Analysis of
General Plan-2020
San Diego County

Prepared for

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December 2005

The Conservation Biology Institute provides scientific expertise to support conservation and recovery of biological diversity in its natural state through applied research, education, planning, and community service.

TABLE OF CONTENTS

		Page
1.	Introduction	1
2.	Literature Review	1
3.	Empirical Evidence for Fragmentation-Development Density Relationship	8
4.	Comparison of GP-2020 Alternatives	12
5.	Differences in Impacts to Vegetation Communities between Alternatives	18
6.	Conclusions	27
7.	References	28
Appendix A		
	Methods for Analysis of Ecological Integrity	33
Appendix B		
	Selected Sensitive, Rare, and Endangered Species Likely to Be Most Impacted by Increased Densities, based on Analysis of Vegetation Community Impacts.	34

List of Figures

		Page
Figure 1.	County of San Diego General Plan-2020 Staff alternative.	2
Figure 2.	County of San Diego General Plan-2020 Board alternative.	3
Figure 3.	Fragmentation analysis results.	10
Figure 4.	County of San Diego General Plan-2020—differences between the Staff and Board alternatives.	13
Figure 5.	Ecological integrity of terrestrial systems in San Diego County, showing three categories of zoning difference between the Staff alternative and Board alternative of the General Plan-2020.	16

List of Tables

		Page
Table 1.	Acreages of vegetation communities in San Diego County General Plan-2020 categories where Staff and Board alternatives differ (Staff/Board).	14
Table 2.	Acreages of vegetation communities impacted by zoning densities of 1 DU/40 acres and higher and acreages impacted by zoning densities lower than 1 DU/40 acres.	20
Table 3.	Acreages of vegetation communities in 3 General Plan-2020 categories where Staff alternative density is less than 1 DU/40 acres and Board alternative density is greater than or equal to 1 DU/40 acres (Staff/Board).	21
Table 4.	Largest grassland complexes in San Diego County.	24
Table 5.	Approximate area of occupied Stephens' kangaroo rat habitat for the largest remaining habitat areas in Riverside and San Diego counties.	26

1. INTRODUCTION

San Diego County is experiencing rapid growth that is spreading from urban centers to the historically rural and undeveloped portions of the county. These development patterns are controlled to a large degree by land use and residential development density zoning embodied in the County's General Plan. The changing land use in the county, and associated loss and fragmentation of natural habitats, has profound implications for the long-term viability of natural resources in the region.

County of San Diego staff are currently evaluating two land use alternatives as part of the update of the County General Plan (GP-2020), which we term the Staff alternative and the Board alternative (Figures 1 and 2). These alternative maps have significant differences in their zoning patterns which, in turn, will have significantly different levels of adverse effects to natural resources. The purpose of this report is to:

1. Review the scientific literature on the biological effects of land use changes associated with development.
2. Evaluate empirical evidence of habitat loss and fragmentation associated with differing densities of development that currently exist in San Diego County.
3. Compare the two GP-2020 alternatives with respect to their residential development density zoning and implications for specific vegetation communities in San Diego County.
4. Evaluate the significance of the impacts of the Staff and Board alternatives on vegetation communities and associated sensitive species in the county, focusing on areas of rare vegetation communities where the densities of the two alternatives differ in their zoning patterns.

2. LITERATURE REVIEW

Changing land use patterns in natural areas can have profound effects on the species they support. These effects include habitat loss and fragmentation, loss of native species, increases in nonnative and human-tolerant species, and altered physical processes (e.g., hydrologic regimes and fire cycles) that reduce habitat quality. Many of these effects are indirect impacts of development projects (e.g., increasing light and noise, facilitating invasions of nonnative species, increasing wildlife-human encounters, fire suppression), which can greatly exceed the magnitude of direct impacts on natural resources. Therefore, even though habitats may not be directly impacted by development, habitat values can be lost from indirect impacts of adjacent development and associated human uses and recreational activities.

Habitat fragmentation—breaking up contiguous natural habitats into small patches that are isolated from intact areas of habitat—and habitat loss are considered the single greatest threat to biodiversity at global and regional scales (Myers 1997, Noss and Csuti 1997, Brooks et al. 2002). Over 80% of imperiled or federally listed species in the U.S. are at risk from habitat degradation

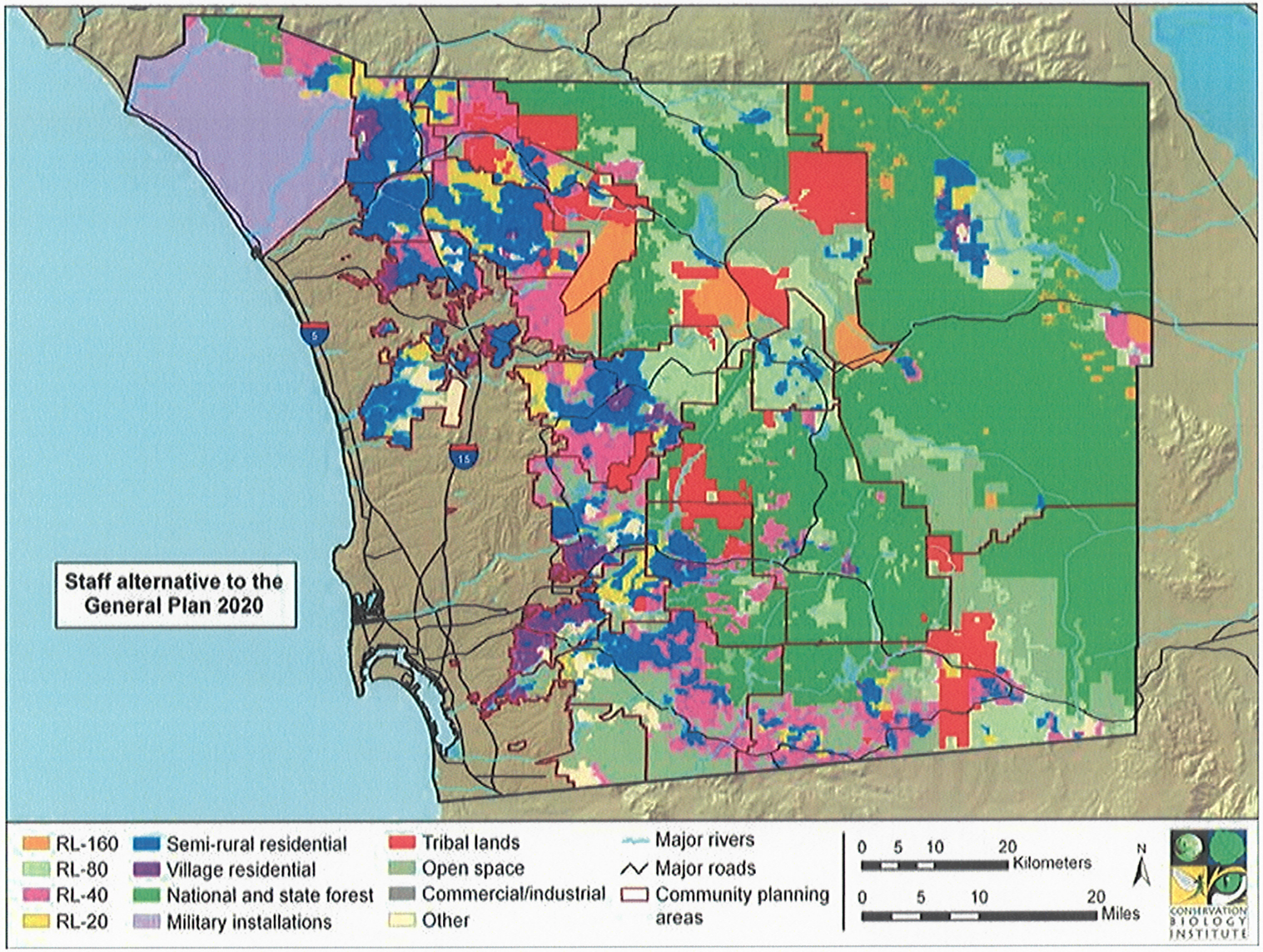


Figure 1. County of San Diego General Plan-2020 Staff alternative.

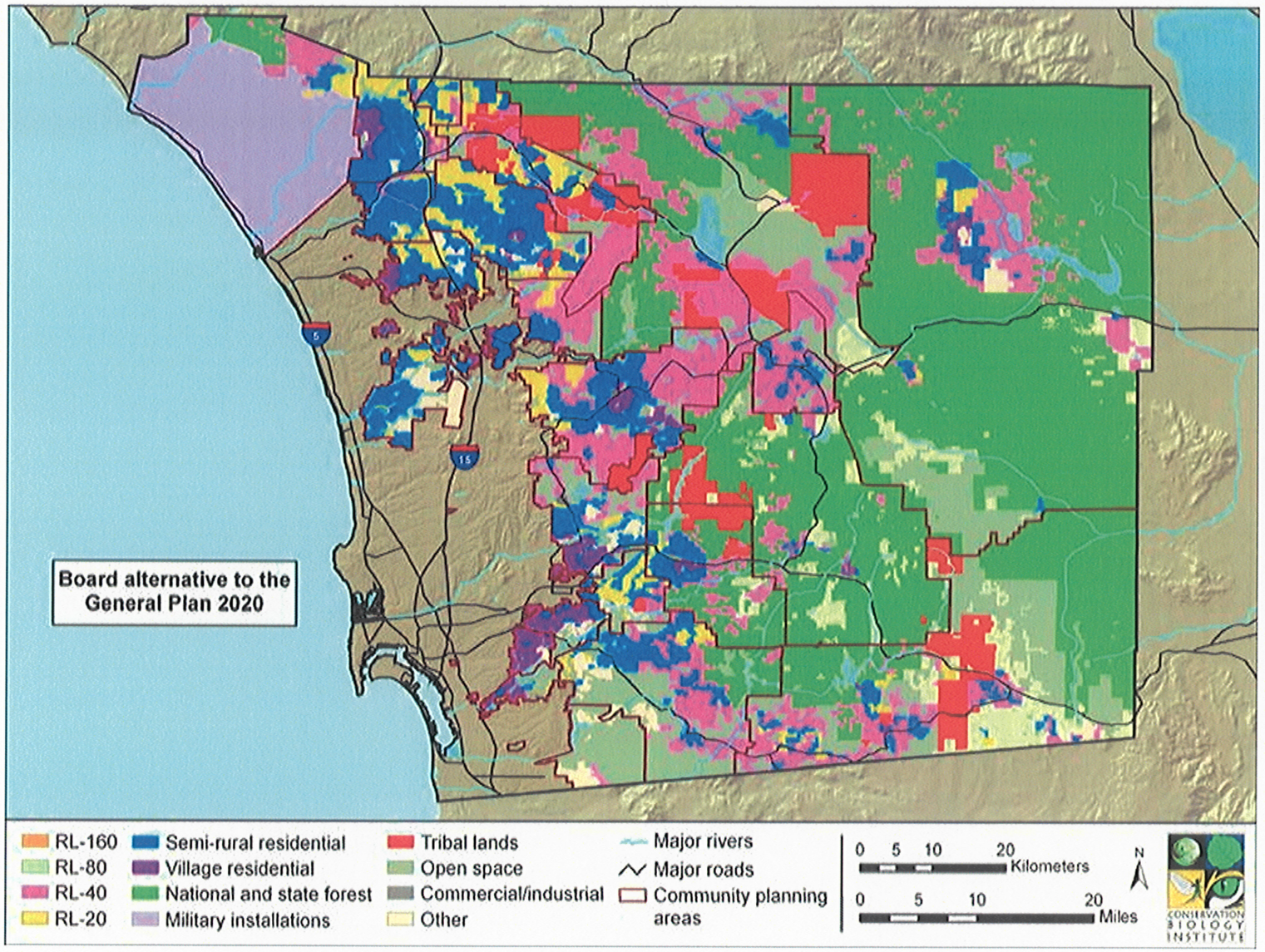


Figure 2. County of San Diego General Plan-2020 Board alternative.



and loss (Wilcove et al. 2000), and approximately 32% of California's diverse flora and vertebrate fauna are at risk (Stein et al. 2000). Urban sprawl, defined as encroachment of low-density, automobile-dependent development into natural areas outside of cities and towns, imperils 65% of species listed as Threatened or Endangered in California (Czech et al. 2001).

