heat sensors and switches to keep lights off when not required.
    b. Lights should be hooded downward and directed to minimize horizontal and skyward illumination.
    c. Minimize use of high intensity lighting, steady-burning, or bright lights such as sodium vapor, quartz, halogen, or other bright spotlights.
6. Remove wind turbines when they are no longer cost effective to retrofit.

Repowering

Repowering may include removal and replacement of turbines and associated infrastructure. BMPs include:

1. To the greatest extent practicable, existing roads, disturbed areas and turbine strings should be re-used in repower layouts.

2. Roads and facilities that are no longer needed should be demolished, removed, and their footprint stabilized and re-seeded with native plants appropriate for the soil conditions and adjacent habitat and of local seed sources where feasible, per landowner requirements and commitments.
3. Existing substations and ancillary facilities should be re-used in repowering projects to the extent practicable.
4. Existing overhead lines may be acceptable if located away from high bird crossing locations, such as between roosting and feeding areas, or between lakes, rivers and nesting areas. Overhead lines may be used when they parallel tree lines, employ bird flight diverters, or are otherwise screened so that collision risk is reduced.
5. Above-ground low and medium voltage lines, transformers and conductors should follow the 2006 or most recent APLIC "Suggested Practices for Avian Protection on Power Lines."
6. Guyed structures should be avoided. If use of guy wires is absolutely necessary, they should be treated with bird flight diverters or high visibility marking devices, or are located where known low bird use will occur.
7. FAA visibility lighting of wind turbines should employ only red, or dual red and white strobe, strobe-like, or flashing lights, not steady burning lights.
8. Lighting at both operation and maintenance facilities and substations located within ½ mile of the turbines should be kept to the minimum required.
    a. Use lights with motion or heat sensors and switches to keep lights off when not required.
    b. Lights should be hooded downward and directed to minimize horizontal and skyward illumination.
    c. Minimize use of high intensity lighting, steady-burning, or bright lights such as sodium vapor, quartz, halogen, or other bright spotlights.

Decommissioning

Decommissioning is the cessation of wind energy operations and removal of all associated equipment, roads, and other infrastructure. The land is then used for another activity. During decommissioning, contractors and facility operators should apply BMPs for road grading and native plant re-establishment to ensure that erosion and overland flows are managed to restore pre-construction landscape conditions. The facility operator, in conjunction with the landowner and state and federal wildlife agencies, should restore the natural hydrology and plant community to the greatest extent practical.

1. Decommissioning methods should minimize new site disturbance and removal of native vegetation, to the greatest extent practicable.
2. Foundations should be removed and covered with soil to allow adequate root penetration for native plants, and so that subsurface structures do not substantially disrupt ground water movements.
3. If topsoils are removed during decommissioning, they should be stockpiled and used as topsoil when restoring plant communities. Once decommissioning activity is complete, topsoils should be restored to assist in establishing and maintaining pre-construction native plant communities to the extent possible, consistent with landowner objectives.
4. Soil should be stabilized and re-vegetated with native plants appropriate for the soil conditions and adjacent habitat, and of local seed sources where feasible, consistent with landowner objectives.
5. Surface water flows should be restored to pre-disturbance conditions, including removal of stream crossings, roads, and pads, consistent with storm water management objectives and requirements.
6. Surveys should be conducted by qualified experts to detect invasive plants, and comprehensive approaches to controlling any detected plants should be implemented and maintained as long as necessary.
7. Overhead pole lines that are no longer needed should be removed.

8. After decommissioning, erosion control measures should be installed in all disturbance areas where potential for erosion exists, consistent with storm water management objectives and requirements.
9. Fencing should be removed unless the landowner will be utilizing the fence.
10. Petroleum product leaks and chemical releases should be remediated prior to completion of decommissioning.

Chapter 8

Mitigation

Mitigation is defined in this document as avoiding or minimizing significant adverse impacts, and when appropriate, compensating for unavoidable significant adverse impacts, as determined through the tiered approach described in the recommended Guidelines. Several tools are available to determine appropriate mitigation, including the USFWS Mitigation Policy (USFWS Mitigation Policy, 46 FR 7656 (1981)). The USFWS policy provides a common basis for determining how and when to use different mitigation strategies, and facilitates earlier consideration of wildlife values in wind energy project planning.

The amount of compensation, if necessary, will depend on the effectiveness of any avoidance and minimization measures undertaken. If a proposed wind development is poorly sited with regard to wildlife effects, the most important mitigation opportunity is largely lost and the remaining options can be expensive, with substantially greater environmental effects. The Service will work with developers to report on the success of industry's mitigation efforts.

Ideally, project impact assessment is a cooperative effort involving the developer, the Service, tribes, local authorities, and state resource agencies. The Service does not expect developers to provide compensation for the same habitat loss more than once. But the Service, state resource agencies, tribes, local authorities, state and federal land management agencies may have different species or habitats of concern, according to their responsibilities and statutory authorities. Hence, one entity may seek mitigation for a different group of species or habitat than does another.

Compensation is most often appropriate for habitat loss under limited circumstances or for direct take of wildlife (e.g., Habitat Conservation Plans). In certain limited situations, compensation may be appropriate. Compensatory mitigation may involve contributing to a fund to protect habitat or otherwise support efforts to reduce existing impacts to species affected by a wind project. Developers should consult with the Service and state agency prior to initiating such an approach. When appropriate, developers should consider using adaptive management as discussed in Chapter 1 and throughout this document.

More typically, avoidance and minimization are used to offset direct take. However, E.O. 13186, which addresses responsibilities of federal agencies to protect migratory birds, includes a directive to federal agencies to restore and enhance the habitat of migratory birds as practicable. So for any wind projects with a federal nexus, E.O. 13186 provides a basis and a rationale for mitigating for the loss of migratory bird habitat that result from developing the project.

Regulations concerning eagle take permits in 50 CFR 22.26 and 50 CFR 22.27 may allow for compensation as part of permit issuance. Compensation may be a condition of permit issuance in cases of nest removal, disturbance or take resulting in mortality that will likely occur over several seasons, result in permanent abandonment of one or more breeding territories, have large scale impacts, occur at multiple locations, or otherwise contribute to cumulative negative effects. The draft ECP Guidance has additional information on the use of compensation for programmatic permits.

The ESA also has provisions that allow for compensation through the issuance of an Incidental Take Permit (ITP). Under the ESA, mitigation measures are determined on a case by case basis, and are based on the needs of the species and the types of effects anticipated. If a federal nexus exists, or if a developer chooses to seek an ITP under the ESA, then effects to listed species need to be evaluated through the Section 7 and/or Section 10 processes. If an ITP is requested, it and the associated HCP must provide for minimization and mitigation to the maximum extent practicable, in addition to meeting other necessary criteria for permit issuance. For further information about compensation under federal laws administered by the Service, see the Service's Habitat and Resource Conservation website http://www.fws.gov/habitatconservation.

In cases where adverse effects cannot be avoided or minimized, it may be possible to offset all, or a portion, of these effects through compensation. One approach for compensation is the Service Mitigation Policy, which describes steps for addressing habitat loss in detail and includes information on Resource Categories to assist in considering type and amount of compensation to offset losses of habitat.

Under the Service Mitigation Policy, the highest priority is for mitigation to occur on-site within the project planning area. The secondary priority is for the mitigation to occur off-site. Off-site mitigation should first occur in proximity to the planning area within the same ecological region and secondarily elsewhere within the same ecological region. Generally, the Service prefers on-site mitigation over off-site mitigation because this approach most directly addresses project impacts at the location where they actually occur. However, there may be individual cases where off-site mitigation could result in greater net benefits to affected species and habitats. Developers should work with the Service in comparing benefits among multiple alternatives.

Recommended measures may include on- or off-site habitat improvement, and may consist of in-kind or out-of-kind compensation. Compensatory measures may be project-specific, species-specific, or may be part of a mitigation banking approach. The Service recommends that the method for implementing compensation (e.g., fee-title acquisition, in-lieu fee, conservation easement, etc.) be determined as early in the process as possible.

In some cases, a project's effects cannot be forecast with precision. The developer and the agencies may be unable to make some mitigation decisions until post-construction data have been collected. If adverse effects have not been adequately addressed, additional mitigation for those adverse effects from operations may need to be implemented.

Mitigation measures implemented post-construction, whether in addition to those implemented pre-construction or whether they are new, are appropriate elements of the tiered approach. The general terms and funding commitments for future mitigation and the triggers or thresholds for implementing such compensation should be developed at the earliest possible stage in project development. Any mitigation implemented after a project is operational should be well defined, bounded, technically feasible, and commensurate with the project effects.

Some industries, such as the electric utilities, have developed operational and deterrent measures that when properly used can avoid or minimize "take" of migratory birds. Many of these measures to avoid collision and electrocution have been scientifically tested with publication in peer-reviewed, scientific journals. The Service encourages the wind industry to use these measures in siting, placing, and operating all power lines, including their distribution and grid-connecting transmission lines.

Chapter 9
Advancing Use, Cooperation and Effective Implementation

This chapter discusses a variety of policies and procedures that may affect the way wind project developers and the Service work with each other as well as with state and tribal governments and non-governmental organizations. The Service recommends that wind project developers work closely with field office staff for further elaboration of these policies and procedures.

Conflict Resolution

The Service and developers should attempt to resolve any issues arising from use of the Guidelines at the Field Office level. Deliberations should be in the context of the intent of the Guidelines and be based on the site-specific conditions and the best available data. However, if there is an issue that cannot be resolved within a timely manner at the field level, the developer and Service staff will coordinate to bring the matter up the chain of command in a stepwise manner.

Avian and Bat Protection Plan (ABPP)

A project-specific Avian and Bat Protection Plan (ABPP) is an example of a document that describes the steps a developer could take to apply these Guidelines to avoid and minimize effects to birds and bats, and any compensatory mitigation and address the post-construction monitoring efforts the developer intends to undertake. A stand-alone ABPP-type document may facilitate Service review. Typically, a project-specific ABPP will explain the analyses, studies, and reasoning that support progressing from one tier to the next in the tiered approach. A developer may prepare an ABPP in stages, over time, as analysis and studies are undertaken for each tier. It will also address the post-construction monitoring efforts for mortality and habitat effects, and may use many of the components suggested in the Suggested Practices for Avian

Protection on Power Lines (APLIC 2006). Any Service review of, or discussion with a developer, concerning its ABPP is advisory only, does not result in approval or disapproval of the ABPP by the Service, and does not constitute a federal agency action subject to the National Environmental Policy Act or other federal law applicable to such an action.

Project Interconnection Lines

The Guidelines are designed to address all elements of a wind energy facility, including the turbine string or array, access roads, ancillary buildings, and the above- and below-ground electrical lines which connect a project to the transmission system. The Service recommends that the project evaluation include consideration of the wildlife- and habitat-related impacts of these electrical lines, and that the developer include measures to reduce impacts of these lines, such as those outlined in the Suggested Practices for Avian Protection on Power Lines (APLIC 2006). The Guidelines are not designed to address transmission beyond the point of interconnection to the transmission system. The national grid and proposed smart grid system are beyond the scope of these Guidelines.

Confidentiality of Site Evaluation Process as Appropriate

Some aspects of the initial pre-construction risk assessment, including preliminary screening and site characterization, occur early in the development process, when land or other competitive issues limit developers' willingness to share information on projects with the public and competitors. Any consultation or coordination with agencies at this stage may include confidentiality agreements.

Collaborative Research

Much uncertainty remains about predicting risk and estimating impacts of wind energy development on wildlife. Thus there is a need for additional research to improve scientifically based decision-making when siting wind energy facilities, evaluating impacts on wildlife and habitats, and testing the efficacy of mitigation measures. More extensive studies are needed to further elucidate patterns and test hypotheses regarding possible solutions to wildlife and wind energy impacts.

It is in the interests of wind developers and wildlife agencies to improve these assessments to better avoid or minimize the impacts of wind energy development on wildlife and their habitats. Research can provide data on operational factors (e.g. wind speed, weather conditions) that are likely to result in fatalities. It could also include studies of cumulative impacts of multiple wind energy projects, or comparisons of different methods for assessing avian and bat activity relevant to predicting risk. Monitoring and research should be designed and conducted to ensure unbiased data collection that meets technical standards such as those used in peer review. Research projects may occur at the same time as project-specific Tier 4 and Tier 5 studies.

Research would usually result from collaborative efforts involving appropriate stakeholders, and is not the sole or primary responsibility of any developer. Research partnerships (e.g., Bats and Wind Energy Cooperative (BWEC)[8], Grassland and Shrub Steppe Species Collaborative (GS3C)[9]) involving diverse players will be helpful for generating common goals and objectives and adequate funding to conduct studies (Arnett and Haufler 2003). The National Wind Coordinating Collaborative (NWCC)[10], the American Wind Wildlife Institute (AWWI)[11], and the California Energy Commission (CEC)'s Public Interest Energy Research Program[12] all support research in this area.

Study sites and access will be necessary to design and implement research, and developers are encouraged to participate in these research efforts when possible. Subject to appropriations, the Service also should fund priority research and promote collaboration and information sharing among research efforts to advance science on wind energy-wildlife interactions, and to improve these Guidelines.

[8] www.batsandwind.org
[9] www.nationalwind.org
[10] www.nationalwind.org
[11] http://www.awwi.org
[12] http://www.energy.ca.gov/research

Service - State Coordination and Cooperation

The Service encourages states to increase compatibility between state guidelines and these voluntary guidelines, protocols, data collection methods, and recommendations relating to wildlife and wind energy. States that desire to adopt, or those that have formally adopted, wind energy siting, permitting, or environmental review regulations or guidelines are encouraged to cooperate with the Service to develop consistent state level guidelines. The Service may be available to confer, coordinate and share its expertise with interested states when a state lacks its own guidance or program to address wind energy-wildlife interactions. The Service will also use states' technical resources as much as possible and as appropriate.

The Service will explore establishing a voluntary state/federal program to advance cooperation and compatibility between the Service and interested state and local governments for coordinated review of projects under both federal and state wildlife laws. The Service, and interested states, will consider using the following tools to reach agreements to foster consistency in review of projects:

- Cooperation agreements with interested state governments.

- Joint agency reviews to reduce duplication and increase coordination in project review.

- A communication mechanism:
  - To share information about prospective projects
  - To coordinate project review
  - To ensure that state and federal regulatory processes, and/or mitigation requirements are being adequately addressed
  - To ensure that species of concern and their habitats are fully addressed

- Establishing consistent and predictable joint protocols, data collection methodologies, and study requirements to satisfy project review and permitting.

- Designating a Service management contact within each Regional Office to assist Field Offices working with states and local agencies to resolve significant wildlife-related issues that cannot be resolved at the field level.

- Cooperative state/federal/industry research agreements relating to wind energy -wildlife interactions.

The Service will explore opportunities to:

- Provide training to states.
- Foster development of a national geographic data base that identifies development-sensitive ecosystems and habitats.
- Support a national database for reporting of mortality data on a consistent basis.
- Establish national BMPs for wind energy development projects.
- Develop recommended guidance on study protocols, study techniques, and measures and metrics for use by all jurisdictions.
- Assist in identifying and obtaining funding for national research priorities.

Service - Tribal Consultation and Coordination

Federally-recognized Indian Tribes enjoy a unique government-to-government relationship with the United States. The United States Fish and Wildlife Service (Service) recognizes Indian tribal governments as the authoritative voice regarding the management of tribal lands and resources within the framework of applicable laws. It is important to recall that many tribal traditional lands and tribal rights extend beyond reservation lands.

The Service consults with Indian tribal governments under the authorities of Executive Order 13175 "Consultation and Coordination with Indian Tribal Governments" and supporting DOI and Service policies. To this end, when it is determined that federal actions and activities may affect a Tribe's resources (including cultural resources), lands, rights, or ability to provide services to its members, the Service must, to the extent practicable, seek to engage the affected Tribe(s) in consultation and coordination.

Tribal Wind Energy Development on Reservation Lands:

Indian tribal governments have the authority to develop wind energy projects, permit their development, and establish relevant regulatory guidance within the framework of applicable laws.

The Service will provide technical assistance upon the request of Tribes that aim to establish regulatory guidance for wind energy development for lands under the Tribe's jurisdiction. Tribal governments are encouraged to strive for compatibility between their guidelines and these Guidelines.

Tribal Wind Energy Development on Lands that are not held in Trust:

Indian tribal governments may wish to develop wind energy projects on lands that are not held in trust status. In such cases, the Tribes should coordinate with agencies other than the Service. At the request of a Tribe, the Service may facilitate discussions with other regulatory organizations. The Service may also lend its expertise in these collaborative efforts to help determine the extent to which tribal resource management plans and priorities can be incorporated into established regulatory protocols.

Non-Tribal Wind Energy Development – Consultation with Indian Tribal Governments

When a non-Tribal wind energy project is proposed that may affect a Tribe's resources (including cultural resources), lands, rights, or ability to govern or provide services to its members, the Service should seek to engage the affected Tribe(s) in consultation and coordination as early as possible in the process. In siting a proposed project that has a Federal nexus, it is incumbent upon the regulatory agency to notify potentially affected Tribes of the proposed activity. If the Service or other federal agency determines that a project may affect a

Tribe(s), they should notify the Tribe(s) of the action at the earliest opportunity. At the request of a Tribe, the Service may facilitate and lend its expertise in collaborating with other organizations to help determine the extent to which tribal resource management plans and priorities can be incorporated into established regulatory protocols or project implementation. This process ideally should be agreed to by all involved parties.

In the consultative process, Tribes should be engaged as soon as possible when a decision may affect a Tribe(s). Decisions made that affect Indian Tribal governments without adequate Federal effort to engage Tribe(s) in consultation have been overturned by the courts. *See, e.g.*, *Quechan Tribe v. U.S. Dep't of the Interior*, No. 10cv2241 LAB (CAB), 2010 WL 5113197 (S.D. Cal. Dec. 15, 2010). When a tribal government is consulted, it is neither required, nor expected that all of the Tribe's issues can be resolved in its favor. However, the Service must listen and may not arbitrarily dismiss concerns of the tribal government. Rather, the Service must seriously consider and respond to all tribal concerns. Regional Native American Liaisons are able to provide in-house guidance as to government-to-government consultation processes. (See *Section D. USFWS-State Coordination and Cooperation*, above).

Non-Governmental Organization Actions

If a specific project involves actions at the local, state, or federal level that provide opportunities for public participation, non-governmental organizations (NGOs) can provide meaningful contributions to the discussion of biological issues associated with that project, through the normal processes such as scoping, testimony at public meetings, and comment processes. In the absence of formal public process, there are many NGOs that have substantial scientific capabilities and may have resources that could contribute productively to the siting of wind energy projects. Several NGOs have made significant contributions to the understanding of the importance of particular geographic areas to wildlife in the United States. This work has benefited and continues to benefit from extensive research efforts and from associations with highly qualified biologists. NGO expertise can – as can scientific expertise in the academic or private consulting sectors – serve highly constructive purposes. These can include:

- Providing information to help identify environmentally sensitive areas, during the screening phases of site selection (Tiers 1 and 2, as described in this document)
- Providing feedback to developers and agencies with respect to specific sites and site and impact assessment efforts
- Helping developers and agencies design and implement mitigation or offset strategies
- Participating in the defining, assessing, funding, and implementation of research efforts in support of improved predictors of risk, impact assessments and effective responses
- Articulating challenges, concerns, and successes to diverse audiences

Non-Governmental Organization Conservation Lands

Implementation of these Guidelines by Service and other state agencies will recognize that lands owned and managed by non-government conservation organizations represent a significant investment that generally supports the mission of state and federal wildlife agencies. Many of these lands represent an investment of federal conservation funds, through partnerships between agencies and NGOs. These considerations merit extra care in the avoidance of wind energy development impacts to these lands. In order to exercise this care, the Service and allied agencies can coordinate and consult with NGOs that own lands or easements which might reasonably be impacted by a project under review.

Appendix A

Glossary

Comment [UF&WS6]: Definitions for red terms will be added. New terms are highlighted.

Accuracy – The agreement between a measurement and the true or correct value.

Adaptive management – An iterative decision process that promotes flexible decision-making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. The term as used in the recommendations and the Guidelines specifically refers to "passive" adaptive management, in which alternative management activities are assessed, and the best option is designed, implemented, and evaluated.

Anthropogenic – Resulting from the influence of human beings on nature.

Area of interest – For most projects, the area where wind turbines and meteorological (met) towers are proposed or expected to be sited, and the area of potential impact.

Avian – Pertaining to or characteristic of birds.

Avoid – To not take an action or parts of an action to avert the potential effects of the action or parts thereof. First of three components of "mitigation," as defined in Service Mitigation Policy. (*See* **mitigation**.)

Barotrauma - Involves tissue damage to air-containing structures caused by rapid or excessive pressure change; pulmonary barotrauma is lung damage due to expansion of air in the lungs that is not accommodated by exhalation (Baerwald et al 2009).

Before-after/control-impact (BACI) – A study design that involves comparisons of observational data, such as bird counts, before and after an environmental disturbance in a disturbed and undisturbed site. This study design allows a researcher to assess the effects of constructing and operating a wind turbine by comparing data from the "control" sites (before and undisturbed) with the "treatment" sites (after and disturbed).

Best management practices (BMPs) – Methods that have been determined by the stakeholders to be the most effective, practicable means of avoiding or minimizing significant adverse impacts to individual species, their habitats or an ecosystem, based on the best available information.

Buffer zone – A zone surrounding a resource designed to protect the resource from adverse impact, and/or a zone surrounding an existing or proposed wind energy project for the purposes of data collection and/or impact estimation.

Community-scale – Wind energy projects greater than 1 MW, but generally less than 20 MW, in name-plate capacity, that produce electricity for off-site use, often partially or totally owned by members of a local community or that have other demonstrated local benefits in terms of retail power costs, economic development, or grid issues.

Comparable site – A site similar to the project site with respect to topography, vegetation, and the species under consideration.

