California's Forests and Rangelands:
2010 ASSESSMENT

CALIFORNIA DEPARTMENT OF FORESTRY AND FIRE PROTECTION

FIRE AND RESOURCE ASSESSMENT PROGRAM

Fire and Resource Assessment Program
California Department of Forestry and Fire Protection

California's Forests and Rangelands:

2010 Assessment

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Table of Contents

Executive Summary

BACKGROUND

For over 30 years, state law (PRC 4789) has mandated periodic assessments of California's forest and rangeland resources. To meet this mandate assessments were produced in 1979, 1988, 1996 (Fire Plan), and 2003. In 2008, the Federal Farm Bill added a provision to federal law that required states to do assessments of forest resources. These assessments are to identify key issues and define the status and trends across all forest lands in each state. To the extent possible, spatial areas (called priority landscapes) are to be delineated that help focus investments and other programs to deal with associated issues. A separate document must also be prepared that presents strategies to address issues and priority landscapes identified in the assessment. The intent of the 2010 Forest and Range Assessment is to meet both the state and federal mandates, hence it covers both forest and rangeland resources, on private as well as publically managed lands.

In many ways, this assessment portrays a continuation of past trends of impacts from wildfire, development, forest pests, and exotic invasive species. However, there are also relatively new or markedly increasing potential threats from renewable energy infrastructure, off highway vehicle use, and climate change. Finally, traditional as well as new opportunities exist for shaping future conditions through emerging markets for biomass and other renewable energy sources; carbon, niche markets, and ecosystem services; innovative regional and local partnerships and strategies to conserve and manage open space and working landscapes for both commodity production and non-market benefits; and various tools, policies, programs and incentives to positively influence land management and use decisions.

PRESENTATION OF THE 2010 ASSESSMENT

As required by the 2008 Farm Bill, this assessment presents an analysis of trends, conditions, and the development of priority landscapes. Unlike previous assessments done to meet the state mandate, it is organized around three themes presented in related federal assessment and strategy Redesign guidance documents (http://www.fs.fed.us/spf/redesign/index.shtml). The three themes and eleven related subthemes are covered in both this assessment and the strategies document. Each of the eleven subthemes constitutes a unique assessment chapter:

1. Conserve Working Forest and Range Landscapes

1.1 Population Growth and Development Impacts
1.2 Sustainable Working Forests and Rangelands

2. Protect Forests and Rangelands from Harm

2.1 Wildfire Threat to Ecosystem Health and Community Safety
2.2 Forest Pests and Other Threats to Ecosystem Health and Community Safety

3. Enhance Public Benefits from Trees, Forests and Rangelands

3.1 Water Quality and Quantity Protection and Enhancement
3.2 Urban Forestry for Energy Conservation and Air Quality
3.3 Planning for and Reducing Wildfire Risks to Communities
3.4 Emerging Markets for Forest and Rangeland Products and Services
3.5 Plant, Wildlife and Fish Habitat Protection, Conservation and Enhancement
3.6 Green Infrastructure for Connecting People to the Natural Environment
3.7 Climate Change: Threats and Opportunities

There is an additional chapter relating to issues in Bordering States, and an Appendix that describes Data and Analytical Needs. The FRAP website has supporting information regarding assessment methodologies and other background material.

The eleven assessment chapters contain 23 unique spatial analyses and their resultant priority landscapes and generate 150 key findings, found at the beginning of each chapter. The number of priority landscapes reflects the diversity of issues, ecosystems, and values at work in California. Resultant priority landscapes are purposefully kept separate to focus on those particular assets and threats being modeled. While attempting to cover a broad range of issues, they may not be exhaustive due to factors such as data limitations and availability, and constraints on time and personnel, or other challenges.

OVERARCHING FINDINGS

From this assessment's key findings, six overarching issues emerged that unite disparate chapter results:

1. *Forest and rangelands, and urban forests, remain valued assets, critical to the economic, social, and environmental well-being of California.*

   Forests, rangelands, and urban forests clearly are among the major factors contributing to the quality of life enjoyed by Californians. These lands serve as high quality habitat for fish and wildlife species, sequester carbon to mitigate climate change, capture vital runoff for agricultural and domestic water supply, and provide a variety of outdoor recreation and education opportunities. Many rural communities depend on working landscapes for timber and rangeland livestock industries, or for amenity values to attract new residents seeking a better lifestyle, such as retirees. Finally, in metropolitan areas urban forests contribute to improved air quality, cooling of heat islands for energy conservation, and local employment.

2. *California's forest and rangelands face a variety of threats, and trends indicate that these are increasing in number, extent, and severity.*

   For a variety of reasons, pressure to convert forest and rangeland to more developed land uses continues. In addition, wildfire trends point to increasing acres of forests and rangelands burned statewide, particularly in conifer forests. Impacts are likely to increase in the future, based on climate change research indicating increased fire activity and severity. Forest pests cause major damage, resulting in significant public and private costs and losses. Increased prevalence of exotic invasive forest pest species is a major concern.

Since California (1984) and Federal Endangered Species Acts (1973) were passed, the general trend has been an increase in the number of both animals and plants listed as threatened or endangered. California's native fish are having great difficulty adapting to human induced changes, such as introduction of exotic species and in and near-stream habitat degradation. The California Wildlife Action Plan (2007) presents at least 20 main threats to plant, wildlife and fish populations and their habitats across the state.

Finally, climate change poses a major new challenge across all forest and range landscapes, with temperatures likely to increase and large uncertainty in future precipitation amounts and distribution patterns. Over the long-term, climate change is likely to shift plant and animal species distributions, and cause unknown impacts on forest and rangelands.

3. *Demands on forest and rangeland resources are increasing, especially for ecosystem services. Emerging markets are placing new demands on these lands.*

The state's already large population continues to increase, particularly in Southern California, and an estimated 3.9 million residents will be added over the next decade. This trend places increasing pressure on land development and natural ecosystems in the state. The demand for clean water from forest and rangeland watersheds will keep growing, while the supply remains static or uncertain. In addition, the development of renewable energy sources from forest and rangelands potentially will affect all bioregions, given the increased infrastructure required. Finally, the increasing popularity of specific recreation activities such as off highway vehicle use creates a significant challenge to provide adequate recreation opportunities in locations where best management practices can be applied and impacts minimized.

4. *A significant portion of forest and rangelands, urban forests, and the infrastructure required to meet demands from these lands, is in a degraded or undesirable condition.*

The analyses in this assessment showed that much of the state's forest and rangeland has been compromised by disturbance and past uses. At least 2.35 million acres were found to be impacted from past wildfires statewide, and over 6 million acres by pests, mostly on U.S. Forest Service lands. The 2002 list of impaired waterbodies estimated that California has over 26,000 miles of impaired streams, about 14 percent of the total miles of streams and rivers in California. Twenty-eight fish taxa are listed as state or federally threatened or endangered, and at least 45 percent of California's 62 native fish species are considered by the California Department of Fish and Game (DFG) as those of greatest conservation need.

The infrastructure required to meet demands from these lands and provide opportunities for treatment of impacted areas is similarly in an unfavorable condition. The softwood sawmill capacity in California shrank by 25 percent in the last few years, indicating an overall contraction of the sector in jobs, capacity and economic activity. The ranching industry has also been in steady long-term contraction, and large ranching operations must find means to remain economically viable to avoid conversion, abandonment or fragmentation.

Agencies that provide recreation opportunities are struggling to meet demand for diverse, safe, high-quality recreation opportunities with smaller budgets, which is resulting in instances of reduced hours of operation and deferred maintenance. In metropolitan areas, about 800,000 densely populated acres, or 15 percent of the state's urban area, has been identified with high threat from air pollution and urban heat islands. Close to 28 percent of the state's population (9.5 million people) live in these areas.

5. *Opportunities exist to improve the quality and quantity of benefits from these lands. There are management options leading to desired future conditions to sequester more carbon, improve water quality, foster more vibrant rural economies, and make natural landscapes more resistant to threats. Reaching desired future conditions will require surmounting numerous political, social, and economic challenges.*

   Emerging markets for renewable energy, carbon, niche products, and ecosystem services are already having an impact on how forest and rangelands are managed. Developing appropriate policies will require a better understanding of the benefits and environmental impacts of these emerging markets, and how society values the various market and non-market products and services provided by forests and rangelands. Emerging markets for ecosystem services have the potential to not only provide incentives to sustain forest and rangelands in the face of development pressures, but also influence how they are managed. Many policies, programs, agencies and stakeholders are involved with making decisions over where to make investments that affect ecosystem services. This typically involves protecting areas that provide unique or high levels of desired services, or restoring areas impacted by past events. Augmenting this with emerging market-based solutions could enhance our ability to sustain these important services into the future.

   For example, carbon markets could provide incentives for longer rotation ages, maintaining fully stocked conifer stands, and conducting treatments to minimize risk from wildfire and forest pests. California has large acreages of forests that, with additional management and investment, could provide larger future benefits in terms of forest products, jobs, and carbon storage and sequestration. Similarly, biomass energy from forestlands can provide a financial incentive for reducing wildfire and forest pest risk, and for treatment of impacted areas.

6. *One of California's great strengths is its human capital. The potential to reach desired future conditions across forest and rangelands will depend in large part on taking advantage of and augmenting existing collaborative efforts and groups, initiatives, strategies, and success stories.*

   At the state, regional, and local level, there are many examples of innovative, collaborative, successful efforts to develop and implement policies and strategies to improve current conditions.

At the state level, a number of strategic planning documents, programs and initiatives have been drafted that have bearing on forest and rangelands, such as the California Wildlife Action Plan, the Water Plan, the Renewables Portfolio Standard, Bioenergy Action Plan, California Outdoor Recreation Plan and the Off Highway Vehicle Strategic Plan, and Assembly Bill 32 Scoping Plan. Each has a particular focus on one or more key resources. While touched on in this assessment, they are covered in more detail in the strategy document.

A large amount of work has been completed or is underway in California to identify, preserve and protect important wildlife, plant, and fish habitat. For example, nearly $200 million in grant monies has been awarded by DFG alone for fish habitat restoration in 26 counties since 1981. A recently released DFG study on essential wildlife corridors connecting areas of core habitat gives a regional scale view of areas which should be looked at in more detail for conservation. Similarly, federal and state funding promote water quality through efforts such as CALFED, and recreation opportunities through the Land and Water Conservation Fund.

At the region level, there are excellent examples of efforts to develop and implement strategies to protect and manage green infrastructure for both commodity production and ecosystem services. These efforts are typically cross-jurisdictional, involve stakeholders, and address multiple issues such as recreation, water, wildlife habitat and economic development. For example, counties in the Bay/Delta bioregion have achieved a significant level of green infrastructure protection despite the absence of large federal landholdings by developing a shared strategy and adopting a wide range of complementary public-private programs.

At a more local level, the number of Firesafe Councils and watershed groups is testament to the value of public involvement, as are the various organizations that serve to educate local residents in the value of care of local landscapes, and involve them in stewardship and volunteer efforts.

Finally, many private companies, non-profit organizations, and governmental programs have worked hard to sustain and improve California's urban forest. This strong network of organizations provides many public benefits by improving the urban forest, and the public awareness of the importance of urban forests is growing. The Urban Forest Protocols were approved to benefit local governments and provide incentive to others through offset carbon credits for planting trees in urban settings.

SUMMARY OF CHAPTER RESULTS

Key findings and highlights from each topic covered in this assessment are supplied in this section, organized according to the guidance given by the Forest Service's Redesign program. These highlights do not cover the topics in detail, but provide a quick review of topic coverage to serve as a supplement to the strategy report.

1.1: Population Growth and Development Impacts

CHAPTER OVERVIEW

Many of the same ecosystems that have been hard hit by historical development are projected to be further impacted by development in the near future, particularly in and around the largest urban areas. The state's already large population is still growing, particularly in Southern California, and an estimated 3.9 million residents will be added over the next decade. This ongoing trend will maintain or increase pressure for land development that can increasingly compromise ecosystems across the state.

Tools to address development threat to ecosystems, include land acquisition, easements, zoning policies, and policies to promote in-filling of existing developed areas.

This chapter has a single spatial analysis which examines the threat of near-term development to ecosystems.

ANALYSIS: POPULATION GROWTH AND DEVELOPMENT IMPACTS

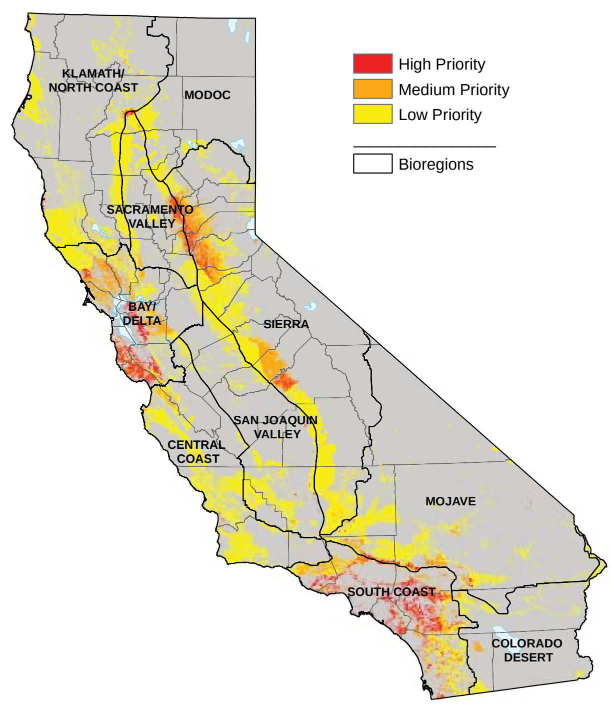
Key Findings

- The habitat types in California with the most acres at risk from development statewide are Annual Grassland, followed by Coastal Scrub, Montane Hardwood and Blue Oak Woodland.
- The bioregions with the highest proportion of acres at risk are the South Coast, Bay/Delta, and the central and northern foothill areas of the Sierra. Types found to be most at risk in these regions:

  — South Coast: Coastal Scrub, Annual Grassland and Mixed Chaparral.
  — Bay/Delta: Annual Grassland, Coastal Oak Woodland, Montane Hardwood and Redwood.
  — Sierra: Montane Hardwood, Blue Oak Woodland, Annual Grassland and Montane Hardwood-Conifer.