Habitat fragmentation also produces a habitat *edge*, where natural habitat conditions transition to a human-altered condition. This transition in habitat condition produces what are referred to as *edge effects* (Murcia 1995). Edge effects decrease the net, biologically functional area of habitats left undeveloped within landscapes fragmented by development. Edge effects take on many forms, including physical or structural changes (e.g., moisture levels, vegetation density), plant growth rates, and species interactions (e.g., predation, competition, brood parasitism, herbivory, pollination, and seed dispersal) (Murcia 1995, Sauvajot et al. 1998). As the precise nature of edge effects is variable and species- or habitat-specific, the extent of habitat impacts is also variable, usually disappearing within 50 m (160 ft) from the edge (Murcia 1995).. However, Wilcove et al. (1986) demonstrated effects that extended as far as 1,600 ft from the development-habitat edge.

Development and other human land uses generally facilitate the invasion of nonnative plant species into adjacent natural habitats, especially in small habitat fragments (McConnaughay and Bazzaz 1987, Tyser and Worley 1992, Brothers and Spingarn 1992, Matlack 1993). Invasive nonnative species in landscaping can become established and spread into the interior of natural open space areas. Construction of roads and other infrastructure (e.g., pipelines and transmission lines) and recreational activities within open space disturb existing vegetation, compact soils, and change natural runoff patterns. These alterations facilitate the invasion of nonnative plants, particularly annual grasses and forbs, by providing points of establishment within the interior of open space areas, where nonnative species can successfully outcompete native species in the altered physical environment. Clearing native vegetation to reduce fire threat and planting non-native ornamental plants around dwelling units also facilitates establishment of nonnative plant species in habitat areas adjacent to development.

Changes in land cover associated with development can modify physical processes that are integral to ecosystem function and thus can alter the dynamics of adjacent, undisturbed ecosystems (Pickett et al. 2001, Saunders et al. 1991). Poff et al. (1997) discuss the concept of the *natural flow regime* of riverine systems as the critical determinant of their biological composition. Because urbanization can modify the natural flow regime of stream systems, aquatic and riparian communities that depend on a natural flow regime are ultimately affected. Urbanization increases the area of impervious surfaces (Paul and Meyer 2001), which increases storm runoff, peak discharges, and flood magnitudes downstream (Dunne and Leopold 1978, Gordon et al. 1992, Leopold 1994). White and Greer (2006) found that increasing watershed urbanization and the use of landscaping irrigation produced increasing dry-season stream flow, which altered the historic composition of the riparian vegetation community associated with the stream. Impervious surfaces can also decrease the infiltration of precipitation into the soil, thus reducing groundwater recharge of streams and their dry-season baseflow (Klein 1979). Urbanization results in increased nutrient and sediment loads, elevated water temperatures, nonnative species invasions, and, ultimately, reduced abundance of native aquatic and riparian



species (Paul and Meyer 2001). Impervious surface cover associated with development can be used as a predictor of degradation of aquatic systems; a threshold of 10% of a watershed basin with impervious surface cover is indicative of degraded systems, and the level of degradation increases with increasing amounts of surface cover (Klein 1979, Booth and Jackson 1994).

Urbanization also alters natural fire cycles, as fuel loads are modified and fires are suppressed to protect human lives and property. Increasing human presence in Southern California has been associated with an increased frequency of wildlife ignition from anthropogenic sources (Keeley and Fotheringham 2001). Even very low density development can greatly change the fire regime of an area, and thus the dynamics of this ecological process, by altering fire frequency and fire suppression/protection requirements, such as fuel modification of native habitats and extinguishing fires that could otherwise be allowed to burn naturally. Fire protection activities can change the natural fire regime of areas in the vicinity of development, such that they may no longer sustain natural ecological systems and processes. Therefore, the many species that depend on natural physical processes to maintain suitable habitat can be locally extirpated as an area is developed.

While some species are tolerant of or respond positively to human modifications associated with development (i.e., *synanthropic* species), many native species are not (Soulé et al. 1988, Soulé et al. 1992, Bolger et al. 1991, Blair 1996, Crooks 2002). For example, in a study of forest birds in the northwest, synanthropic bird species, such as the house sparrow, American crow, European starling, and rock dove, and nonnative vegetation tended to increase in abundance in the vicinity of urbanization, whereas native forest species decreased in these areas (Donnelly and Marzluff 2004). Habitat fragmentation from development in Southern California has resulted in the loss of top carnivores from small habitat fragments, thereby allowing smaller *mesopredators* (e.g., opossums, skunks, etc.) to increase in number. This has the cascading effect of increasing predation rates on other species in the community (Soulé et al. 1988, Crooks 2002). Nest predation rates have been shown to be higher closer to habitat edges in other studies as well (Wilcove 1985, Andrén and Angelstam 1988), presumably from a greater abundance of synanthropic predator species. Harrison (1997) documented changes in gray fox diets and home range characteristics between rural residential and undeveloped areas, with foxes in residential areas consuming a higher frequency of mammal prey and anthropogenic food items than in undeveloped areas. Even human use of recreational trails in reserve areas has been associated with changes in bird species composition and a reduced frequency of nesting in the vicinity of trails (Miller et al. 1998).

The alterations of ecosystems by urbanization have been well documented by ecologists (see review by Pickett et al. 2001) and, like their responses to natural gradients (e.g., climate or productivity gradients), ecosystems also predictably respond to urban-rural gradients (McDonnell and Pickett 1990). Landscape-scale ecosystem studies along an 87-mile urban-rural transect in an eastern oak forest demonstrated significant reductions in forest patch size and increases in urban edge (Medley et al. 1995), as well as altered ecosystem processes resulting in modified physical and chemical environments (McDonnell et al. 1997), as one moved toward the urban end of the transect. Medley et al (1995) also note that the forest habitats in the suburban region of this transect are much more susceptible to fragmentation and recommend that



conservation and management actions should be directed at minimizing fragmentation and maintaining sustainable landscape structures.

Numerous studies have documented decreases in the numbers of native wildlife species and increases in the numbers of nonnative species tolerant of human-modified habitats along development intensity gradients extending from natural open space to urban areas. In the Sonoran Desert outside of Tucson, Arizona, Germaine et al. (1998) found that housing density best explained changes in bird species richness. In this study, nonnative bird species richness was positively related to housing density, while the richness of a group of sensitive bird species was negatively correlated with housing density. This pattern is largely a result of the greater abundance of nonnative plants and anthropogenic food sources in urban settings, which allow nonnative bird species to effectively outcompete native specialist bird species. Consistent with this pattern, Donnelly and Marzluff (2004) found that in western Washington, species richness of native forest bird communities was always higher in areas of exurban development than in suburban or urban areas, whereas the richness of synanthropic species was higher in suburban and urban areas.

In the oak woodlands of the Palo Alto area, both butterfly and bird communities exhibited responses to land use changes along an urban-wildland gradient (Blair and Launer 1997, Blair 1999). This gradient included a highly developed business district and office park, residential neighborhoods, a golf course, open space used for recreational activities (jogging, dog-walking, hiking, and equestrians), and a biological preserve with access for research and docent-led groups only. Along this gradient, both butterfly and bird species found in the biological preserve (the native oak woodland community) dropped out of the community in sites with increasing urbanization and human activity, including the open space recreational area, suggesting that any development or increased human use of an area is detrimental to the integrity of the original species assemblage (Blair and Launer 1997). They also found that golf courses, which are frequently classified as *open space*, do not function as well as natural open space areas for maintaining native species richness of bird and butterfly communities (Blair 1996, Blair and Launer 1997, Blair 1999). Comparable results were found in oak woodlands in the foothills of the Sierra Nevada (Placer County), where the abundance of native oak woodland species declined and the abundance of synanthropic species (e.g., house finch, western scrub jay) increased with increasing development density (Stralberg and Williams 2002). Native species richness and density in riparian habitats has also been shown to decrease adjacent to development and bridges, whereas the abundance of nonnative species increases (Rottenborn 1999).

A few studies have compared responses of wildlife species associated with specific development densities, thus allowing inferences regarding the threshold of development density at which adverse effects can be observed. For example, significant changes in lizard species composition in the Sonoran Desert outside of Tucson, Arizona were found at housing densities above 1 dwelling unit (DU)/2 acres (Germain and Wakeling 2001). In forested areas of Canada, Friesen et al. (1995) demonstrated average bird species diversity and abundance were lower in forest patches with housing densities ranging from 1DU/47 acres to 1DU/141 acres than in forest

patches of comparable size with no houses present. In this study, bird species diversity and abundance fell rapidly when housing density increased above 1DU/47 acres.

In a mosaic of shrub-steppe and prairie in Colorado, Maestas et al. (2001) assessed plant, bird, and mammalian carnivore community changes along a gradient of land use intensity from exurban development (1 DU/35-49 acres), to private ranch land, to protected public open space. They found that the greatest number of nonnative plant species occurred in areas of exurban development and the fewest on private ranches. Human-tolerant bird species (i.e., black-billed magpie, European starling, Brewer's blackbird, American goldfinch, house wren, broad-tailed hummingbird, and Bullock's oriole) were significantly denser in areas of exurban development than on either private ranches or public open space, whereas no statistical difference was found in their densities on private ranches or public open space. Several human-intolerant species (i.e., vesper sparrow, dusky flycatcher, savannah sparrow, and lark bunting) either were never seen or were statistically less abundant in areas of exurban development. Domestic dogs and cats were detected significantly more frequently and coyotes less frequently in exurban areas.

In a study of exurban development in a shrub oak-sagebrush community in western Colorado, Odell and Knight (2001) looked both at how bird and mammal species assemblages responded to two different densities of development relative to undeveloped land and their responses relative to distance from individual houses. In this study, Odell and Knight classified exurban development density in their sample plots as high (average of 1 DU/2.4 acres ± 1 DU/3.7 acres) or low (1 DU/26 acres ± 1 DU/30 acres). They found that the density of human-tolerant bird species (i.e., American robin, black-billed magpie, brown-headed cowbird, European starling, house wren, and mountain bluebird) were higher in developed areas than in undeveloped areas, and the density of human-intolerant species (i.e., black-capped chickadee, blue-gray gnatcatcher, black-headed grosbeak, dusky flycatcher, green-tailed towhee, orange-crowned warbler, plumbaceous vireo, and Virginia's warbler) was lower in developed areas than in undeveloped areas. Interestingly, the densities of both human-tolerant and intolerant species were generally not significantly different between the high and low density development areas, but low density areas were almost always significantly different than the undeveloped areas. Odell and Knight also found that the frequency of detection of mammal species followed a similar pattern, with domestic dogs and cats detected more frequently in developed areas and coyotes and foxes detected much more frequently in undeveloped areas, even when compared to the plots in low development density areas. Thus, even at very low exurban development densities, significant reductions of human-intolerant species and significant increases in human-tolerant species densities have been documented.