Compensatory mitigation – Replacement of project-induced losses to fish and wildlife resources. Substitution or offsetting of fish and wildlife resource losses with resources considered to be of equivalent biological value.

- **In-kind –** Providing or managing substitute resources to replace the value of the resources lost, where such substitute resources are physically and biologically the same or closely approximate to those lost.
- **Out-of-kind –** Providing or managing substitute resources to replace the value of the resources lost, where such substitute resources are physically or biologically different from those lost. This may include conservation or mitigation banking, research or other options.

Cost effective – Economical in terms of tangible benefits produced by money spent.

Covariate – Uncontrolled random variables that influence a response to a treatment or impact, but do not interact with any of the treatments or impacts being tested.

Critical habitat – For listed species, consists of the specific areas designated by rule making pursuant to Section 4 of the Endangered Species Act and displayed in 50 CFR § 17.11 and 17.12.

Cumulative impacts – *See* **impact**.

Curtailment – The act of limiting the supply of electricity to the grid during conditions when it would normally be supplied. This is usually accomplished by cutting-out the generator from the grid and/or feathering the turbine blades.

Cut-in Speed – The wind speed at which the generator is connected to the grid and producing electricity. It is important to note that turbine blades may rotate at full RPM in wind speeds below cut-in speed.

Displacement – The loss of habitat as result of an animal's behavioral avoidance of otherwise suitable habitat. Displacement may be short-term, during the construction phase of a project, temporary as a result of habituation, or long-term, for the life of the project.

Distributed wind – Small and mid-sized turbines between 1 kilowatt and 1 megawatt that are installed and produce electricity at the point of use to off-set all or a portion of on-site energy consumption.

Ecosystem – A system formed by the interaction of a community of organisms with their physical and chemical environment. All of the biotic elements (i.e., species, populations, and communities) and abiotic elements (i.e., land, air, water, energy) interacting in a given geographic area so that a flow of energy leads to a clearly defined trophic structure, biotic diversity, and material cycles. Service Mitigation Policy adopted definition from E. P. Odum 1971 *Fundamentals of Ecology.*

Endangered species – *See* **listed species**.

Extirpation – The species ceases to exist in a given location; the species still exists elsewhere.

Fatality – An individual instance of death.

Fatality rate – The ratio of the number of individual deaths to some parameter of interest such as megawatts of energy produced, the number of turbines in a wind project, the number of individuals exposed, etc., within a specified unit of time.

Feathering – Adjusting the angle of the rotor blade parallel to the wind, or turning the whole unit out of the wind, to slow or stop blade rotation.

Federal action agency – A department, bureau, agency or instrumentality of the United States which plans, constructs, operates or maintains a project, or which reviews, plans for or approves a permit, lease or license for projects, or manages federal lands.

Federally listed species – *See* **listed species**.

Footprint – The geographic area occupied by the actual infrastructure of a project such as wind turbines, access roads, substation, overhead and underground electrical lines, and buildings, and land cleared to construct the project.

G1 (Global Conservation Status Ranking) Critically Imperiled – At very high risk of extinction due to extreme rarity (often five or fewer populations), very steep declines, or other factors.

G2 (Global Conservation Status Ranking) Imperiled – At high risk of extinction or elimination due to very restricted range, very few populations, steep declines, or other factors.

G3 (Global Conservation Status Ranking) Vulnerable – At moderate risk of extinction or elimination due to a restricted range, relatively few populations, recent and widespread declines, or other factors.

Guy wire – Wires used to secure wind turbines or meteorological towers that are not self-supporting.

Habitat – The area which provides direct support for a given species, including adequate food, water, space, and cover necessary for survival.

Habitat fragmentation – The separation of a block of habitat for a species into segments, such that the genetic or demographic viability of the populations surviving in the remaining habitat segments is reduced.

Impact – An effect or effects on natural resources and on the components, structures, and functioning of affected ecosystems.

- **Cumulative –** Changes in the environment caused by the aggregate of past, present and reasonably foreseeable future actions on a given resource or ecosystem.
- **Direct –** Effects on individual species and their habitats caused by the action, and occur at the same time and place.
- **Indirect impact –** Effects caused by the action that are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect impacts include displacement and changes in the demographics of bird and bat populations.

Infill – Add an additional phase to the existing project, or build a new project adjacent to existing projects.

In-kind compensatory mitigation – See **compensatory mitigation.**

Intact habitat – An expanse of habitat for a species or landscape scale feature, unbroken with respect to its value for the species or for society.

Intact landscape – Relatively undisturbed areas characterized by maintenance of most original ecological processes and by communities with most of their original native species still present.

Lattice design – A wind turbine support structure design characterized by horizontal or diagonal lattice of bars forming a tower rather than a single tubular support for the nacelle and rotor.

Lead agency – Agency that is responsible for federal or non-federal regulatory or environmental assessment actions.

Lek – A traditional site commonly used year after year by males of certain species of birds (e.g., greater and lesser prairie-chickens, sage and sharp-tailed grouse, and buff-breasted sandpiper), within which the males display communally to attract and compete for female mates, and where breeding occurs.

Listed species – Any species of fish, wildlife or plant that has been determined to be endangered or threatened under section 4 of the Endangered Species Act (50 CFR §402.02), or similarly designated by state law or rule.

Local population – A subdivision of a population of animals or plants of a particular species that is in relative proximity to a project.

Loss – As used in this document, a change in wildlife habitat due to human activities that is considered adverse and: 1) reduces the biological value of that habitat for species of concern; 2) reduces population numbers of species of concern; 3) increases population numbers of invasive or exotic species; or 4) reduces the human use of those species of concern.

Megawatt (MW) – A measurement of electricity-generating capacity equivalent to 1,000 kilowatts (kW), or 1,000,000 watts.

Migration – Regular movements of wildlife between their seasonal ranges necessary for completion of the species lifecycle.

Migration corridor – Migration routes and/or corridors are the relatively predictable pathways that a migratory species travel between seasonal ranges, usually breeding and wintering grounds.

Migration stopovers – Areas where congregations of birds assemble during migration, and supply high densities of food, such as wetlands and associated habitats.

Minimize – To reduce to the smallest practicable amount or degree.

Mitigation – (*Specific to these Guidelines)* Avoiding or minimizing significant adverse impacts, and when appropriate, compensating for unavoidable significant adverse impacts.

Monitoring – 1) A process of project oversight such as checking to see if activities were conducted as agreed or required; 2) making measurements of uncontrolled events at one or more points in space or time with space and time being the only experimental variable or treatment; 3) making measurements and evaluations through time that are done for a specific purpose, such as to check status and/or trends or the progress towards a management objective.

Mortality rate – Population death rate, typically expressed as the ratio of deaths per 100,000 individuals in the population per year (or some other time period).

Operational modification – Deliberate changes to wind energy project operating protocols, such as the wind speed at which turbines "cut in" or begin generating power, undertaken with the object of reducing collision fatalities.

Passerine – Describes birds that are members of the Order *Passeriformes*, typically called "songbirds."

Population – A demographically and genetically self-sustaining group of animals and/or plants of a particular species.

Practicable – Capable of being done or accomplished; feasible.

Prairie grouse – A group of gallinaceous birds, includes the greater prairie-chicken, the lesser prairie-chicken, and the sharp-tailed grouse, occurring in the broader Midwest region and much of Canada and Alaska.

Project area – The area that includes the project site as well as contiguous land that shares relevant characteristics.

Project commencement – The point in time when a developer begins its preliminary evaluation of a broad geographic area to assess the general ecological context of a potential site or sites for wind energy project(s). For example, this may include the time at which an option is acquired to secure real estate interests, an application for federal land use has been filed, or land has been purchased.

Project Site – The land that is included in the project where development occurs or is proposed to occur.

Project transmission lines – Electrical lines built and owned by a project developer.

Raptor – As defined by the American Ornithological Union, a group of predatory birds including hawks, eagles, falcons, osprey, kites, owls, vultures and the California condor.

Relative abundance – The number of organisms of a particular kind in comparison to the total number of organisms within a given area or community.

Risk – The likelihood that adverse effects may occur to individual animals or populations of species of concern, as a result of development and operation of a wind energy project. For detailed discussion of risk and risk assessment as used in this document see Chapter One - General Overview.

Rotor – The part of a wind turbine that interacts with wind to produce energy. Consists of the turbine's blades and the hub to which the blades attach.

Rotor-swept area – The area of the circle or volume of the sphere swept by the turbine blades.

Rotor-swept zone – The altitude within a wind energy project which is bounded by the upper and lower limits of the rotor-swept area and the spatial extent of the project.

S1 (Subnational Conservation Status Ranking) Critically Imperiled – Critically imperiled in the jurisdiction because of extreme rarity or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the jurisdiction.

S2 (Subnational Conservation Status Ranking) Imperiled – Imperiled in the jurisdiction because of rarity due to very restricted range, very few populations, steep declines, or other factors making it very vulnerable to extirpation from jurisdiction**.**

S3 (Subnational Conservation Status Ranking) Vulnerable – Vulnerable in the jurisdiction due to a restricted range, relatively few populations, recent and widespread declines, or other factors making it vulnerable to extirpation.

Sage grouse – A large gallinaceous bird living in the sage steppe areas of the intermountain west, includes the greater sage grouse and Gunnison's sage grouse.

Significant – For purposes of impacts to species of concern and their habitats, as used in these Guidelines, significance will be determined in the context of the degree to which each individual project affects the particular locality and region. The determination will focus on the degree to which the project is likely to affect the long-term status of the population(s) of the affected species of concern. Short-term, long-term, and cumulative effects are relevant.

Species of concern – For a particular wind energy project, any species which 1) is either a) listed as an endangered, threatened or candidate species under the Endangered Species Act, and subject to the Migratory Bird Treaty Act or Bald and Golden Eagle Protection Act; b) is designated by law, regulation, or other formal process for protection and/or management by the relevant agency or other authority; or c) has been shown to be significantly adversely affected by wind energy development, and 2) is determined to be possibly affected by the project.

Species of habitat fragmentation concern—Species of concern for which a relevant federal, state, tribal, and/or local agency has found that the genetic or demographic viability of these species is reduced by separation of their habitats into smaller blocks, thereby reducing connectivity, and that habitat fragmentation from a wind energy project may create significant barriers to genetic or demographic viability of the affected population.

String – A number of wind turbines oriented in close proximity to one another that are usually sited in a line, such as along a ridgeline.

Strobe – Light consisting of pulses that are high in intensity and short in duration.

Threatened species – *See* **listed species**.

Tubular design – A type of wind turbine support structure for the nacelle and rotor that is cylindrical rather than lattice.

Turbine height – The distance from the ground to the highest point reached by the tip of the blades of a wind turbine.

Utility-scale – Wind projects generally larger than 20 MW in nameplate generating capacity that sell electricity directly to utilities or into power markets on a wholesale basis.

Voltage (low and medium) – Low voltages are generally below 600 volts, medium voltages are commonly on distribution electrical lines, typically between 600 volts and 110 kV, and voltages above 110 kV are considered high voltages.

Wildlife – Birds, fishes, mammals, and all other classes of wild animals and all types of aquatic and land vegetation upon which wildlife is dependent.

Wildlife management plan – A document describing actions taken to identify resources that may be impacted by proposed development; measures to mitigate for any significant adverse impacts; any post-construction monitoring; and any other studies that may be carried out by the developer.

Wind turbine – A machine for converting the kinetic energy in wind into mechanical energy, which is then converted to electricity.

Appendix B

Comment [UF&WS7]: FWS will cross-reference the literature cited with citations throughout.

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Appendix C

Sources of Information Pertaining to Methods to Assess Impacts to Birds and Bats

The following is an initial list of references that provide further information on survey and monitoring methods. Additional sources may be available.

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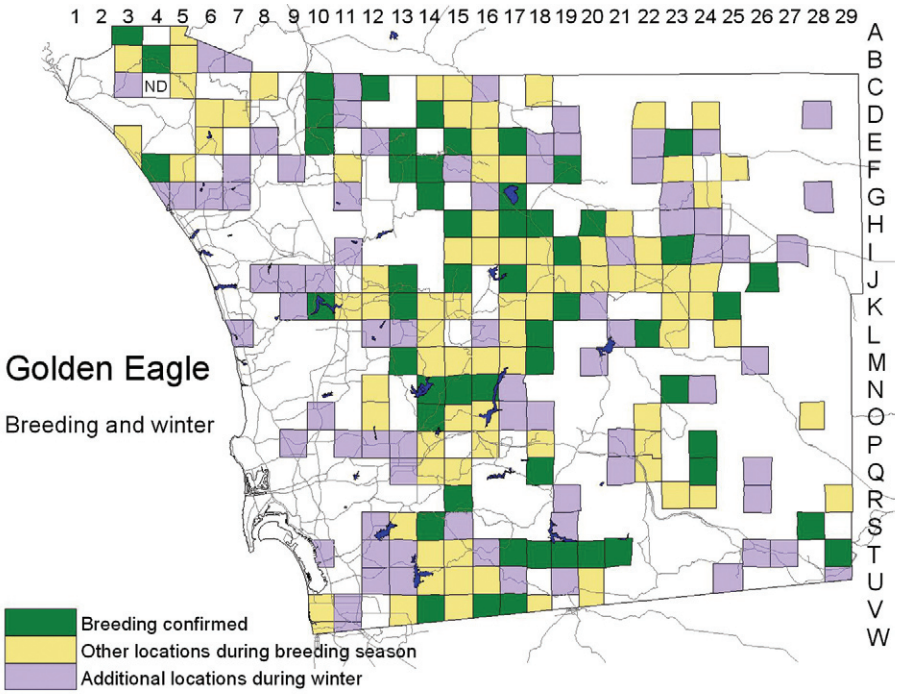
Golden Eagle ***Aquila chrysaetos***


Photo by Anthony Mercieca

As a top predator, the Golden Eagle has the largest territory and the lowest population density of any San Diego County bird. Pairs remain in their territories year round, though the young disperse widely. Most pairs nest on cliff ledges, the rest in trees on steep slopes, hunting in nearby grassland, sage scrub, or broken chaparral. San Diego County's Golden Eagle population has dropped from an estimated 108 pairs at the beginning of the 20th century to about 53 pairs at the century's end, mainly as a result of urban development of foraging habitat. Many of the territories persisting at the beginning



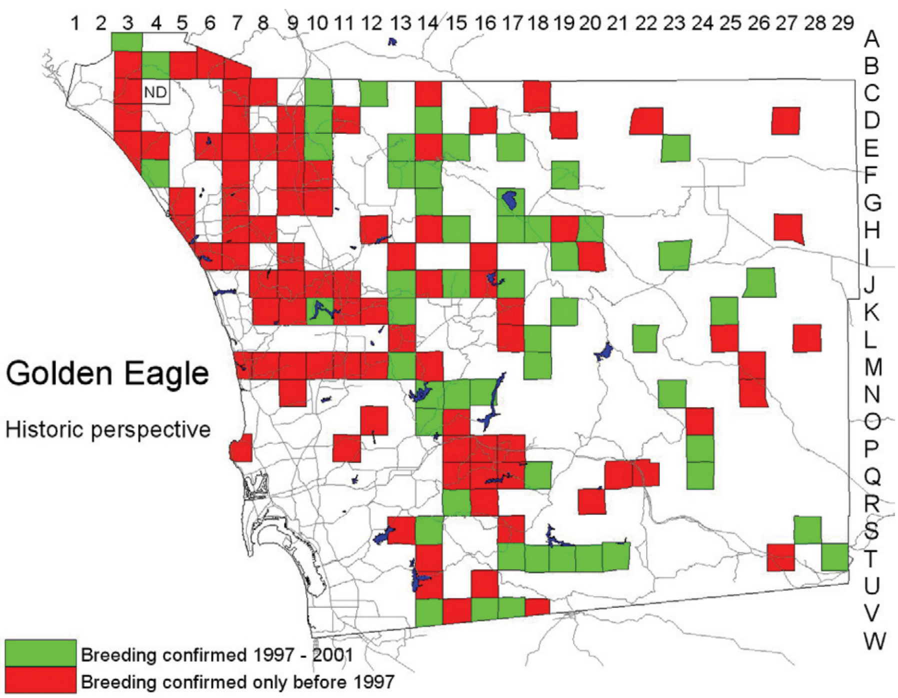
of the 21st century lie near the edge of the urban growth front, a shadow over the future of the capstone of San Diego County's ecosystem.

Breeding distribution: The Golden Eagle's distribution in San Diego County is known better through history than that of any other bird, thanks to study by generations of San Diegans: James B. Dixon, John Colton, John Oakley, Thomas A. Scott, David Bittner, and their collaborators through the Wildlife Research Institute. Since 1988, Bittner and Oakley have organized a team of observers to monitor the county's nesting eagles annually and have checked some inaccessible nest sites via helicopter. This account is based largely on data kindly provided by Bittner.

From 1997 to 2001, about 50–55 pairs nested in the county. Fewer than 20 pairs fledged young each year, averaging 1.5 young per successful nest. Only four of these territories lie west of Interstate 15: three in Camp Pendleton, one around Lake Hodges (K10). Most of the remaining pairs nest within a band 20 to 25 miles wide through the foothills. In southern San Diego County, San Miguel Mountain (S13/S14) and Otay Mountain (U15/V14/V15) mark the western limit of the current breeding range.

In and along the edges of the Anza–Borrego Desert there are 10 known nest sites or clusters of nest sites, though some of these went unused during the entire atlas study, even following the wet winter of 1997–98. Only seven of these territories were active during the atlas period 1997–2001, and at most three were active in any given year. In some nests (D27, L28) new material was added but no eggs were laid; these squares are shown as occupied only before 1997. Since 1998, drought has suppressed numbers of the eagle's principal prey in the Anza–Borrego Desert, the black-tailed jackrabbit. Only two young eagles fledged in the Anza–Borrego Desert in 2003 (D. Bittner).

The Golden Eagle is absent from some surprisingly large yet little disturbed areas of San Diego County, such as Cuyamaca Mountains and the Campo Plateau between Lake Morena and Jacumba.



The map of the species' breeding distribution somewhat overrepresents its abundance. A few pairs straddle two atlas squares. Nesting in three squares (F19, M13, R15) has ceased since 1997.

Nesting: Scott (1985) found about 80% of San Diego County's Golden Eagle nests built on cliff ledges, 20% in trees, usually on steep slopes. A pair typically rotates among several nest sites, including both cliff and tree nests. Many of the cliff sites have been in regular use since the early 20th century and undoubtedly long before that. Though the giant stick nests are reused for years, the birds refurbish them annually. In San Diego County, fallen yucca leaves, with their tough fibers, are a common ingredient in the nest's lining (Dixon 1937, D. Bittner).

The Golden Eagle's schedule of nesting in San Diego County is also supported by abundant data. Nest building begins with the first heavy rain of fall (Dixon 1937). Copulation begins as early as 5 January (D. Bittner). Dates of 407 egg sets collected or observed from 1891 to 1957 range from 2 February to 26 April, except for one on 7 May and another on 16 June. The mean date is 4 March, standard deviation 17 days. Eggs laid after the first week of March, however, are probably replacement clutches (Dixon 1937). During his recent surveys, Bittner has found most eggs laid in mid February, most chicks hatching in late March or early April, and most young fledging in June. Occasionally, however, he encounters nestlings on dates suggesting they hatched from eggs laid in mid January (e.g., chicks five weeks old on 15 April 2004).

Migration: Once a Golden Eagle acquires a mate and a territory, it remains with them year round, except for occasional swapping (Kochert et al. 2002). Young birds, however, may disperse considerable distances: birds banded in San Diego County have been recovered in Ojai, Ventura County, in Apple Valley, San Bernardino County, in Utah, in the Grand Canyon, Arizona, and near Guadalajara in central Mexico (T. A. Scott, D. Bittner).

Winter: In spite of the mobility of immatures and nonterritorial adults, the nonbreeding distribution of the Golden Eagle in San Diego County does not differ greatly from the breeding distribution. In southern San Diego County a few birds often spread west to the Otay and Tijuana River valleys, accounting for the near regularity of the eagle on the San Diego Christmas bird count (noted on 16 of 20 counts 1983–2002). One on the fill north of the Sweetwater River mouth, National City (T10), 15 December 2001 (S. M. Wolf) was our only sighting during the atlas period of a Golden Eagle that must have flown several miles over developed areas. The count circles other than San Diego include at least one nesting territory. Our maximum winter count per atlas square per day was three, all within a few miles of nest sites.

Conservation: Following studies by Dixon (1937) and Scott (1985), David Bittner and John Oakley (pers. comm.) estimate the Golden Eagle population of San Diego County in 1900 at 108 pairs. It remained near 100 pairs until the rapid growth of the county's human population following World War II. In the 1970s, following the building of the interstate highways and the spread of avocado and citrus orchards along Interstate 15, the decline became precipitous. By 2004, the population had dropped to about 53 pairs, with some uncertainty because of a few territories straddling the county line and long vacancy of some territories in the Anza–Borrego Desert. Since 1988, the surveys organized by the Wildlife Research Institute have located about 15 previously unknown pairs in remote parts of the county, accounting for the variation from the estimate of 40–50 pairs reported by Unitt (1984) on the basis of studies by T. A. Scott (pers. comm.).

The eagles abandoned four territories just within the five-year atlas period, and the Wildlife Research Institute estimates that nine more are in imminent danger of abandonment. Without better planning for habitat conservation, the institute estimates the county's eagle population could be halved again by 2030.

The most important factor in this decrease has been urban sprawl covering former foraging habitat. From 1900 to 1936, when eagle territories still filled northwestern San Diego County, Dixon (1937) found the territories of 27 pairs in that region to range from 19 to 48 square miles and average 36 square miles. Thus the area needed to support the species is considerably greater than for any other San Diego County bird. The viability of territories that become isolated from the main block of the species' range is also questionable. Of the 27 territories mapped by Dixon (1937), only nine were occupied at the beginning of the 21st century.