- Other habitat types of much smaller extent show up as threatened in local areas of other bioregions, such as the Blue Oak - Foothill Pine in the northern Sacramento Valley bioregion.

Priority Landscapes



This analysis identifies California landscapes of high ecosystem values that are currently facing significant threats from development. High ecosystem value landscapes are defined as areas where specific wildlife habitat types are at significant risk from regional development over the next ten to 30 years.

1.2: Sustainable Working Forests and Rangelands

CHAPTER OVERVIEW

The concept of "working landscapes" was developed to encompass the idea that lands used for commodity production also provide crucial ecosystem services and that future demands make it essential that these systems are managed for joint production of ecosystem services as well as food, fiber, energy, and other economic values.

Current condition and trends of working landscapes and the industries that depend on them, as well as threats to their sustainability from various land use practices are discussed in chapter sections related to: Land Use and Land Cover Impacts, Forests and Woodlands, Forest Products Sector, and Rangelands and Range Industry.

The final chapter section addresses opportunities for landowner assistance to enhance productivity and health of working landscapes. This includes three unique spatial analyses, each identifying priority landscapes where additional investments have both the potential to enhance commodity production and the capacity to provide ecosystem services:

1. Risk Reduction on Forestlands: identifies areas with timber and biomass energy assets that are threatened by wildfire and forest pests.
2. Risk Reduction on Rangelands: identifies areas where rangeland productivity is threatened by wildfire.
3. Restoring Impacted Timberlands: identifies areas with timber and biomass energy assets that have been impacted by past wildfires or forest pest outbreaks.

A fourth non-spatial statistical analysis is included to quantify opportunities for improving stocking levels on timberlands. The landowner assistance section concludes with a discussion of the various state and federal programs that exist to provide technical, financial and other assistance to forest and range landowners.

Land Use and Land Cover Impacts Key Findings

- Permanent land cover change occurs most often (47,000 acres a year) in grassland/shrubland types, most dramatically in grazing lands along the edges of the Central Valley.
- Forest disturbance from harvest peaked between 1986 and 1992 with fire-caused disturbance most common in forests from 1992-2000.
- Monitoring of Best Management Practices on private and public forestlands shows generally high compliance with implementation and effectiveness when implemented properly.
- Unmanaged outdoor recreation may adversely impact natural resources by causing erosion, spread of invasive weeds, compaction, plant damage, wildlife disturbance, damage to cultural resources and others.

Forests and Woodlands Key Findings

- Both private and public forestlands appear to continue to build inventory volume.
- A U.S. Forest Service analysis indicates that while carbon sequestration is occurring, long-term carbon storage will be a function of management inputs over the next 100 years.
- A carbon sequestration and storage analysis of California's private timberlands suggests that less total storage and sequestration is occurring relative to public lands, but given management inputs may be more sustainable in the long-run. The annual net sequestration is estimated to be about 5 million metric tons per year on private forestlands and about 25 million metric tons per year on public forestlands.
- The propensity for the conversion of working forests and woodlands is increasing due to pressures from high costs, low income, infrastructure loss and generational turnover.

Forest Products Sector Key Findings

- The forest products infrastructure of California is declining in terms of jobs, capacity and overall economic activity. Softwood sawmill capacity shrank by 25 percent in the last few years. Climate change adaption, biomass energy production, and risk reduction and restoration activities depend on that infrastructure, as do many of the rural economies of California.
- Industrial ownership patterns have shifted from publicly held corporations to privately held firms.
- Individual Timber Harvesting Plans (THPs) have been increasing in size. Their total acreage was fairly steady before 2009. Acres under Non-Industrial Timber Management Plans (NTMPs) continue to rise but with smaller landowners increasing in participation. As of January 1, 2010, there are 711 NTMPs covering 301,598 acres.
- The acres of alternative prescriptions have declined and clearcutting acreage has been generally constant over the last several years.
- Cost reduction and regulatory streamlining is necessary for the forest products sector in California to compete and be sustainable in the long-term.

Rangelands and Range Industry Key Findings

- Rangeland productivity is highly variable across space and time. Climate change impacts this further. Buffering public lands with grazing helps protect ecosystem health from development and protect development from wildfires originating on public wildlands.
- Like the timber industry, the ranching industry has been in steady long-term contraction. The maintenance of large ranches across California landscapes cannot rely on amenity values; these must be economically viable operations to avoid conversion, abandonment or fragmentation.
- The propensity for the conversion of working rangelands is increasing due to pressures from high costs, low income, infrastructure loss and generational turnover.

LANDOWNER ASSISTANCE

ANALYSIS: RISK REDUCTION ON FORESTLANDS

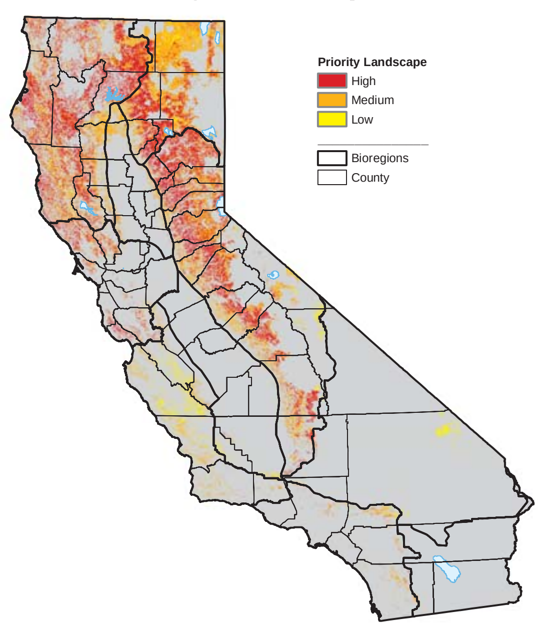
Key Findings

- High priority landscapes were found primarily in the Klamath/North Coast, Modoc and Sierra bioregions.

For this analysis, economic assets include timber and forest biomass. High priority landscapes represent areas with important economic assets that face significant threat from wildfire and forest pests.

High priority landscape acres by ownership	
USFS	3,940,000
BLM	140,000
DOD	<10,000
Tribal	50,000
NPS	<10,000
Other Federal	10,000
Other Gov.	90,000
Private	3,570,000
NGO	10,000

Priority Landscapes



ANALYSIS: RISK REDUCTION ON RANGELANDS

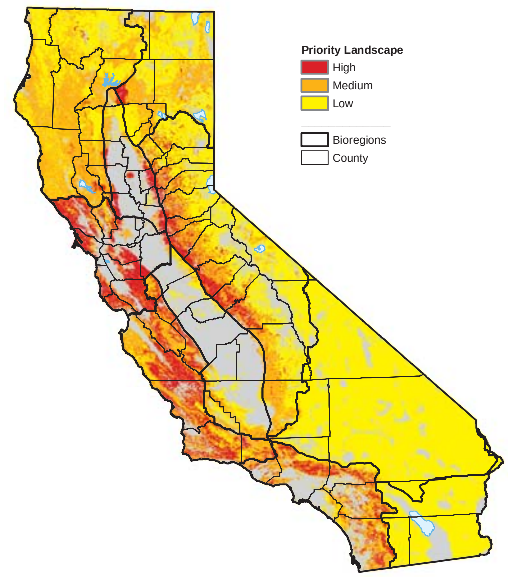
Key Findings

- High priority landscapes were found primarily in the Bay/Delta, Central Coast, Sierra, and South Coast bioregions. Bioregions with smaller acreages of high priority landscapes or extensive areas of medium priority included the Klamath/North Coast, Modoc and Sacramento Valley bioregions.

This analysis identifies areas where rangeland productivity asset that is threatened by wildfire.

High priority landscape acres by ownership	
USFS	1,520,000
BLM	270,000
DOD	160,000
Tribal	70,000
NPS	130,000
Other Federal	40,000
Other Gov.	620,000
Private	6,420,000
NGO	60,000

Priority Landscapes



ANALYSIS: RESTORING IMPACTED TIMBERLANDS

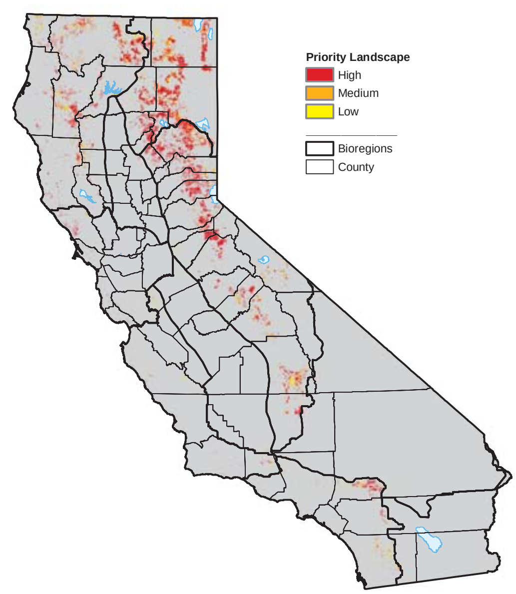
Key Findings

- Extensive areas of high and medium priority landscapes were found in the Klamath/North Coast, Modoc and Sierra bioregions. Bioregions with smaller acreages of these priority areas include the South Coast and Bay/Delta.

For this analysis, economic assets include timber and forest biomass. Threats were derived from areas impacted by past wildfires and forest pest outbreaks. High priority landscapes represent areas with important economic assets that have already been significantly damaged by past wildfires or forest pest outbreaks.

High priority landscape acres by ownership	
USFS	2,050,000
BLM	20,000
DOD	<10,000
Tribal	<10,000
NPS	<10,000
Other Federal	<10,000
Other Gov.	10,000
Private	570,000
NGO	<10,000

Priority Landscapes



ANALYSIS: STAND IMPROVEMENT

A clear opportunity exists to implement strategies for improving forest stands across California. The costs and benefits are variable, but competing for resources to implement stand improvement projects often benefits from both matching resources and economies of scale. Opportunities to tie projects to landscape plans are currently limited, especially across public/private boundaries. Examples of successful landowner aggregation are with existing watershed and Firesafe groups and CFIP projects that aggregate landowners with less than 20 acres.

2.1 Wildfire Threats to Ecosystem Health and Community Safety

CHAPTER OVERVIEW

California is a complex wildfire-prone and fire-adapted landscape. Natural wildfire has supported and is critical to maintaining the structure and function of California's ecosystems. As such, the ability to use wildfire, or to mimic its impact by other management techniques, is a critical management tool and policy issue. Simultaneously, wildfire poses a significant threat to life, public health, infrastructure and other property, and natural resources.

Data suggests a trend of increasing acres burned statewide, with particular increases in conifer vegetation types. This is supported in part by the fact that the three largest fire years since 1950 have all occurred this decade. Wildfire related impacts are likely to increase in the future based on trends in increased investment in fire protection, increased fire severity, fire costs and losses, and research indicating the influence of climate change on wildfire activity.

Developing coherent strategies involves collaborative planning, given the unique and disparate audience for dealing with the threat (i.e., numerous individual landowners). In terms of protecting communities, this is discussed in detail in Chapter 3.3: Planning for and Reducing Wildfire Risks to Communities.