When looking at species responses to distance from individual houses, Odell and Knight (2001) found that the density of human-tolerant bird species was always higher and the density of human-intolerant bird species was lower at 30 m (96 ft) from a house than at either 180 m (576 ft) or 330 m (1,056 ft) from a house. This relationship also held for the detection frequency of mammal species, with detections of domestic dogs and cats decreasing with distance from houses (neither was detected at 330 m from houses) and detections of coyotes and foxes increasing with distance from houses. Therefore, in this study there appears to be a threshold of



effect of houses on the density of birds and detection frequency of mammals at a distance between 96 and 576 ft.

In summary, a great deal of research conducted within many different ecosystems documents a very clear negative effect of urbanization intensity on biological communities. Urbanization changes many physical and biological characteristics of adjacent natural areas, either via direct impacts or, perhaps more importantly, via indirect impacts. Indirect impacts to wildlife communities are often expressed as an increase in human-tolerant species at the expense of human-intolerant species. Edge effects have been documented to extend at least 100-160 ft into a patch from the edge, but can penetrate substantially greater distances in specific situations. Thus, accurate impact calculations for development projects must consider indirect impacts beyond the footprint of the development or individual houses themselves. In addition to documenting adverse effects of urban areas, this research also demonstrates significant biological effects of low density suburban or exurban development. Even development densities as low as 1 DU/40-50 acres have been documented to result in reduced abundances of human-sensitive species and increases in human-tolerant species. It is unclear whether significant effects may occur at densities below this threshold, as we found no published studies that explicitly compared effects to development densities above and below this threshold.

3. EMPIRICAL EVIDENCE FOR FRAGMENTATION-DEVELOPMENT DENSITY RELATIONSHIP

The scientific literature reviewed for this analysis documents a relationship between increasing DU density and adverse biological effects, and these effects are evident at densities as low as 1 DU/40-50 acres. In addition to changing vegetation composition and structure and providing more human-subsidized food sources, increasing DU density also results in the physical fragmentation of the landscape, not only from construction of houses and roads, but also from associated disturbances around DUs, such as clearing vegetation for fuel reduction, construction of stables and outbuildings, and recreational activities. We are particularly interested in the effects of very low density residential development (i.e., <1 DU/20 acres) on fragmentation. To examine the relationship between disturbance and fragmentation of natural vegetation and development density, we conducted an empirical analysis of habitat fragmentation on privately owned land in the unincorporated portion of San Diego County.

Methods

We conducted a fragmentation analysis by creating a grid of 160-acre cells for overlay on all privately owned land in the unincorporated county. We randomly selected 90 cells for analysis. Using year-2000 aerial photographs, we digitized areas of undisturbed natural vegetation and human disturbance (DUs, outbuildings, paved and dirt roads, cleared areas, crops) within each 160-acre cell and totaled the number of DUs for each cell. We excluded 30 grids that had extensive areas of crops (e.g., orchards) from our sample to focus the analysis on development from single-family residential development.



Using the computer program FRAGSTATS (McGarigal and Marks 1995), a commonly used tool in landscape ecology, we calculated a series of fragmentation metrics for each of the grid cells in our sample. FRAGSTATS computes 60 different fragmentation metrics that quantify various area, patch, edge, shape, core area, nearest neighbor, diversity, and contagion statistics. To illustrate the effects of development density on fragmentation, we selected four of these metrics as examples:

- Percent natural habitat—percent of each grid cell with undisturbed habitat.
- Mean patch size—average size of patches in each cell.
- Percent in core area—percent of each grid cell with habitat lying within a core area. Core areas are defined as the interior portion of patches after subtracting a 30 m (96 ft) buffer.
- Mean core area per patch—average size of core area patches (with core area defined as above) in each cell.

Formulas for calculating these metrics can be found in McGarigal and Marks (1995).

Based on the number of existing houses in each cell, we grouped cells into 7 density classes:

- 1DU/4 acre (6 cells)
- 1 DU/10 acre (12 cells)
- 1 DU/20 acre (9 cells)
- 1 DU/40 acre (9 cells)
- 1 DU/80 acre (9 cells)
- 1 DU/160 acre (9 cells)
- undeveloped areas (6 cells)

We used the replicate grid cell results for each density class to calculate a mean and 95% confidence interval (CI) for each fragmentation metric. The true mean of each population (i.e., each development density class) is found within the CI 95% of the time, given number of samples and their variation. The CI for a sample is calculated as:

$$95\% \text{ Confidence Interval (CI)} = t_{0.05,\,df}\,(\text{S.E.})$$

Where $t_{0.05,\,df}$ = Student's t critical statistic for Type I error rate = 0.05, and degrees of freedom (df) = n-1, S.E. = standard error of the mean, and n = sample size.

Results

The results of this analysis are presented graphically in Figure 3, with each of the four fragmentation metrics as a function of DU density class in four separate panels. For each metric, we plotted the mean fragmentation statistic ± 95% CI for each development density. The results show that there is a logarithmic relationship between fragmentation metrics and development density. The regression equation for each of the metrics is significant at $P < 0.02$.

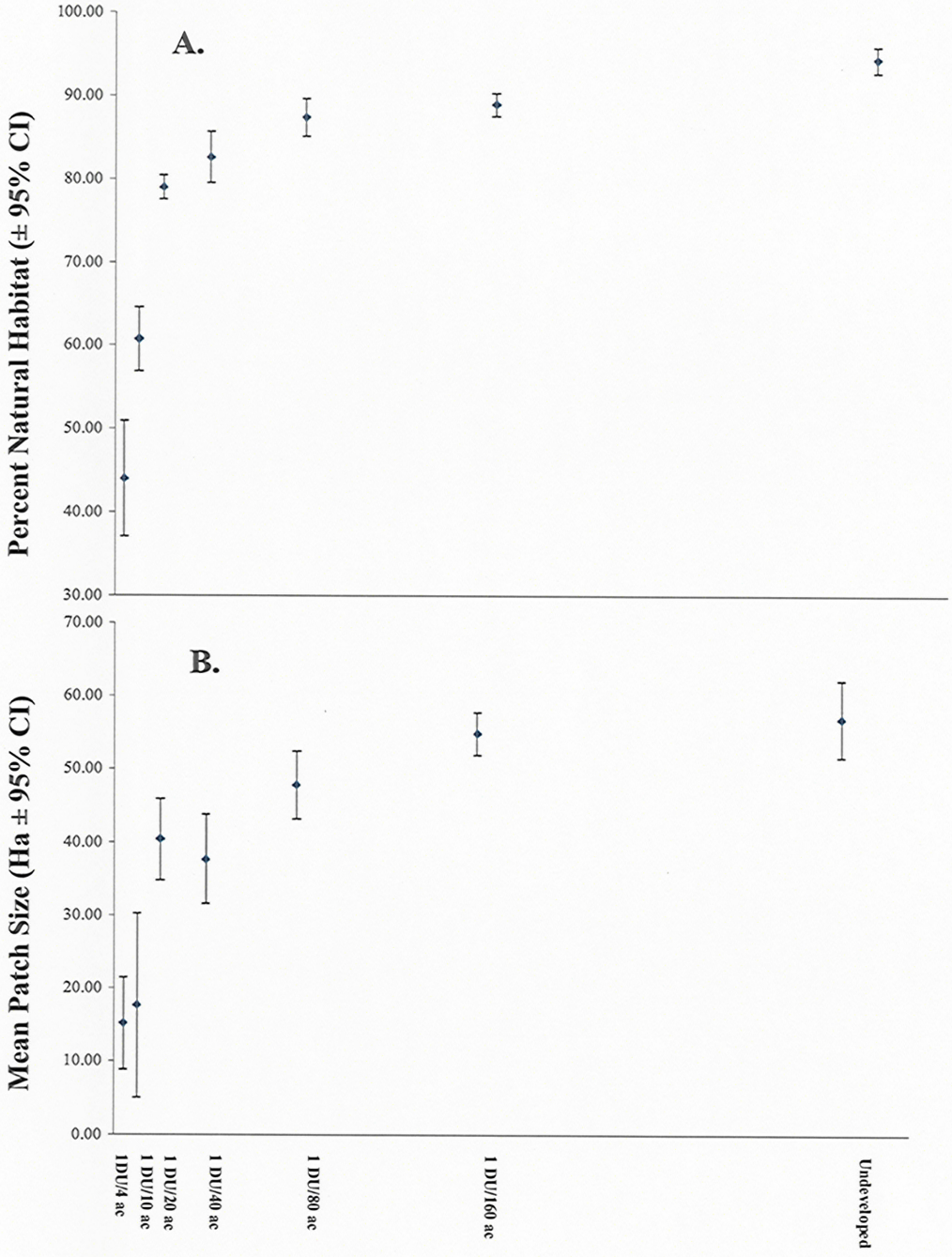


Figure 3. Fragmentation analysis results. **A.** Percent natural habitat per grid (mean ± 95% CI). **B.** Mean natural habitat patch size per grid (mean ± 95% CI).