Other factors affecting the eagle are human disturbance, especially rock climbing on nesting cliffs, but also shooting (both recreational and for military training on Camp Pendleton), and agriculture (avocado orchards planted near nest sites). Electrocution on power lines is now the biggest source of mortality: 37 of 55 dead eagles picked up in and near San Diego County 1988–2003 and reported to Bittner had been electrocuted. The Golden Eagle was less subject to poisoning by insecticides like DDT than other birds of prey but has suffered poisoning by scavenging prey killed by rodenticides. Three of the 55 dead birds recovered had been killed through such secondary poisoning. Ever more prolonged droughts could depress the population further, a factor Hoffman and Smith (2003) suggested as affecting raptors throughout the western United States.

Taxonomy: *Aquila c. canadensis* (Linnaeus, 1758) is the only subspecies of the Golden Eagle in North America.

The Wildlife Society

Impacts of Wind Energy Facilities on Wildlife and Wildlife Habitat

Technical Review 07–2
September 2007

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The Wildlife Society
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COVER: Wind turbines at the Maple Ridge Wind Farm in Lowville, New York (center): Ed Arnett, Bat Conservation International; Silver-haired bat (left): Merlin D. Tuttle, Bat Conservation International; Bluetit in spring (upper right); Greater prairie chicken (lower right): U.S. Geological Survey.

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Foreword

Presidents of The Wildlife Society occasionally appoint ad hoc committees to study and report on select conservation issues. The reports ordinarily appear as either a Technical Review or a Position Statement. Review papers present technical information, and position statements are based on these reviews. Preliminary versions of position statements are published for review and comment by Society members. Following the comment period, revision, and Council's approval, the statements are published as official positions of The Wildlife Society.

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We wish to thank past-President Richard Lancia and The Wildlife Society Council for appointing the Technical Review Committee on the Impacts of Wind Energy Facilities on Wildlife and Wildlife Habitat and addressing this important and growing issue. Tom Franklin, Jim Mosher, and Paul Racey reviewed a previous draft of this document. We also thank Laura Bies, Associate Director of Government Affairs for TWS, and TWS Council Technical Review Subcommittee Chair Gary Potts and Subcommittee members Tom Decker, Marti Kie, and Tom Ryder for their guidance and review of previous drafts. Bat Conservation International and TWS provided financial assistance and logistical support for the review, committee meetings, and publication.

Table of Contents

SYNOPSIS

Development of wind power offers promise of contributing to renewable energy portfolios to reduce greenhouse gas emissions from carbon-based sources, which contribute to accelerating climate change. This report summarizes information on the impacts of wind energy facilities on wildlife and wildlife habitat, including state and federal permitting processes, wildlife fatality, habitat loss and modification, animal displacement and fragmentation, offshore development, and issues surrounding monitoring and research methodology, including the use of technological tools.

Impacts of wind energy facilities on wildlife can be direct (e.g., fatality, reduced reproduction) or indirect (e.g., habitat loss, behavioral displacement). Although fatalities of many bird species have been documented at wind facilities, raptors have received the most attention. Turbine characteristics, turbine siting, and bird abundance appear to be important factors determining risk of raptor fatalities at wind energy facilities. In comparison with other sources of fatality (e.g., collision with buildings and communication towers, predation by domestic cats), wind turbines, at the current rate of development, appear to be a relatively minor source of passerine fatalities, but these fatalities are cumulative with other sources and their impact may become more pronounced over time. As turbine size increases and development expands into new areas with higher densities of birds, risk to birds could increase. Bat fatalities have been recorded either anecdotally or quantified at every wind facility where post-construction surveys have been conducted, worldwide, and reported fatalities are highest at wind facilities located on ridges in eastern deciduous forests in the United States. However, recent reports of high numbers of bats killed in open prairie in southern Alberta, Canada, and in mixed agriculture and forest land in New York raise concern about impacts to bats in other landscapes. Because bats are long-lived and have exceptionally low reproductive rates, population growth is relatively slow and their ability to recover from population declines is limited, increasing the risk of local extinctions. Given the projected growth of wind power generation, it is essential that future analysis of the impacts of wind energy development consider population effects for some species of bats and birds.

Often overlooked are impacts resulting from loss of habitat for wildlife due to construction, the footprint of the facility, and increased human access. Future development of transmission lines to facilitate wind generation will exacerbate the impacts of wind energy development on wildlife. Ultimately, the greatest impact to wildlife from habitat modification may be due to disturbance and avoidance of habitats in proximity to turbines and fragmentation of habitat for wide-ranging species. For example, habitat for many species of grassland birds in the Northern Great Plains has been dramatically reduced by land use changes, primarily agriculture, and further development of wind energy in undisturbed native and restored grasslands may result in further declines of these species.

Offshore wind facilities have been established throughout Europe, but few studies have been conducted to determine direct impacts on animals. A major concern with offshore developments in Europe has been loss of habitat from avoidance of turbines and the impact that boat and helicopter traffic to and from the wind development sites may cause with regard to animal behavior and movements, although little is known about such effects. Resident seabirds and rafting (resting) waterbirds appear to be less at risk than migrating birds, as they may adapt better to offshore wind facilities. The effects on marine mammals and bats are currently unknown. Although wind turbine/bird collision studies seem to indicate that onshore wind-generating facilities in those locations of the United States studied to date result in few fatalities compared with other sources of collision mortality, we cannot assume that similar impacts would occur among birds (or bats) using wind-generating sites established in unstudied areas such as coastal and offshore areas.

There is a dearth of information upon which to base decisions regarding siting of wind energy facilities, their impacts on wildlife, and possible mitigation strategies. With few exceptions, most work conducted to date at terrestrial facilities has been relatively short-term (e.g., one year or in some cases only one field season). Longer-term studies are required to elucidate patterns and develop predictive models for estimating fatalities and evaluating possible habitat fragmentation or other disturbance effects. The shortage of studies published in the scientific literature on wind-wildlife interactions is problematic and must be overcome to ensure the credibility of studies.

Potential mitigation measures exist and their effectiveness should be evaluated before mandated on a large scale. New mitigation measures are needed and effort must be focused on their development and evaluation. Mitigation measures can be patterned after other efforts that have been demonstrated to work. For example, conservation reserve program lands have replaced some habitat lost to grassland species as a result of agriculture.

Development of clean, renewable energy sources is an important goal, and wind power offers promise for contributing to renewable energy portfolios. However, given the projected development of wind energy, biologically significant cumulative impacts are possible for some species and may become more pronounced over time, unless solutions are found. Avoiding, minimizing, and mitigating harmful impacts to wildlife is an important element of "green energy" and developers of wind energy sources should cooperate with scientists and natural resource agency specialists in developing and testing methods to minimize harm to wildlife.

INTRODUCTION

Economically developed countries worldwide, most notably the United States, are highly dependent on fossil fuels to supply their energy needs. Conventional power generation from fossil fuels has a host of well-documented environmental impacts, globally the most notable being the emission of carbon dioxide (CO_2). The IPCC (2007) documents and projects significant and rapid world-wide changes in climate from increased atmospheric CO_2 concentrations, including rising temperatures, altered precipitation patterns, more severe extremes in droughts and floods, and rising sea levels. These changes in climate are already having significant impacts on flora and fauna (Parmesan 2006), which must adapt to changing environmental conditions (Inkley et al. 2004) if they are to survive.

Increasingly, the world is looking for alternatives for supplying energy. Alternatives frequently considered are nuclear, coal with CO_2 sequestration (i.e., capture and storage of CO_2 and other greenhouse gases that otherwise would be emitted into the atmosphere), conservation, and renewable energy. Conservation and energy-efficiency are perhaps the most cost-effective options, but they alone cannot fill the gap between growing demand for energy and available supply, while simultaneously reducing carbon emissions.

Wind has been used to commercially produce energy in North America since the early 1970s and currently is one of the fastest-growing forms of renewable energy worldwide (Figure 1), at a time of growing concern about the rising costs and long-term environmental impacts from the use of fossil fuels and nuclear power (McLeish 2002, Kunz et al. 2007a). Of the renewable energy technologies, wind-generated electricity is becoming cost-effective in many locations, and electrical utilities in the United States and Europe are increasingly turning to wind energy for new electricity supplies that are free of emissions and carbon. Wind turbines are able to generate electricity without many of the negative environmental impacts associated with other energy sources (e.g., air and water pollution, greenhouse gas emissions associated with global warming and climate change). The National Energy Modeling System (NEMS) model projects that the installed capacity of wind generators will grow to about 100,000 megawatts (MW) over the next 20 years and that these generators will displace approximately the equivalent of 69 million metric tons of carbon, while avoiding the installation of 17,000 MW of conventional generating capacity and saving energy consumers about $17.6 billion/year on energy costs.

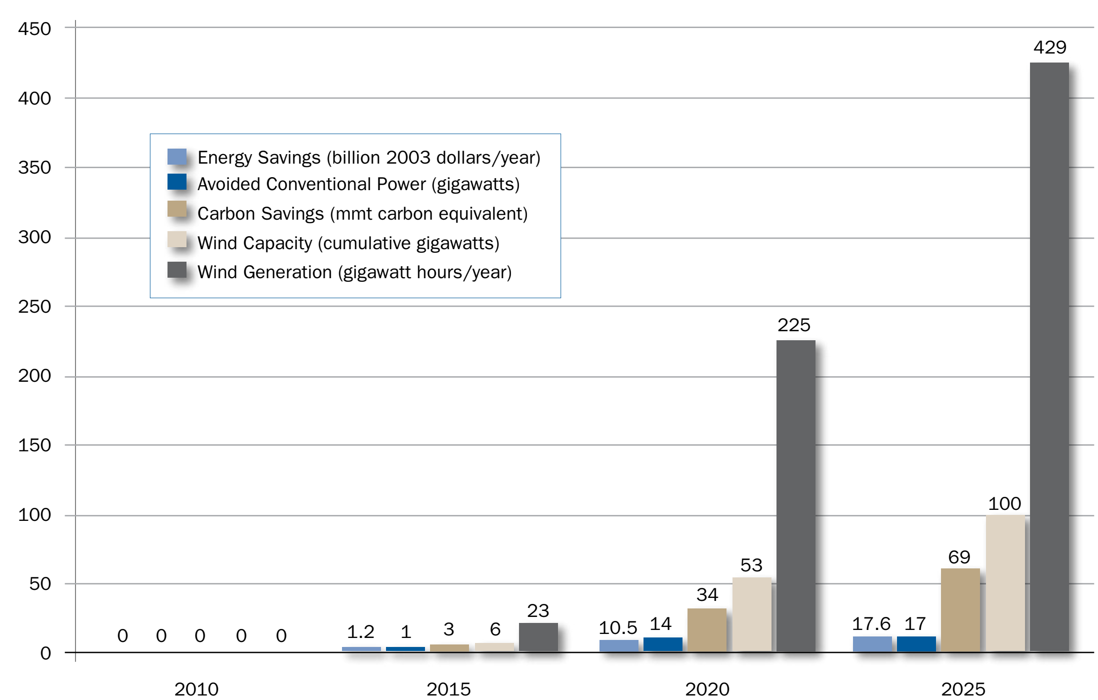
Some wind experts project that wind energy could ultimately contribute 20 percent of the United States' electrical energy needs, as Denmark has already achieved (Advanced Energy Initiative 2006). This would amount to about three times the installed capacity projected by the NEMS model, and while the various quantities in the figure do not scale linearly, the benefits would be roughly three times greater. Wind energy detractors, however, argue that while wind energy is growing exponentially in the United

States, fossil-fuel-burning power plants also continue to grow exponentially. Thus, while wind is producing more electricity, based on public demand, it is not replacing fossil fuels. Indeed, the proportion of fossil-fuels in the world's energy mix, currently at 86 percent, is not projected to change by 2030 (EIA 2007). Whether wind energy ever provides 20 percent of electricity in the United States will depend on many variables, not the least of which is connectivity to the power grid.

However, wind energy development is not environmentally neutral. Often overlooked are habitat impacts, both direct (e.g., resulting from turbine construction and increased human access) and indirect (e.g., habitat fragmentation and avoidance of habitats in proximity to turbines). Better known are fatalities of birds and bats that have been documented at wind facilities worldwide, including Australia (Hall and Richards 1972), the United States and Canada (e.g., Erickson et al. 2002, Johnson et al. 2002, 2003ab), and northern Europe (e.g., Ahlen 2003, Dürr and Bach 2004, Brinkman 2006). Raptor fatalities have been well documented in California (e.g., Orloff and Flannery 1992, Smallwood and Thelander 2004). Furthermore, recent reports of large numbers of bats being killed at wind energy facilities (e.g., Fiedler 2004, Kerns and Kerlinger 2004, Arnett 2005, Arnett et al. 2008) raise concerns about potential cumulative population-level impacts. Wildlife research related to wind energy has focused primarily on bird collisions with wind turbine blades, towers, support structures, and associated power lines (Erickson et al. 2001, Orloff and Flannery 1992). Wildlife advocates and experts have been slower to grasp other potential impacts of wind power development, such as bat fatalities and habitat effects.

This report summarizes information on the impacts of wind energy facilities on wildlife and wildlife

Figure 1. Projected growth and usage of wind energy in the U.S. through 2025, (National Renewable Energy Laboratory 2006).



habitat primarily at land-based facilities. We present information on world energy demands, wind energy development and technology, state and federal permitting processes, wildlife fatality, habitat loss (including modification, animal displacement, and fragmentation), offshore development, and issues surrounding monitoring and research methodology and use of technological tools. We also discuss information needs for siting wind energy facilities and the need to monitor wind energy impacts so that agency managers and biologists, researchers, decision makers, wind industry, and other stakeholders are sufficiently informed about impacts to help avoid, minimize, and mitigate impacts of wind energy facilities on wildlife and wildlife habitat.

FEDERAL AND STATE REGULATIONS AND PERMITTING

Federal resource and land management agencies, non-governmental organizations, contractors, developers, and utilities have dominated the discussion about wildlife interactions with wind energy facilities. Until recently, most state fish and wildlife agencies have not been deeply or proactively involved. This limited participation reflects a variety of factors, including more immediate management priorities, lack of fiscal and human resources, and the limited regulatory authority to apply wildlife considerations to these decisions. These facts notwithstanding, wind energy regulation in most of the United States is primarily the responsibility of state and local governments. First, most North American wind energy development has occurred and is occurring on private land (Government Accountability Office [GAO] 2005). Second, with the exception of federal trust species (Sullivan 2005), wildlife conservation in the United States lies within the exclusive jurisdictional authority of state fish and wildlife agencies (Baldwin vs. Fish and Game Commission of Montana 1978, Manville 2005). Federal jurisdiction over wildlife habitat is limited to sites located on federally owned lands, or where federal funding or federal permits are involved, or Critical Habitat designated under the federal Endangered Species Act. Several states have set up wind working groups to address issues and advise legislators and regulators about the potential impacts and benefits of wind development, including effects on wildlife resources.

Where wind projects are proposed for development in federal waters (generally > 3 NM [5.6 km], or for Texas, 3 leagues [~10.2 mi; 16.3 km]), the Interior Department's Minerals Management Service (MMS) now has jurisdictional authority. At this writing, MMS is developing an EIS review process under the National Environmental Policy Act. In Texas State waters, the Texas Lands Office retains siting authority. In the Great Lakes, the Army Corps of Engineers retains authority for offshore wind development.

Federal Regulatory Approaches

The primary federal laws that pertain to wind energy development, permitting, and impacts on wildlife include the MBTA (16 U.S.C. 703-712; MBTA), Bald and Golden Eagle Protection Act (16 U.S.C. 668-668d; BGEPA), Endangered Species Act (16 U.S.C. 1531-1544; ESA), and the National Environmental Policy Act (16 U.S.C. 4371 et seq.; NEPA). Strict liability statutes under the MBTA and BGEPA, which lack a consultation process, require developers of wind energy on private and federally owned lands to perform within the spirit and the intent of these laws. Under the ESA, development of a Habitat Conservation Plan (Section 10) and subsequent acquisition of a "takings permit" are voluntary on the part of the developer, but any violation of the ESA is not. Other relevant aspects of facility development require compliance with federal laws and regulations such as the 404 b(1) of the Clean Water Act and use of aircraft warning lights, as required by the Federal Aviation Administration (FAA) under its current "obstruction marking and lighting" Advisory Circulars.

There currently is no oversight agency or commission tasked to review and regulate wind energy development on private lands, which complicates regulation among local, state, and federal governing bodies. How the federal government and specific federal agencies tasked to address issues related to wind development deal with wind siting, permitting, and development depends on a federal "nexus" or specific federal connection related to the proposed site. A federal nexus would include wind development 1) on federal lands or waters; 2) where federal funding has been provided to a project; 3) where a federal permit is involved; or 4) where there is a connection to a federal power grid, such as the Bonneville Power Authority (BPA) or the Western Area Power Administration (WAPA) transmission grids. While the federal production tax credit (currently $0.019/kilowatt [Kw] hour) is a tax-payer-financed subsidy, currently authorized through the end of 2008, it is not currently considered a federal nexus, has not yet been challenged in court, and thus does not require NEPA review. Where a commercial wind facility intends to connect to a federal power grid such as BPA or WAPA, the U.S. Department of Energy requires environmental review under NEPA. For wind development on private lands, where no federal permit or no federal funding is involved, no clear federal nexus presently exists. While NEPA typically evaluates proposed projects in terms of biological significance, ESA protects both individuals and populations, and strict liability statutes, such as the Migratory Bird Treaty Act, make it difficult for federal agencies to address only population impacts (Manville 2001, 2005).

To assist U.S. Fish and Wildlife Service (USFWS) staff, particularly those in the Service's 78 Ecological Services Field Offices whose task is to provide technical assistance to wind developers or their consultants, the Service developed interim voluntary land-based guidance to avoid or minimize impacts to wildlife and their habitats (found at www.fws.gov/habitatconservation/wind.pdf, May 13, 2003, Deputy Director's cover memo, and pp. 1–33, 52–55, released to the public on July 10, 2003). The voluntary guidance was intended to allow Field Offices to help wind developers avoid future take of migratory birds and federally listed threatened and endangered species, as well as minimally impact their habitats. The guidelines do this by making recommendations on the proper evaluation of potential sites; the proper location and design of wind turbines, and their associated infrastructures; and by suggesting pre- and post-construction research and monitoring to identify and assess risk and potential impacts to wildlife. While voluntary, the guidelines will remain in use until they are updated with recommendations from an advisory committee soon to convene.

State Regulatory Approaches

As of 2006, 11,603 MW of wind energy capacity was installed in the United States (Figure 2; U.S. Department of Energy 2006). Development is concentrated where adequate wind resources and transmission currently exist. At present, 16 states are without any wind power facilities (Alabama, Arizona, Arkansas, Connecticut, Delaware, Florida, Georgia, Indiana, Kentucky, Louisiana, Maryland, Mississippi, Nevada, North Carolina, South Carolina, and Virginia), although some have projects proposed or under development.

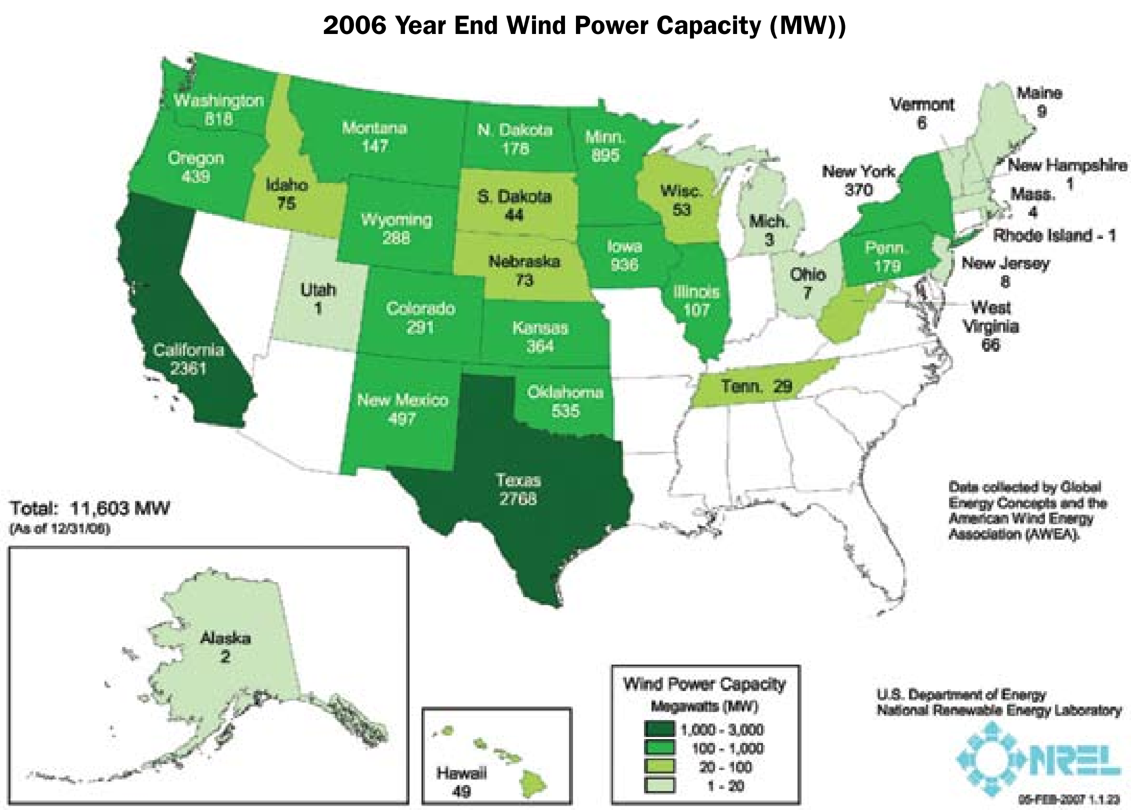
State fish and wildlife agency participation in wind energy development has varied from proactive involvement with clear regulatory guidance (e.g., Washington) to piecemeal reactive involvement with specific projects of special concern. With several notable exceptions, most states have statutes that can be applied (albeit indirectly) to regulate the siting, construction, and operation of wind energy facilities. These include industrial siting laws, zoning regulations, state environmental laws, and home-rule requirements at the local level (e.g., New York), among others. To date, state and local governments have used these authorities to encourage development rather than as a basis for litigation. Typically, state public service commissions, local or county planning commissions, zoning boards, and/or city councils are the permitting authorities for wind development projects (GAO 2005). Given this diversity, it is not surprising that there are considerable differences in the requirements imposed. Currently, several states (e.g., Vermont, Pennsylvania, and California) are in the process of developing state guidelines and regulations to address wind energy development (Stemler 2007).