This chapter contains three unique spatial analyses that generate priority landscapes:

1. Preventing Wildfire Threats to Maintain Ecosystem Health
2. Restoring Wildfire-Impacted Areas to Maintain Ecosystem Health
3. Preventing Wildfire Threats for Community Safety

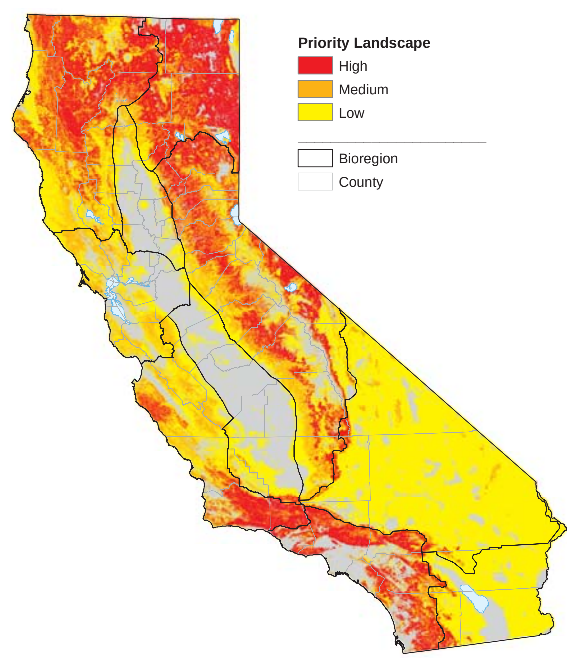
ANALYSIS: PREVENTING WILDFIRE THREATS TO MAINTAIN ECOSYSTEM HEALTH

Key Findings

- Over 21 million acres statewide are viewed as high priority ecosystems for protection from threats from wildfires, with large concentrations in the South Coast, Sierra, and Modoc bioregions, and the northern interior portions of the Klamath/North Coast.
- Key ecosystems at risk include conifer types such as Klamath and Sierran Mixed Conifer and Douglas-fir; shrub systems at risk include Sagebrush, Mixed Chaparral, and Coastal Scrub.
- Managing these risks requires understanding the specific mechanisms of disruption of the natural fire regimes that once formed the ecological stability of the ecosystem, and determining actions that best mimic and or restore these natural processes in manners that are appropriate for different types of land ownership and management. As such, tools must be tailored to the specific ecosystem.

High priority landscape acres by ownership	
USFS	10,980,000
BLM	1,980,000
DOD	130,000
Tribal	230,000
NPS	370,000
Other Federal	60,000
Other Gov.	640,000
Private	6,890,000
NGO	50,000

Priority Landscapes



This analysis identifies priority landscapes where unique ecosystems have high levels of threat of damage from future fires, and should be viewed as a basic assessment of need for strategies and adoption of tools to protect these key areas in the future.

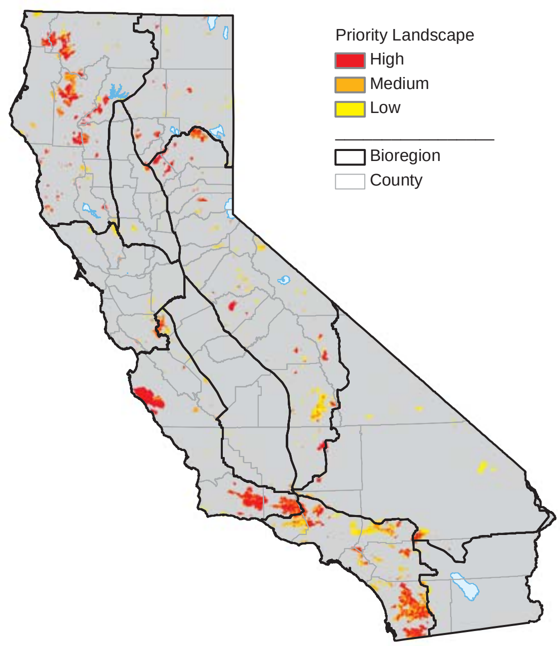
ANALYSIS: RESTORING WILDFIRE-IMPACTED AREAS TO MAINTAN ECOSYSTEM HEALTH

Key Findings

- A total of 2.35 million acres are in high priority for restoration statewide.
- In the northern portion of the state, high priority landscapes include the Klamath, Trinity, and Feather River water basins, and highlight the fire-restoration issue in conifer ecosystems adapted to a frequent, low-severity fire regime, but burning under a less-frequent, more severe modern era regime.
- A total of 445,000 acres in Douglas-fir, Klamath Mixed Conifer, and Sierran Mixed Conifer are in high priority for restoration.
- In the southern portion of the state, a large area of Mixed Chaparral is in high priority status (over 700,000 acres) highlighting direct impacts on soils and watersheds due to fire's typical high intensity/high severity nature in this habitat type, as well as some areas suffering repeated burning and associated type-conversion.
- Similarly, the 200,000 acres of Coastal Scrub in high priority landscapes deserve special attention due to loss of key ecosystem components, and the apparent trend in increased fire frequency, increased non-native invasive dominance, and loss of ecosystems due to land use practices.
- Priority for restoration efforts reflect areas recently burned in wildfire, and will require more resources than have historically been available due to the large area burned in recent fires.

High priority landscape acres by ownership	
USFS	1,440,000
BLM	120,000
DOD	20,000
Tribal	40,000
NPS	30,000
Other Federal	20,000
Other Gov.	150,000
Private	530,000
NGO	10,000

Priority Landscapes



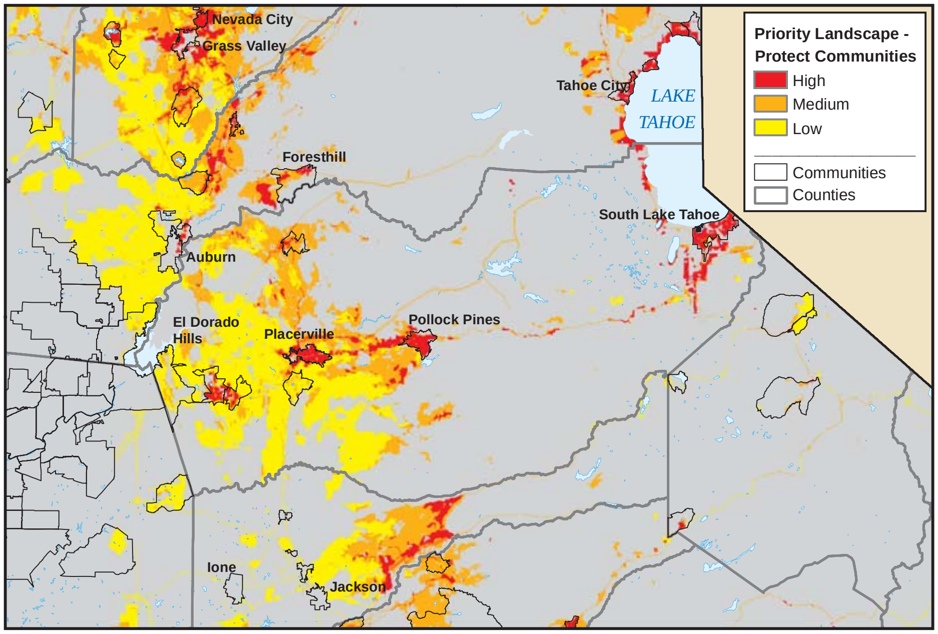
This analysis focuses on restoring fire damaged lands by prioritizing areas that have recently burned in wildfires, especially where a majority of entire ecosystems are impacted. The objective is to define areas in need of activities designed to facilitate recovery of key ecosystem components.

ANALYSIS: PREVENTING WILDFIRE THREATS FOR COMMUNITY SAFETY

Key Findings

- Community areas of high and medium priority are scattered throughout the state, occurring in at least modest (500 acres) abundance in 46 of 58 counties statewide.
- Areas of high priority landscape concentration occur in the South Coast and Sierra bioregions, and other isolated urban areas near significant wildfire high threat areas, such as the East Bay and Redding.
- The cities of San Diego and Los Angeles are by far the largest communities in terms of high priority landscapes. Urban populations of San Bernardino, Riverside, Orange and Ventura counties also have extensive high priority areas. Many of these densely populated areas require coordinated fuel management across significant amounts of adjacent areas to be effective.
- Many rural counties have significant numbers of communities and acreage in medium priority landscapes – a result of extensive low density housing areas in high threat landscapes. These are areas where individual homeowner vegetation management can make a large difference.
- A total of 404 communities meet a basic asset-area threshold for significance, and many more lands not captured within the community layer represent significant areas of risk from wildfires.

Priority Landscapes



This analysis derives priority landscapes as the convergence of areas with high wildfire threat and human infrastructure assets. This is summarized using indicators for prioritizing communities in terms of investments to prevent likely wildfire events that would create the most severe public safety hazards.

Map depicts an example priority landscape for the western Sierra Nevada/Lake Tahoe region, where high wildfire threat converges with high infrastructure assets. Priority landscapes were derived for the entire state.

Population of top counties with high priority landscapes	
Los Angeles	813,000
San Diego	432,000
Orange	235,000
Ventura	174,000
San Bernardino	120,000
Riverside	93,000
El Dorado	67,000
Alameda	65,000
Contra Costa	42,000
Nevada	39,000
Butte	38,000
Shasta	37,000

2.2: Forest Pests and Other Threats to Ecosystem Health and Community Safety

CHAPTER OVERVIEW

The term forest pest, as used in this assessment, refers to both forest insects and diseases. In California, they cause widespread damage to forest economic values and ecosystem services. Bark beetles and wood boring insects have undergone periodic outbreaks nearly every decade, often related to several years of drought. For example, in 2003 Congress provided over $225 million over three years to address hazards from bark beetle killed trees in Southern California, allowing agencies to remove over 1.5 million dead trees to address a potential public safety hazard. Other examples of past widespread damage are numerous, including sudden oak death in the San Francisco Bay Area and the north coast, and bark beetles and wood borers in the south coast and Sierra. Areas of attack tend to be in stands under extreme stress due to root disease, other insect and disease impacts, drought, or overstocking.

While native forest pests are expected to continue to cause extensive problems, the ratio of exotic (non-native) pests to native pests has been increasing over time. Currently, up to one-third of the total number of significant pests are now non-native to California. These risks are increasing rapidly and additional resources that can work across all lands are needed. The potential for spread and impact of gypsy moths, light brown apple moths, the goldspotted oak borers and exotic bark beetles is a major concern for forest management agencies. Pitch canker disease, sudden oak death, white pine blister rust and Port-Orford-Cedar root disease are examples of exotic diseases of major concern.

In California, responsibility for the control of forest pest outbreaks often falls to the California Department of Forestry and Fire Protection (CAL FIRE) on state and privately owned lands and the U.S. Forest Service on federal lands. CAL FIRE, with the approval of the California Board of Forestry and Fire Protection (BOF) can declare a Zone of Infestation for native and exotic insect and disease pests. Within a Zone of Infestation CAL FIRE employees may go on private lands to attempt eradication or control in a manner approved by the BOF.

Forest management tools include the removal of dead, dying and diseased trees, thinning of small and medium live trees, replanting multiple species, and other techniques used to remove hazards and improve ecosystem health. Lack of mills in some areas and historically low wood prices have left many spot infestations untreated and growing rapidly.

This chapter includes four unique spatial analyses that identify priority areas where forest management practices are most likely to prevent and mitigate impacts;

1. Restoring Forest Pest Impacted Areas to Maintain Ecosystem Health
2. Restoring Forest Pest Impacted Communities for Public Safety
3. Preventing Forest Pest Outbreaks to Maintain Ecosystem Health
4. Preventing Forest Pest Outbreaks for Community Safety

Finally, other threats from invasive non-native plants and air pollution could not be analyzed spatially due to data limitations, and are discussed by narrative. Invasive non-native plants damage ecosystems in California by displacing native species, out-competing native plants, changing plant communities and structure, altering natural processes related to water and fire, and reducing wildlife habitat value. This chapter also addresses regional air pollution impacts that can adversely affect natural ecosystems and working landscapes in California.

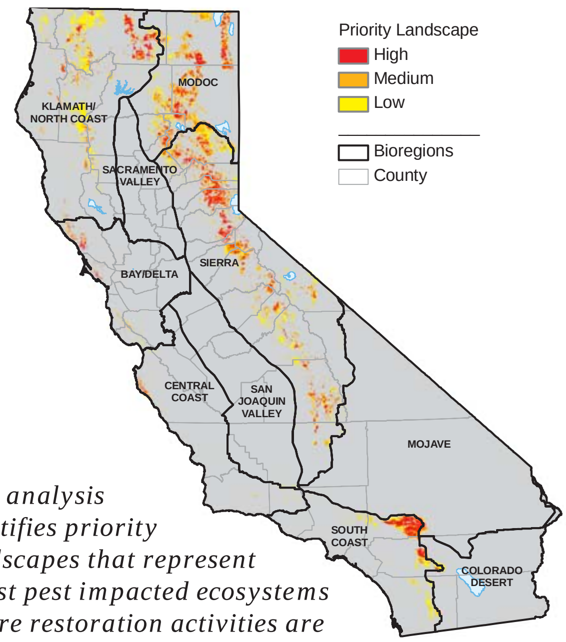
ANALYSIS: RESTORING FOREST PEST IMPACTED AREAS TO MAINTAIN ECOSYSTEM HEALTH

Key Findings

- There are over six million acres of priority landscapes that are impacted by forest pests in California, with 31 percent of these ranked high. Seventy-five percent of priority landscapes are on lands managed by the U.S. Forest Service (USFS), only 18 percent are on privately owned lands.
- Sierra Mixed Conifer (SMC), Eastside Pine (EPN), Red Fir (RFR) and White Fir (WFR) are the habitat types with the most priority acres.
- White Fir had the largest proportion of its habitat identified as a priority landscape (43 percent), and almost 240,000 acres (26 percent) designated as high priority. Twenty-eight percent of Red Fir was designated as high.

High priority landscape acres by ownership	
USFS	1,430,000
BLM	10,000
DOD	0
Tribal	<10,000
NPS	60,000
Other Federal	<10,000
Other Gov.	30,000
Private	340,000
NGO	10,000

Priority Landscapes



This analysis identifies priority landscapes that represent forest pest impacted ecosystems where restoration activities are most needed.