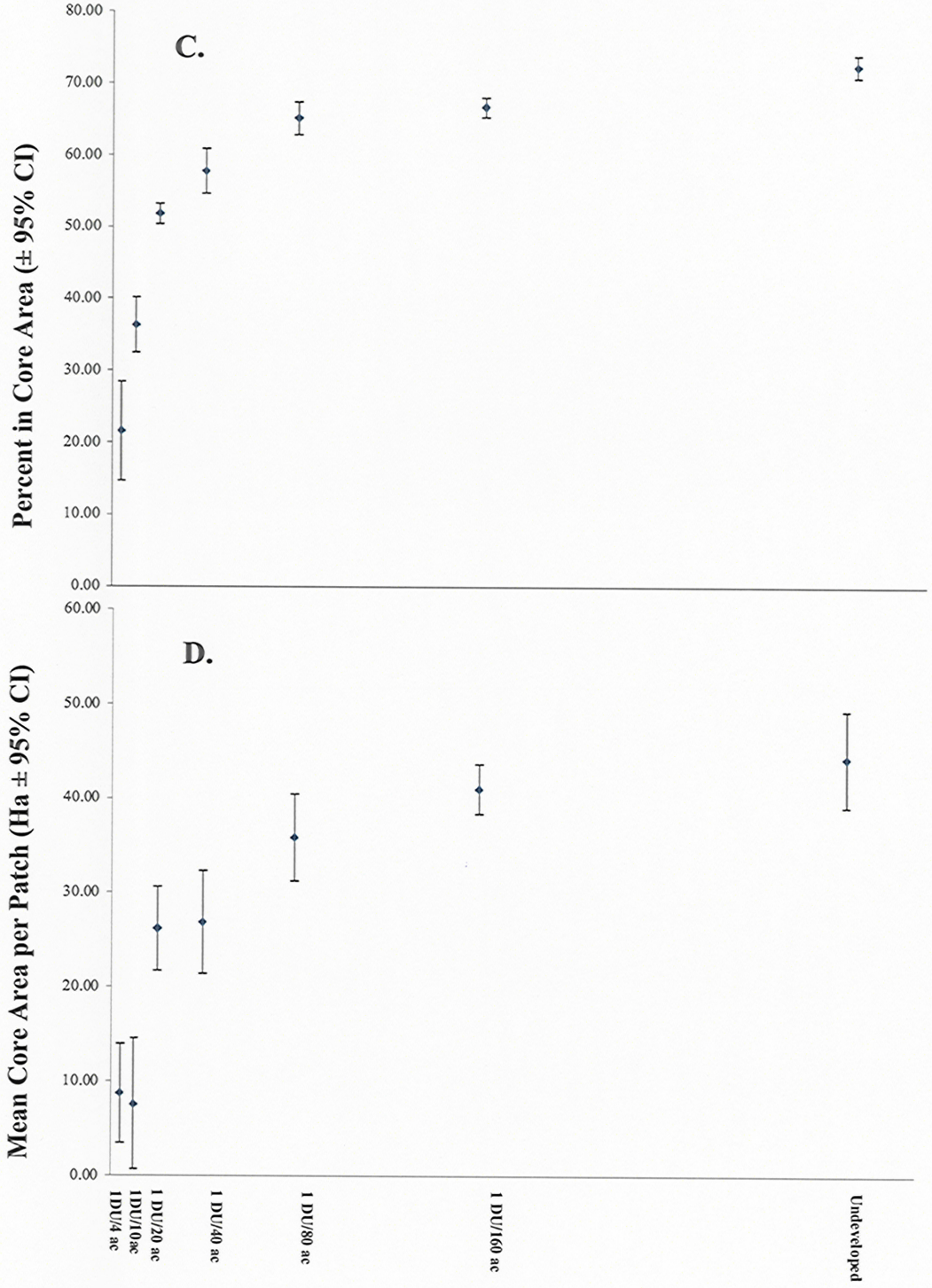


Figure 3. Fragmentation analysis results. **C.** Percent core area per grid (mean ± 95% CI). **D.** Mean core area per patch per grid (mean ± 95% CI).

The graphs show that total habitat area and habitat patch size decrease with increasing development density. For each of these graphs, the slope of the regression line is highest at densities above 1 DU/80 acre. This indicates that at densities of 1 DU/40 acre and above, incremental increases in density result in relatively large changes in fragmentation. At densities of 1 DU/80 acres and below, changes in fragmentation with changes in density are relatively small. Thus, in this analysis 1 DU/40 acres represents the threshold at which fragmentation appears to increase substantially, and we consider this to be the threshold density for significant fragmentation impacts.

4. COMPARISON OF GP-2020 ALTERNATIVES

While there are several geographic areas of difference in the Staff alternative and Board alternative, the major differences in their geographic allocation of DU density are shown in Figure 4. In this report, we use the following labeling convention: Staff /Board alternative (e.g., RL-160/RL-40) is the difference in the zoning of DU density in the Staff alternative (i.e., RL-160) relative to the Board alternative (i.e., RL-40), which are allocated to the same geographic unit. In Figure 4, the major areas with different zoning designations in the Staff and Board alternatives are mapped, with minor areas of zoning density difference aggregated in the category *Other*. In all instances, the Board alternative is zoned with higher DU densities than the same areas of the Staff alternative. Based on the areal extent of the Staff/Board categories across vegetation communities, the RL-80/RL-40, RL-160/RL-40, and RL-40/RL-20 categories account for 86% of the total difference between the two alternatives (i.e., 190,158 acres in these three categories, compared to 222,171 acres total, excluding areas that are mapped as Agriculture, Disturbed, and Developed in the current San Diego County vegetation database). The areas that would be affected by these differences correspond to the blue, orange, and magenta categories, respectively, in Figure 4.

To assess how these differences translate into potential effects on biological resources, we tabulated the acreage of vegetation communities in each category of Staff/Board alternative zoning density difference (Table 1). In the following sections, we describe the primary geographic areas and vegetation communities that will be affected for each of the three major Staff/Board alternative zoning density differences. Note that the total direct and indirect impacts of development at a particular development density within each category are unknown and will depend largely on distribution of housing within each zoning category (e.g., whether the housing is clustered or spread somewhat evenly throughout the development area), the amount and configuration of infrastructure (e.g., need for new roads), proximity to other areas of development, etc. Our focus in this section is on the general patterns of these different Staff/Board alternative development densities and how they will affect areas of the county with different biological resources, as described primarily by vegetation communities.

We also examine the potential effects of alternative zoning densities on existing ecological integrity in the county. Ecosystems of plant and animal species and their habitats are maintained by dynamic processes that operate across large landscapes. These ecological processes include disturbances from fire, flood, and soil erosion and deposition, as well as nutrient and energy flow through food webs, population dynamics, gene flow, and species interactions such as predation

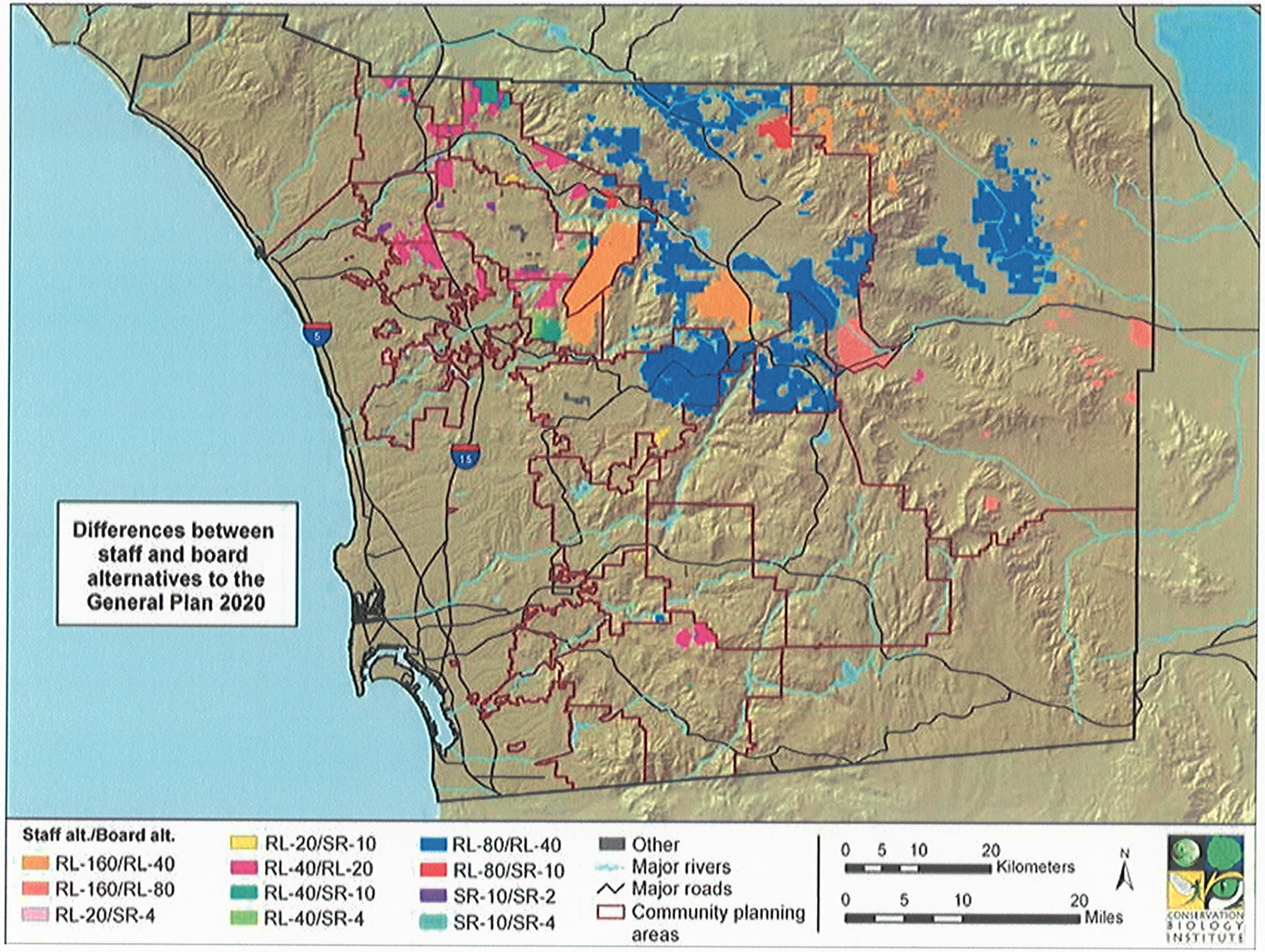


Figure 4. County of San Diego General Plan-2020—differences between the Staff and Board alternatives.

Table 1. Acreages of vegetation communities in County of San Diego General Plan-2020 categories where Staff and Board alternatives differ (Staff/Board).

Vegetation Category	RL-80/ RL-40	RL-160/ RL-40	RL-40/ RL-20	RL-160/ RL-80	Other	RL-40/ SR-10	RL-80/ SR-10	RL-40/ SR-4	RL-20/ SR-10	RL-20/ SR-4	SR-10/ SR-2	SR-10/ SR-4	**Total County
Beach/dunes	428	0	0	0	0	0	0	0	0	0	0	0	2,445
Chaparral	46,997	12,101	11,464	2,459	1,414	3,262	2,536	577	754	693	175	99	915,921
Coastal scrub	4,718	457	3,939	15	845	1,246	5	752	79	394	63	84	237,452
Coniferous forest	15,924	282	64	0	47	0	48	0	0	0	0	0	75,142
Desert/montane scrub	28,616	3,333	134	7,111	105	0	7	0	0	0	0	0	466,078
Eucalyptus woodland	116	2	12	2	37	0	0	0	0	2	0	12	3,416
Grasslands													
Foothill/Mtn Perennial Grassland	3,190	2,004	0	1,029	5	0	10	0	0	0	0	5	25,194
Nonnative Grassland	2,064	4,861	1,359	5	853	109	37	0	20	0	44	12	63,336
Transmontane Dropseed Grassland	0	0	0	0	0	0	143	0	0	0	0	0	139
Valley and Foothill Grassland	1,535	1,001	15	0	279	44	20	7	0	7	0	0	25,331
Valley Needlegrass Grassland	67	94	7	0	0	0	121	0	0	0	0	0	30,819
Wildflower Field	84	0	0	0	0	0	0	0	0	0	0	0	1,517
Undifferentiated Grassland	55	0	4	0	0	0	0	0	0	0	0	0	864
Total Grasslands	6,995	7,960	1,386	1,034	1,137	153	331	7	20	7	44	17	147,200
Meadow, seep, and playa	2,269	801	0	618	161	0	17	63	0	0	0	0	59,231
Freshwater	215	30	12	0	32	2	0	0	5	0	0	0	9,723
Riparian/wetland	4,580	798	428	1,883	264	59	35	44	0	22	32	27	83,619
Woodlands													
Engelmann Oak Woodland	7,214	8,823	608	0	259	30	227	24	0	0	0	25	34,880
Black Oak Forest and Woodland	969	0	0	0	0	35	0	0	0	0	0	0	1,526
Coast Live Oak Woodland	6,608	1,945	1,216	2	413	450	662	36	109	22	24	27	9,889
Mixed Oak Woodland	5,835	1,317	0	0	74	0	0	0	0	0	0	0	13,777
Cismontane Woodland	0	5	0	0	0	0	0	0	0	0	0	0	138
Undifferentiated Woodland	568	593	0	0	0	0	0	0	0	0	0	0	3,276
Total Woodlands	21,194	12,683	1,824	2	746	514	890	61	109	22	24	52	63,486
Pinyon-Juniper	22	376	0	739	0	0	0	0	0	0	0	0	53,493
Barren	0	0	0	15	0	0	0	0	0	0	0	0	613
Total Vegetation Communities*	132,072	38,822	19,264	13,879	4,788	5,237	3,869	1,503	966	1,141	338	292	2,499,800

Source: County of San Diego.
*Excludes Agriculture, Disturbed, and Developed.
**Total acreage of these community types in county (not total acreage of all vegetation communities in county).

and competition, which can be adversely affected by human modifications of the landscape. The ecological integrity of a landscape refers to the extent that it remains free of human modifications, which is an indication of the ability of ecosystems to function naturally. We measured ecological integrity in San Diego County, using 574-acre grids (5,000 ft on a side) as the unit of analysis, using the distribution of roads and urban and agricultural development as a measure of the loss of ecological integrity (Figure 5, Appendix A).