More often than not, state fish and wildlife agencies lack regulatory authority to directly participate in the permitting of any type of development, and so instead rely on cooperating with the state regulating authority and federal partners, such as the Bureau of Land Management (BLM), to control when and where development occurs. This approach is only moderately effective because wildlife concerns are only one of a myriad of social, political, and economic inputs considered by decision-makers. State natural resource or environmental agencies, historic preservation boards, industrial development boards, public utility commissions, or siting boards often provide an additional level of oversight (in many cases, state authorities supersede local oversight). This involvement also varies among jurisdictions, reflecting the evolution of authorities in response to the growth of the industry. Pre-existing authorities to regulate development often are insufficient, ill-suited, or simply not applicable to wind energy projects. Compounding this difficulty, state and local governments sometimes lack the experience, staff, and capability necessary to adequately address the environmental impacts of wind energy development.

A critical point is that while many species potentially affected by wind energy development are under federal jurisdiction, others, such as prairie and sage grouse, mule deer, and bighorn sheep, are not, unless they become federally listed under the ESA. These species are managed by state fish and wildlife agencies, and, at least in the states that comprise major portions of their core habitat, the lack of regulatory authority compromises conservation and restoration objectives. Enhancing legislative authorities for state fish and wildlife agencies related to all forms of development, including wind energy, is the purview of the states involved.

A growing number of states have (or are developing) Renewable (Energy) Portfolio Standards (RPS) (Stemler 2007). In most cases, these are numerical targets requiring utilities to increase reliance on solar radiation, wind, water, and other renewable sources for electrical generation (American Wind Energy Association 1997). The Western Governors Association Clean and Diversified Energy Initiative for the West (WGA Proposed Policy Resolution 04-12, 2004) proposes to encourage development of RPS across the western United States. In 2001, 75 percent of wind power developed in the United States was in states with portfolio requirements. Some believe that RPS or purchase mandates are the most powerful tool that states can implement to promote renewable energy use (Bird et al. 2003). Unfortunately, RPS usually focus on benefits of renewable energy, with less attention to negative environmental impacts.

Figure 2. Installed wind capacity (megawatts; MW) in the United States as of 31 December 2006 (National Renewable Energy Laboratory; http://www.eere.energy.gov/windandhydro/windpoweringamerica/wind_installed_capacity.asp)



Washington Department of Fish and Wildlife Wind Power Guidelines

Among state fish and wildlife agencies, the Washington Department of Fish and Wildlife was the first to provide comprehensive guidelines for wind energy development (Washington Department of Fish and Wildlife 2003). These guidelines consist of three sections: (a) baseline and monitoring studies for wind projects, (b) wind project habitat mitigation, and (c) wind power alternative mitigation pilot program. The guidance applies to projects east of the Cascade Mountains in sage steppe habitats.

Baseline and monitoring studies for wind projects. Developers, in consultation with the agency, are required to collect information about potential environmental impacts. Site-specific components of the assessment include project size, availability of existing comparison baseline data, habitats affected, and the likelihood and timing of threatened, endangered species, and state-sensitive species occurring in the proposed project location. The guidance requires use of the best available evaluation protocols and communication of baseline and pre-construction study results to stakeholders (i.e., state agencies and other groups with an interest in the siting, construction, and operation of facilities).

Developers are required to conduct habitat mapping and report general vegetation and land cover types, habitats for wildlife species of concern, and the extent of noxious weeds at the development location. At least one raptor survey during the breeding season is required. If the occurrence of threatened, endangered, or state-sensitive species is likely, then monitoring within a 3.2 km buffer of the development location is recommended. At least one full season of general bird surveys is recommended during seasons of occurrence or for longer periods of time if avian use is high or if few data exist to indicate which seasons might be important. The guidelines also require state-of-the-art protocols that are reviewed and approved by the state wildlife agency.

The guidance recommends that developers use already disturbed lands (i.e., agricultural land, existing transmission corridors, established road systems), and it discourages the use of sites supporting high-value plant communities. It requires the use of tubular towers and discourages the use of guy wires either on turbine or associated meteorological towers. The guidance makes a series of recommendations with the intent of reducing impacts, including minimizing overhead power lines, minimizing lighting on turbines (to the extent permitted under Federal Aviation Administration [FAA] regulation), encouraging noxious weed control, and requiring a fire protection plan. The guidance requires that development locations be restored to (at least) pre-development conditions when turbines are decommissioned.

When a wind energy facility becomes operational, the guidance requires ongoing monitoring, the scope of which depends on size of the project and availability of data from similar projects. A Technical Advisory Committee reviews and evaluates mitigation actions (included as conditions of the permitting document) on a quarterly basis. Research studies are encouraged, but not as part of an operational monitoring plan.

Wind project habitat mitigation. The Washington guidance indicates that mitigations specified in permitting documents are considered to be entirely adequate, except for any subsequently identified impacts to threatened, endangered, and state-sensitive species. Developers are required to acquire and then manage replacement wildlife habitat for the life of the project, unless the development occurs on land with little or no wildlife habitat value (land under cultivation or otherwise developed or disturbed). The acquisition of replacement habitat is guided by five criteria: (1) replacement lands should be comparable to habitat disturbed by development; (2) replacement habitat should be given legal protection; (3) replacement habitat should be protected from degradation for the life of the project; (4) replacement habitat should be in the same geographic region as the project; (5) replacement habitat should be jointly agreed to by the developer and the Washington Department of Fish and Wildlife.

The area of replacement habitat varies depending on the value of the disturbed land. The ratio is 1:1 for habitat subject to imminent development, or to acquisition for grassland or CRP replacement. The ratio is 2:1 for sage steppe plant community replacement. When disturbance is temporary, the replacement ratios are 0.1:1 for habitats subject to imminent development and 0.5:1 for sage steppe plant community. Replacement habitats must be prepared and seeded, noxious weeds must be controlled, and the land otherwise protected from degradation.

Alternative mitigation pilot program. Developers can pay a median fee of $55.00/acre to the Washington Department of Fish and Wildlife. This cost is reviewed annually and may be adjusted by up to 25 percent to reflect current land values and/or the quality of the disturbed habitat. Funding obtained is used to purchase and manage high-value wildlife habitat in the same geographic region as the development project.

No RPS consider the potential impacts of renewable energies development on fish, wildlife, and their habitats. Revising existing standards to account for wildlife impacts and inclusion of guidelines in the permitting process would further strengthen agency participation and implementation of guidelines.

WILDLIFE COLLISION FATALITY AT WIND FACILITIES

Factors Influencing Estimation of Fatality Rates

Experimental designs and methods for conducting post-construction fatality searches are well established (e.g., Anderson et al. 1999, Morrison 1998, 2002). While the statistical properties for at least some common estimators have been evaluated and suggested to be unbiased under the assumptions of the simulations (Barnard 2000, W. P. Erickson, Western Ecosystems Technology, unpublished data), important sources of field sampling bias must be accounted for to correct estimates of fatality. Important sources of potential bias include 1) fatalities that occur sporadically; 2) carcass removal by scavengers; 3) searcher efficiency; 4) failure to account for the influence of site (e.g., vegetation) conditions (Wobeser and Wobeser 1992, Philibert et al. 1993, Anderson et al. 1999, Morrison 2002); and 5) fatalities or injured animals that may land or move outside the search plots.

Fatality searches usually are conducted on a systematic schedule of days (e.g., every 3, 7, or 14 days). Most estimators assume fatalities occur at uniformly

Estimates of bird and bat fatality at wind facilities are conditioned on field sampling biases such as searcher efficiency which varies considerably with vegetative conditions. (Credit: Merlin D. Tuttle, Bat Conservation International)

distributed, independent random times between search days and apply an average daily rate of carcass removal expected during the study. However, if the distribution of fatalities is highly clustered, then estimates may be biased, especially if carcass removal rates are high. If most fatalities occur immediately after a search, those fatalities would have a longer time to be removed before the next search, resulting in higher scavenging rates than the average rate used in the estimates. This would lead to an underestimate of fatalities. On the other hand, if most fatalities occur before, but close to the next search, the fatality estimate may be an overestimate. The second source of bias in fatality estimation relates to assessing scavenging rates (also referred to as carcass removal). Most studies have used house sparrows as surrogates for small birds and bats during carcass removal trials, while using pigeons for medium-sized birds (Erickson et al. 2001, Morrison 2002). While the use of these surrogates may be reasonable for birds, past experiments assessing carcass removal may not be representative of scavenging on bats in the field when small birds are used as surrogates for bats (Kerns et al. 2005). Scavenging of both birds and bats should be expected to vary from site to site and among both macro-scale habitats (e.g., forests compared with grass pasture) and micro-scale vegetation conditions at any given turbine (e.g., bare ground compared with short grass). As scavengers learn of the presence of available carcasses, scavenging rates may significantly increase. A third source of bias relates to detectability: the rate by which searchers detect bird and bat carcasses. Searcher efficiency can be biased by many factors, including habitat, observer, condition of carcasses (e.g., decomposed remains compared with fresh, intact carcasses), weather, and lighting conditions. Searcher efficiency and carcass scavenging should be expected to vary considerably within and among different vegetation cover conditions (Wobeser and Wobeser 1992, Philibert et al. 1993, Anderson et al. 1999, Morrison 2002). Proportion of fatalities that land outside of search plots can be estimated by using the distribution of fatalities as a function of distance from turbines (Kerns et al. 2005). Bias associated with injured animals that leave search plots is difficult to quantify and has not been reported to date.

Below, we discuss patterns and estimates of fatalities reported for raptors, resident and migratory songbirds, other avian species, and bats, but caution that estimates are 1) conditioned upon the above described factors, 2) calculated differently for most studies reviewed and synthesized here, and 3) may be biased in relation to how the sources of field sampling bias were or were not accounted for.

Raptors

Early utility scale wind energy facilities, most of which were developed in California in the early 1980s, were planned, permitted, constructed, and operated with little consideration for potential impacts to birds (Anderson et al. 1999). Although fatalities of many bird species have been documented at wind facilities, raptors have received the most attention (e.g., Anderson et al. 1996a, 1996b, 1997, 2000; Anderson and Estep 1988, Estep 1989, Howell 1997, Howell and Noone 1992, Hunt 2002, Johnson et al. 2000a, 2000b, Martí 1994, Orloff and Flannery 1992, 1996, Thelander and Rugge 2000, Smallwood and Thelander 2004). In the United States, all raptors are protected under the MBTA and several species are protected by the ESA. Initial observations of dead raptors at the Altamont Pass Wind Resource Areas (APWRA) (Anderson and Estep 1988, Estep 1989, Orloff and Flannery 1992) triggered concern about possible impacts to birds from wind energy development from regulatory agencies, environmental groups, wildlife resource agencies, and wind and electric utility industries. Raptors occur in most areas with potential for wind energy development, but appear to differ in their susceptibility to collisions. Early fatality studies only reported carcasses discovered during planned searches of wind facilities and did not account for potential survey biases described above. Contemporary fatality estimates are based on extrapolation of the number of observed fatalities at surveyed turbines to the entire wind power facility, corrected for searcher efficiency and carcass removal.

Older generation turbines. Earlier studies on fatalities at wind facilities occurred in California because most wind power was produced by three California facilities (APWRA, San Gorgonio, and Tehachapi). APWRA currently has 5,000 to 5,400 turbines of various types and sizes and with an installed capacity of approximately 550 MW (~102 kw/turbine), San Gorgonio consists of approximately 3,000 turbines of various types and sizes with an installed capacity of approximately 615 MW (~205 kw/turbine), and Tehachapi Pass has approximately 3,700 turbines with an installed capacity of approximately 600 MW (~162 kw/turbine). While some replacement of smaller turbines with modern, much larger turbines has occurred (i.e., repowering), all three of these facilities are populated primarily with relatively small "old generation" turbines ranging from 40 to 300 kw, with the most common turbine rated at approximately 100 kw. The best wind sites located within each facility have a relatively high density of turbines. Turbine support structures are both lattice and tubular, all with abundant perching locations on the tower and nacelle. Additionally, all three facilities have above-ground transmission lines. Perching sites for raptors are ubiquitous within all three facilities, but particularly at APWRA. Vegetation communities differ among the sites, with San Gorgonio being the most arid and Tehachapi the most montane.

Widely publicized reports of avian fatalities at Altamont prompted considerable scrutiny of the problem (Orloff and Flannery 1992). Subsequent industry attempts to reduce fatalities at APWRA have not significantly reduced the problem, as suggested by recent results of avian fatality studies conducted by Smallwood and Thelander (2004). Notwithstanding, the turbines studied by Smallwood and Thelander ranged from 40 to 330 kw, and small sample sizes for turbines greater than 150 kw make extrapolation of fatality rates to all turbines in the AWPRA problematic. Nevertheless, Smallwood and Thelander (2004) extrapolated their results to the entire wind resource area and estimated that 881–1,300[1] raptors are killed by collision at APWRA each year. These estimates translate to 1.5–2.2 raptor fatalities/MW/year. Fatality estimates include 75 to 116 golden eagles, 209 to 300 red-tailed hawks *(Buteo jamaicensis)*, 73 to 333 American kestrels *(Falco sparverius)*, and 99 to 380 burrowing owls *(Athene cunicularia)*. The number of burrowing owls was particularly disconcerting given that it is classified as a species of special concern in California. Hunt (2002) completed a four-year telemetry study of golden eagles at APWRA and concluded that while the population is self-sustaining, fatalities resulting from wind power production were of concern because the population apparently depends on immigration of eagles from other subpopulations

[1]adjusted for scavenging and searcher efficiency from data at Oregon/Washington wind projects.

to fill vacant territories. A follow-up survey conducted in 2005, Hunt and Hunt (2006) reported on 58 territories in the APWRA and found that all territories occupied by eagle pairs in 2000 were also occupied in 2005. Early studies conducted at San Gorgonio documented relatively low raptor mortality (McCrary et al. 1983, 1984, 1986). More recent studies at San Gorgonio (Anderson et. al. 2005) and Tehachapi Pass (Anderson et al. 2004) also suggest lower raptor fatalities compared with APWRA. The unadjusted average per turbine and per MW raptor fatality rates, respectively, for these three sites are 0.006 and 0.03 for San Gorgonio, 0.04 and 0.20 for Tehachapi, and 0.1 and 1.23 for APWRA. Differences in fatality appear to be related to density of raptors on these facilities; APWRA has the highest density of raptors, presumably because of abundant prey (particularly small mammals), while San Gorgonio has the fewest raptors and Tehachapi Pass has intermediate densities of raptors (Anderson et al. 2004, 2005).

Newer generation wind facilities. Contemporary wind developments use a much different turbine than older facilities discussed above. In addition, many facilities have been constructed in areas with different land use than existing facilities in California. Results from 14 avian fatality studies, where surveys were conducted using a systematic survey process for a minimum of one year and scavenging and searcher efficiency biases were incorporated into estimates, indicate that combined mean fatality rate for these studies is 0.03 raptors per turbine and 0.04 raptors per MW (See Table 1 on page 47). Regional fatalities per MW were similar, ranging from 0.07 in the Pacific Northwest region to 0.02 in the East (Table 1). With the exception of two eastern facilities in forested habitats (68 MW; 7.5%), landuse/landcover is similar in all regions. Most of these facilities occur in agricultural areas (333 MW; 37%) including agriculture/grassland/Conservation Reserve Program (CRP) lands (438 MW; 48%), and the remainder occur in short grass prairie (68; 7.5%). Landscapes vary from mountains, plateaus, and ridges, to areas of low relief, but aside from size of rotor-swept area, all of these facilities had similar technology, including new generation turbines with lower rotational speeds (~15–27 rpm, but still with tip speeds exceeding 280 km/hr [175 mi/hr]), tubular towers, primarily underground transmission lines, FAA-recommended lighting, and few perching opportunities. Fatality search protocols varied, but all generally followed guidance in Anderson et al. (1999), although standard estimates of raptor use are not available for all 14 studies.

Two factors commonly associated with raptor collision risk are turbine type and bird abundance. Figure 3 illustrates the difference between raptor fatalities at older facilities in California and newer facilities in the United States outside of California. Fatality rates for older turbines are unadjusted for searcher detection and scavenger removal, while rates from the 14 sites with newer generation turbines are adjusted for these biases. Three of the four studies at older generation sites report higher fatality rates than at newer, larger turbine sites, even without bias adjustment. It is noteworthy that even though reported raptor fatalities are higher at older facilities, there is a rather dramatic difference among older facilities. Reported raptor fatalities at APWRA are higher than for Montezuma Hills (Howell 1997); fatalities are somewhat lower at Tehachapi (Anderson et al. 2004) and very few raptor fatalities are reported for San Gorgonio (Anderson et al. 2005). Because the three facilities have similar technology, this difference must be strongly influenced by other factors, most likely raptor abundance. The relationship of abundance and technology will be better addressed when it is possible to study old and new generation turbines in areas of varying raptor density. Three wind facilities in northern California, High Winds and Shiloh in Solano County and APWRA in Alameda County, may present such an opportunity when estimates of fatalities are published. Estimates of raptor use near the Solano County wind facilities are higher than the estimated use at APWRA. These estimates are based on numerous avian use studies conducted in both areas (e.g., Orloff and Flannery 1992, Smallwood and Thelander 2004). The Solano County sites have newer generation turbines and, with the exception of golden eagles, higher raptor use than APWRA.

Other factors such as site characteristics at wind facilities also may be important (Smallwood and Thelander 2004). Additionally, it is also possible that siting of individual turbines may relate to risk of collision and raptor fatalities. Orloff and Flannery (1992) concluded that raptor fatalities at APWRA were higher for turbine strings near canyons and at the end of row turbines. Smallwood and Thelander (2004) also concluded that fatalities were related to turbine site characteristics and position of turbines within a string. The implication of both studies is that turbine siting decisions during construction of a facility are important.

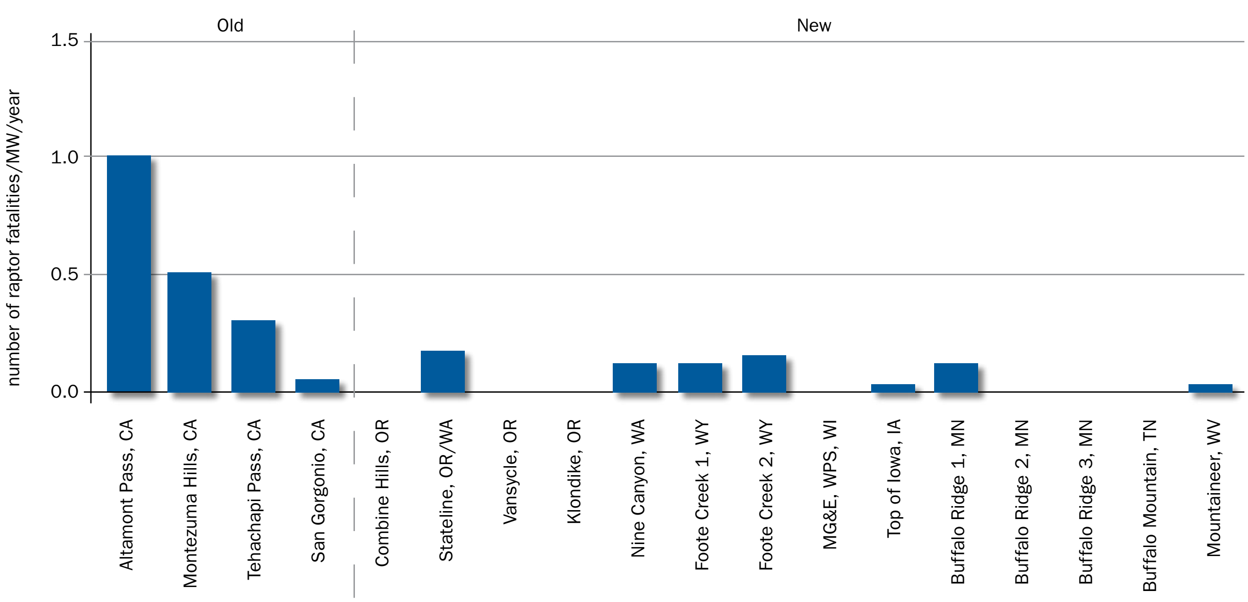
Resident and Migratory Passerines

The available data from wind facilities studied to date suggest that fatality of passerines from turbine blade strikes generally is not numerically significant at the population level (e.g., LGL Ltd. 1995, 1996, 2000; Nelson and Curry 1995; Osborn et al. 2000, Erickson et al. 2001, Strickland et al. 2001), but ill-sited facilities, particularly in areas where migrating birds are concentrated and in areas of abundance for rare species (e.g., listed songbirds, candidate species, and Birds of Conservation Concern), could constitute exceptions.

In a review of avian collisions reported in 31 studies at wind energy facilities, Erickson et al. (2001) reported that 78 percent of carcasses found at facilities outside of California were passerines that are protected under the MBTA. The balance of fatalities was waterfowl (5.3%), waterbirds (3.3%), shorebirds (0.7%), diurnal raptors (2.7%), owls (0.5%), gallinaceous (4.0%), other (2.7%), all protected under the MBTA, and non-protected birds (3.3%). Concerns have been raised by USFWS regarding fatalities at wind facilities of "Birds of Conservation Concern" (BCC) and birds whose populations have been declining based on Breeding Bird Survey (BBS) data. For example, 12 of 33 species reported retrieved were BCC and/or BBS declining from Buffalo Ridge, Minnesota (Johnson et al. 2002), seven of 19 species from northwestern Wisconsin (Howe et al. 2002), nine of 25 species from Mountaineer, West Virginia (Kerns and Kerlinger 2004), and eight of 24 species at Buffalo Mountain, Tennessee (Nicholson 2003).