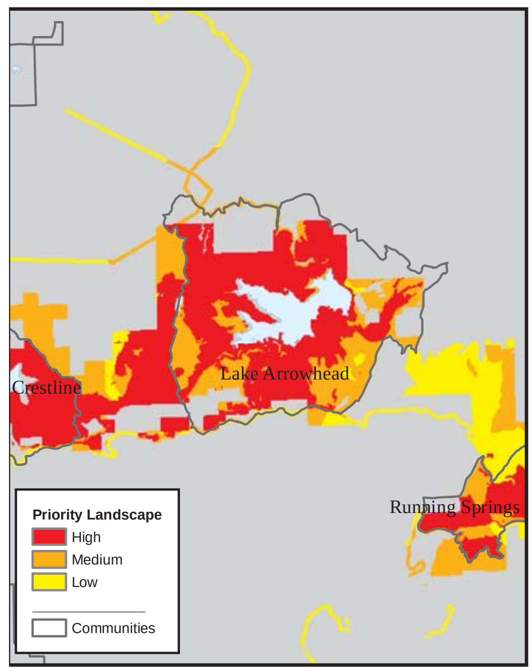
ANALYSIS: RESTORING FOREST PEST IMPACTED COMMUNITIES FOR PUBLIC SAFETY

Key Findings

- Restoration priorities were identified in 13 communities with at least 20 percent of their area in priority landscapes. Eight of these are in the South Coast bioregion and are covered by state and county level declared emergencies. Four of the remaining five priority communities are in the Bay/Delta bioregion and are covered under a Zone of Infestation order, which has been declared by CAL FIRE to address sudden oak death.
- The South Coast, Bay/Delta and Sierra bioregions comprise 98 percent of high priority areas and 83 percent of priority landscapes. Bark beetles in the South Coast and Sierra bioregions and sudden oak death in the Bay Area are major issues; Zones of Infestation have been declared to address many of these concerns.
- San Bernardino, Sonoma, San Diego, Riverside and Placer Counties have over half of the priority landscapes. San Bernardino County alone has almost 60 percent of the highest priority acres.

High priority landscape acres by county	
San Bernardino	17,709
Riverside	4,371
Sonoma	1,801
Marin	913
Nevada	720
Placer	624
San Mateo	546
San Diego	536
Tulare	472
Kern	328

Priority Landscapes



This analysis identifies priority landscapes that represent areas of tree mortality coincident with human infrastructure such as houses, roads, and transmission lines where falling trees are a public safety issue, and restoration activities are most needed.

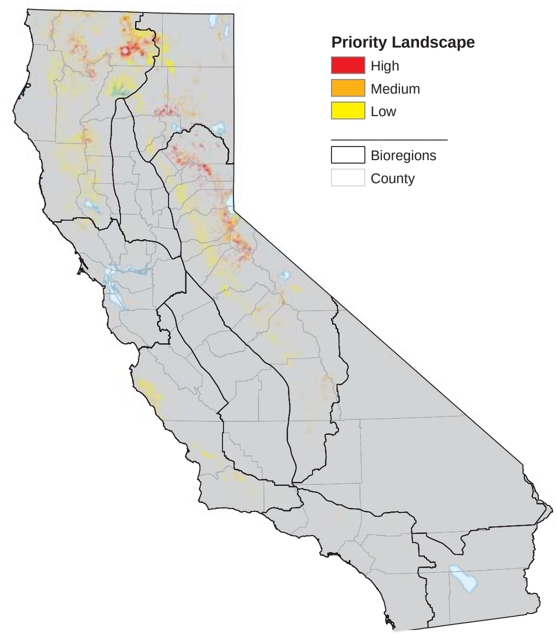
ANALYSIS: PREVENTING FOREST PEST OUTBREAKS TO MAINTAIN ECOSYSTEM HEALTH

Key Findings

- The Klamath/North Coast (48 percent), Sierra (33 percent), and Modoc (13 percent) bioregions comprise almost 95 percent of priority landscape acres.
- Two-thirds of areas at risk are U.S. Forest Service lands, one-third are private.
- White Fir (30 percent), Red Fir (29 percent), and Lodgepole Pine (16 percent) are the habitat types most at risk (high plus moderate priorities) from future tree mortality. These results are partially supported by findings from the previous analysis, which identifies these types as having significant pest activity over the last 15 years.
- Montane Hardwood is the habitat with the most total priority landscape acres in the Klamath/North Coast Bioregion. Red Fir, Ponderosa Pine, and White Fir are the most at risk habitat types in the Sierra bioregion.

High priority landscape acres by ownership	
USFS	310,000
BLM	<10,000
DOD	0
Tribal	0
NPS	20,000
Other Federal	<10,000
Other Gov.	<10,000
Private	70,000
NGO	<10,000

Priority Landscapes



This analysis identifies priority landscapes that represent ecosystems most at risk from damage from future outbreaks.

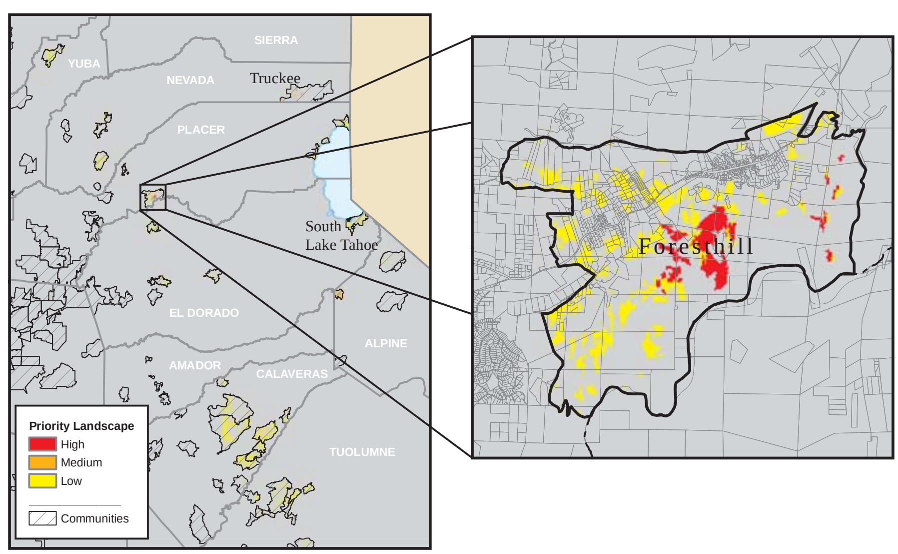
ANALYSIS: PREVENTING FOREST PEST OUTBREAKS FOR COMMUNITY SAFETY

Key Findings

- Over 82,000 acres of community infrastructure are found to be at risk from future forest pest outbreaks.
- Magalia, South Lake Tahoe, Paradise and Truckee are the largest communities identified as priorities for forest pest prevention activities.

High priority landscape acres by county	
Placer	300
Mono	200
Alpine	100
Plumas	100
Nevada	100
Nevada	100
Humboldt	100
Tehama	100
El Dorado	<100
Shasta	<100
Siskiyou	<100

Priority Landscapes



This analysis identifies priority landscapes that represent communities most at risk from damage from future outbreaks.

3.1: Water Quality and Quantity Protection and Enhancement

CHAPTER OVERVIEW

Forested watersheds in California provide an abundant supply of clean water that supports a broad range of downstream uses. The major watersheds across California differ distinctly in climate, geology, ecosystems, and land use; each of which has an affect on the availability of water resources. This has resulted in different water resource conflicts and constraints that vary regionally across the state. To account for this tremendous variation, flexible water management tools and policies are needed. In addition, public education is needed to increase awareness of the role forests play in protecting critical water resource assets and the threats that exist to water resources in headwater regions.

Protecting and managing forests in source watersheds is an essential part of future strategies for providing a sustainable supply of clean water for a broad range of beneficial uses. Tools to address threats to water supply include: water conservation, restoration of riparian forests, restoration of mountain meadows, and protection of groundwater. Tools to address water quality concerns include: reduction of soil erosion through Best Management Practices for forest roads and timber harvesting, additional protection for riparian areas in salmonid watersheds, road maintenance and fuel reduction treatments designed to reduce high severity wildfires. Urban forests have also been shown to improve water quality by filtering stormwater runoff.

This chapter includes an analysis of threats to water supply and a second analysis that includes an evaluation of threats to water quality.

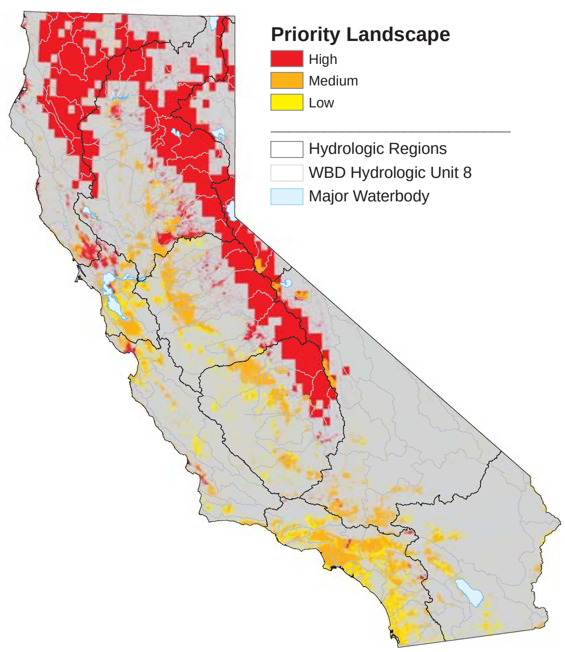
ANALYSIS: WATER SUPPLY

Key Findings

- High Priority Landscape (HPL) is concentrated in watersheds across the Sierra, Cascade, Klamath and Siskiyou Ranges.
- Projected decreases in snowpack from climate change are expected to affect the timing and distribution of runoff in watersheds throughout the Sierra Nevada.
- Restoration of mountain meadows offers an opportunity to improve the storage, groundwater recharge and the timing of runoff in Sierra Nevada upper elevation watersheds.
- The Klamath/North Coast bioregion also has substantial water supply assets, but little storage capacity. These watersheds are predominately rain fed; the water supply impacts from climate change will likely be less dramatic than in the Sierra Nevada. Impacts in the Klamath Mountains are expected to be between those in the Sierra Nevada and those in the Coast Ranges.
- Groundwater basins in the two Central Valley bioregions are an abundant resource heavily threatened due to over pumping.
- Watersheds in the South Coast bioregion mountain ranges contribute to local municipality water supplies which reduces dependence on imported water from northern portions of the state.

High priority landscape acres by ownership	
USFS	10,563,902
BLM	510,189
DOD	2,354
Tribal	59,719
NPS	1,617,618
Other Federal	15,983
Other Gov.	148,109
Private	5,277,503
NGO	6,951

Priority Landscapes



The high priority landscape (HPL) identifies locations where high value water supply coincides with high threats and thus represents areas where stewardship projects are most needed.

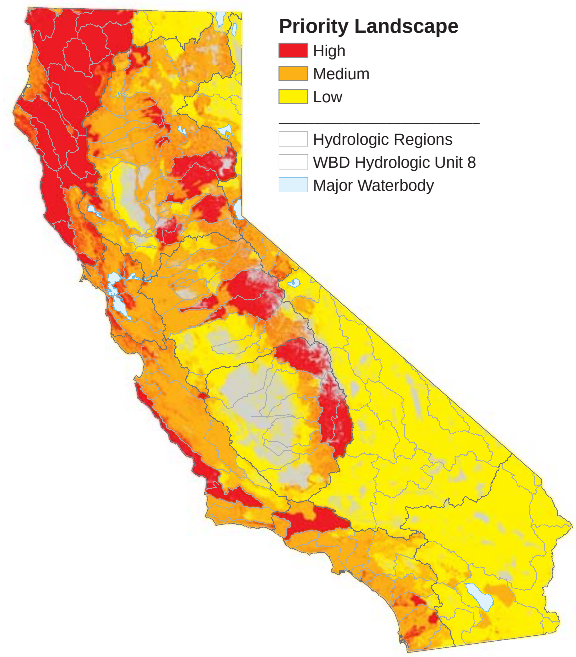
ANALYSIS: WATER QUALITY

Key Findings

- Water quality impairments from forests and rangelands are most pronounced in watersheds in the North Coast/Klamath bioregion. These watersheds are critical for recovery of state and federally listed anadromous salmonids.
- The watersheds in the Sierra Nevada Mountains include a mix of medium and high priority landscape. The Lake Tahoe basin has the highest priority for the watersheds in this region.
- The watersheds of the Central Coast and South Coast bioregions are mostly ranked as medium priorities. Forest health (see Forest Pests Chapter 2.2) and fire management (see Wildfire threats Chapter 2.1) greatly influence water quality conditions in these watersheds.

High priority landscape acres by ownership	
USFS	8,840,000
BLM	1,200,000
DOD	<10,000
Tribal	40,000
NPS	1,700,000
Other Federal	400,000
Other Gov.	380,000
Private	53,330,000
NGO	10,000

Priority Landscapes



The analysis presented identifies locations where high value water assets in watersheds supporting a broad range of beneficial uses coincide with high risks that threaten water quality. For this analysis the threat of water quality in watersheds was assumed to increase with the number of water quality stressors that are present.