RL-80/RL-40

This category of Staff/Board alternative difference totals 132,072 habitat acres, by far the largest acreage of difference between the two alternatives. The land in this category is distributed throughout the northeastern portion of the unincorporated area, largely within the Palomar, North Mountain, Julian, and Borrego Springs community planning areas (Figure 4). This difference category would affect various chaparral communities (46,997 acres), desert/montane scrub communities (28,616 acres of primarily desert shrub communities), woodlands (21,194 acres of primarily coast live oaks and Engelmann oaks), coniferous forests (15,924 acres of primarily mixed oak and coniferous/bigcone/Coulter pine), grasslands (6,995 acres of primarily native grasslands), and riparian/wetland communities (4,580 acres, half of which is mesquite bosque). Most of the land in this category is in areas supporting high and very high ecological integrity within the last remaining large core biological resources areas in San Diego County (Figure 5; Stallcup et al. 2005).

Increasing the housing density within this very large area of the county from 1 DU/80 acres to 1 DU/40 acres would have widespread and significant impacts to a variety of sensitive communities. Research on the effects of exurban development shows that even densities as low as 1DU/40-50 acres produce significant negative effects on native communities (Friesen et al. 1995, Maestas et al. 2001, Odell and Knight 2001). Our fragmentation analysis for San Diego County also shows that areas with densities of 1 DU/40 acres are more fragmented than areas with lower densities, such as 1 DU/80acres. At the RL-80 zoning, 1,651 houses would be allowed on the land within this category; at the RL-40 zoning, this number would increase to 3,301 houses. The additional 1,650 DUs that could be built under the Board alternative, along with all of the infrastructure requirements and indirect effects associated with them, would produce substantially increased fragmentation, negative impacts to wildlife communities, greater area of impervious surfaces, and increased water use.

RL-160/RL-40

This category of Staff/Board alternative difference totals 38,822 habitat acres, and occurs in some of the most intact and important habitat in San Diego County. The land in this category is located largely within two major areas, Rancho Guejito and the Santa Ysabel Valley (Figure 4). This category is also scattered within the Desert community planning area. Development in this category will affect oak woodlands (12,683 acres of primarily coast live and Engelmann oak woodlands), various chaparral communities (12,101 acres), grasslands (7,960 acres), and various desert/montane scrub communities (3,333 acres). Most of the land in this category is in areas supporting high and very high ecological integrity within the last remaining large core biological

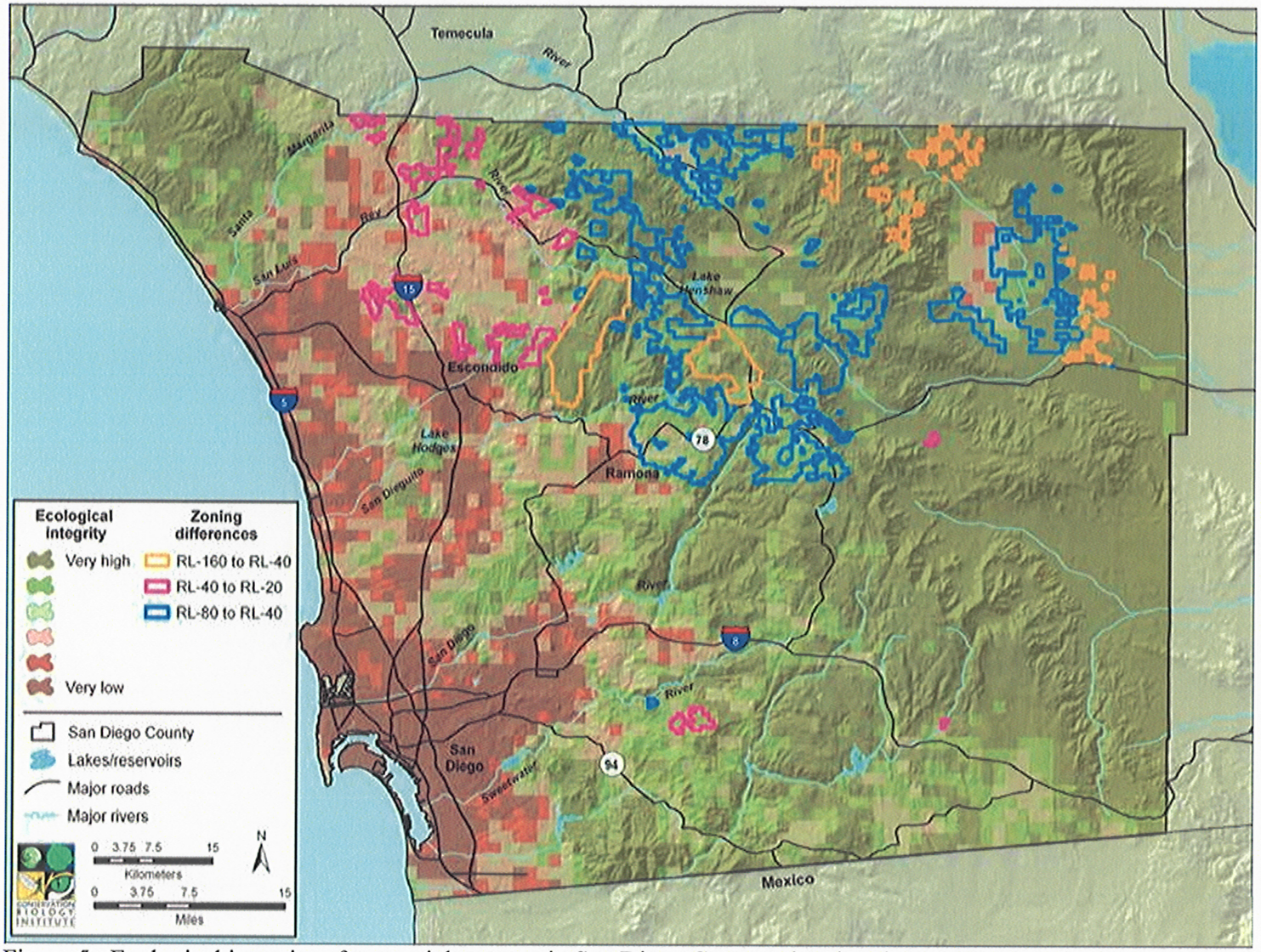


Figure 5. Ecological integrity of terrestrial systems in San Diego County, showing three categories of zoning difference between the Staff alternative and Board alternative of the General Plan-2020.

resources areas in San Diego County (Figure 5, Stallcup et al. 2005). In addition, Rancho Guejito represents the largest and most intact core area within the County of San Diego's North County Multiple Species Conservation Program (MSCP) Pre-Approved Mitigation Area (PAMA). Based on our empirical analysis of fragmentation, increasing housing density from 1 DU/160 acres to 1 DU/40 acres significantly decreases mean patch size and percent of core area. In addition, significant changes in wildlife composition have been noted at densities of 1 DU/ 40 acres, with human-sensitive species decreasing in abundance. At the RL-160 zoning, 243 houses would be allowed on the land within this category; at the RL-40 zoning, this would increase by 728 units to 971 houses along with the increased impervious surface cover, water use, and indirect effects to biological resources.

RL-40/RL-20

This category of Staff/Board alternative difference totals 19,264 habitat acres and is geographically distributed primarily in the northwestern portion of the unincorporated area (Fallbrook, Valley Center, Bonsall, Hidden Meadows, Twin Oaks, North County Metro, and Pala-Pauma community planning areas), the northwestern portion of the Jamul-Dulzura community plan area, and scattered locations in the eastern portion of the county (Figure 4). Vegetation communities that would be affected to the largest extent include chaparral (11,464 acres of primarily southern mixed chaparral), sage scrub (3,939 acres of primarily Diegan coastal sage scrub), oak woodlands (1,824 acres of coast live oak and Engelmann oak woodland), and grasslands (1,386 acres of primarily nonnative grassland, Table 1). Several areas of RL-40/RL-20 are located within the PAMA for the North County MSCP, including areas of very high and high ecological integrity (Figure 5).

Increasing housing density from 1 DU/40 acres to 1 DU/20 acres would have significant effects on biological resources. As discussed above, the magnitude of biological impacts increases along an urbanization or housing density gradient, with greater impacts in areas of high DU density (Medley et al. 1995, McDonnell et al. 1997). This is consistent with the empirical trend of increasing disturbance and fragmentation with increasing DU density from our fragmentation analysis (Section 3). Odell and Knight (2001) documented increases in human-tolerant wildlife species at the expense of human-intolerant wildlife species at DU densities above 1 DU/40 acres. Likewise, our fragmentation analysis shows fragmentation tends to be higher at DU densities of 1 DU/20 acres relative to 1 DU/40 acres. For example, average number of vegetation patches tends to be higher at 1 DU/20 acres than at 1 DU/40 acres, and the percentage of natural vegetation and percentage of core area tend to be lower at 1 DU/20 acres than at 1 DU/40 acres. Within the 19,264 acres of this DU density difference category, 482 DUs would be allowed under the RL-40 zoning, while 963 DUs would be allowed under the RL-20 zoning. Thus, an additional 481 DUs would be allowed, along with their associated roads and infrastructure, disturbance in fuel management zones, impervious surface cover, domestic animals, and ornamental plants, all factors contributing to fragmentation and adverse impacts to natural resources.