Estimates of total passerine fatality vary considerably among studies conducted at 14 new generation facilities (see Table 1 on page 47), but fatalities per turbine and per MW are similar for all regions represented by these studies, although the two eastern sites studied suggest that more birds may be killed at wind facilities constructed on forested ridge tops in the East. The number of fatalities reported by in-

Figure 3. Fatality rates for raptors at four older generation turbines unadjusted for searcher efficiency and carcass removal bias (Smallwood and Thelander 2004, Howell 1997, Anderson et al. 2004, Anderson et al. 2005), and fatality rates adjusted for searcher efficiency and carcass removal at 14 wind projects (Erickson et al. 2000, 2003, 2004, Young et al. 2005, Johnson et al. 2003b, Young et al. 2003, Howe et al. 2002, Johnson et al. 2002, Jain 2005, Nicholson 2003, Kerns and Kerlinger 2004) with newer generation turbines.



dividual studies ranged from zero at the Searsburg, Vermont facility (Kerlinger 1997) to 11.7 birds/MW at Buffalo Mountain, Tennessee (Nicholson 2003). Most studies report that passerine fatalities occur throughout the facility, with no particular relationship to site characteristics.

Based on data from the 14 studies, it appears that approximately half the reported fatalities at new generation wind power facilities are nocturnally migrating birds, primarily passerines, and the other half are resident birds in the area. In reviewing the timing of fatalities at eight western and mid-western wind power facilities, it appears that fatalities of passerines occur in all months surveyed (e.g., Erickson et al. 2001, 2003a, 2004, Young et al. 2005, Johnson 2003a, Young et al. 2003, Howe et al. 2002, Johnson et al. 2002, Koford et al. 2004, Nicholson 2003, Kerns and Kerlinger 2004), although fatalities are most common from April through October. The timing of fatalities varies somewhat from site to site. For example, peak passerine fatalities occurred during spring migration at Buffalo Ridge, Minnesota (Johnson et al. 2002), and during fall migration at Stateline in Washington and Oregon (Erickson et al. 2004).

Vulnerability of birds colliding with wind turbines and associated infrastructures has not been thoroughly examined. Most fatalities at wind facilities are assumed to be from collisions with moving wind turbine blades, although there is no specific evidence suggesting that passerines do not occasionally collide with turbine support structures or stationary blades. Perhaps the most difficult task in interpreting breeding passerine fatalities is the estimation of exposure. The most common fatalities reported in western and mid-western wind power facilities are some of the more common species such as horned lark *(Eremophila alpestris)*, vesper sparrow *(Pooecetes gramineus)*, and bobolink *(Dolichonyx oryzivorus)*. These species perform aerial courtship displays that frequently take them high enough to enter the rotor-swept area of a turbine (Kerlinger and Dowdell 2003). In contrast, the western meadowlark *(Sturnella neglecta)*, also a common species, is frequently reported in fatality records, yet is not often seen flying at these altitudes. Also, corvids are a common group of birds observed flying near the rotor-swept area of turbines (e.g., Erickson et al. 2004, Smallwood and Thelander 2004), yet are seldom found during carcass surveys. Clearly, the role of abundance relative to exposure of birds to collisions with wind turbines is modified by behavior within and among species and likely varies across locations.

The estimation of exposure of nocturnal migrating passerines is even more problematic. Bird and bat "targets" identified by most radar systems currently cannot be distinguished, and not all targets are exposed to turbines because nocturnal migrating passerines are known to migrate at relatively high altitudes during favorable weather conditions, except during take-off and landing. Radar studies suggest there is a large amount of night-time variation in flight altitudes (e.g., Cooper et al. 1995), with targets averaging different altitudes among nights and at different times during each night. No doubt, some intra-night variation is due to birds landing and taking off at dawn and dusk, respectively. Kerlinger and Moore (1989) and Bruderer et al. (1995) concluded that atmospheric conditions affect choice of flight direction and flight height by migrating passerines. For example, Gauthreaux (1991) found that birds crossing the Gulf of Mexico appear to fly at altitudes at which favorable winds exist. Inclement weather has been identified as a contributing factor in avian collisions with other obstacles, including power lines, buildings, and communications towers (Estep 1989, Howe et al. 1995, Manville 2005). Johnson et al. (2002) estimated that as many as 51 of 55 collision fatalities discovered at the Buffalo Ridge wind facility may have occurred in association with inclement weather, such as thunderstorms, fog, and gusty winds. There is some concern that nocturnal migrating passerines may be compressed near the surface when cloud ceilings are low or when flying over high mountain ridges, increasing the risk of collisions with turbines. Estimating the effect of weather is problematic because marine radar is ineffective during rain events, but the association of avian fatalities at wind power facilities (e.g., Johnson et. al. 2002) and communications towers (Erickson et al. 2001, Manville 2005) with weather suggests this could be an issue. Recent radar evidence from studies in New York and Pennsylvania also shows that birds may vary their flight heights considerably, depending on weather conditions and landings/take-offs at stopover sites (ABR Inc. 2004).

The effect of topography on bird migration also is somewhat uncertain. It generally is assumed that nocturnal migrating passerines move in broad fronts and rarely respond to topography (Lowery and Newman 1966, Able 1970, Richardson 1972, Williams et al. 1977, Evans et al. 2007). However, Williams et al. (2001) cite work in Europe suggesting migrating birds respond to coastlines, river systems, and mountains (e.g., Eastwood 1967, Bruderer 1978, 1999; Bruderer and Jenni 1988). While bird response to coastlines and major rivers has been noted in North America (e.g., Richardson 1978), evidence is limited on response to major changes in topography (Seilman et al. 1981, McCrary et al. 1983). Mabee et al. (2006) reported that for 952 flight paths of targets approaching a high mountain ridge along the Allegheny Front in West Virginia, the vast majority (90.5%) did not alter their flight direction while crossing the ridge. The remaining targets either shifted their flight direction by at least 10 degrees (8.9%) while crossing the ridge or turned and did not cross the ridge (0.6%), both of which were considered reactions to the ridgeline. This study suggests that only those birds flying at relatively low levels above the ground respond to changes in topography.

Although FAA lighting has been associated with increased avian fatalities at communications towers and other tall structures (Manville 2001, 2005, Erickson et al. 2001, Longcore et al. 2005, Rich and Longcore 2005), there is no evidence suggesting a lighting effect for wind power-associated passerine fatalities (Erickson et al. 2001b, P. Kerlinger, Curry and Kerlinger LLC, unpublished data). While steady-burning, red incandescent L-810 lights appear to be the major bird attractant to communications towers (Gehring et al. 2006), lighting at wind turbines tends to be red strobe or red-blinking/pulsating incandescent lighting (USFWS 2007). At the Mountaineer facility in West Virginia, Kerns and Kerlinger (2004) reported the largest avian fatality event at a wind facility, when 33 passerines were discovered on May 23, 2002. These fatalities apparently occurred just prior to the survey during heavy fog conditions; all carcasses were located at a substation and three adjacent turbines. The substation was brightly lit with sodium vapor lights. Following the discovery of these fatalities, the bright lights were turned off and no further major mortality events were documented during surveys at this site through fall 2003 (Kern and Kerlinger 2004) or during six weeks in the summer and fall of 2004 (Kerns et al. 2005).

Wind facilities located on forest ridges in the eastern U.S. have the highest documented bat and passerine fatalities. (Credit: Merlin D. Tuttle, Bat Conservation International)

Other Avian Species

Fatality studies almost universally report very few fatalities of waterfowl, shorebirds, or gallinaceous birds, as previously noted by Erickson et al. (2001). Kerlinger (2002) speculated that the upland sandpiper *(Bartramia longicauda)* might be at low to moderate risk of colliding with turbines, because of its aerial courtship flight. It has been documented that grouse are susceptible to powerlines and other structures. Borell (1939) reported greater sage-grouse *(Centrocercus urophasianus)* mortalities from powerlines, and 4 percent to 14 percent of greater prairie-chicken *(Tympanuchus cupido)* deaths in Wisconsin resulted from powerline strikes (Toepfer 2003). Wolfe et al. (2003) found that collisions with structures, fences, and vehicles by radio-collared lesser prairie-chickens *(Tympanuchus pallidicinctus)* accounted for 42 percent of the total mortalities, from a total of 122 recovered carcasses. They speculated that collision deaths could be additive to other mortality factors. In a review of five wind facilities, Fernley and Lowther (2006) reported that 1) collision of medium to large species of geese with wind turbines is an extremely rare event (unadjusted rates of 0–4/year for the 5 sites reviewed), 2) there appears to be no relationship between observed collision fatality and number of goose flights per year, and 3) geese appear to be adept at avoiding wind turbines.

Bats

Recent surveys have reported large numbers of bat fatalities at some wind energy facilities, especially in the eastern United States (e.g., Fiedler 2004, Kerns and Kerlinger 2004, Arnett 2005) and, more recently, in Canada (Brown and Hamilton 2006b) and New York (Jain et al. 2007). Relatively large numbers of bat fatalities at wind facilities also have been reported in Europe (Ahlen 2003, Dürr and Bach 2004, Brinkmann 2006). Although bats collide with other tall anthropogenic structures, the frequency and number of fatalities reported in the literature (e.g., Avery and Clement 1972, Crawford and Baker 1981, Mumford and Whitaker 1982) are much lower than those for birds or for bat fatalities observed at wind turbines.

Migratory, tree-roosting species like the hoary bat (Lasiurus cinereus) are most frequently found killed at wind facilities in North America (Credit: Ed Arnett, Bat Conservation International)

Several plausible hypotheses relating to possible sources of attraction, density and distribution of prey, and sensory failure (i.e., echolocation), for example, have been proposed to explain why bats are killed by wind turbines (Arnett 2005, Kunz et al. 2007a).

Estimates of bat fatality from 21 studies located at 19 different facilities from five different regions in the United States and one province in Canada ranged from 0.9–53.3 bats/MW (See table 2 on page 48); Arnett et al. 2008). These estimates vary due in part to region of study, habitat conditions, sampling interval, and bias corrections used to adjust estimates. Currently, forested ridges in the eastern United States have the documented highest fatalities of bats reported in North America and are higher than estimates of bat fatality reported from European studies (Dürr and Bach 2004, Brinkmann 2006).

Johnson (2005) and Arnett et al. (2008) recently synthesized existing information on bat fatalities at wind facilities; here, we summarize key patterns they identified. Bat fatality appears to be higher during late summer and early fall when bats typically begin autumn migration (Griffin 1970, Cryan 2003, Fleming and Eby 2003). Johnson (2005) reported that approximately 90 percent of 1,628 documented bat fatalities, when the approximate date of the collision was reported, occurred from mid-July through the end of September, with over 50 percent occurring in August. Collision fatality appears to be low during spring migration, but few studies have been conducted during this time period. Migratory tree bats may follow different migration routes in the spring and fall (Cryan 2003), and behavioral differences between migrating bats in the spring and fall also may be related to mortality patterns (Johnson 2005). Rarely have studies been conducted simultaneously at multiple sites within a region to evaluate seasonal patterns between sites. In 2004, Kerns et al. (2005) conducted daily fatality searches at the Mountaineer and Meyersdale Wind Energy Centers in West Virginia and Pennsylvania, respectively, and found that the timing of bat fatalities over a six-week period at the two sites was highly correlated ($r = 0.8$). Although Kerns at al. (2005) found more male than female fatalities, the timing of fatality by sex was similar at both sites, as well. Additionally, timing of fatalities of hoary *(Lasiurus cinereus)* and eastern red bats *(Lasiurus borealis)* was positively correlated between the Meyersdale and Mountaineer sites. These findings suggest broader landscape, perhaps regional, patterns of activity and migratory movement that could be influenced by weather and prey abundance and availability.

Eleven of the 45 species of bats that occur in North America north of Mexico have been among fatalities reported at wind facilities (Johnson 2005). Ten species of bats have been reported killed by turbines in Europe (Dürr and Bach 2004). In most regional and individual studies, bat fatalities appear heavily skewed to migratory foliage roosting species that include the hoary bat, eastern red bats, and migratory tree-roosting silver-haired bats (*Lasionycteris noctivagans*; Johnson 2005, Kunz et al. 2007, Arnett et al. 2007). In Europe, migratory species also dominate fatalities (Dürr and Bach 2004). Fatalities of eastern pipistrelles *(Pipistrellus subflavus)* have been reported as high as 25.4 percent of total fatalities at facilities in the eastern United States (Kerns et al. 2005). No studies have been reported from wooded ridges in the western United States and few from the southwest (e.g., New Mexico, Texas), where different species of bats may be more susceptible in some areas (e.g., Brazilian free-tailed bats [*Tadarida brasiliensis*]). Interestingly, the only two investigations at wind facilities within the range of the Brazilian free-tailed bat report high proportions of fatalities of that species (31.4 and 85.6% in California [Kerlinger et al. 2006] and Oklahoma [Piorkowski 2006], respectively). To date, no fatalities of a threatened or endangered species of bat (e.g., Indiana bat [*Myotis sodalis*]) have been found at existing wind facilities, but continued development of wind facilities may pose risk to these species at other locations in the future.

Spatial patterns of bat fatality and relationships between weather and turbine variables are poorly understood. Fatalities appear to be distributed across most or all turbines at wind facilities, with no discernable pattern of collisions reported to date. Bats do not appear to strike the turbine mast, non-moving blades, or meteorological towers (Arnett 2005). Horn et al. (2008) observed bats through thermal imaging cameras attempting to and actually landing on stationary blades and investigating turbine masts. They also reported that seven out of eight observed collisions were between bats and turbine blades spinning at their maximum rotational speed of 17 rpm. Activity and fatality of bats, as with birds, do not appear to be influenced by FAA lighting (Arnett 2005, Arnett et al. 2008).

Bat activity and fatality appear to be higher on nights with relatively low wind speed. Kerns et al. (2005) reported that the majority of bats were killed on low wind nights when power production appeared insubstantial (low percentage of total possible capacity generation), but turbine blades were still moving, often times at or close to full operational speed (17 rpm). The proportion of 10 min intervals from 2000–0600 hr when wind speed was <4 m/sec was positively related to bat fatalities ($r = 0.561$, $p < 0.001$ at Mountaineer; $r = 0.624$, $p < 0.001$ at Meyersdale), whereas the reverse was true for proportion of the night when winds were >6 m/sec ($r = -0.634$, $p < 0.001$ at Mountaineer; $r = -0.66$, $p < 0.001$ at Meyersdale). Horn et al. (2008) found a negative relationship between the number of bat passes observed from infrared thermal images and average nightly wind speed at the Mountaineer facility, corroborating the finding of higher bat fatalities on low wind nights at this facility. In Germany, Brinkmann (2006) observed higher activity of bats via thermal imaging when wind speeds were between 3.5 and 7.5 m/s, but also observed some activity up to 10.9 m/s. At Buffalo Mountain, Tennessee, Fiedler (2004) found a negative relationship between bat fatality and wind speed and temperature and a positive relationship with wind direction. The positive relationship with wind direction indicated that the farther nightly wind direction was from the Southwest (the prevailing wind direction), the more likely a fatality event was to occur, perhaps due to more northerly winds associated with storm fronts and/or conditions that are conducive for bat migration (Fiedler 2004). Fiedler (2004) also suggested that the presence of more northerly winds during nights with fatality may be related to weather conditions conducive for bat migration, and that negative associations with the other three variables imply that fatality occurrence was more likely during cooler nights with calmer, less variable winds. Acoustic monitoring of bats at proposed wind facilities corroborates these findings and indicates that bat activity generally is higher on low wind nights (Reynolds 2006; Arnett et al. 2006). Studies in Europe also corroborate these findings (Brinkman 2006). These observed patterns offer promise toward predicting periods of high fatality and warrant further investigation at wind facilities worldwide to assess whether these findings represent predictable, annual patterns.

WILDLIFE HABITAT IMPACTS AND DISTURBANCE AT WIND FACILITIES

Little is known about habitat impacts from development associated with wind facilities. Most permitting documents contain estimates of short- and long-term disturbance, but seldom include estimates of indirect impact. Additionally, efforts to follow up with post-construction estimates of actual impact are rare. Wildlife habitat impacts can be considered direct (e.g., vegetation removal and/or modification and physical landscape alteration, direct habitat loss) or indirect (e.g., behavioral response to wind facilities, hereinafter referred to as displacement or attraction). Impacts may be short-term (e.g., during construction and continuing through the period required for habitat restoration) and long-term (e.g., surface disturbance and chronic displacement effects for the life of the project). Duration of habitat impacts vary depending on the species of interest, the area impacted by the wind facility (including number of turbines), turbine size, vegetation and topography of the site, and climatic conditions in a particular region, which influences vegetation. Road construction, turbine pad construction, construction staging areas, installation of electrical substations, housing for control facilities, and transmission lines connecting the wind facility to the power grid also are potential sources of negative habitat impacts. Presence of wind turbines can alter the landscape so as to change habitat use patterns of wildlife, thereby displacing wildlife from areas near turbines. It is possible that audible noise from wind turbines can impact wildlife, but these effects are largely unknown.

Below, we synthesize what is known about habitat impacts from the few studies that have been conducted, draw inference from a broader literature on habitat impacts, and hypothesize potential impacts of wind turbines on wildlife.

Habitat Loss and Fragmentation

Wind facilities can cover relatively large areas (e.g., several square kilometers), but have relatively low direct impact to the project area. The BLM Programmatic Environmental Impact Statement (BLM 2005) estimated that the permanent footprint of a facility is 5 percent to 10 percent of the site, including turbines, roads, buildings, and transmission lines. This estimate was made for the more arid West and may differ for areas in the East, particularly in mountainous regions. Information on actual habitat loss was estimated from a review of permitting documents for 17 existing facilities or those under construction. The facilities ranged in size from 34 turbines (50 MW) at the proposed Chautauqua, New York, facility to the San Gorgonio, California, wind facility including more than 4,000 turbines of a variety of sizes. The total area of estimated impact ranged from 434 ha at the Foote Creek, Wyoming, wind plant to only 6.5 ha for the 16 turbine Buffalo Mountain, Tennessee, wind facility. In general, direct loss of habitat is relatively small, with the maximum surface disturbance of approximately 1.2 ha/turbine during construction (BLM 2005). However, a careful examination of the estimated direct impacts for the 17 facilities gave unrealistic, underestimated ranges of per turbine estimates of impact. For example, per turbine estimates of the size of permanent footprints for 1.5 MW turbines ranges from 1.4 ha for the proposed 34-turbine Chautauqua facility to 0.4 ha/turbine for the 120-turbine Desert Claim project in Kittitas County, Washington. While there appears to be some economy of scale for site impacts, the largest variable in all projects was length of new road construction.

Short-term construction surface disturbance has been estimated to be as much as three times the long-term surface disturbance, although short-term impacts for 17 permitting documents reviewed suggest that approximately 1.6 times the number of hectares of the permanent project footprint were affected. Construction impacts primarily result from wide construction rights of way to accommodate large cranes and, in mountainous terrain, the wide turning radius required to accommodate trucks hauling turbine blades in excess of 40 m. In addition, construction staging and equipment storage areas may be temporary disturbances. The length of time required to reclaim a site will vary depending on climate, vegetation, and reclamation objective. For example, if the objective is to return the site to pre-disturbance condition, reclamation may be relatively rapid in grassland, on the order of 2 to 3 years, versus de-

The presence of wind turbines can alter the landscape and may change habitat use patterns, thereby displacing some species of wildlife from areas near turbines. (Credit: Ed Arnett, Bat Conservation International)

Wind facilities located in habitats modified by agriculture will have fewer habitat impacts relative to those developed in undisturbed habitats. (Credit: Ed Arnett, Bat Conservation International).

cades in desert environments.

Ultimately, the greatest habitat-related impact to wildlife may result from disturbance and avoidance of habitat. Because direct habitat loss appears to be relatively small for wind power projects, the degree to which this disturbance results in habitat fragmentation depends on the behavioral response of animals to turbines and human activity within the wind facility.

Aerial perspective of structural habitat fragmentation due to oil, gas, and wind energy development within sand sagebrush (Artemesia filifolia) rangelands, Oklahoma. (Credit: D. Wolfe, G. M. Sutton Avian Research Center).

Habitat-Related Impacts on Birds

Grassland birds. Much attention regarding wind energy development and habitat fragmentation has focused on grassland birds for a number of reasons. First, North America's interior grassland habitats (tall, mixed, short, and sage) have steadily become more fragmented by a variety of human-induced influences (Samson and Knopf 1994, Knopf and Samson 1997). In many areas already fragmented by agriculture, the uncultivated grassland that remains exists on hilltops and in other locations that are difficult to plow but also have the greatest wind energy production potential (perhaps as much as 90 percent of the United States wind power potential [Weinberg and Williams 1990]). Second, among all bird groups, grassland birds have suffered population declines more consistently than any other suite of species, including Neotropical migrants (Droege and Sauer 1994), owing in part to the aforementioned habitat loss and fragmentation. Finally, of the three ecosystem types in the United States with greatest wind resources (Great Lakes, mountains, and grassland; Elliott et al. 1986), grassland habitats have the fewest logistical impediments to construction when transmission is available and currently have extensive wind energy development ongoing or planned (Weinberg and Williams 1990).

Relatively little work has been done to determine the effect of wind facilities on use of grasslands by birds. Here, we focus primarily on breeding birds, but recognize that it is likely that migrating and wintering birds may avoid wind facilities (Exo et al. 2003), although habitat for those activities is not suspected to be limiting or to influence population dynamics of grassland birds. In addition to the findings from studies of wind energy developments, we draw inferences from the larger body of literature on habitat fragmentation, which for grassland birds has grown considerably in the past decade (Johnson 2001).