3.2: Urban Forestry for Energy Conservation and Air Quality

CHAPTER OVERVIEW

The California urban forest is concentrated in metropolitan areas and encompasses about five percent (7,944 square miles, or approximately 5 million acres) of land and supports 94 percent of the population. Urban areas are the most populated areas in the state as defined by the U.S. Census.

Many private companies, non-profit organizations and governmental programs have worked hard to sustain and improve California's urban forest. This strong network of organizations provides many public benefits by improving the urban forest and by increasing public awareness of the importance of urban forests.

Urban forests provide recreation, pollution reduction, carbon storage, heat island mitigation, storm water control, noise reduction, wildlife habitat, energy conservation and increased property values. Benefits vary with tree size and location and increase in hotter climates and as urban population grows. In addition, urban forestry adds jobs and economic value to the California economy.

Many daily activities, such as driving, mowing lawns, dry-cleaning clothes and natural occurrences such as wind blown dust and fires pollute the air. California has some of the most polluted areas in the nation. Urban forests help filter out air pollutants by depositing pollutants in the canopy, sequestration of CO2 in woody biomass and reduce air temperatures. The value of these benefits is considerable across the state, and maximum results achieved when the efforts and benefits are focused in highly populated areas.

Population growth and hotter summers have increased the need for electricity in California. Energy shortages and urban heat potential increase with urban development which adds impervious surfaces such as asphalt, concrete and roofs to urban areas. Urban trees reduce summer air temperatures by absorbing water through their roots and evaporating it through their leaves in a process called evapotranspiration and by providing shade. Urban trees can help conserve energy by providing shade in hot summer months.

This chapter includes two analyses:

1. Urban Tree Planting: identifies priority areas where tree planting can provide the greatest benefit to urban populations in terms of mitigating air pollution and urban heat islands.
2. Urban Tree Maintenance: identifies priority areas where maintaining existing tree canopy can provide the greatest benefit to urban populations in terms of mitigating air pollution and conserving energy.

ANALYSIS: URBAN FORESTRY TREE PLANTING

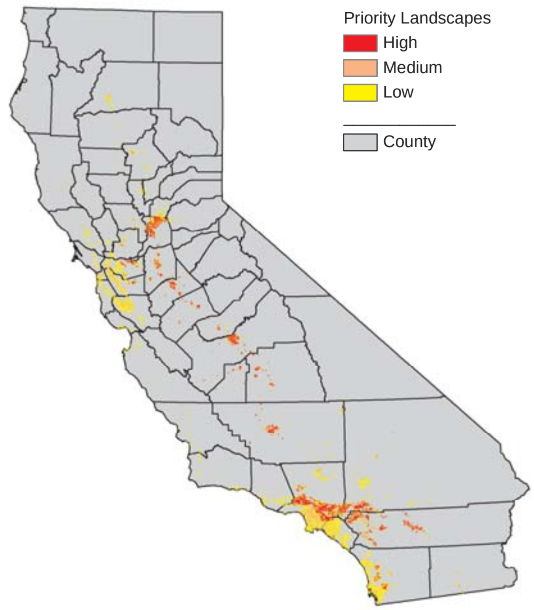
Key Findings

- Close to 800,000 densely populated urban acres, or 15.1 percent of the state's urban area, has been identified with high threat for air pollution and urban heat islands.
- Close to 28 percent of the state's population (9.5 million people) live in high threat areas for air quality and urban heat.
- 372 communities have been identified as high priority planting areas.

Percent county population in high priority landscape	
Stanislaus	74.2
Fresno	73.9
Sacramento	73.7
Riverside	72.1
Merced	67.2
Tulare	65.0
Kings	65.0
Kern	64.1
San Joaquin	62.2
San Bernardino	56.7

This analysis identifies densely populated areas with considerable air pollution and urban heat islands. Planting efforts can reduce the amount of energy consumption due to cooling needs and filter air pollutants.

Priority Landscapes



ANALYSIS: URBAN FORESTRY MAINTENANCE

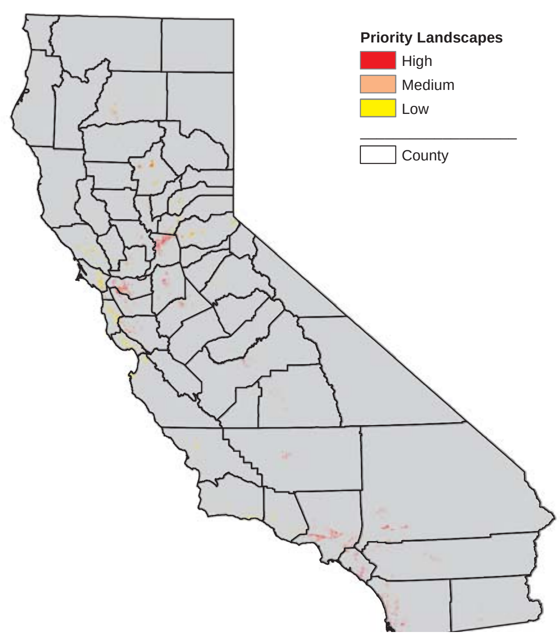
Key Findings

- Close to 217,000 urban acres, about 4.3 percent of the state's urban area, has been identified as densely populated areas with substantial existing tree canopy assets.
- Activities and projects to maintain and protect overall tree canopy would benefit the close to two million people living in these areas.
- A community may be identified as a priority landscape in both maintenance and planting because results are calculated at about 10,000 square feet, approximately one-quarter acre, but reported at a community level.

Percent county population in high priority landscape	
Sacramento	30.7
Butte	26.2
Yolo	25.9
San Joaquin	21.9
El Dorado	16.6
Sutter	15.9
Imperial	14.1
Placer	13.5
Shasta	12.0
Contra Costa	11.8

This analysis identifies areas in California that are densely populated with people and trees, with many days over 90° F and exceeding air pollution standards. Protecting the existing tree canopy in these areas provides public benefit.

Priority Landscapes



3.3: Planning for and Reducing Wildfire Risks to Communities

CHAPTER OVERVIEW

This chapter looks at the current status of collaborative, community-based wildfire planning and the extent of available planning resources relevant to community wildfire safety and protection.

In California, community involvement in wildfire planning is extensive, as evidenced, for example, by community wildfire protection plans (CWPP, as defined under the Healthy Forests Restoration Act of 2003), local and regional Fire Safe Councils, Resource Conservation Districts and community participation in the federal Firewise Communities/USA program. State laws requiring 'defensible space' around structures, building codes, and other responsibilities are aimed at helping communities reduce their risk of loss when wildfire strikes. Federal programs, such as the National Fire Plan, also help with funding for fire hazard reduction.

This chapter contains a single analysis that identifies priority communities where wildfire threat coincides with human infrastructure such as houses, transmission lines and major roads. These priority communities are then summarized in terms of the presence of a CWPP, and Firewise Communities/USA recognition. The availability of community planning resources is also examined.

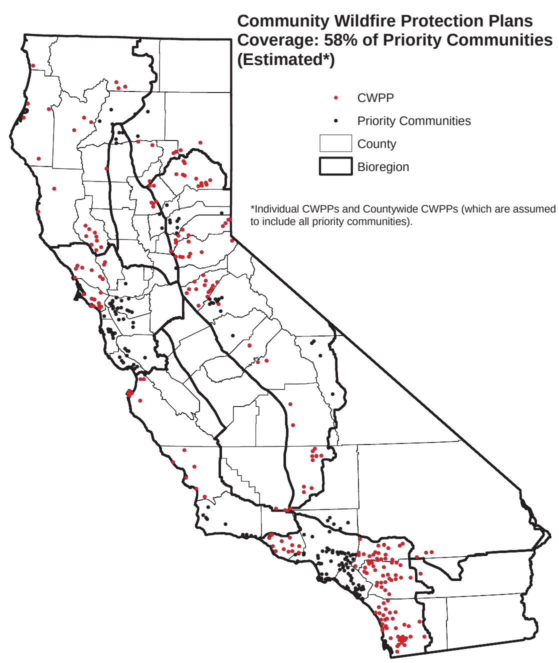
ANALYSIS: COMMUNITY WILDFIRE PLANNING

Key Findings

- It is estimated there are at least 317 communities protected by Community Wildfire Protection Plans throughout the state. Even more are covered by a countywide CWPP.
- A total of 404 priority communities were identified, representing about 2.6 million people living on about 1.1 million acres in high or medium priority landscapes. With the assumption that all priority communities in a county or countywide CWPP are covered by that CWPP, at least 234 (or about 58 percent) of the priority communities are covered by a Community Wildfire Protection Plan.
- About 250 Fire Safe Councils or their equivalent were identified (which included homeowner associations, resource and fire protection districts, local government organizations, advisory groups, CAL FIRE units, Indian Tribes and others). Of these, 47 are countywide in geographic scope. Others are community-centric or regional. There are 38 recognized Firewise Communities. These numbers are growing.
- Priority communities were present in all bioregions, with 62 percent occurring in the South Coast and Sierra bioregions.

Priority communities by bioregion	
South Coast	168
Sierra	83
Bay/Delta	67
Klamath/North Coast	28
Central Coast	24
Sacramento Valley	12
Modoc	9
Mojave	9
San Joaquin Valley	3
Colorado Desert	1

Priority Landscapes



The analysis in Wildfire Threats to Ecosystem Health and Community Safety identifies priority communities at risk from wildfire. In this chapter, an analysis examines which of these priority communities have CWPPs, or are Firewise communities and several other criteria that can suggest the presence of community planning resources and experience.

3.4: Emerging Markets for Forests and Rangeland Products and Services

CHAPTER OVERVIEW

Emerging markets for renewable energy, ecosystem services and niche products are impacting how forest and rangelands are managed. Developing appropriate policies will require a better understanding of the benefits and environmental impacts of these emerging markets and how society values the various market and non-market products and services provided by forests and rangelands.

California Renewables Portfolio Standards (RPS), established by SB 1078 (2002) and accelerated under SB 107 (2006) and Executive Order S-14-08 (2008), creates a target of 33 percent of electricity from renewable energy sources by 2020. Reaching this target will require a significant expansion of energy facilities and related infrastructure on forest and rangelands. In the Mojave and Colorado Desert bioregions the number and size of proposed solar and wind power generation sites has engendered controversy over potential impacts to wildlife habitat.

Biomass energy provides a financial incentive for treating areas for risk reduction or restoration related to wildfire and forest pests. Biomass energy from forestlands provides about one percent of California's electricity use, while having the potential to provide nearly eight times this amount. Biomass also has unutilized potential for heating homes, businesses and schools, and for conversion to liquid transportation fuels. Questions of long-term biomass supply, as well as possible ecological and other impacts of biomass removal on forest sustainability, are key issues in California. The California Energy Commission, working through the California Biomass Collaborative and various stakeholders, has produced a comprehensive strategy for sustainable development of biomass in the state.

California's forests and rangelands provide a variety of ecosystem services, for which landowners are generally not compensated. In many cases, market mechanisms for exchange of values from ecosystem services in California are still limited. Despite this, substantial investments have been made that support ecosystem services. Typically, these investments involve protecting areas that provide unique or high levels of desired services, or restoring areas impacted by past events. These investments come through a variety of programs, agencies and stakeholders. Augmenting this with emerging market-based solutions could enhance the ability to sustain these important services into the future. One example of an emerging market for an ecosystem service, carbon sequestration, is discussed in detail.

Finally, there is a substantial potential for niche markets to stimulate rural economies, for example through certified products, micro-biomass, or landowner collaboratives to produce and market timber using small scale or portable milling technologies.

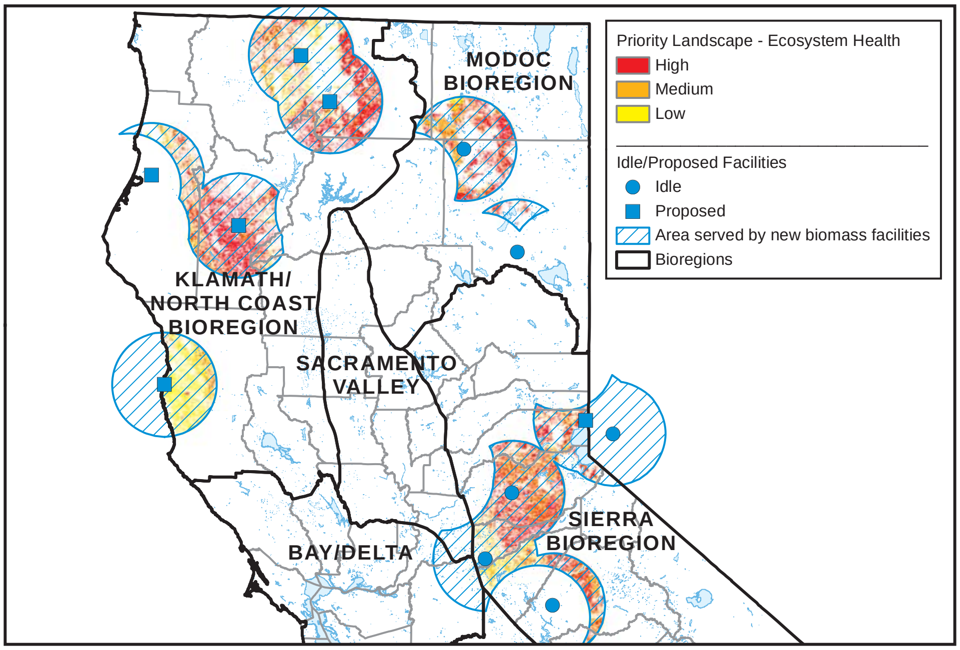
This chapter includes two unique spatial analyses, which explore the potential for treating priority landscapes for risk reduction and restoration related to wildfire and forest pests from previous chapters, if six idle and six proposed biomass facilities are made operational. The first analysis is for ecosystem health, the second for community safety.