Areas of High Ecological Integrity and Existing Conservation Investments

Enormous investments by federal, state, and local governments have been made in the acquisition and conservation of natural lands in San Diego County, and these investments will be jeopardized if the lands are not linked and managed within a network of conserved landscapes of sufficient size, integrity, and connectivity. The importance of conserving private land within large blocks of core habitats to landscape-scale ecological functions is emphasized when considering the distribution of the remaining core habitat blocks of very high ecological integrity in San Diego County (Figure 5, Appendix A). Much of the habitat in the coastal portion of the county has been lost or degraded by development. Within the central foothills of the county, there are basically three intact blocks of habitat remaining: (1) Rancho Guejito-Santa Ysabel Valley (ca. 72,000 acres), (2) Eagle Peak-Capitan Grande Indian Reservation (ca. 105,000 acres), and (3) Otay Mountain Wilderness-Tecate Peak (ca. 100,000 acres), each of which is contiguous with adjacent intact habitat blocks of montane and desert habitat to the east. These three blocks of habitat are core areas of the regional system of natural lands in the western portion of San Diego County. Maintaining their core area functions is critical to maintaining (1) biodiversity throughout the region, including the biodiversity of smaller patches of habitat within Natural Community Conservation Planning (NCCP) reserves to the west, and (2) connectivity with higher elevation conservation areas to the east, e.g., Cleveland National Forest, Palomar Mountain State Park, and Agua Tibia Wilderness.

Moreover, much of the area that is zoned RL-40 by the Board alternative and RL-80 or RL-160 by the Staff alternative lies within the upper portions of the San Dieguito River, San Luis Rey River, and San Felipe Creek watersheds. Enormous conservation investments have already been made in these watersheds. For example, in the San Dieguito River watershed downstream of these areas, more than 2,200 acres have already been protected in the San Pasqual Valley alone. Protection of the watershed functions and values of these upper watershed areas builds on these investments and contributes to their long-term protection.

5. DIFFERENCES IN IMPACTS TO VEGETATION COMMUNITIES BETWEEN ALTERNATIVES

In Sections 2 and 3, we examined the effects of different residential development densities on biological communities using a review of relevant scientific literature and an analysis of habitat fragmentation patterns associated with different development densities in San Diego County, respectively. In both instances, it was demonstrated that densities of about 1 DU/40 acres and higher result in markedly greater direct and indirect impacts to species and communities as a result of habitat loss, fragmentation, and changes in species composition than do densities lower than 1 DU/40 acres. In this analysis, we use 1 DU/40 acres as a threshold for significant impacts to biological resources, i.e., densities of 1DU/40 acres or higher are considered to result in significant impacts to biological resources. While there are also potentially significant differences in impacts at densities lower than 1 DU/40 acres (e.g., 1 DU/80 acres vs. 1DU/160 acres), as suggested by the empirical evidence for San Diego County (Figure 3), there is little research that has examined the effects of development densities much lower than 1 DU/40 acres.



To better illustrate the implications of zoning differences between the Staff and Board alternatives to natural resources in San Diego County, this section focuses on vegetation communities and associated sensitive species that would be significantly impacted by zoning development densities at 1 DU/40 acres or higher and where potential impacts of these development densities would affect a significant proportion of the county-wide distribution of rare vegetation communities.

Table 2 shows acreages of different vegetation communities directly impacted by zoning densities of 1 DU/40 acres and higher and acreages directly impacted by zoning densities of lower than 1 DU/40 acres for the Staff and Board alternatives. Overall, the Board alternative results in 173,608 acres more in development densities ≥1 DU/40 acres than does the Staff alternative (502,766 – 329,158 acres, Table 2). This includes approximately 132,000 acres where the Staff alternative is RL-80 and the Board alternative is RL-40, 38,800 acres where the Staff alternative is RL-160 and the Board alternative is RL-40, and 3,800 acres where the Staff alternative is RL-80 and the Board alternative is SR-10 (Table 1). [Note that there is a total difference of about 1,000 acres between Tables 1 and 2 as a result of GIS database inconsistencies between the two alternatives. This difference does not affect the conclusions of this analysis.] These greater levels of impacts associated with the Board alternative would occur primarily in the north-central and north-eastern portions of the county (Figure 4).

Rare Vegetation Communities

The areas where the Staff alternative proposes densities lower than 1 DU/40 acres and the Board alternative proposes densities equal to or higher than 1 DU/40 acres (i.e., Staff/Board categories RL-80/RL-40, RL-160/RL-40, and RL-80/SR-10; Table 3) support a significant percentage of communities that are naturally rare in Southern California and which have been further reduced in extent via loss to development and type conversion (Oberbauer and Vanderwier 1991, Scott 1991). Oak woodlands, grasslands, coniferous forests, and wetlands are considered rare by the County of San Diego's Biological Mitigation Ordinance, which lists them as Tier I communities, i.e., communities that are limited in distribution and that support rare or listed species. Impacts to Tier I communities must be mitigated in-kind or by conservation of other communities within Tier I, indicating the irreplaceable nature of these resources.

Table 3 shows how these communities would be differentially impacted by the Staff and Board alternatives in the aforementioned three zoning categories. In summary,

- Oak woodlands in these three categories total 34,766 acres or 55% of all of the oak woodlands in San Diego County.
- Of the oak woodlands, 16,264 acres are comprised of Engelmann oak woodlands, representing 47% of all Engelmann oak woodlands in the county.
- Coniferous forests in these categories represent 16,254 acres or 22% of all coniferous forests in the county.
- Grasslands in these three categories total 15,286 acres or about 10% of the grasslands in the entire county.

Table 2. Acreages of vegetation communities impacted by zoning densities of 1 DU/40 acres and higher and acreages impacted by zoning densities lower than 1 DU/40 acres.

STAFF ALTERNATIVE	Zoning Description**				Total***
Vegetation Category	**>1DU/40**	**RL-40**	**RL-80**	**RL-160**	
Beach/dunes	2	72	468	0	543
Chaparral	68,182	99,330	97,281	15,789	280,582
Coastal scrub	43,307	20,418	7,064	482	71,270
Coniferous forest	3,555	2,303	17,561	282	23,701
Desert/montane scrub	14,494	6,070	41,501	10,618	72,683
Eucalyptus woodland	1,470	45	157	6	1,678
Grasslands	19,897	7,159	9,664	8,992	45,711
Meadow, seep, and playa	388	1,219	4,123	1,436	7,166
Freshwater	431	250	362	31	1,073
Riparian/wetland	9,163	6,357	6,744	2,805	25,069
Woodlands	12,010	13,036	28,324	12,311	65,681
Pinyon-Juniper	0	0	22	1,115	1,137
Total Vegetation Communities*	**172,899**	**156,259**	**213,270**	**53,866**	**596,295**

Total ≥ 1DU/40 acres = 329,158

BOARD ALTERNATIVE	Zoning Description**				Total***
Vegetation Category	**>1DU/40**	**RL-40**	**RL-80**	**RL-160**	
Beach/dunes	2	496	45	0	542
Chaparral	86,338	143,880	50,221	0	280,439
Coastal scrub	49,280	19,649	2,388	0	71,316
Coniferous forest	3,672	15,429	4,577	0	23,677
Desert/montane scrub	14,516	38,265	20,036	0	72,818
Eucalyptus woodland	1,498	152	47	0	1,697
Grasslands	21,867	21,008	3,460	0	46,335
Meadow, seep, and playa	512	4,317	2,459	0	7,287
Open water	461	473	155	0	1,088
Riparian/wetland	9,781	11,414	3,996	0	25,191
Woodlands	15,446	43,914	6,436	0	65,796
Pinyon-Juniper	0	398	740	0	1,138
Total Vegetation Communities*	**203,373**	**299,393**	**94,559**	**0**	**597,325**

Total ≥ 1DU/40 acres = 502,766

*Excludes Agriculture, Disturbed, and Developed.

**Excludes military, tribal lands, national forest, state parks, public/semi-public lands, and other open space.

***Differences in Totals reflect inconsistencies in the way the alternatives are presented in the GIS database.

Table 3. Acreages of vegetation communities in 3 General Plan-2020 categories where Staff alternative density is less than 1 DU/40 acres and Board alternative density is greater than or equal to 1 DU/40 acres (Staff/Board).

Vegetation Category	RL-80/ RL-40	RL-160/ RL-40	RL-80/ SR-10	SUM	**Total County
Beach/dunes	428	0	0	428	2,445
Chaparral	46,997	12,101	2,536	61,634	915,921
Coastal scrub	4,718	457	5	5,180	237,452
Coniferous forest	15,924	282	48	16,254	75,142
Desert/montane scrub	28,616	3,333	7	31,956	466,078
Eucalyptus woodland	116	2	0	119	3,416
Grasslands					
Foothill/Mountain Perennial Grassland	3,190	2,004	10	5,205	25,194
Nonnative Grassland	2,064	4,861	37	6,962	63,336
Transmontane Dropseed Grassland	0	0	143	143	139
Valley and Foothill Grassland	1,535	1,001	20	2,555	25,331
Valley Needlegrass Grassland	67	94	121	282	30,819
Wildflower Field	84	0	0	84	1,517
Undifferentiated Grassland	55	0	0	55	864
Total Grasslands	6,995	7,960	331	15,286	147,200
Meadow, seep, and playa	2,269	801	17	3,087	59,231
Freshwater	215	30	0	245	9,723
Riparian/wetland	4,580	798	35	5,413	83,619
Woodlands					
Engelmann Oak Woodland	7,214	8,823	227	16,264	34,880
Black Oak Forest and Woodland	969	0	0	969	1,526
Coast Live Oak Woodland	6,608	1,945	662	9,216	9,889
Mixed Oak Woodland	5,835	1,317	0	7,152	13,777
Cismontane Woodland	0	5	0	5	138
Undifferentiated Woodland	568	593	0	1,162	3,276
Total Woodlands	21,194	12,683	890	34,766	63,486
Pinyon-Juniper	22	376	0	398	53,493
Barren	0	0	0	0	613
Total Vegetation Communities*	132,072	38,822	3,869	174,764	2,455,136

Source: County of San Diego.
*Excludes Agriculture, Disturbed, and Developed.
**Total acreage of these community types in county (not total acreage of all vegetation communities in county).



- Riparian and wetland communities in these categories total 5,413 acres or >6% of the mapped riparian and wetland communities in the county (because of their scale, some of these wetlands may be under-mapped).

The following sections describe the importance of these communities to rare species in the county, with a focus on oak woodlands and grasslands, which are under-represented in protected areas in the region and in San Diego County (Stallcup et al. 2005). Appendix B lists selected sensitive, rare, and endangered species and their vegetation community associations, which are likely to be most impacted by increased development densities, based on our analysis of vegetation community impacts in specific geographic locations in the county.

Oak woodlands

Oaks are a *keystone* species of biological diversity in Southern California, because they provide habitat and food sources for thousands of other species and profoundly influence ecological communities (Pavlik et al. 1991). Indeed oaks are often recognized as a cultural icon of California landscapes, dating back to their importance to early Indian groups that settled here. In San Diego County, oak woodlands (communities shown in Tables 1 and 3) are most abundant in the central foothills, from Cedar Creek north to Santa Ysabel Valley and west to Rancho Guejito. The Engelmann oak, which is endemic to Riverside and San Diego counties in the U.S. and northern Baja California, has the smallest range of any oak in California (Lathrop and Osborne 1990), with the majority of its distribution in San Diego County (Scott 1991).

Engelmann oak woodlands in the RL-160/RL-40, RL-80/RL-40, and RL-80/SR-10 categories represent almost half of Engelmann oak woodlands mapped in San Diego County (Table 3), including some of the largest trees and largest stands of Engelmann oak woodlands in the county (PSBS et al. 1993). Therefore, decisions concerning residential densities in these areas have huge implications for conservation of oaks in San Diego County, including the rare Engelmann. In the Board alternative, densities of RL-40 and higher would impact 34,314 acres more oak woodlands than in the Staff alternative (59,360 acres in the Board alternative vs. 25,046 acres in the Staff alternative, Table 2). Engelmann oaks represent approximately half of this impact.