Leddy et al. (1999) found that total breeding bird densities were lower in Conservation Reserve Program (CRP) fields with turbines compared with those without turbines in southwestern Minnesota. Moreover, densities of birds along transects increased with distance from turbines. While the extent of influence of turbines was uncertain, densities of birds were markedly lower within 80 m of the turbine string (Table 3; Leddy et al. 1999). Reduced avian use near turbines was attributed to avoidance of turbine noise and maintenance activities and reduced habitat effectiveness because of the presence of access roads and large gravel pads surrounding turbines (Leddy 1996; Johnson et al. 2000a). Other studies (e.g., Johnson et al. 2000b, Erickson et al. 2004) suggest that the area of influence of wind turbines is fairly small and that grassland birds occur in lower densities only within 100 m of a turbine. However, at a large wind facility at Buffalo Ridge, Minnesota, abundance of shorebirds, waterfowl, gallinaceous birds, woodpeckers, and several groups of passerines was significantly lower at survey plots with turbines compared with those without turbines (Johnson et al. 2000b). There were fewer differences in avian use as a function of distance from turbines, however, suggesting that the area of reduced use was limited primarily to those areas within 100 m of turbines (Johnson et al. 2000b). Some proportion of these displacement effects likely resulted from direct loss of habitat near the turbine from concrete pads and associated roads. These results are similar to those of Osborn et al. (2000), who reported that birds at Buffalo Ridge avoided flying in areas with turbines. Preliminary results from the Stateline (Oregon-Washington) wind facility suggest a fairly small-scale impact of the wind facility on grassland nesting passerines, with a large part of the impact related to direct loss of habitat from turbine pads and roads, and temporary disturbance of habitat between turbines and road shoulders (Erickson et al. 2004). Horned larks appeared least affected, with some suggestion of displacement for grasshopper sparrows *(Ammodramus savannarum),* although sample sizes were limited.

Research on habitat fragmentation has demonstrated that several species of grassland birds are area-sensitive, prefer larger patches of grassland, and tend to avoid trees. Area-sensitivity in grassland birds was reviewed by Johnson (2001); 13 species have been reported to favor larger patches of grassland in one or more studies. Other studies have reported an avoidance of trees by certain grassland bird species. Many of the studies refer to an avoidance of "edge," but edges in most studies consisted of woody vegetation. Seven grassland bird species have been shown to be edge-averse (Johnson 2001). Based on the available information, it is probable that some disturbance or displacement effects may occur to the grassland/shrub-steppe avian species occupying a site. The extent of these effects and their significance is unknown and hard to predict but could range from zero to several hundred meters.

Raptors. Development of wind turbines near raptor nests may result in indirect and direct impacts; however, the only report of avoidance of wind facilities by raptors occurred at Buffalo Ridge, where raptor nest density on 261 km^2 of land surrounding a wind facility was 5.94/100 km^2, yet no nests were present in the 32 km^2 wind facility itself, even though habitat was similar (Usgaard et al. 1997). Similar numbers of raptor nests were found before and after construction of Phase 1 of the Montezuma Hills, California, wind plant (Howell and Noone 1992). A pair of golden eagles *(Aquila chrysaetos)* successfully nested 0.8 km from the Foote Creek Rim, Wyoming, wind facility for three different years after it became operational (Johnson et al. 2000b), and a Swainson's hawk *(Buteo swainsoni)* nested within 0.8 km of a small wind plant in Oregon (Johnson et al. 2003a). In a survey to evaluate changes in nesting territory occupancy, Hunt and Hunt (2006) found that all 58 territories occupied by eagle pairs at APWRA in 2000 also were occupied in 2005.

Prairie grouse. Prairie grouse, which exhibit high site fidelity and require extensive grasslands, sagebrush, and open horizons (Giesen 1998, Fuhlendorf et al. 2002), may be especially vulnerable to wind energy development. Serious population declines and the fact that prairie grouse distributions intersect with some of the continent's most prime wind generation regions (Weinberg and Williams 1990) compound the concern. Leks, the traditional courtship display grounds of greater sage-grouse, Gunnison's sage-grouse *(Centrocercus minimus)*, sharp-tailed grouse *(Tympanuchus phasianellus)*, lesser prairie-chicken, and greater prairie-chicken, are consistently located on elevated or flat grassland sites with few vertical obstructions (Flock 2002). Several studies indicate that prairie grouse strongly avoid certain anthropogenic features (e.g., roads, buildings, powerlines), resulting in sizable areas of habitat rendered less suitable (Braun et al. 2002, Robel et al. 2004, Pitman et al. 2005). Robel et al. (2004) observed mean avoidance buffers (mean distances based on 90% avoidance by 187 nesting hens) of 397 m (se = 70) from transmission lines, 93 m (se = 25) from oil or gas wellheads, 1,371 m (se = 65) from buildings, 336 m (se = 51) from center pivot irrigation fields, and 859 m (se = 44) from either side of improved roads (32 m (se = 15) from unimproved roads). Robel (2002) predicted that utility-scale (1.5 MW) wind turbines would create an approximate 1,600 m radius avoidance zone for greater prairie-chicken nesting and brood-rearing activities. Based on this estimate, they projected that a proposed 100 MW wind facility in the Flint Hills, Kansas, would render 6,070–7,280 ha of very good to excellent tallgrass prairie habitat unsuitable for nesting and brood-rearing purposes; the actual size of this proposed project was roughly half this area.

The widespread expansion of wind energy development, as is proposed in many ecologically intact areas of the Great Plains, could threaten already sensitive and declining species. The lesser prairie-chicken may best illustrate this onerous potential. The remaining habitat of this species overlaps almost entirely with areas identified as prime for wind generation in Oklahoma. If wind energy development expands into unbroken native and restored grasslands of the five states the species inhabits, increased negative impacts could be expected. In addition to loss of habitat as a result of abandonment, it is probable that wind development will negatively affect landscape structure. Declining grouse populations are strongly affected by broad spatial landscape changes (e.g., fragmenting and diminishing prairie chicken home ranges; Woodward et al. 2001, Fuhlendorf et al. 2002). Patten et al. (2005) suggested that landscape fragmentation would result in an expansion of home range size for greater prairie-chickens, likely resulting in decreased survivorship due to predation, collisions, and increased energy expenditures.

Other avian species. Estimated size of the mountain plover *(Charadrius montanus)*[2] population at the Foote Creek Rim wind facility declined from 1995 to 1999 during the wind facility construction period (1998 to 2000). It is not known if plovers were simply displaced from the rim because of construction activity or if the population declined, but declines recorded at a reference area and in other regional populations (southeast Wyoming – northeast Colorado) suggest a larger species-wide or regional phenomena coincidental to observations at Foote Creek Rim. In Europe, some species appear unaffected by the presence of wind turbines (Winkelman 1990), while certain waterfowl, shorebird, and songbird species are known to avoid turbines (e.g., European golden plovers [*Pluvialis apricaria*] and northern lapwings [*Vanellus vanellus*; Pederson and Poulsen 1991], Eurasian curlews [*Numenius arquata*; Winkelman 1990]). Spaans et al. (1998) suggested variable levels of disturbance for feeding and roosting birds and concluded that with the exception of lapwings, black-tailed godwits *(Limosa limosa)*, and redshanks *(Tringa tetanus)*, many species used areas for breeding that were close (within 100 m) to the wind facilities. Displacement effects of up to 600 m from wind turbines (reduced densities) have been recorded for some waterfowl species (e.g., pink-footed goose [*Anser brachyrhunchus*]; and European white-fronted goose [*Anser albifrons albifrons*]; Spaans et al. 1998). Larsen and Madsen (2000) found that avoidance distance of pink-footed geese from wind farms with turbines in lines and in clusters were estimated to be 100 m and 200 m, respectively. Low estimated waterfowl mortality at these sites may be due to the ability of waterfowl to avoid turbines, as suggested by Fernley and Lowther (2006). However, ability to avoid turbines may be related to weather conditions and availability of other suitable habitats. In Iowa, primary foraging habitat for geese (corn fields) is very common surrounding wind facilities, and no large-scale displacement of Canada geese *(Branta canadensis)* was apparent based on counts and behavior observations of geese in areas with and without turbines (Koford and Jain 2004).

David Young (Western Ecosystems Technology) studied mountain plovers at the Foote Creek Rim wind facility from 1995–1999. Declines of this species were reported at the wind facility, a reference area, and for other regional populations in southeast Wyoming and northeast Colorado, suggesting broader species-wide or regional phenomena coincidental to observations at Foote Creek Rim. (Credit: Fritz Knopf)

[2]The U.S. Fish and Wildlife Service proposed listing mountain plover as a threatened species under the Endangered Species Act in February 1999 (USFWS 1999). Prior to this time, mountain plover had been included on the USFWS list of candidate species. In 2003, the USFWS found that listing mountain plover as threatened was not warranted and withdrew the proposed rule, stating that the threats to the species as identified are not as significant as earlier believed, and the plover is now not designated as a candidate species.

Habitat-Related Impacts on Bats

Unlike some forest-dependent species, bats may actually benefit from modifications to forest structure and the landscape resulting from construction of a wind facility. Bats are known to forage readily in small clearings (Grindal and Brigham 1998, Hayes 2003, Hayes and Loeb 2007) like those around turbines. Studies also have suggested that many species use linear landscape elements, such as those created by roads built through forest, for successful foraging or commuting (Grindal 1996, Russo et al. 2002, Patriquin and Barclay 2003), echo-orientation (Verboom et al. 1999) and protection from predators or wind (Verboom and Huitema 1997). Forest edge effects created by clearing also may be favorable to insect congregations and a bat's ability to capture them in flight (Verboom and Spoelstra 1999). Both local populations of bats as well as migrants making stopovers may be similarly attracted to these areas. However, the removal of roost trees would be detrimental to bats. Disturbance to tree- and crevice-roosting bats from wind turbines is completely unknown. It is not likely that noise generated by turbines influences roosting bats, but no empirical data exist to support or refute this contention. Increased human activity at wind facilities could disturb roosting bats, but, again, no data exist.

Habitat-Related Impacts on Large Mammals

Direct evidence of impacts on large mammals generally is lacking, and inferences are indirect based on disturbance from other anthropogenic sources. At western wind facilities located in native range, the species of concern are usually elk *(Cervus elaphis)*, mule deer *(Odocoileus hemionus)*, and pronghorn *(Antelocapra americanus)*. In the Midwest and eastern United States and Canada, white-tailed deer *(Odocoileus virginianus)* and black bear *(Ursus americanus)* may be impacted by development of wind energy. Deficiencies in quality and/or quantity of habitat can lead to population declines. During the 9- to 12-month period of construction at a wind facility, it is expected that large mammals will be temporarily displaced from the site due to the influx of humans and heavy construction equipment and associated disturbance (e.g., blasting). Construction is rarely performed during winter, thus minimizing construction disturbance to wintering ungulates. Following completion of a project, disturbance levels from construction equipment and humans diminish, and the primary disturbances will be associated with operations and maintenance personnel, occasional vehicular traffic, and presence of turbines and other facilities.

Direct loss of habitat for large mammals resulting from wind development has been documented in several states, although these losses generally encompassed habitat in adequate supply and, to date, have not been considered important. The impacts of habitat loss and fragmentation are greatest when habitat is in short supply. Roads associated with energy development also may fragment otherwise continuous patches of suitable habitat, effectively decreasing the amount of winter range, for example, available for ungulates. Fragmentation of habitat also may limit the ability of ungulate populations to move throughout winter range as conditions change, causing animals to utilize less suitable habitat (Brown 1992). At the Foote Creek Rim facility in Wyoming, pronghorn observed during raptor use surveys were recorded year-round before and after construction (Johnson et. al. 2000) and results indicated no reduction in use of the immediate area. A recent study regarding interactions of a transplanted elk population with an operating wind facility found no evidence that turbines had significant impact on elk use of the surrounding area (Walter et al. 2004). There is concern that development of wind power in the northeastern United States on forested ridge tops, in stands of mast-producing hardwoods, and in wetlands will have a negative impact on black bears. In the state's wind policy, the Vermont wildlife agency expresses this concern, but notes that negative impacts have not yet been documented. Perhaps the greatest potential for impact is disturbance of denning black bears. In a review of the literature on den site selection, Linnell et al. (2000) found that black bears generally select dens 1–2 km from human activity (roads, habitation, industrial activity) and seemed to tolerate most activities that occurred >1 km from the den. Activity <1 km and especially within 200 m caused variable responses, including den abandonment. While the loss of a single den site may not lead to deleterious effects, den abandonment can lead to increased cub mortality (Linnell et al. 2000).

While the footprint of wind facilities is relatively small, if the facilities are placed in critical habitat areas, the direct loss of habitat would be a negative for large mammals. Additionally, studies on the impacts of oil and gas developments on ungulates suggest shifts in use, avoidance of roads, and potential declines in reproduction and abundance (Van Dyke and Klein 1996, Sawyer et al. 2006). Studies of mule deer and elk in Oregon suggest that habitat selection and movements may be altered by roads, primarily because of the associated human activities (Johnson et al. 2000, Wisdom et al. 2004). Large mammals may avoid wind facilities to some extent, depending on the level of human activity. These impacts could be negative and perhaps biologically significant if facilities are placed in the wrong locations, particularly if the affected area is considered a critical resource whose loss would limit the populations.

Habitat-Related Impacts on Other Wildlife

Virtually nothing is known about habitat-related impacts on other species of wildlife, including reptiles, amphibians, forest carnivores, and small mammals. In a study addressing the influence of audible noise from turbines on predator strategies employed by California ground squirrels *(Spermophilus beecheyi)* at Altamont Pass, Rabin et al. (2006) reported that this species may be able to cope with noise from wind turbines through behavioral modifications in a predatory context. While inferences about potential habitat impacts from wind facilities on other wildlife could be drawn from data on other sources of disturbance, more studies would be useful for understanding and mitigating these potential impacts for other species.

OFFSHORE WILDLIFE—WIND ISSUES

Interest is high in establishing wind-generating facilities along portions of the Atlantic Coast, Lower Gulf Coast (LGC) of Texas, and the Great Lakes. Terrain offshore (coastal shelf) in these areas is shallow for a relatively long distance from shore, which permits placement of towers into the bottom substrate with existing technology. The first major wind-energy development proposed for the Atlantic Coast is located in Nantucket Sound, Massachusetts (Cape Wind Project). This project met with opposition from several groups, including those concerned with potential impacts to local fauna and the lack of studies on the movements of birds through the project area. In 2005, the State of Texas began steps for permitting the first commercial offshore wind-energy development, planned for a location off Galveston Island.

Although studies seem to indicate that wind facilities in some locations of the United States have a minor impact on birds compared to other sources of collision mortality, one cannot assume that similar impacts would occur among birds using wind-generating sites established offshore. As with land-based wind development, offshore development must also address cumulative impacts to birds, bats, and marine resources.

Offshore Bird Movements and Behavior

Three migratory bird corridors converge immediately north of Corpus Christi, Texas, effectively funneling tens of millions of birds along the LGC to wintering grounds in south Texas and Latin America. Over 200 species of birds migrate along the LGC in Texas annually and several federally threatened or endangered species are included among these. The largest numbers of migrating birds cross the Gulf of Mexico from the northern Texas coast, eastward to the Florida panhandle (Figure 4). Crossing the Gulf represents the shortest route to extreme southeast Mexico for some migrants, while birds migrating along the LGC tend to follow the coastline because of its primary north-south orientation, rendering crossing the Gulf relatively less important (Figure 4, route 5; Lincoln et al. 1998).

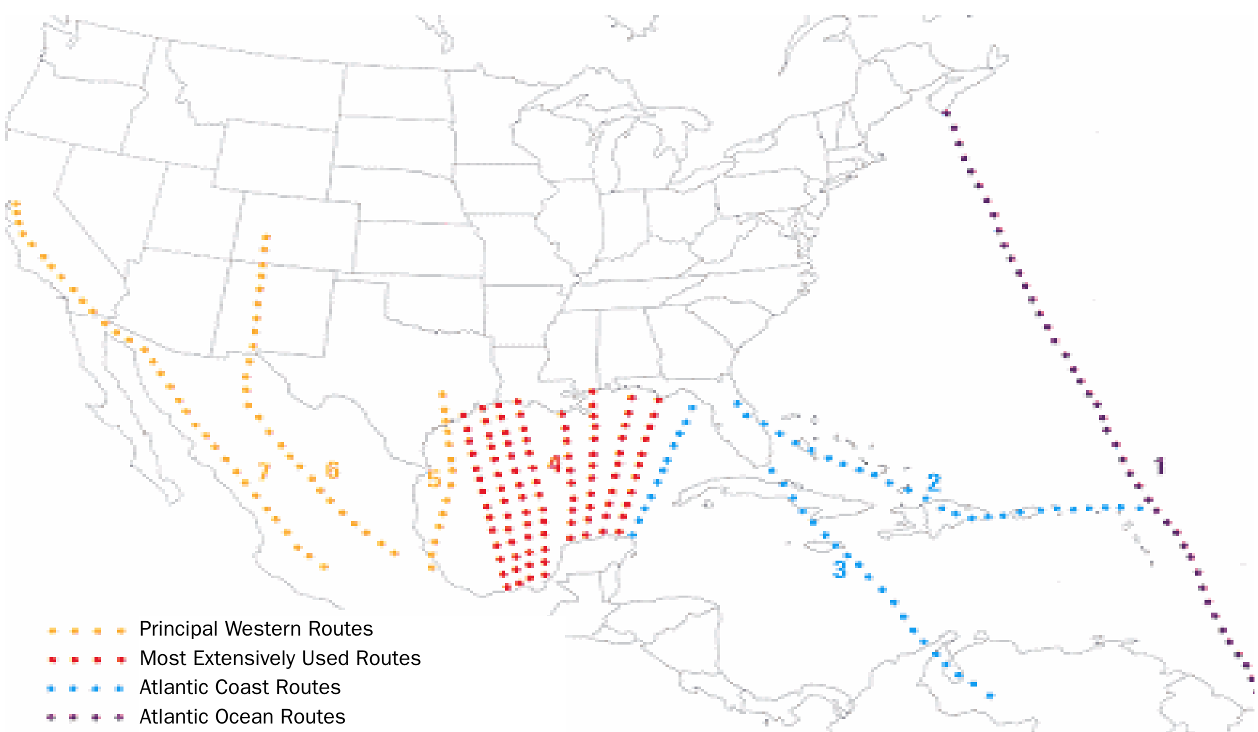
One of the most important components of avian migration strategies is their use of local habitats for resting and refueling while en route. In light of the absence of natural islands or other terrestrial habitats in the Gulf of Mexico, it seems inevitable that the installation of thousands of artificial islands in the northern Gulf must affect migrants in some fashion. However, few systematic studies have examined the influence of Gulf oil platforms on trans-Gulf migrating birds. From 1998–2000, Russell (2005) studied the ecology of trans-Gulf migration and the influence of platforms and showed that most spring trans-Gulf migration detected by radar occurred between 25 March and 24 May, but very large flights (>25 million migrants) occurred only in the three-week period from 22 April to 13 May. Waterfowl and herons peaked by early

April and shorebirds had widely varying migration schedules, with different species peaking as early as mid-March and as late as the end of May. Landbird migrants showed peaks throughout the season, but a majority of species peaked in the second half of April. Theoretical analyses of radar data yielded total seasonal estimates of 316 million trans-Gulf migrants in spring 1998 and 147 million trans-Gulf migrants in spring 1999. Radar-observed spring migration was characterized by a series of pulses and tended to be "all-or-nothing"; that is, either significant trans-Gulf migration was evident on radar or else it was essentially entirely absent. Dramatic hiatuses in radar-observed migration were always associated with strong cold fronts that penetrated deep into Mexico and set up persistent northerly winds over most of the Gulf (Russell 2005). Studies such as that of Russell (2005) indicate that potential exists for interactions between a substantial number of migrant birds and offshore and near-shore wind turbines.

Although Neotropical migrant birds do pass offshore along the Atlantic Coast (Figure 4), the magnitude of migration is small relative to that along the Gulf Coast. Concern along the Atlantic Coast is focused more on potential impacts to waterbirds such as gulls, terns, waterfowl, and other species that make regular movements in near-shore areas. There are many "Important Bird Areas," locations that harbor a high number of birds or species of special concern (e.g., Federally designated Birds of Conservation Concern and Federally listed threatened or endangered birds), along the eastern seaboard. Although areas where birds migrate through or concentrate seasonal activities are generally known, the specific timing, routes, and altitudes of movement within and between resting and foraging areas and altitudes that migrants use are poorly known, and such information is needed to conduct assessments of the potential risk of to birds from offshore wind developments.

Consequently, impacts of a wind-generating facility located on the LGC and Atlantic Coast could be different from each other and also different than those located at other sites throughout the United States simply because the behavior, abundance and diversity of birds that migrate or reside on any wind-generating facility site may be much different than at inland facilities. Russell (2005) found that migrants would sometimes arrive at certain oil platforms

Figure 4. Primary migratory routes of birds (from Lincoln et al. 1998).



shortly after nightfall and proceed to circle those platforms for variable periods ranging from minutes to hours. The numbers of birds involved varied from a single individual to many hundreds of migrants and, while a wide variety of species was recorded in circulations, herons, shorebirds, swallows, and warblers were most common. This behavior, if repeated around offshore wind turbines, could raise the risk of collision with the tower or the blade. Russell (2005) concluded that this circling behavior was related to attraction of the birds to platform lights. Many offshore developments have proposed turbine-tower combinations that are near or exceed 160 m in total height, making them highly visible from several km away. In some locations, aircraft warning lights may be required by the FAA, which adds another dimension to visual considerations.