ANALYSIS: BIOMASS ENERGY - ECOSYSTEM HEALTH

Key Findings

- Currently, only 22 percent of high priority landscapes are within 25 miles of an operational biomass facility. Adding 12 facilities would increase this number to 39 percent, and primarily benefit the Klamath/North Coast, Modoc and Sierra bioregions.
- Even with the additional facilities, 61 percent of high priority landscapes are not within the 25 mile distance. Since 57 percent of these high priority landscapes are on U.S. Forest Service lands, coordination across agency boundaries will critical.

Priority Landscapes



This analysis determines the benefits of making six idle and six proposed facilities operational, in terms of facilitating fuel reduction or restoration projects for treating priority landscapes for ecosystem health from the wildfire and forest pests analyses in previous chapters.

ANALYSIS: BIOMASS ENERGY – COMMUNITY SAFETY

Key Findings

This analysis determines the benefits of making six idle and six proposed facilities operational, in terms of treating priority communities from the wildfire and forest pests community safety analyses in previous chapters.

- Currently, only 14 of the 66 priority communities are within 25 miles of an operational biomass facility. Adding the new facilities would reach 11 additional priority communities. Of the remaining 41 priority communities, 31 are in the South Coast bioregion.
- Developing a biomass industry in the South Coast bioregion that addresses the significant wildfire and forest pest threats will be challenging, since there are large acreages in shrub species that are difficult to utilize as biomass, and much of the forestland is in public ownership.

CARBON HIGHLIGHTS

Carbon sequestration is an emerging market that actually quantifies and helps pay for an ecosystem service. This section discusses how terrestrial carbon sequestration is considered in policy and at the project level, the role of carbon in compliance markets, the economics of carbon and the opportunities in California for forest and rangeland carbon.

There are two kinds of carbon markets, voluntary and compliance. Voluntary carbon markets are generally unregulated by government, with transactions usually occurring directly between the buyer and seller. Specific systems, protocols and registries exist for the voluntary market. Compliance markets occur under regulatory schemes, usually cap-and-trade, where offsets are sold to emitters.

Carbon credits will be in demand for both the voluntary and compliance markets. Protocols are in place for many project types. The price of carbon, however, is generally low relative to the value for high quality timber products.

Key Findings

- Carbon sequestration is an ecosystem service for which markets are emerging. As part of these markets, the value of the service is quantified, prices determined and dollars generated for "carbon credits." Markets are arising for both voluntary exchange between parties (voluntary markets) and in response to the need to reduce carbon impacts as part of regulatory requirements (compliance markets).
- Demand for forest and rangeland-related carbon in such markets or other venues appears to be very significant.
- Carbon credit supply is constrained by economics, risk and other factors. It is estimated that only one to two million tonnes a year will be available to the compliance market from California forests, which is only 10-25 percent of demand.
- "Protocols" have already been developed for both forest and range-related carbon. The development of additional project type protocols for forests and rangelands could promote activities with ecological and economic co-benefits and increase the supply of carbon credits.
- California has large acreages of forest stands that with additional investment could provide larger future benefits in terms of forest products, jobs, and carbon storage and sequestration. Opportunities also exist on rangeland, but the markets and necessary technologies to capture carbon are not sufficiently developed to quantify these opportunities.

3.5: Plant, Wildlife, and Fish Habitat Protection, Conservation and Enhancement

CHAPTER OVERVIEW

A wide variety of climates, geology, fire and ecological processes combine to make California a hotspot of plant, animal and ecosystem diversity. But for the past decades there has been a trend towards increasing numbers of both animal and plant taxa listed under federal and state laws as threatened or endangered. Native fish species, though well-adapted to natural disturbance regimes, are also generally in decline in the face of human-related changes across many watersheds.

The California Wildlife Action Plan (CWAP), the guiding document on state wildlife conservation issues and strategies, presented at least 20 different threats to plant, wildlife and fish populations and their habitats. Four occur statewide: growth and development, water management conflicts, invasive species and climate change. Others occurring in multiple regions include pollution and urban/agricultural runoff, excessive livestock grazing, altered fire regimes (due to fire suppression and wildland-urban interface expansion), recreational pressure/ human disturbance, and other land management conflicts.

Numerous efforts in California are working towards identifying, preserving and protecting important wildlife, plant, and fish habitat. Tools for addressing wildlife habitat needs include the purchase of land and conservation easements, development planning, zoning, habitat mitigation banking, and habitat restoration, and polices, regulations and funding mechanisms that support these efforts.

This chapter has a single spatial analysis which ranks the threat to areas of important wildlife habitat from uncharacteristic and potentially catastrophic wildfire.

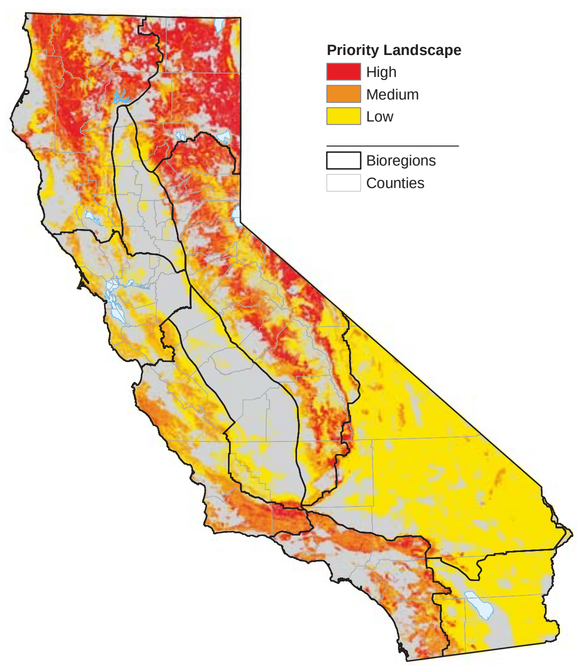
ANALYSIS: WILDFIRE THREAT TO AREAS PROTECTED FOR HABITAT

Key Findings

- Based upon an analysis of wildfire threat to areas that are protected or included in a recent study on corridors, over 14 percent of the state was determined to be in high priority landscapes and over 12 percent in medium priority landscapes.
- The medium and high priority landscapes are concentrated mostly in the Sierra, Klamath/North Coast, Modoc and Central Coast bioregions. Lands managed by federal agencies dominate the priority landscapes.
- At least 45 percent of California's 62 native fish species are considered by the California Department of Fish and Game (DFG) as those of greatest conservation need, and there are 28 fish taxa listed as state or federally threatened or endangered.
- Black bear, pronghorn antelope, bighorn sheep, deer and elk populations are generally stable, but are now at much lower numbers than in the pre-European settlement era.

High priority landscape acres by ownership	
USFS	11,526,000
BLM	2,693,000
DOD	280,000
Tribal	355,000
NPS	995,000
Other Federal	110,000
Other Gov.	1,203,000
Private	6,946,000
NGO	127,000

Priority Landscapes



For this analysis the fire threat layer was used to estimate the potential for fire impacts on protected habitat.

3.6: Green Infrastructure for Connecting People to the Natural Environment

CHAPTER OVERVIEW

For the purposes of this assessment, green infrastructure refers to all public and private forest and rangeland landscapes which provide economic, social, cultural, and environmental services such as recreation, open space, watersheds, wildlife habitat, viewsheds, and working landscapes for commodity production. This definition ignores the vital importance of smaller urban parks, bikeways, and greenbelts – areas that are not mapped statewide. In addition, although agricultural lands provide open space and other values, they are also not included in this discussion.

Current trends identified in this chapter include:

- Given decreasing budgets, agencies are struggling with how to meet public demand for diverse, safe, high-quality recreation opportunities. Ongoing fiscal challenges have already resulted in instances of reduced hours of park operation, and deferred maintenance.
- Activities such as off-highway vehicle (OHV) recreation, mountain biking, boating, and adventure recreation have increased dramatically in recent years, while at the same time population growth, urbanization and alternative energy production compete for suitable lands. To meet these demands and minimize associated impacts, it is critical that opportunities are provided to the public in a responsibly managed environment, where it is possible to efficiently apply Best Management Practices, law enforcement and education efforts, monitoring of impacts, and restoration efforts.
- Effective regional and local efforts to protect and manage green infrastructure are found throughout California. These efforts are typically cross-jurisdictional, involve stakeholders, and address multiple issues such as recreation, water, wildlife habitat and economic development.
- Public involvement in supporting green infrastructure is critical in terms of advocacy, participation in the decision-making process, and involvement in local stewardship and program activities.

Tools for protecting green infrastructure from development include acquisition, easements, establishing reserves and various state and local zoning policies. Tools for managing green infrastructure for protection from wildfire and forest pests include control burning, thinning overstocked stands, biomass projects to reduce fuel loads, and various other stand improvement projects.

California's statewide outdoor recreation strategy is formulated through a combination of:

- the California Outdoor Recreation Plan (CORP), published every five years by the California Department of Parks and Recreation, which identifies various issues and needs of statewide importance;
- the Recreation Policy, developed by the State Park and Recreation Commission, which outlines the state's strategies, priorities, and actions based on issues and needs identified in the CORP; and
- the California Department of Parks and Recreation's Off-Highway Motor Vehicle Recreation Division legislatively mandated Strategic Plan which provides guidance for motorized recreation in the eight State Vehicular Recreation Areas (SVRAs).

This chapter includes two analyses:

- Conserving green infrastructure: this analysis identifies unprotected (buildable) green infrastructure that serves local communities that is at risk from near-term development.
- Managing green infrastructure: this analysis identifies important recreation areas and other green infrastructure that serves local communities that is at risk from wildfire and forest pests.

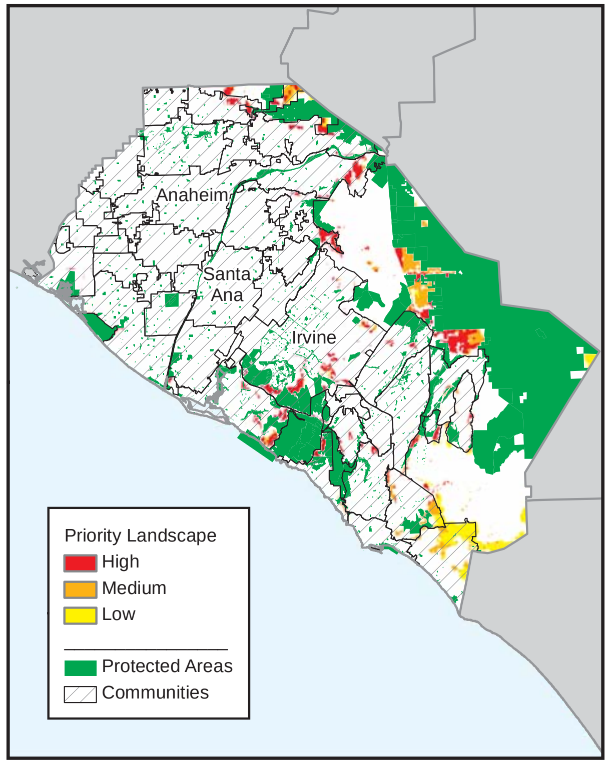
ANALYSIS: CONSERVING GREEN INFRASTRUCTURE

Key Findings

- The South Coast bioregion has by far the most high priority landscape acres since green infrastructure there serves large populations and faces high development pressures.
- In the Sacramento Valley and San Joaquin Valley bioregions, high development pressure is eliminating options for protecting remaining green infrastructure that serves local communities.
- In the Sierra bioregion, development is an emerging issue, and is mostly in the foothills.
- Counties in the Bay/Delta bioregion have achieved a significant level of green infrastructure protection despite the absence of large federal landholdings, by adopting a wide range of complementary public-private strategies and programs.

This analysis identifies priority landscapes which emphasize green infrastructure that serves larger communities and faces significant development threat. Map shows an example priority landscape for Orange County.