Other sensitive species likely to be adversely impacted by loss and fragmentation of oak woodland habitats include the mountain lion, mule deer, Cooper's hawk, which commonly nests in oak woodlands, western bluebird, and several different species of sensitive plants that are rare or have limited distributions, such as the Ramona horkelia, felt-leaved monardella, and San Miguel savory (Appendix B). These sensitive species would be significantly adversely affected by the increased area of oak woodlands that would be zoned at ≥1 DU/40 acres in the Board alternative, as a result of habitat loss and fragmentation, increases in human-tolerant species (e.g., starlings and scrub jays), and increased potential for human-wildlife encounters and roadkill.

Coniferous forests

Coniferous forests in these three categories within San Diego County include bigcone Douglas-fir, Coulter pine, Cuyamaca cypress, Jeffrey pine, white fir, mixed fir, and mixed pine associations. All of these associations are often mixed with oaks. Those communities that are most limited in their regional distribution are bigcone Douglas-fir (1,842 acres in category RL-80/RL-40, representing 23% of this association in the county) and Coulter pine (208 acres in category RL-80/RL-40, 208 acres in RL-160/RL-40, and 26 acres in RL-80/SR-10, representing 9% of this association in the county). Approximately 4,874 acres of mixed pine and fir forests are in category RL-80/RL-40. Coniferous forests in these categories represent 16,254 acres or 22% of all coniferous forests in the county, occurring mostly in the north-central portion of the county. In the Board alternative, densities ≥1 DU/40 acres would impact approximately 13,243 acres more coniferous forest than in the Staff alternative (19,101 acres in the Board alternative vs. 5,858 acres in the Staff alternative, Table 2).

The Coulter pine, a California endemic, reaches the end of its southern distributional limit in San Diego County, with a few scattered stands in northern Baja California (Griffin and Critchfield 1972, Minnich and Franco Vizcaíno 1998). Pine Mountain on Rancho Guejito is the westernmost of the disjunct populations in San Diego County. Almost 300 acres of Coulter pine would be impacted by high density development (≥1 DU/40 acres) proposed by the Board alternative that the Staff alternative proposes for lower densities than 1 DU/40 acres. Similarly, the bigcone Douglas fir relies on interconnected habitats for its long-term persistence and would be adversely impacted by loss and fragmentation of habitat.

In San Diego County and other parts of Southern California, the California spotted owl occurs as a series of small, relatively isolated populations in montane, late-seral stage, closed-canopy woodlands of oaks and conifers (Noon and McKelvey 1992, LaHaye et al. 1994, Unitt 2004). As a result of habitat loss and fragmentation, decline in habitat quality due to development, adverse effects to its habitat from groundwater drawdown resulting from new rural development and use for bottled drinking water, and intolerance of human activity near nest sites, spotted owl populations in Southern California are declining, with only 25-50 pairs estimated in San Diego County. Because of their low numbers and narrow habitat requirements, spotted owls may be especially susceptible to habitat loss. In addition, wide-ranging sensitive species such as mule deer and mountain lion, which use conifer habitats, would be significantly impacted by the increased area zoned for development densities of ≥1 DU/40 acres in the Board alternative, due to loss and fragmentation of their habitats, greater probability for human-wildlife encounters, and increased roadkill.

Grasslands

Grasslands have historically been undervalued as a resource in Southern California, as most of them have been planted with or heavily invaded by nonnative annual grasses, and, until the last decade, plant and animal species in these areas had not been listed by state and federal governments as Threatened or Endangered. Moreover, their locations on flat or gentle slope areas make them ideal for development.

Over the past decade, as significant acreage of grasslands in Southern California has been lost to development and, concurrently, populations of grassland species have declined, grasslands—both those mapped as native and nonnative—have become more valuable for conservation. Moreover, as field surveys are conducted in grasslands, biologists are finding that native grasses and forbs are still there, but have been overlooked because of the taller nonnative annuals. So, in many cases, areas mapped as nonnative grasslands are really a combination of native and nonnative species that still retain significant habitat values. Regardless of plant species composition, grasslands are a very important resource for wildlife.

Grasslands in the three aforementioned development density difference categories represent >10% of all grasslands in San Diego County (Table 3). In the Board alternative, densities ≥1 DU/40 acres would impact approximately 15,819 acres more grasslands than in the Staff alternative (42,875 acres in the Board alternative vs. 27,056 acres in the Staff alternative, Table 2).

The grasslands on Rancho Guejito and in Santa Ysabel Valley (category RL-160/RL-40) comprise about half of the 15,819-acre difference between the higher density categories of the two alternatives (Table 2) and are particularly significant because of their overall size and integrity. Large grassland patches are rare in San Diego County (Table 4), and the largest are not conserved for their biological values. Therefore, decisions concerning residential densities in these areas have huge implications for the county's remaining grasslands.

Large, intact grasslands, provide habitat for declining species such as raptors, badgers, grasshopper sparrows, burrowing owls, and Stephens' kangaroo rats. These species, among other grassland species considered sensitive by the County of San Diego (Appendix B), are known to use the grasslands and associated oak savannas in the three aforementioned development density difference categories.

Table 4. Largest grassland complexes in San Diego County.

Location	Approx. Size* (acres)
Camp Pendleton	45,000
Lake Henshaw	16,000
Santa Ysabel/Mesa Grande	5,400
Rancho Guejito	4,900
Ramona	2,000
Otay/Sweetwater NWR	1,900

*Based on San Diego County vegetation data.

Based on the extent, type and quality of suitable habitat (uncultivated grasslands and savannas on friable soils), and availability of prey (primarily rodents), the grasslands within the areas zoned for ≥1 DU/40 acres in the Board alternative may support the few sustainable populations of badgers remaining in San Diego County. Badgers have relatively large home ranges, with some estimates as large as >4,000 acres (Sargeant and Warner 1972), and young badgers have been

recorded to disperse as far as 68 miles from their natal ranges (Lindzey 2003), making the availability of large, intact grassland areas necessary for their persistence. Increasing development densities to ≥1 DU/40 acres across over 15,000 acres of grasslands in the county would result in greatly increased fragmentation and human disturbance of badger habitat and is considered a significant impact to this sensitive species.

The large expanses of grasslands in areas zoned for ≥1 DU/40 acres in the Board alternative and <1 DU/40 acres in the Staff alternative support at least 16 different raptor species:

Turkey vulture (*Cathartes aura*)
Bald eagle (*Haliaeetus leucocephalus*)
Northern harrier (*Circus cyaneus*)
Sharp-shinned hawk (*Accipter striatus*)
Cooper's hawk (*Accipter cooperii*)
Red-shouldered hawk (*Buteo lineatus*)
Red-tailed hawk (*Buteo jamaicensis*)
Ferruginous hawk (*Buteo regalis*)
Golden eagle (*Aquila chrysaetos*)
American kestrel (*Falco sparverius*)
Merlin (*Falco columbarius*)
Prairie falcon (*Falco mexicanus*)
Barn owl (*Tyto alba*)
Great horned owl (*Bubo virginianus*)
Western screech owl (*Otus kennicottii*)
Burrowing owl (*Athene cunicularia*)

Large grasslands with abundant prey resources are crucial to raptor populations that breed, winter, or migrate through San Diego County. The loss and fragmentation of habitat, increase in human-tolerant species (a number of which can be nest predators), and increased human uses of grassland areas associated with increasing development densities to ≥1 DU/40 acres under the Board alternative will diminish habitat quality for these species, resulting in significant adverse impacts.

The grasslands on Rancho Guejito (in Staff/Board category RL-160/RL-40) also support one of the largest remaining populations of the endangered Stephens' kangaroo rat—second in size only to the Warner Basin area among the San Diego populations (Table 5), and it appears comparable or slightly smaller (based on actually occupied habitat acreage) to the two largest Riverside County *core* populations. Development can directly affect Stephens' kangaroo rat habitat via direct loss and indirectly affect its habitat by adversely affecting our ability to manage its habitat via grazing or prescribed fire. This species is sensitive to changes in grassland structure that would accompany eliminating these disturbances in residential areas. Thus, increasing development densities to ≥1 DU/40 acres on Rancho Guejito under the Board alternative would be considered a significant impact to this species.

Riparian and wetland communities

Riparian associations in the county include white alder riparian forest, southern cottonwood-willow riparian forest, southern coast live oak riparian forest and woodland, southern sycamore-alder riparian woodland, riparian forest and scrub, southern willow scrub, and mule fat scrub. Riparian and wetland communities are the life blood of many sensitive, rare, and endangered species that rely on these habitats for some or all of their life histories (Appendix B). Of all the categories in Table 1, the RL-80/RL-40 category would affect the greatest acreage of riparian and wetland communities (4,580 acres), followed by the RL-160/RL-80 category (1,883 acres). In the Board alternative, densities ≥1 DU/40 acres would affect approximately 5,675 acres more

Table 5. Approximate area of occupied Stephens' kangaroo rat habitat for the largest remaining habitat areas in Riverside and San Diego counties.

Location	Occupied Habitat	
	Hectares	Acres
Riverside County		
Lake Matthews-Estelle Mountain	1,726	4,264
Lake Perris-San Jacinto	1,528	3,775
Lake Skinner-Dominigoni Valley	805	1,988
Sycamore Canyon-March Air Force Base	548	1,355
Motte Rimrock-Steele Peak	484	1,195
San Diego County		
Lake Henshaw-Warner Basin	4,600	11,370
Rancho Guejito	1,219	3,012
Ramona Grasslands	~243	~600
Marine Corps Base Camp Pendleton	~160	~400
Fallbrook Naval Weapons Station	<160	<400

Source: USFWS (1997), Montgomery (2005), Ogden (1998), and S.J. Montgomery and W. Spencer unpublished data.

riparian and wetland communities than in the Staff alternative (21,195 acres in the Board alternative vs. 15,520 acres in the Staff alternative, Table 2). Many of the direct impacts to wetlands may be avoided by development, but impacts to wetlands via indirect effects, such as increasing impervious surfaces in their watersheds or groundwater withdrawals, can be far greater than direct impacts.

Because development can reduce the integrity of watersheds and modify the magnitude, frequency, duration, timing, and rate of discharge of stream systems, aquatic and riparian communities that depend on a natural flow regime are ultimately affected, as are the species they support. Impacts to watershed basins in the central foothills of the county, which support the headwaters of all of our coastal drainages, will have cascading effects downstream. For example, development in the RL-160/RL-40 and RL-80/RL-40 categories would have adverse impacts to lands downstream in the San Luis Rey, San Dieguito, and San Diego River watersheds, including lands that have been conserved as part of the MSCP. In the San Pasqual Valley alone, this could result in adverse impacts to core breeding populations of the endangered least Bell's vireo and southwestern willow flycatcher, communities of other neotropical migrant bird species that breed in San Diego County, and a core population of the endangered arroyo toad (CBI 2003, Appendix B). Riparian and wetland communities also provide important habitat for wide-ranging species like the mountain lion and mule deer, and the increased area with densities ≥1 DU/40 acres in the Board alternative would result in greater potential for significant adverse effects to these species from increased human encounters.