Offshore Impacts on Habitat and Animal Movements

Offshore wind facilities have been established throughout Europe, but few studies have been conducted to determine impact on animals. Most of these developments are small relative to onshore developments (although larger projects are being planned). Some disruption in bird flight patterns has been noted in Europe, although additional study is needed. However, there does not appear to be disruption in fish movements or populations (Morrison 2006). The effects on marine mammals warrant study and clarification, especially since most great whales are federally listed. A major concern with offshore developments relates to impacts on animal behavior and movement from boat and helicopter traffic to and from the wind development that could extend far outside the boundaries of the turbines.

European Studies

More than 280 studies have been conducted relating environmental and human effects from offshore wind installations in Europe. There have been, however, concerns about the adequacy of these studies because most projects had few turbines (less than 10), did not employ rigorous study design, and were not peer-reviewed. To address uncertainty from past studies, two major projects were developed: Concerted Action for the Offshore Wind Energy in Europe (CA-OWEE) and Concerted Action for the Deployment of Offshore Wind (COD). In 2005, COD compiled available studies in a searchable electronic database and summarized its findings in a final report: "The COD work on the establishment of an environmental body of experience has brought an important overview of the present state of knowledge in this up-to-now unknown field" (COD 2005, 2).[3] Two Greenpeace International reports summarized environmental impact assessment studies in Europe prepared by Deutsches Windenergie Institute (2000) and Deutsche WindGuard GmbH (2005), respectively.[4]

These reports suggest that major risks from offshore wind turbines to sea birds and resting birds are:

- Permanent loss of habitat due to displacement;
- Collisions with the turbines; and
- Barrier effects, including fragmentation of the ecological habitat network (e.g., breeding or feeding areas).

Of these, collisions and disturbance were considered primary impacts on sea birds and resting birds, although these groups may be at less risk than migrating birds, as they may adapt better to offshore wind facilities (COD 2005). Large offshore wind facilities may diminish foraging and resting conditions and so assessment of cumulative effects is needed. Thus far, risks of habitat loss and barrier effects for birds have not been quantitatively estimated. Avoidance behavior of birds is significant in evaluating these risks; species-specific avoidance behavior and overall availability of suitable areas are important considerations when evaluating impacts.

Collisions of birds with wind turbines at offshore wind facilities, in most cases, are only a minor problem (but with exceptions in some poorly sited land-based facilities [Greenpeace International 2000, section 5.3.3]). Quantitative risk estimates for collision risks are difficult to obtain due to the fact that impacts are highly site-dependent, inadequate data exist on bird migration routes and flight behavior

[3]See the CA-OWEE and COD reports and database at www.offshorewindenergy.org. See the summary in "COD, Principal Findings 2003-2005," prepared by SenterNovem in the Netherlands, as part of a series highlighting the potential for innovative non-nuclear energy technologies.
[4]See "Offshore Wind: Implementing a New Powerhouse for Europe; Grid Connection, Environmental Impact, Assessment, Political Framework," 4 April 2005, WindGuard GmbH, commissioned by Greenpeace, at http://www.greenpeace.org/international/press/reports/offshore-wind-implementing-a and "North Sea Offshore Wind—A Powerhouse for Europe; Technical Possibilities and Ecological Consideration," 2000.

(Exo et al. 2003), impacts vary for different bird species, measurements address only found bird corpses, and results thus far are often contradictory between studies (Desholm and Kahlert 2005). Winkelman (1994) provides an overview of research carried out in Europe with special emphasis on results of the two most in-depth studies (Winkelman 1992, parts 1-4). At 108 sites, 303 dead birds were found, of which at least 41 percent were proven collision deaths. Of 14 collisions visually observed, 43 percent were caused by birds swept down by the wake behind a rotor, 36 percent by a rotor, and 21 percent unknown. The author states that total numbers likely to be killed per 1,000 MW of wind power capacity are low relative to other human-related causes of death. Because fewer birds probably collided with the middle row of wind turbines, Winkelman (1992) suggested that a cluster formation of turbines may cause fewer impacts than a line formation. Lighting of wind turbines was believed to be harmful rather than beneficial, particularly when weather and visibility are bad (Winkelman 1992, 1994). Still, a number of studies conducted thus far at offshore facilities suggest little or no impact on bird life (COD 2001). A recent study of 1.5 million migrating seabirds from Swedish wind facilities in Kalmarsund concluded that fatality risk to passing seabirds was only one in 100,000 (Eriksson and Petersson 2005). In Denmark, radar studies indicate that migrating birds avoid flying through the Nysted wind facility. These studies reveal that 35 percent of the birds fly through the area at baseline, but only 9 percent after construction. Monitoring at the operating Horns Rev wind facility in Denmark found that, "…most bird species generally exhibit an avoidance reduction to the wind turbines, which reduces the probability of collisions" (Elsam Engineering and ENERGI E2 2005). From the European point of view, in most circumstances disturbance and habitat loss are thought to be of much more importance than bird mortality, although the consequences on populations remain unknown.

Winkelman (1994) also summarized findings on disturbance and effect of turbines on flight behavior, which were investigated in most studies. Up to a 95 percent reduction in bird numbers has been shown to occur in the disturbance zones (250–500 m from the nearest turbines). Winkelman (1985) studied the possible danger to birds of medium-sized wind turbines (tower height 10–30 m) situated on six small wind facilities located along or near the Dutch coast and reported that diurnal migrants seemed to respond more to operating turbines than did local birds. An average of 13 percent of migrating flocks and 5 percent of local flights showed a change in flight behavior that could be attributed to the turbines during this study, suggesting that local birds may habituate to wind turbines. Fox and Nilsson (2005) summarized results from offshore radar studies in Denmark and Sweden, respectively, and reported marked seaduck avoidance of existing wind facilities ("Offshore and Nearshore Wind Development, and Impacts to Sea Ducks and Other Waterbirds," 2nd N. Am. Sea Duck Conference, Annapolis, MD, 2005; results on USGS-Patuxent Wildlife Research Area website). Winkelman (1990) studied behavior of birds approaching wind turbines during day and night conditions and found that 92 percent of birds approached the rotor without any hesitation during the day compared to 43 percent at night. During high-use nights, Winkelman (1990) found that 56 percent to 70 percent of the birds passed at rotor height (21–50 m) and more birds collided with the rotor at night and twilight than during the day. Of 51 birds recorded trying to cross the rotor area during twilight and total darkness, 14 (28%) collided while only one of 14 birds (7%) collided, during the day. Based on the number of birds passing at rotor height and the proportion of birds colliding, Winkelman (1990) estimated 1 out of 76 birds passing the towers at night was expected to collide with turbines when the facility was fully operational.

Following Winkelman's (1994) review, Exo et al. (2003) reviewed the status of offshore wind-energy developments and research on birds in Europe and noted that European seas are internationally important for a number of breeding and resting seabird populations that are subject to special protection status. Moreover, every year tens of millions of birds cross the North Sea and the Baltic Sea on migration. They concluded the erection of offshore wind turbines may affect birds as follows: (1) risk of collision; (2) short-term habitat loss during construction; (3) long-term habitat loss due to disturbance by turbines, including disturbances from boating activities in connection with maintenance; (4) formation of barriers on migration routes; and (5) disconnection of ecological units, such as between roosting and feeding sites. These researchers also stated it was vital that all potential construction sites are considered as part of an integral assessment framework, so that cumulative effects can be fully taken into account. They concluded, however, that making these assessments was hindered by a lack of good data on migration routes and flight behavior of many of the relevant bird species. They added that, based on experience gained from studies at inland wind facilities and at the near-shore sites where environmental impact assessments are currently under way, marine wind facilities could have a significant adverse effect on resident seabirds and other coastal birds as well as migrants. Moreover, the potential impacts may be considerably higher offshore than onshore. Disturbance and barrier effects probably constitute the highest conflict potential (Exo et al. 2003). While further studies are needed to better define the risks, precautionary measures to reduce and mitigate such risks exist. For example, careful siting of wind facilities away from bird migratory paths, bird habitats, and large concentrations of species at higher risk is possible.

ISSUES REGARDING STUDIES ON WIND ENERGY AND WILDLIFE

The location of a wind facility can be critically important based on its known, suspected, or potential impacts on wildlife and their habitats. By performing risk evaluations and pre-construction monitoring, potential impacts could be predicted and potentially avoided or mitigated. Post-construction evaluations, in turn, can validate (or negate) hypotheses, conclusions, and assumptions reached from risk evaluations and pre-construction monitoring performed before the project is actually built. Post-construction monitoring also provides data allowing "mid-course corrections" to respond to problems discovered by monitoring through subsequent use of deterrents (although no deterrents of proven effectiveness are currently available), mitigation, or alternative actions and can assist in the permitting and design of future facilities.

Peer Review and Publication

Currently, few studies of wildlife interactions with wind turbines have been published in refereed scientific journals, although this trend is changing. Most reports on wind-wildlife relationships have entered the "gray literature" and appear on the Internet, possibly accompanied by archived paper copies. Many others are retained by wind energy companies as proprietary material not available to outside parties, including regulatory agencies. We believe that peer review lends some credibility to "gray literature" even if a document is never published as a stand-alone paper in a scientific journal, but strongly encourage publication in journals. Peer review is an integral component of scientific research and publishing and an important means of ensuring sound information (The Wildlifer May-June 2006). The shortage of scientific publication on wind-wildlife interactions (GAO 2005, Kunz et al. 2007a) must be overcome to place the problem on a base of solid science.

Study Design and Duration

Investigations of wind turbine and wildlife interactions and impacts are relatively recent and there is a dearth of information upon which to base decisions. With few exceptions, most work conducted to date has been short-term (e.g., only one field season) and the frequency of study (e.g., both season length and time into the night at which research is conducted) also may be inadequate. Longer-term studies are required to elucidate patterns, better estimate fatality, and develop predictive models to estimate the risk of fatalities and evaluate possible habitat fragmentation or other disturbance effects. As one example, birds may continue to occupy habitats suddenly rendered unsuitable because of some "inertia" (Wiens et al. 1986). If that occurs, an unsuitable site will continue to support birds for several years, and a short-term evaluation will not identify effects of the treatment. Another example: some disturbance to the vegetation caused by construction might induce short-term effects that will diminish over time. For these reasons, it is desirable to monitor wind facilities for several years after construction. Years need not always be consecutive, although conducting studies in alternate years may pose budgeting difficulties. The British Government, for example, requires three to five years of post-construction monitoring on offshore projects constructed on Crown lands (DEFRA 2005).

Because randomization of "treatments" (installation of wind turbines) is not feasible, true experimentation is impossible. Before-After, Control-Impact (BACI) studies are the next best approach (Stewart-Oaten et al. 1986, Smith 2002), along with impact gradient studies in some cases (e.g., where habitats are homogeneous or where before data are unavailable). Some guidelines for conducting such studies have been developed recently (Anderson et al. 1999, Erickson et al. 2005), but these need to be modified to accommodate each particular site. Acquiring data on wildlife use at a site before construction begins is essential to account for variation in populations among sites. Collecting site-specific pre-construction data can be complicated when exact locations of wind turbines are not identified or divulged far enough in advance of construction to allow time to design and conduct monitoring. Data from reference sites without wind turbines improves understanding of potential cause and effect relationships, particularly where variation among years is common, such as in grassland bird populations, for example. In some situations, however, it is difficult to find sites that are similar in location, topography, vegetation, and land use, and which themselves are not sites of wind turbines.

Metrics and methods guidance document. Anderson et al. (1999) prepared a document for the National Wind Coordinating Committee (see www.nwcc.org) titled "Studying Wind Energy/Bird Interactions: a Guidance Document:Metrics and Methods for Determining or Monitoring Potential Impacts on Birds at Existing and Proposed Wind Energy Sites." This document contains detailed standardized metrics and methods for performing various studies, observations, and evaluations of the impact of wind energy facilities on wildlife. Anderson et al. (1999) present efficient, cost-effective study designs intended to produce similar types of data for comparison among projects, which could potentially reduce the need for detailed surveys or research at other proposed projects in the future. Specifically, the Metrics and Methods Document identifies four levels of surveys, which at the time the document was published were designed primarily for avian studies. They include:

1) "Site evaluation," where information is collected from existing sources including local expertise, literature searches, natural resource databases, lists of state and federally listed species and critical habitats, reconnaissance surveys of the site, vegetation mapping, and an assessment if information available is sufficient to make a defensible determination to build or not build at the site. These "evaluations" generally are not highly rigorous, as they are typically used to screen sites, although they may need to be if federally or state-listed species are present, or species susceptible to collisions or disturbance are present.

2) "Level 1 studies" include pre-permitting baseline studies, risk assessment studies, and monitoring studies designed to detect relatively large effects of operating wind facilities on wildlife. A BACI Design may also be used as part of a "level 1 study" since it may help answer the question, "did the average difference in abundance between the [control] area(s) and the wind plant area change after the construction and operation?" (Anderson et al. 1999:25). Meta-analysis, an approach to combining statistical results from several independent studies all dealing with the same issue, is also suggested as a tool for "level 1 studies."

3) "Level 2 studies" involve detailed studies of one or more populations, manipulative studies designed to determine mechanisms involved in fatality and risk, the quantification of risk to populations, and the evaluation of risk-reduction management practices.

4) "Risk-reduction studies" attempt to assess attributable risk versus preventable risk to avian populations; review suggestions for measuring risk; include counts for bird utilization, mortality, scavenger removal, and observer bias; and review the challenges addressing indirect interactions affecting "habitat" and "vegetation type."

In addition to research protocols suggested in the Metrics and Methods document, regulatory agencies also examine and may recommend other protocols (e.g., "best management practices" suggested by the BLM, suggestions from the Government of Great Britain in its regulatory offshore wind development [DEFRA 2005]), and specific recommendations from USFWS in its voluntary guidance to avoid and minimize impacts to wildlife and habitats [USFWS 2003]).

Inconsistent Methodology and Implementation

One problem with site review and evaluation is inconsistent implementation of procedures to assess impact and risk, and to perform pre-, during- and post-construction evaluation and monitoring. Some assessments are performed at minimal levels of evaluation while others at sites with an apparent comparable level of risk are performed in much more rigorous, scientifically valid ways. Use of standardized protocols to address specific questions would improve comparability of studies and credibility of efforts. Consistency would greatly assist regulatory agencies during decision making in regard to statutory trust responsibilities. However, state permitting processes vary widely in regard to environmental requirements, thus potentially hindering consistent development of objectives and implementation of methodologies. On private lands or where no federal nexus exists, federal agencies can only suggest which protocols might be used and to what extent.

Assessing the overall impact of a wind project is prudent and such broad assessments should include potential impacts such as collision mortality, indirect impacts from reduced nesting and breeding densities, habitat and site abandonment, loss of refugia, displacement to less-suitable habitats, effects on behavior of wildlife, changes in resource availability, disturbance, avoidance, fragmentation, and an assessment of cumulative impact. Unfortunately, indirect effects often are very difficult to predict. Inadequate or no impact assessments are problematic. For example, "risk assessments" performed for bats at Buffalo Mountain, Tennessee, Mountaineer, West Virginia, and Meyersdale, Pennsylvania, did not identify high risk (at least to non-federally listed bats; e.g., hoary and red bats), but later were documented to have the highest bat kills ever recorded at a wind facility (Arnett et al. 2008). While no formal "risk assessment" process was conducted at APWRA, California, USFWS biologists and other agency biologists and managers advised proponents in the late 1980s and early 1990s of potential problems, but these concerns have not been successfully addressed even though high levels of raptor mortality have been documented. Pre-construction estimation of such events and potential impacts requires more extensive study at both existing and proposed wind facilities. These broader assessments, while daunting, will be critical for understanding not only the potential impacts, but also development of solutions.

Technological Tools for Studying Wind-Wildlife Interactions

Numerous technological tools exist for conducting pre-construction assessments and predicting both direct and indirect impacts of wind facilities on wildlife (see Anderson et al. 1999 and Kunz et al. 2007b for detailed reviews). Here, we focus on remote sensing technologies that employ radar, thermal infrared imaging, and acoustic detection, but also recognize that other techniques exist to study wind-wildlife interactions (e.g., night vision, mist-netting, radio telemetry). No single method can be used unambiguously for assessing temporal and spatial variation in natural populations or the impacts of wind turbines on bats and nocturnally active birds. Employing a combination of techniques, including night vision observations, reflectance and thermal infrared imaging, marine radar, NEXRAD Doppler radar, and captures can contribute most toward understanding how bats and birds may be impacted by wind energy developments (Kunz et al. 2007b). Each device or method has its own strengths, limitations, and biases and it is essential for field researchers to understand these limitations and ensure that the fundamentals of study design and sampling (e.g., Anderson et al. 1999, Morrison et al. 2001) are employed and sufficient data are gathered to address the question of interest.

Radar is a broadly-applicable technique for observing flying animals (most radar systems are unable to distinguish individual "targets" or differentiate between birds and bats and insects) and is a widely used tool during pre-construction assessments at proposed wind facilities. Recent reviews by Bruderer (1997a, b), Diehl (2005), and Larkin (2005), as well as the classic text by Eastwood (1967), describe how various kinds of radar operate and their use in wildlife research and monitoring. With regard to wind energy facilities, radar has a role in broad-scale surveys of migratory and roosting movements of flying animals, pre-construction monitoring of proposed sites for wind facilities, and post-construction observation of the behavior of flying animals approaching fields of wind turbines and around individual turbines, and for estimating exposure for use in the analysis of bird and bat fatalities. Appropriate use of radar occupies a prominent position in the available tools because it can report the three-dimensional position of echo-producing objects ("targets"), operates day and night, can detect flying biota beyond the range of most other techniques, can be used freely in conjunction with other techniques such as light- and infrared-based observation, and does not affect the behavior of the animals being observed (Bruderer 1999).

Some kinds of radar data are relatively inexpensive to acquire. The long reach of the equipment and continuous, perhaps even unattended, operation appear ideal for quick surveys of the airborne biota. In the present climate favoring installing wind turbines quickly and the scarcity of funding for research on the machines' effects on wildlife, radar offers a powerful tool, yet decision-makers may be asked to accept radar data out of context and inappropriately. Those considering using radar should be aware of three possibly critical deficiencies:

- **Height (geometry).** Flying animals significantly above or below the rotor-swept area of turbines are probably in little danger. Therefore, surveys of local and migrating flying animals must document how they are distributed vertically. No radar can provide accurate height information at long range, and marine radar mounted in the conventional fashion cannot provide accurate height information.
- **Metal rotor blades.** Radar cannot be used to observe flying animals close to large, metal-containing, moving objects such as blades of wind turbines. "Close" is defined in terms of the resolution (pulse volume) of the radar when sited near a wind turbine. This disadvantage may be unimportant when studying only animals approaching a wind facility or a turbine rather than actually interacting with turbine blades.
- **Distinguishing targets.** A migrating bat may be orders of magnitude more vulnerable to wind turbines than a bird flying nearby, but the flying mammal and bird may present identical-appearing and -moving echoes on most radars. Even the mass of flying animals is only loosely related to body size (Vaughn 1985). This is part of a larger problem of detection bias that includes bias as a function of distance, interaction of targets (e.g., interpretation of intersecting targets), the determination of the actual space sampled by the radar, and the effect of weather and topography. Ongoing research is attempting to use optical techniques to provide taxonomic information when radar is being used.

Thermal Infrared (TI) cameras sense metabolic heat emitted by animals in flight, producing a clear image against the cooler sky and landscape without need for artificial illumination that may disturb normal behavior (Kunz et al. 2007b). Digital images are captured at variable rates up to 100 frames per second and recorded to disk, thus achieving high temporal detail for extended periods. TI may be useful for post-construction research. Horn et al. 2008 demonstrated that bats were more frequently observed in the vicinity of sampled turbines on forested mountain ridges during periods of low wind. Bats were observed striking various regions along the blade, approaching non-moving blades, and investigating the structure with repeated fly-bys, sometimes briefly alighting or landing on them. Small size and portability facilitate use of TI in the field, but monitoring turbines is challenged by finding a compromise between viewable area and resolution. A station may consist of a single high-resolution camera or an array of several lower-resolution cameras to achieve the same resolving power and viewable area. Multiple cameras with large field-of-view can be positioned close to turbines, improving image clarity and, during later analysis, permitting stereo estimation of distances and 3D reconstruction of flight paths. Collection of TI images currently is limited by availability of equipment, the need for large amounts of data storage, and costs of equipment and analysis of data.

Acoustic monitoring allows researchers to detect and record various calls of echolocating bats and vocalizing birds that can be used to assess relative activity and identify species or groups of species, which applies to both pre- and post-construction studies. Acoustic methods have several limitations. Detection is only possible when birds are calling or bats are echolocating within the range of the detectors, and factors influencing detection probability remain poorly understood. The method can only be used to indicate presence, but not absence. Pre-construction monitoring of vocalizations to identify sites with high levels of bird and bat activity or use by sensitive species prior to construction may be valuable in assessment of site-specific risks of turbine construction to birds and bats (Kunz et al. 2007b). A key assumption is that pre-construction activity, as estimated through vocalizations, is correlated with post-construction bird and bat mortality, yet we are currently unaware of any study linking pre-construction monitoring data with post-construction fatality, although such efforts are under way (e.g., Arnett et al. 2006). Acoustic detectors often are used in the field without a thorough understanding of underlying assumptions and limitations or standardized protocols (Hayes 2000, Weller and Zabel 2002, Gannon et al. 2003). Although echolocation calls are reliably distinguishable from other sounds (e.g., bird, arthropod, wind, mechanical), the ability to distinguish species of bats varies with taxon, location, type of equipment, and quality of recording, and may be challenging. Estimating amount of activity of those bats echolocating is straightforward, but estimating abundance requires differentiation between multiple passes of a single bat and multiple bats making single passes and is not usually possible.