Priority Landscapes

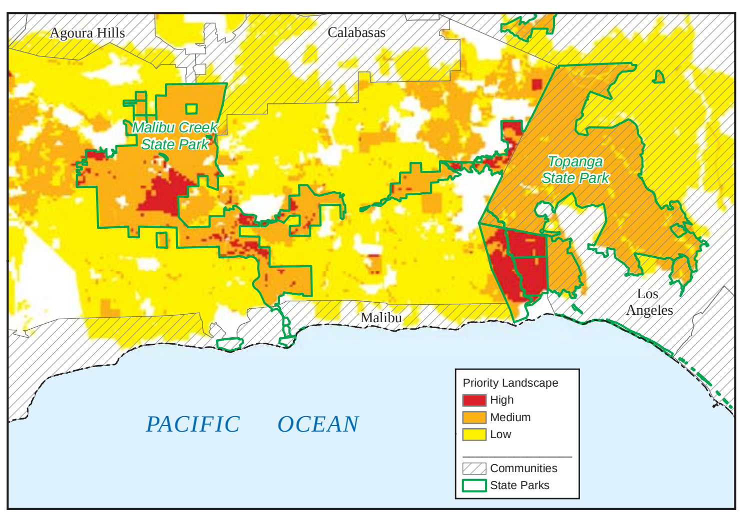


ANALYSIS: MANAGING GREEN INFRASTRUCTURE

Key Findings

- The densely populated and high wildfire threat South Coast bioregion has by far the most high priority landscapes.
- Bioregions such as the Bay/Delta, Sierra and Central Coast have large acreages of medium priority landscapes, which are typically high value areas at a medium threat, or medium value areas at a high threat.
- Although the threat from exotic invasive species has not been adequately mapped and ranked, they do pose a real threat in all bioregions. Similarly, the future impact from climate change cannot be analyzed given current knowledge and data, but will likely pose major challenges.

Priority Landscapes



This analysis identifies priority landscapes that emphasize green infrastructure that serves larger communities or has recreation value, and faces significant threat from wildfire or forest pests. Map shows an example priority landscape for the Santa Monica Mountains above Malibu.

3.7: Climate Change: Threats and Opportunities

CHAPTER OVERVIEW

Climate can greatly influence the dynamics of forest and range ecosystems, and result in changes to the type, mix and productivity of species. While forests and rangelands can be used to sequester carbon and offset greenhouse gas emissions, these same ecosystems may also become vulnerable to changes in climate. For example, under a warmer and drier climate water availability may be more limited with earlier snowmelt and declining snowpack; severity of drought may become more pronounced and the frequency of wildfires may increase.

While future climate scenarios differ in the expected changes to California's climate, there is general agreement that increases in both temperature and carbon dioxide are likely to result in significant changes in the composition of forests and rangelands throughout the state. In some cases, environmental effects from climate change have already been observed in California forest and rangelands. The effects from climate change are likely to include shifts in species ranges, changes in snowpack, changes in the frequency of wildfire and pest disturbance and forest productivity changes.

California's forests and rangelands can play an important role to mitigate the risk of global warming. In forestry this can include both actions that lead to additional carbon sequestration, as well as actions that reduce emissions associated with wildfires, land use conversions and other forms of disturbance. The California Department of Forestry and Fire Protection (CAL FIRE) has identified five strategies to mitigate against greenhouse gas (GHG) emissions: reforestation, forestland conservation, fuels reduction, urban forestry and forest management to improve carbon sequestration. In addition, strategies are being developed to address adaptation needs. The goal of adaptation planning is to reduce vulnerability and to increase the resiliency of forest and rangeland ecosystems to climate changes.

This chapter includes three analyses. To support the first two analyses existing vegetation data and projections from a vegetation dynamics model (MC1) were used to estimate changes in forest carbon stocks over key time periods: 2010, 2020, 2050 and 2100. The first analysis was then conducted to evaluate threats to forest carbon from wildfire, insects and disease. A second analysis was conducted to evaluate potential threats to forest carbon from development. A third analysis, using the computer software BIOMOVE, was conducted to evaluate potential shifts in species ranges from future climate scenarios.

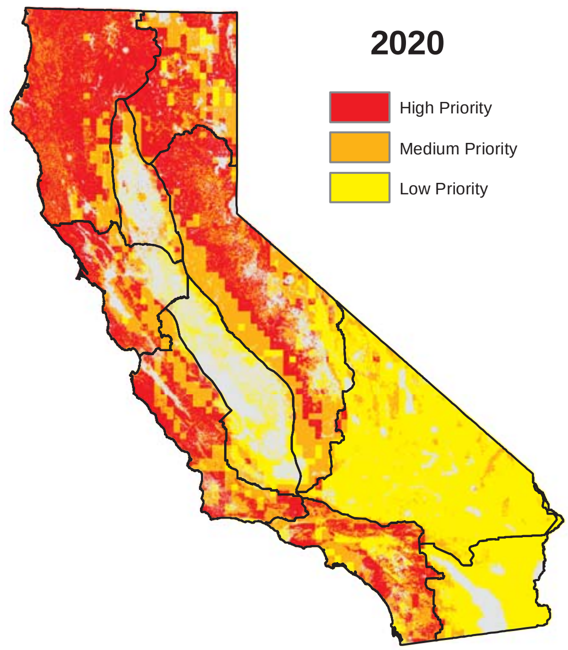
ANALYSIS: THREATS TO FOREST CARBON FROM WILDFIRE, INSECTS, AND DISEASE

Key Findings

- The evaluation of carbon stocks from the baseline conditions for 2020 showed limited gains or losses in priority areas compared to 2010. The priority areas remain relatively stable across all bioregions through 2050 and then declining substantially through 2100.
- Belowground carbon pools showed less variation than aboveground carbon pools; however, due to the relatively limited information on belowground carbon, additional research is needed.
- The expected loss of carbon sequestration from wildfire, insects and disease was much more extensive than loss from development.

High priority landscape acres by ownership	
USFS	12,240,000
BLM	1,350,000
DOD	240,000
Tribal	310,000
NPS	800,000
Other Federal	70,000
Other Gov.	1,120,000
Private	13,390,000
NGO	100,000

Priority Landscapes



This analysis identifies landscapes for forest carbon assets that coincide with threats from wildfire, insects, and disease. The analysis resulted in priority landscapes for 2020, 2050, and 2100.The priority landscape for 2020 is shown as an example.

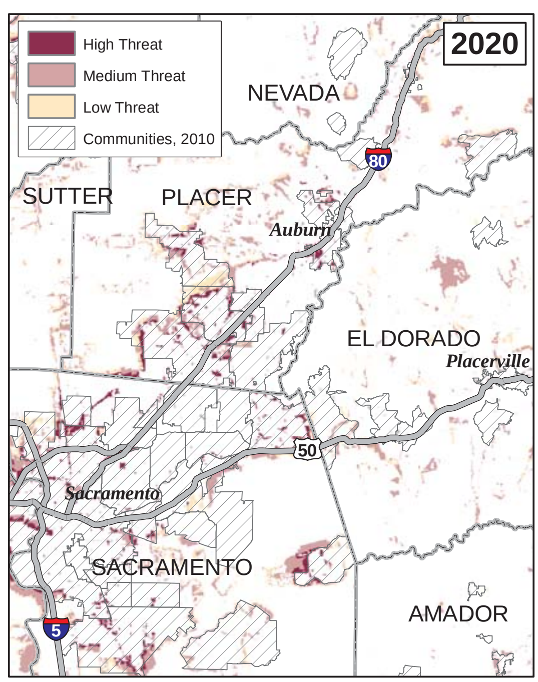
ANALYSIS: THREATS TO FOREST CARBON FROM DEVELOPMENT

Key Findings

- Threats to the loss of terrestrial carbon (forest and range) from development were greatest in Bay Area, South Coast and Sacramento Valley bioregions. The current amount of moderate and high priority landscape is two to three percent in 2010 and expands to ten to fourteen percent by 2100.
- For all other bioregions the amount of high priority landscape was less than five percent of the total land area in the bioregion.
- Threats from development cover a smaller area than threats from wildfire or forest pests, but the impact to forest carbon may be greater.

This analysis identifies priority landscapes for forest carbon assets that coincide with threats from development. The analysis resulted in priority landscapes for 2020, 2050, and 2100. The priority landscape for 2020 is shown as an example.

Priority Landscapes

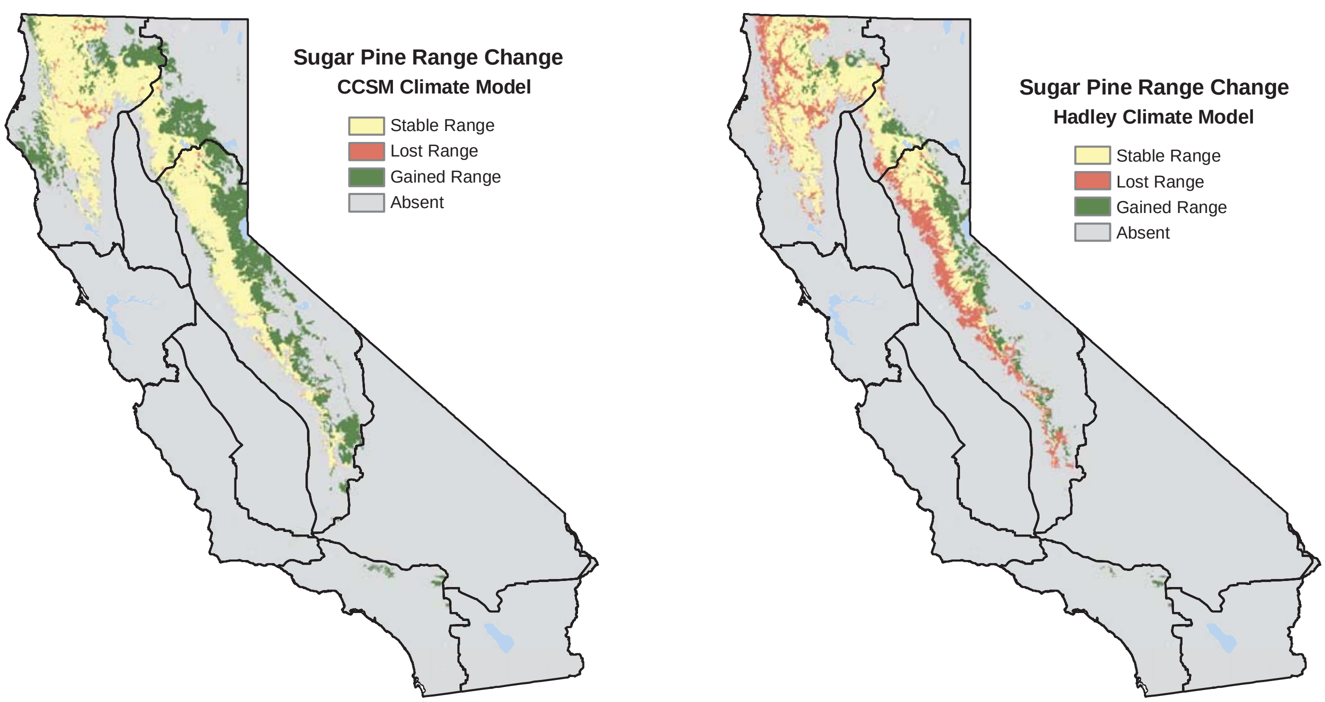


ANALYSIS: VEGETATION RESPONSE – BIOMOVE

Key Findings

- The results show a mixed response among tree species, with some species showing an expansion in range and some species contracting in range by 2080.
- The two climate models used to estimate future conditions were reasonably consistent in predicting the shift in a species range. For several of the indicator species both Global Climate Models (GCM) predicted gains or losses in range that were within 10 percent of each other. Although, for one species (Sequoiadendron Giganteum) the estimated extent of a gain in species range varied by 58 percent between the two climate models.
- Many tree species showed a shift toward higher elevations and towards northern latitudes.

Priority Landscapes



Predicted shift in species range for Sugar Pine. The map on the left shows an expanding range that is influenced by the warmer and wetter conditions predicted under the Community Climate Model (CCM). The map on the right predicts a contraction in species range that is influenced by the hotter and drier conditions forecasted by the Hadley climate model. Areas in green show an expansion in range, while areas in red show a reduction in range, and areas in yellow are considered stable.

Introduction

California law requires periodic assessments and strategic plans be developed to inform policy decisions on the state's forest and rangeland resources. In addition, the U.S. Department of Agriculture's (USDA) Forest Service State and Private Forestry Redesign Program has provided states with funding and direction to take a focused and systematic approach to evaluate opportunities for state-federal agency partnering for stronger forest management. The California Department of Forestry and Fire Protection's (CAL FIRE) Fire and Resource Assessment Program (FRAP) is addressing both requirements with this document. This assessment highlights key issues, resource status and trends and priority landscapes for the subsequent strategy document, which will provide a framework for state and federal programs to support good forest and rangeland stewardship in California.

THE STATE MANDATE

By state law (Public Resource Code 4789) CAL FIRE must periodically assess California's forest and rangeland resources. The last assessment was completed in 2003 (http://frap.fire.ca.gov/assessment2003/) by the Fire and Resource Assessment Program (FRAP), a unit within CAL FIRE whose mission is to produce these periodic forest assessments. Results are used by the State Board of Forestry and Fire Protection (BOF) to develop and update a forest policy statement for California. The last BOF statement was finished in 2007 and reflects various strategies designed to address key issues defined by the 2003 assessment (http://www.bof.fire.ca.gov/board_joint_policies/board_policies/policy_statement_and_program_of_the_board/policyprogram_050107.pdf).

THE FEDERAL MANDATE

The 2008 federal Farm Bill amended the Cooperative Forestry Assistance Act to provide for development of state forest resource assessments and related resource strategies. Among other things, the intent of the amendments is to facilitate identification of priority forest landscape areas, to underscore work needed to address issues on these landscapes, and to frame and focus related strategies and actions.