6. CONCLUSIONS

Based on our analysis of the two GP-2020 alternatives, we conclude that the Staff alternative is environmentally superior to the Board alternative, and implementing the Board alternative would result in significantly greater impacts to natural resources, especially rare resources, as a result of greater direct loss of habitat, greater habitat fragmentation, and greater indirect impacts to habitats and species.

Our review of the peer-reviewed scientific literature concerning the effects of development density on natural resources found that significant adverse effects can be detected at densities as low as 1 DU/50 acres and that the magnitude of these adverse impacts increases as development densities increase. Significant adverse effects include greater abundance of nonnative plants and altered vegetation structure, increased availability of human-subsidized food and water supplies, increased abundance of human-tolerant wildlife, and decreased abundance of human-intolerant wildlife species, likely as a result of competition with human-tolerant species in human-altered environments.

To supplement the information available from the published scientific literature, we conducted an empirical investigation of habitat fragmentation at varying development densities in San Diego County. Consistent with the published literature, we found that the magnitude of fragmentation increases along a gradient of increasing development density. Also consistent with the literature, we found that 1 DU/40 acres appears to be a threshold at which there is significant habitat fragmentation. At densities lower than 1 DU/40 acres fragmentation decreases slowly and is similar to undeveloped habitat, and at densities above 1 DU/40 acres fragmentation is greater and increases rapidly with increasing development density. Therefore, for the purposes of this analysis, we consider development at densities of 1 DU/40 acres or higher to result in significantly greater biological impacts than development at densities less than 1 DU/40 acres.

Comparing density zoning maps from the two GP-2020 alternatives, there are approximately 174,000 acres more of the county zoned at 1 DU/40 acres or higher in the Board alternative than in the Staff alternative. Much of the 174,000 acres is located in parts of the county supporting sensitive and under-protected vegetation communities (e.g., grasslands, Engelmann oak woodlands) that support sensitive, rare, and endangered species (e.g., Stephens' kangaroo rat, burrowing owl, golden eagle and other raptors, arroyo toads, Appendix B). Thus, there would be significant adverse impacts to these and other sensitive species as a result of the substantially increased acreage of habitat loss and fragmentation associated with development densities of 1 DU/40 acres or higher under the Board alternative. Furthermore, much of the 174,000 acres is located in parts of the county that have high existing ecological integrity and that form parts of regionally important blocks of biological core areas (e.g., Rancho Guejito-Santa Ysabel core). Based on the best available scientific information, supplemented with our empirical analyses, we conclude that the Board alternative has significantly greater adverse impacts to biological resources than the Staff alternative and, because of the nature and location of these impacts, they would be unmitigable.

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Appendix A
Methods for Analysis of Ecological Integrity

The ecological integrity of a landscape refers to the extent that it remains free of human modifications, which is an indication of the ability of ecosystems to function naturally. In our model, we used the distribution and extent of human land cover alteration from roads and urban and agricultural development to construct a simple cost surface over the county, which could be used to investigate ecological integrity across the landscape. Costs ranged from 0 to 5, with cost and ecological integrity inversely related. Costs were assigned in the following manner:

1. The 1:100,000-scale USGS roads dataset was buffered according to road class and assigned the following scores (0 = no cost, 5 = high cost):

Road class	Buffer	Cost
Class 1 (major highways)	30m (98 ft)	5
Class 2 (major roads)	20m (66 ft)	5
Class 3 (minor roads)	5m (16 ft)	3
Classes 4,5 (streets and trails)	2m (6 ft)	3

2. Land cover categories in the land cover dataset were assigned costs in the following manner:

Land cover type	Cost
Urban	5
Agriculture	3
Natural habitats	0

3. A grid with 5,000 ft^2 cells was placed over the region. Total area-weighted costs were calculated for each grid cell, and each cell was assigned a final score from 0 (high integrity) to 5 (low integrity). Integrity scores (Figure5) were divided into 5 classes:

Integrity	Cost range
Very high	0 - 0.10
High	0.11 – 0.5
Moderate	0.51 – 1.0
Low	1.01 – 2.5
Very low	2.51 – 5.0

Appendix B
Selected Sensitive, Rare, and Endangered Species Likely to Be Most Impacted by Increased Densities, based on Analysis of Vegetation Community Impacts

Scientific Name	Common Name	Regulatory Status[1]	Primary Habitats[2]
Plants			
Acanthomintha ilicifolia	San Diego thornmint	FT/SE/1B/MSCP	GRS, CHP, Scrub
Arctostaphylos rainbowensis	Rainbow manzanita	1B/MSCP	CHP
Astragalus oocarpus	San Diego milk-vetch	1B	CHP, OW
Baccharis vanessae	Encinitas baccharis	FT/SE/1B/MSCP	CHP
Brodiaea orcuttii	Orcutt's brodiaea	FSC/1B/MSCP	GRS, OW, VP
Clarkia delicata	Delicate clarkia	1B	GRS
Grindelia hirsutula var. *hallii*	San Diego gumplant	1B	CHP, OW
Horkelia truncata	Ramona horkelia	1B	CHP, OW
Machaeranthera juncea	Rush chaparral-star	4	CHP, Scrub
Monardella hypoleuca ssp. *lanata*	Felt-leaved monardella	1B	CHP, OW
Nolina cismontana	Chaparral beargrass	FSC/1B/MSCP	CHP, Scrub
Ophioglossum lusitanicum ssp. *californicu*	California adder's-tongue fern	4	CHP, GRS, VP
Pinus coulteri	Coulter pine	-	CON
Polygala cornuta ssp. *fishiae*	Fish's milkwort	4	CHP, OW RIP
Quercus engelmannii	Engelmann oak	MSCP	OW
Satureja chandleri	San Miguel savory	1B/MSCP	GRS, OW, RIP
Scutellaria bolanderi ssp. *austromontana*	Southern skullcap	1B	CHP, OW, CON
Senecio ganderi	Gander's butterweed	FSC/SR/1B/MSCP	CHP
Tetracoccus dioicus	Parry's tetracoccus	FSC/1B/MSCP	CHP
Invertebrates			
Euphyes vestris harbisoni	Harbison's dun skipper	FSC/MSCP	RIP, OW
Streptocephalus woottoni	Riverside fairy shrimp	FE	VP
Branchinecta sandiegonensis	San Diego fairy shrimp	FE/MSCP	VP
Fish, Reptiles, Amphibians			
Gila orcutti	Arroyo chub	SSC	RIP
Taricha torosa torosa	California newt	SSC/MSCP	RIP
Bufo californicus	Arroyo toad	FE/SSC/MSCP	RIP
Spea hammondii	Western spadefoot	FSC/SSC/MSCP	VP
Rana aurora draytonii	California red-legged frog	FT/SSC	RIP
Clemmys marmorata pallida	Southwestern pond turtle	FSC/SSC/MSCP	RIP
Phrynosoma coronatum blainvillei	San Diego horned lizard	FSC/SSC/MSCP	CHP, Scrub
Aspidoscelis hyperythrus	Orange-throated whiptail	FSC/SSC/MSCP	CHP, Scrub, GRS
Eumeces skiltonianus interparietalis	Coronado skink	SSC	Multi
Thamnophis hammondii	Two-striped garter snake	SSC	RIP
Crotalus ruber ruber	No. red diamond rattlesnake	SSC	Multi
Anniella pulchra pulchra	Silvery legless lizard	SSC	Multi
Salvadora hexalepis virgultea	Coast patchnose snake	SSC	Multi
Birds			
Haliaeetus leucocephalus	Bald eagle	FE/SE/SFP/MSCP	Multi
Aquila chrysaetos	Golden eagle	SSC/SFP/MSCP	Multi

Scientific Name	Common Name	Regulatory Status[1]	Primary Habitats[2]
Accipiter cooperii	Cooper's hawk	SSC/MSCP	OW
Circus cyaneus	Northern harrier	SSC/MSCP	GRS
Accipiter striatus	Sharp-shinned hawk	SSC	Multi
Buteo regalis	Ferruginous hawk	SSC	GRS
Athene cunicularia hypugaea	Burrowing owl	FSC/SSC/MSCP	GRS
Strix occidentalis occidentalis	California spotted owl	SSC	CON
Asio otus	Long-eared owl	SSC	Multi
Asio flammeus	Short-eared owl	CSC	GRS
Falco columbarius	Merlin	SSC	Multi
Falco mexicanus	Prairie falcon	SSC	Multi
Elanus axillaris	White-tailed kite	FSC/SSC	GRS
Polioptila californica californica	California gnatcatcher	FT/SSC/MSCP	Scrub
Campylorhynchus brunneicapillus couesi	Cactus wren	SSC/MSCP	Scrub
Aimophila ruficeps canescens	Rufous-crowned sparrow	FSC/SSC/MSCP	Scrub
Amphispiza belli belli	Bell's sage sparrow	SSC/MSCP	Scrub, GRS
Ammodramus savannarum perpallidus	Grasshopper sparrow	FSC/MSCP	GRS
Chondestes grammacus	Lark sparrow	FSC	GRS
Eremophila alpestris actia	California horned lark	SSC	GRS
Agelaius tricolor	Tricolored blackbird	FSC/SSC/MSCP	GRS, WT
Icteria virens	Yellow-breasted chat	SSC/MSCP	RIP
Dendroica petechia	Yellow warbler	SSC	RIP
Vireo bellii pusillus	Least Bell's vireo	FE/SE/MSCP	RIP
Empidonax trailii extimus	Southwest. willow flycatcher	FE/MSCP	RIP
Sialia mexicana	Western bluebird	MSCP	OW
Lanius ludovicianus	Loggerhead shrike	SSC	GRS, scrub
Mammals			
Eumops perotis californicus	California mastiff bat	SSC	Multi
Antrozous pallidus	Pallid bat	SSC	Multi
Plecotus townsendii	Townsend's big-eared bat	SSC	Multi
Taxidea taxus	American badger	SSC	GRS
Bassariscus astutus	Ringtail	SFP	Rocky outcrops
Lepus californicus bennettii	Black-tailed jackrabbit	FSC/SSC/MSCP	Multi
Chaetodipus californicus femoralis	California pocket mouse	SSC	Multi
Chaetodipus fallax fallax	San Diego pocket mouse	SSC	Multi
Neotoma lepida intermedia	San Diego desert woodrat	SSC	Multi
Dipodomys stephensi	Stephens' kangaroo rat	FE/ST/MSCP	GRS
Odocoileus hemionus fuliginata	Southern mule deer	MSCP	Multi
Felis concolor	Mountain lion	MSCP	Multi

[1] FE = federally listed as endangered.
FT = federally listed as threatened.
FSC = federal species of concern.
SE = state listed as endangered.
ST = state listed as threatened.
SR = state listed as rare.
SSC = state species of concern.
SFP = state fully protected.
1B = CNPS List 1B—rare or endangered in California and elsewhere (CNPS 2001).
4 = CNPS List 4—plants of limited distribution (CNPS 2001).
MSCP = sensitive species addressed by North County MSCP subarea plan.

[2] CHP = chaparral, CON = coniferous forest, GRS = grassland, RIP = Riparian, OW = oak woodland, WT = wetland, Multi = multiple habitats, VP = vernal pools

Source: records from CNDDB, Unitt 2004, Hathaway et al. 2004, PSBS et al. 1993, County predictive models.