RESEARCH NEEDS

Along with providing a framework for development of more robust experimental field design, use of accepted standardized protocols will greatly enhance researchers' ability to compare and analyze data among studies from various facilities. More important than interpreting results from individual studies is the search for consistent patterns ("metareplication," sensu Johnson 2002). What patterns are consistent, and what variation in patterns occurs among species, habitat types, and geographic locations? The effect of changing technologies (e.g., bigger turbines) on bird and bat fatalities should be investigated. Predictions of future impacts will necessarily be based on today's technology, but it is important that we understand how changing technology may affect those predictions. There also is the need to determine effectiveness of mitigation measures currently in use (e.g., turbine placement) and develop and evaluate new mitigation measures. It is important that a better understanding of the influence of wind facilities on wildlife and their habitats be sought and, to that end, studies should be undertaken at wind facilities and reference sites both before and after construction. Short-term studies may not identify potentially deleterious impacts of wind facilities or efficacy of mitigation. Longer-term and broader assessments of cumulative impacts and potential mitigation strategies are clearly warranted. The dearth of available information regarding impacts of wind development on wildlife creates uncertainty that should be addressed in an adaptive management context (Walters 1986, Walters and Holling 1990) until proven solutions to wildlife fatalities and habitat-related impacts are found. As new information becomes available, data should be used to trigger adjustments to mitigation strategies that reduce impacts on wildlife. Decision-making frameworks will be required to establish what data are required and how they will be used to establish triggers and thresholds for adjusting strategies for mitigating wildlife impacts.

Based on our review, we offer the following suggestions for priority research needed to elucidate patterns of fatality, evaluate the context and biological and population implications, determine risk to predict future impacts, develop mitigation strategies, and assess efficacy of methods and tools used to study impacts of wind energy development on wildlife and their habitats. Our suggestions are not exhaustive, but reflect our view of high-priority needs to advance our knowledge and develop effective mitigation strategies for the responsible development of wind energy.

Birds and Bats

Numerous questions require further and immediate investigation to advance the understanding of bird and bat fatalities at wind turbines, develop solutions for existing facilities, and aid with assessing risk at future wind facilities. First there needs to be a better synthesis of existing information. A priority research need for existing wind facilities is an estimate of impacts, both fatalities and habitat-related impacts for facilities located in unstudied or new locations (e.g., eastern mountains, the Southwest, coastal, offshore). Determining numbers of individuals, for both birds and bats, and their exposure to risk at turbines, is critical for developing a context upon which to evaluate fatalities. Bats appear to investigate turbines, perhaps for a number of reasons—acoustic and/or visual response to blade movement, sound attraction, and possible investigation of turbines as roosts, seem plausible given the findings and current state of knowledge. As such, further investigations are needed to determine causes of behavioral response to turbines and how to best mitigate or eliminate factors that put animals at risk of collision. Additional priority research, recommended by Arnett (2005), Arnett et al. (2008), and Kunz et al. (2007a) includes: 1) conducting extensive post-construction fatality searches for a "full season" of bat movement and activity (e.g., April through November in northern latitudes) at facilities encompassing a diversity of surrounding habitat characteristics to fully elucidate temporal patterns of fatality; 2) further investigating relationships between passage of storm fronts, weather conditions (e.g., wind speed, temperature), turbine blade movement, and bat fatality to determine predictability of periods of highest fatality; 3) investigating approaches for developing possible deterrents; testing any such deterrents should be performed under controlled conditions first, and then under a variety of environmental and turbine conditions at multiple sites; and 4) comparing different methods and tools (radar, thermal imaging, and acoustic detectors) simultaneously to better understand bat activity, migration, proportions of bats active in the area of risk, and bat interactions with turbines. It is also important to develop and verify models that allow prediction of impacts to individuals and populations of both birds and bats.

Habitat Loss, Fragmentation, and Disturbance

Two critical questions concerning habitat-related impacts remain unanswered and center on 1) the extent to which strings of wind turbines effectively fragment grassland habitat, and 2) how inferences about avoidance of trees and tall anthropogenic structures by birds transfer to avoidance of wind turbines. There is a need to determine relationships of small scale (e.g., habitat disturbance) versus large-scale habitat impacts (e.g., habitat fragmentation needs investigation) on wildlife. It is important to quantify and predict not only changes in habitat structure, but also displacement impacts, particularly on forest-dwelling and shrub-steppe/grassland birds (e.g. prairie grouse). Furthermore, development of roads for construction and maintenance may have important consequences; this issue is especially a concern in the West, which does not have as extensive networks of roads as in the Midwest. Future development of transmission lines to facilitate wind generation will undoubtedly have broad-ranging impacts on wildlife and their habitats that should be investigated as well. Likewise, potential mitigation of habitat disturbance from wind energy development, particularly in grassland habitats, through restoration of other nearby areas, should be investigated.

Habitat and Prey Density Management

Habitat modification to reduce prey densities has been discussed as a possible avian risk-reduction technique. Directly reducing prey (e.g., rodents) populations within the vicinity of wind turbines might reduce high-risk foraging activities by raptors. Suggested methods include county-sponsored abatement programs, reduced grazing intensities, and re-vegetation with higher-stature plants that pocket gophers and ground squirrels tend to avoid. The effects of widespread vegetation and/or rodent control programs would have to consider the effects on the overall demographics of the affected population as well as effects on other wildlife, such as protected species and special-status species like the San Joaquin kit fox *(Vulpes macrotis mutica)*, burrowing owl, and badger *(Taxidea taxus)*. There also may be impacts on other non-target rodent species such as kangaroo rats *(Dipodomys spp.)* and pocket mice *(Perognathus spp.)*, which have special status in some states. Research is needed to evaluate reductions in fatality relative to these management techniques.

Curtailment Experiments

Decreasing operation time of problem turbines or entire facilities has been suggested as a risk-reduction measure and recently was mandated at APWRA. Studies have reported that a large proportion of bat fatalities occur on nights with low winds and relatively low levels of power production (Feidler 2004, Arnett 2005, Brinkman 2006). Should this pattern prove to be consistent, curtailing operations during predictable nights or periods of high bat kills could reduce fatalities considerably, potentially with modest reduction in power production and associated economic impact on project operations. Thus, critical shutdown times could be predictable and implemented seasonally (e.g., during migration periods) or based on inclement weather or nighttime periods when visibility is reduced. Rigorous experimentation of moving and non-moving turbines at multiple sites to evaluate the effect on bird and bat fatality and the associated economic costs are needed. While the results from studies at APWRA, and studies just begun at Tehuantepec, Mexico, are not yet available, these datasets should provide important new information about the effects of seasonal shutdowns and turbine "feathering" (i.e., changing blade pitch to make turbines inoperative). Related research is ongoing in Europe and Canada and is anticipated in the United States beginning in 2008.

Alerting and Deterring Mechanisms

There currently is no effective alerting or deterring mechanism that has been proven to effectively reduce fatality of birds or bats. Laboratory tests suggest that some blade painting schemes may increase a bird's ability to see turbine blades (Hodos 2003), but these painting schemes have not been field-tested. Young et al. (2002) field tested the effect of painting turbines and blades with a UV gel coat, theoretically to increase a bird's ability to see the structures. However, field tests showed no difference in fatalities between treatment and control turbines. Although no research has been conducted on auditory deterrents to birds approaching wind turbines, audible devices to scare or warn birds have been used at airports, television towers, utility poles, and oil spills, yet most studies of auditory warning devices have found that birds become habituated to these devices. Birds do not hear as well as humans (Dooling 2002) and minor modifications to the acoustic signature of a turbine blade could make blades more audible to birds, while at the same time making no measurable contribution to overall noise level. Some research has been suggested on the use of infrasound, which appears to deter homing pigeons (*Columba livia*; Hagstrum 2000), but no studies have yet been conducted on this potential tool. At present there is no research under way that tests the effects of auditory deterrents on birds and, because of the low likelihood of developing a successful application, none is planned for the foreseeable future.

Development and testing of ultrasonic sound emission as a possible deterrent to bats has been undertaken in the United States (E. B. Arnett, Bat Conservation International, unpublished data); more research is needed to quantify the effectiveness of such devices at an operating facility that will include measures of fatality reduction as well as behavioral responses of bats. If such deterrents can be built and prove effective, long-term monitoring would be required at multiple sites to elucidate and justify effectiveness and determine whether bats habituate over time. Furthermore, a deterrent for bats will probably need to nullify or counteract the hypothetical attraction of some bats to wind turbines. Simply making turbines more easily perceived by bats may have no effect or could increase the hypothesized attraction. Although devices or procedures to repel bats from wind turbines may be discovered by trial and error, it is almost certain that an effective deterrent will emerge only after further basic research in the field permits us to understand the mechanism of attraction of bats to turbines (Larkin 2006).

Offshore

The priority research objective is to quantify seasonal occurrence, abundance, use, and location of birds along the Lower Gulf and Atlantic coasts. Specifically, research should focus on three major areas. First, the location, magnitude, and timing of movements of bats and birds during spring and fall migration need to be determined. It appears that a substantial number of passerines and other non-raptorial birds move along the LGC during migration, likely staying close to the coastline and along the near-shore area. Such behavior could increase risk for these species relative to direct flights out over the Gulf.

Second, identification of locations where species of concern and threatened or endangered species (bats and birds) occur during breeding and nonbreeding periods is warranted. Finally, a method for estimating fatalities at existing and planned wind facilities offshore will be required to understand impacts and develop mitigation strategies; retrieving dead birds and bats at sea will be a considerable challenge.

Cumulative Effects

We need to know not only how likely impacts are to occur, but also what the consequences will be cumulatively over time. Given the projected development of wind energy, biologically significant cumulative impacts are likely for some species. A meta-analysis, for example, conducted by Stewart et al. (2004) of bird mortality studies performed worldwide, suggests that impacts of wind facilities on bird abundance may become more pronounced over time, indicating that short-term abundance studies do not provide robust indicators of the potentially deleterious impacts of wind facilities on bird abundance. Broader assessments of the cumulative impacts for both birds and bats clearly are warranted. We also must consider the context of wildlife mortality at wind facilities in relation to other natural and anthropocentric sources of mortality, and determine if mortality from wind development is additive or compensatory.

RECOMMENDATIONS

This review identified several areas in need of immediate improvement to establish a scientific basis for decision-making, provide more rigorous and consistent requirements during permitting of wind facilities, and develop effective mitigation strategies to reduce or eliminate impacts on wildlife and their habitats from wind energy development. The following recommendations should help managers and decision-makers meet the challenges of developing wind energy responsibly.

1. Improve state agency involvement and consistency for requirements and regulation. Coordination among states and their agencies responsible for wildlife and energy development will be critical to ensure consistency in permitting requirements, research efforts, and acceptable mitigation, especially for species of migratory wildlife. Focused leadership among the states, for example, by the Western Governor's Association, would be one approach to gain acceptance of principles and guidelines for wind energy development. The Association of Fish and Wildlife Agencies could provide a useful facilitative role and has initiated dialogue with state, federal, and industry stakeholders to help reach these goals.

2. Renewable Portfolio Standards. A Renewable Portfolio Standard (RPS) is a state-level policy mandating a state to generate a percentage of its electricity from renewable sources, including wind energy. The standards usually focus on benefits of renewable energy, and currently no RPS considers the potential impacts of renewable energy's development on fish and wildlife and their habitats. Revising existing standards to account for wildlife impacts and the inclusion of this language and mitigation measures in new standards could lead to a more balanced and accurate presentation in the RPS.

3. Develop federal and state guidelines. State permitting processes vary widely in regard to environmental requirements, thus potentially hindering consistent development of objectives and implementation of methodologies. Developing consistent guidelines for siting, monitoring, and mitigation strategies among states and federal agencies would assist developers with compliance with relevant laws and regulations and establish standards for conducting site-specific, scientifically sound and consistent pre- and post-construction evaluations, using comparable methods as much as is feasible. Such consistency would greatly assist regulatory agencies during decision-making in regard to statutory trust responsibilities. Inclusion of guidelines in the permitting process would further strengthen agency participation and implementation of guidelines.

4. Avoid siting wind facilities in high-risk areas. A primary goal of wind energy development should be to avoid high-risk sites that are determined based on the best science available. Criteria and standards for high-risk sites need to be established for different groups of species and any designated "critical habitats" on a state-by-state or regional basis, and developers of wind energy should be required to avoid impacts to these areas. Examples may include locations important to threatened or endangered species or in large, contiguous areas of unfragmented native habitat. Siting wind facilities in areas where habitat is of poor quality and/or already fragmented, for example (see sidebar on Washington State guidelines), will likely result in fewer habitat-related impacts, although these sites should be monitored to determine collision impacts.

5. Reduce fragmentation and habitat effects. Developers should attempt to reduce habitat impacts by using existing roads when possible, limiting construction of new roads, and restoring disturbed areas to minimize impact from a facility's footprints. While clearing and perhaps maintaining low vegetation density will be important for post-construction surveys, habitat rehabilitation should be planned for disturbed areas after monitoring has been completed. On- and off-site habitat mitigation may be necessary to reduce habitat-related impacts.

6. Conduct priority research. Immediate research is needed to develop a solid scientific basis for decision-making when siting wind facilities, evaluating their impacts on wildlife and habitats, and testing efficacy of mitigation measures. More extensive pre- and post-construction surveys are needed to further elucidate patterns and test hypotheses regarding possible solutions. Monitoring and research should be designed and conducted to ensure unbiased data collection that meets peer review and legal standards (Kunz et al. 2007a). Research partnerships (e.g., Arnett and Haufler 2003, Bats and Wind Energy Cooperative [www.batcon.org], Grassland and Shrub Steppe Species Cooperative [www.nwcc.org]) among diverse players will be helpful for generating common goals and objectives and adequate funding to conduct studies.

7. Evaluate pre-construction assessments and predicted impacts. Prior to construction, industry, federal and state agencies, and others should conduct studies to determine what, if any, environmental risk would be posed by a planned wind facility. Resulting assessments are used in the permitting process and elsewhere. Rarely, however, is the quality of those assessments evaluated. Linking pre-construction assessments to post-construction monitoring is fundamental to assessing risk of a facility. Such comparisons are needed and would not only inform the pre-construction assessment process, but also provide valuable information about the environmental risks of wind facilities.

8. Conduct more consistent, longer-term studies. Most "research" conducted in association with wind development is short-term, and there appears to be little follow-up to determine if predictions from research are accurate. Long-term studies clearly are needed to address many questions on impacts of wind energy development on wildlife. Use of standardized protocols to address specific questions would improve comparability of studies and credibility of efforts. Consistency across data collection efforts, post-construction evaluations, and access to resulting data will be critical for conducting meta-analyses so that consistent effects, even if they are small, could be detected.

9. Develop and evaluate habitat-related mitigation strategies. All too often, mitigation measures have been generally required without adequate evaluation. Strategies for mitigating habitat impacts associated with wind facilities should be developed and evaluated. Effective mitigation measures should then be employed.

10. Employ principles of adaptive management. Operations and mitigation strategies should be adjusted as new information becomes available, following the principles of adaptive management (Walters 1986, Walters and Holling 1990). For example, future permitting requirements and guidelines should clearly define monitoring standards, mitigation measures (e.g., curtailment), and how data will be used to trigger adjustments to operations to mitigate impacts on wildlife. Strategies should be adjusted as new information becomes available.

11. Conduct regional assessments and forecasting of cumulative land-use and impacts from energy development. Given projected increases in multiple sources of energy development, including biomass, wind, and oil and gas development, future conflicts surrounding land-use, mitigation, and conservation strategies should be anticipated. Habitat mitigation options, for example, when developing wind in open prairie, may be compromised by development of other energy sources. Regional assessments of existing and multiple forecasts of possible land uses are needed, and planning regional conservation strategies among industries, agencies, and private landowners could reduce conflicts and increase options for mitigation and conservation.

12. Improve public education, information exchange, and participation. There is an immediate need to better educate the public and decision-makers regarding the full range of trade-offs and benefits regarding all forms of energy, including wind energy development. Impacts on wildlife and their habitat must be integrated into the political dialogue so that all tradeoffs can be considered during decision-making. Maintaining relationships with private landowners and communicating the importance of conservation efforts and their benefits will be critical toward developing wind energy responsibly. ■

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Table 1. Avian fatality rates from new generation wind facilities where standardized fatality monitoring was conducted.

	Project Size		Turbine Characteristics			Raptor Fatality Rates		All Bird Fatality Rates		Source
	#	#	RD	RSA		#/	#/	#/	#/	
Wind Project	turbines	MW	(m)	m^2	MW	turbine	MW	turbine	MW	
Pacific Northwest										
Stateline, OR/WA	454	300	47	1735	0.66	0.06	0.09	1.93	2.92	Erickson et al. 2004
Vansycle, OR	38	25	47	1735	0.66	0.00	0.00	0.63	0.95	Erickson et al 2000
Combine Hills, OR	41	41	61	2961	1.00	0.00	0.00	2.56	2.56	Young et al. 2005
Klondike, OR	16	24	65	3318	1.50	0.00	0.00	1.42	0.95	Johnson 2003
Nine Canyon, WA	37	48	62	3019	1.30	0.07	0.05	3.59	2.76	Erickson et al. 2003
Overall	586	438	56	2554	1.02	0.03	0.03	2.03	2.03	
Weighted averages	586	438	49	1945	0.808	0.05	0.07	1.98	2.65	
Rocky Mountain										
Foote Creek Rim, WY Phase I	72	43	42	1385	0.60	0.03	0.05	1.50	2.50	Young et al. 2001
Foote Creek Rim, WY Phase II	33	25	44	1521	0.75	0.04	0.06	1.49	1.99	Young et al. 2002
Totals or simple averages	105	68	43	1453	0.675	0.04	0.05	1.50	2.24	
Totals or weighted averages	105	68	43	1428	0.655	0.03	0.05	1.50	2.31	
Upper Midwest										
Wisconsin	31	20	47	1735	0.66	0.00	0.00	1.30	1.97	Howe et al. 2002
Buffalo Ridge Phase I	73	22	33	855	0.30	0.01	0.04	0.98	3.27	Johnson et al. 2002
Buffalo Ridge Phase II	143	107	48	1810	0.75	0.00	0.00	2.27	3.03	Johnson et al. 2002
Buffalo Ridge, MN Phase III	139	104	48	1810	0.75	0.00	0.00	4.45	5.93	Johnson et al. 2002
Top of Iowa	89	80	52	2124	0.90	0.01	0.01	1.29	1.44	Koford et al. 2004
Totals or simple averages	475	333.96	46	1667	0.67	0.00	0.01	2.06	3.13	
Totals or weighted averages	475	333.96	46	1717	0.53	0.00	0.00	2.22	3.50	
East										
Buffalo Mountain, TN	3	2	47	1735	0.66	0.00	0.00	7.70	11.67	Nicholson 2003
Mountaineer, WV	44	66	72	4072	1.50	0.03	0.02	4.04	2.69	Kerns and Kerlinger 2004
Totals or simple averages	47	68	60	2903	1.08	0.02	0.01	5.87	7.18	
Overall (weighted average)	47	68	70	3922	1.45	0.03	0.02	4.27	2.96	

Table 2. Estimates of bat fatalities at wind facilities in North America (modified from Arnett et al. 2007).

Study Area Location	Estimated Fatality/Turbine	Estimated Fatality/MW	Source
Canada			
Castle River, AB	0.5	0.8	Brown and Hamilton 2002
McBride Lake, AB	0.5	0.7	Brown and Hamilton 2006a
Summerview, AB	18.5	10.6	Brown and Hamilton 2006b
Eastern U.S.			
Buffalo Mt, TN (Phase 1) [a]	20.8	31.5	Nicholson 2003, Fiedler 2004
Buffalo Mt, TN (Phase 2, 0.66 MW) [a]	35.2	53.3	Fiedler et al. 2007
Buffalo Mt, TN (Phase 2, 1.8 MW) [b]	69.6	38.7	Fiedler et al. 2007
Maple Ridge, NY	24.5	14.9	Jain et al. 2007
Meyersdale, PA	23	15.3	Arnett 2005
Mountaineer, WV (2003)	48	32	Kerns and Kerlinger 2004
Mountaineer, WV (2004)	38	25.3	Arnett 2005
Rocky Mountains U.S.			
Foote Ck. Rim, WY	1.3	2.0	Young et al. 2003
Pacific Northwest U.S.			
Highwinds, CA	3.4	1.9	Kerlinger et al. 2006
Klondike, OR	1.2	0.8	Johnson et al. 2003b
Stateline, OR/WA	1.1	1.7	Erickson et al. 2003b, 2004
Vansycle, OR	0.7	1.1	Erickson et al. 2001
Nine Canyon, WA	3.2	2.5	Erickson et al. 2003a
Midwestern U.S.			
Buffalo Ridge, MN Phase 1) [c]	0.1	0.3	Johnson et al. 2003a
Buffalo Ridge, MN (Phase 2) [d]	2.0	2.7	Johnson et al. 2003a, 2004
Buffalo Ridge, MN (Phase 3) [e]	2.1	2.7	Johnson et al. 2004
Lincoln, WI	4.3	6.5	Howe et al. 2002
Top of Iowa	7.8	8.7	Jain 2005
South-central U.S.			
Woodward, OK [f]	1.2	0.8	Piorkowski 2006

[a]Estimated bats killed by 3 Vestas V47 0.66 megawatt turbines.
[b]Estimated bats killed by 15 Vestas V80, 1.8 megawatt turbines.
[c]Estimated bats killed by 73 Kenetech 33 0.33 megawatt turbines based on 4 years of data.
[d]Estimated bats killed by 143 Zond 0.75 megawatt turbines based on 4 years of data.
[e]Estimated bats killed by 138 Zond 0.75 megawatt turbines based on 3 years of data.
[f]Estimated average over eight surveys in two years.

Table 3. Densities of male grassland birds (all species combined) in Conservation Reserve Program fields along transects at various distances from strings of wind turbines, and at a control site, in southwestern Minnesota (from Leddy et al. 1999).

Distance from turbine string (m)	Mean density of males (per 100 ha)
0 m	58.2
40 m	66.0
80 m	128.0
180 m	261.0
Control	312.5

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