Chapter 1.1
Population Growth and Development Impacts

In many parts of the United States, forests and other open space are being fragmented and converted to development. Forestry agencies can work with partners, stakeholders and communities to identify and protect priority forest landscapes through land acquisition, conservation easements, and land use policies. Forestry agencies can also provide technical assistance to communities to help them strategically plan for and conserve forests and other open space.

Factors contributing to loss include residential, commercial and industrial development; expansion of utility infrastructure and transportation networks; and planning, zoning, and policies that favor conversion. Consequences include the outright loss of public benefits associated with forests or the marginalization of those values provided by contiguous forested landscapes. Fragmentation also includes "parcelization," or the fracturing of large singular ownerships into numerous smaller ones.

Assessments and strategies should attempt to identify, protect and connect ecologically important forest landscapes, and open space, thus maintaining a green infrastructure, particularly around and within areas of, population growth and development (excerpted from the U.S. Forest Service State and Private Forestry Farm Bill Requirement and Redesign Strategies).

KEY FINDINGS

- California's population continues to increase, particularly in Southern California. An estimated 3.9 million residents will be added over the next decade. This continued trend will place increasing pressure on land development and ecosystems in the state.

- Population impacts occur through urbanization, rural development and parcel fragmentation. The latter two impacts are not always driven by population increases but can arise from shifting internal demographics (retirement communities, second homes, etc.).
- Over the next decade between 200,000 and 550,000 acres of undeveloped or underdeveloped land will be required to accommodate the needs of new urban residents, depending on average housing densities. About 55 percent of this total will come from rangelands or other natural or near-natural land cover types.
- The habitat type in California with the most acres at risk from development statewide is Annual Grassland, followed distantly by Coastal Scrub, Montane Hardwood and Blue Oak Woodland.
- The bioregions with the highest proportion of acres at risk are: the South Coast, Bay/Delta and the central and northern foothill areas of the Sierra. Habitat types found to be most at risk in these regions:
  - *South Coast*: Coastal Scrub, Annual Grassland and Mixed Chaparral
  - *Bay/Delta*: Annual Grassland, Coastal Oak Woodland, Montane Hardwood and Redwood
  - *Sierra*: Montane Hardwood, Blue Oak Woodland, Annual Grassland and Montane Hardwood-Conifer
- Other habitat types of much smaller extent show up as threatened in local areas of other bioregions, for example, Blue Oak-Foothill Pine type in the northern Sacramento Valley bioregion.

INTRODUCTION

California contains a wide variety of topography, climates, and soils across its ten bioregions (http://biodiversity.ca.gov/bioregions.html). This variation has given rise to rich and diverse ecosystems with many and contrasting natural vegetation types, from cool-moist redwood forests in the northwest, to hot subtropical deserts in the southeast. From amphibians to mammals, the state's numerous species of wildlife depend on these habitats. California's rich biodiversity, the number of native and endemic species of flora and fauna, is unparalleled in the western hemisphere north of the tropics (http://www.biodiversityhotspots.org/).

Since settlement by Spain in the late 18th century and colonization by Euro-Americans in the 19th century, many formerly natural landscapes in California have undergone major transformations. These changes have occurred directly from activities including historical overgrazing by cattle, development, land reclamation and conversion to agriculture, and indirectly from the introduction and widespread colonization of non-native plant and animal species, recent livestock grazing, timber harvesting, and in recent decades, wildfire suppression. Much of the state's natural habitat has been lost or severely degraded in quality from the cumulative effects of these pressures (CAL FIRE, 2003).

With about 38.3 million residents in the year 2009, California is the most populous state in the union and will likely be for the foreseeable future. The most recent projections show its population increasing to about 42.2 million by 2020, and 46.4 million residents by the year 2030 (U.S. Census Bureau, 2005). A population growth rate of about 1.5 percent is expected for future years thereafter. This trend, plus the growing movement of more residents into rural areas, will likely continue impacting natural landscapes and habitats in areas of the state.

Ecosystems and Past Development

Historically, the ecosystems most adversely impacted by development have been low elevation coastal plains, flat valley bottoms and wetlands where large areas of formerly natural landscapes have been transformed into farms and cities (CAL FIRE, 2003). Over large tracts of the Central Valley, land reclamation projects converted riparian forests, marshes and grasslands into agricultural fields. A report from the 1970s estimated at that time that less than two percent of the original riparian forests still remained in the northern Sacramento Valley (Swift, 1984). An even larger proportion of this high-value habitat type was converted in areas of the Central Valley to the south.

Profound changes have occurred also in other regions of the state. The coastal sage scrub and oak savannas that once dominated Southern California's coastal plains and alluvial fans were diminished first by citrus groves, and more recently by huge expanses of urban and suburban development. Large areas of grasslands, oak savannas and hardwood tree dominated habitat types have been developed in other portions of the state. The high number of narrowly-distributed endemic plant and animal species and sharp decline in the extent of some ecosystems has contributed to California's many varieties of plants and animals that are now threatened, endangered or of other special concern (DFG, 2009; Thelander, 1994). This is particularly true around the state's two largest urbanized areas in the South Coast and Bay/Delta bioregions.

CURRENT STATUS AND TRENDS

This section gives an overview of historic and current expansion of urban and rural development in California, as well as some tools and organizations that help guide development and address its adverse impacts.

Growth of Urban Development

Over the past decades urban development has steadily expanded into areas of formerly undeveloped or agricultural lands. Sleeter et al., (2010) estimated from satellite data that from 1986 to 2000 an average of 64,000 acres was converted annually in California from other land uses to urban development. A different study indicates that about 70 percent of that total (average of 44,000 acres/year) was previously agricultural land, approximately 15,500 acres of which was rangeland formerly used for grazing stock (California Department of Conservation, 2006). The remainder (about 20,000 acres/year) came from converting lands from a natural or near-natural state.

Data modeled by decade for the period 1950–2000 show a similar but somewhat lower estimate over a longer time frame (U.S. Environmental Protection Agency, 2009). On average, about 55,000 acres per year were converted from other uses to urban/suburban land use (Figure 1.1.1). Overall, during the past two decades or more the rates of conversion to urban land use have varied due to economic and other factors, but show a slight downward trend. Moreover, recent planning policies are favoring higher population densities than historically typical, so the acreage conversion rates may continue to decline.

Growth of Low Density Rural Development

Movement of low density development into new areas can be difficult to determine spatially. A central challenge is selecting a characteristic scale and buffer area with which to generalize the development across landscapes into sparse housing densities. Different methodologies and standards used in studies can thus make comparisons difficult.

Estimates were made of low density housing growth in rural areas using data from the U.S. Environmental Protection Agency (2009), shown in Figure 1.1.1 as the newly parcelized acres by decade, from 1950–2000. Newly parcelized acreage peaked in the 1970–1980 at about 110,000 acres per year, decreasing steadily to just over 75,000 acres per year in the 1990 to 2000 time frame. Data for the current decade will be available with completion of the 2010 census now in progress.

The Regulatory Environment

California's system of laws and regulations that have bearing on new development is one of the most complex in the nation (CAL FIRE, 2003; Governor's Office of Planning and Research, 2009). Some operate at the local level, such as those enacted in the 478 incorporated cities in the state, while others apply across county or broader regional or statewide scales. At the local level, zoning and city ordinances regulate the types of development that are allowed within specified areas of the city limits (California Legacy Project, 2004).

Counties, and their Local Agency Formation Commissions and Regional Transportation Planning Agencies, actively plan and manage development. In addition, at least 25 Metropolitan Planning Organizations and Councils of Government form multi-agency regional planning bodies in California (Office of Planning and Research, 2009). Counties, major metropolitan areas and other areas of the state coordinate land use planning and development through these agencies at much larger scales and around the most burgeoning cities and communities.

The California Environmental Quality Act (CEQA) was first enacted in the 1970s to provide systematic examinations of the environmental consequences of new development projects. CEQA requires new developments comply with negative declarations (where there is no significant impact) or create an Environmental Impact Report to elaborate on the likely impacts of a proposed project. The California and federal Endangered Species Acts (CESA and ESA) can have bearing on land development in areas where threatened and endangered species and their habitats occur or are potentially present, and where federal species recovery plans determine critical habitat areas. The Clean Water Act can also affect types and locations of development in watersheds that are listed 303(d) and where Total Maximum Daily Loads (TMDLs) of pollutants have been established to limit further potential sources of pollution.

Other statewide legislation has been enacted in response to broad concerns about development threats to certain land uses and habitat types. These include the Williamson Act of 1965 and the Forest Tax Reform Act of 1976, the Natural Communities Conservation Planning Act (NCCPA) of 1991 and the Oak Woodlands Conservation Act of 2001. The voluntary Williamson Act reduces the property tax on owners of agricultural lands in return for it not being

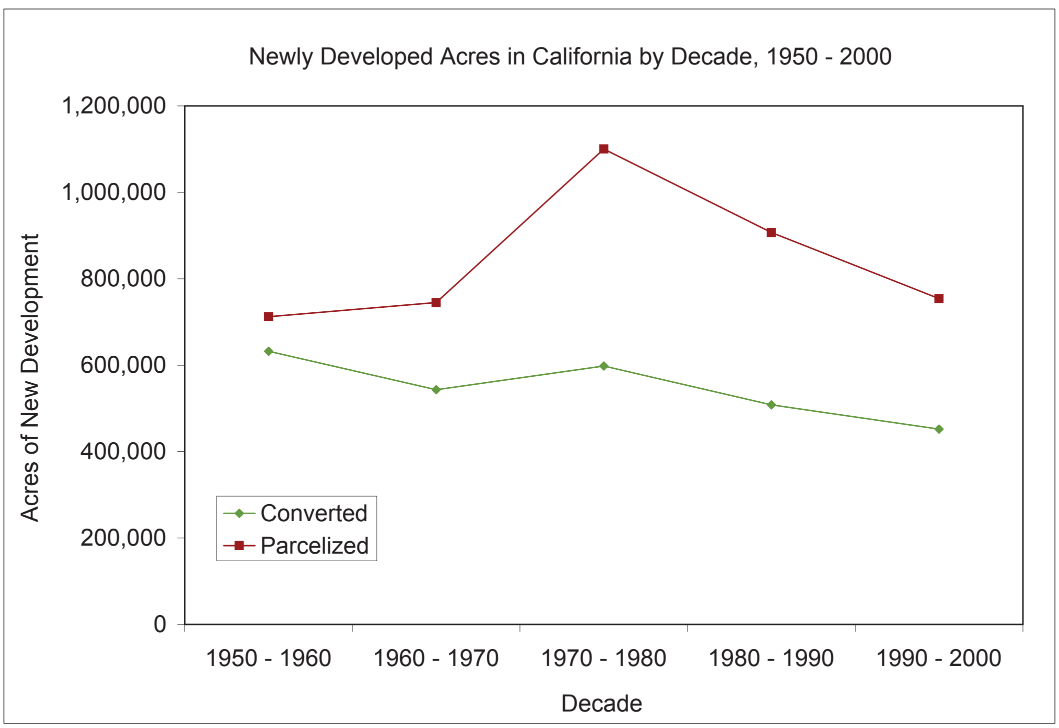


Figure 1.1.1.
Growth of development in two density categories shown by decade from 1950 through 2000. Converted and parcelized acres correspond to housing density categories urban/exurban and low density rural, respectively. These density categories were also used in the risk analysis for this chapter.
Data Source: U.S. Environmental Protection Agency, 2009

parcelized or developed. Timber Production Zones (TPZ), under the Forest Tax Reform Act of 1976, replaced the Williamson Act on timberland. This program helps keep forestlands in timber production by reducing assessed property taxes. The NCCPA, administered by the California Department of Fish and Game (DFG), promotes voluntary conservation planning and enables exchanges of development rights for protecting other local areas of land with high value habitat, the process referred to as conservation and mitigation banking.

Public Agencies

Public agencies have been involved in land use planning and open space conservation for many decades. City and county level general plans, with seven required elements that include land use, conservation and open space, have played major roles in guiding the locations of development in California since at least the 1960s. From county general plans, zoning ordinances are put in place to regulate the land use in counties and cities. In many counties, special districts for parks, open space and agricultural land preservation have been created in recent decades. Some of the larger ones are the East Bay Regional Park District, Midpeninsula Regional Open Space District and the Sonoma County Agricultural Preservation and Open Space District. State government conservancies operating at the regional level include the San Joaquin River, Santa Monica Mountains, Coastal, Tahoe and Sierra Nevada Conservancies. Through planning, easements and land acquisition, these agencies have aided efforts to minimize adverse regional impacts to ecosystem values caused by new development.

At the state level, the role of the Governor's Office of Planning and Research (OPR) has been to coordinate planning across all 58 counties. A primary mission of OPR has been to "formulate long-range goals and policies for land use, population growth and distribution, urban expansion, land development, resource preservation, and other factors affecting statewide development patterns." Key publications include the California Planning Guide and the annual California Planners' Book of Lists, which summarizes statewide the status of county general plans and agencies of all levels involved in planning. However, OPR does not administer land use policy or directly affect local land use decisions.

In 2008, state legislation created the Strategic Growth Council (SGC), a cabinet level committee tasked with coordinating other State agencies with duties that include:

- Improving air and water quality
- Protecting natural resource and agricultural lands
- Assisting State and local entities in planning sustainable communities and meeting AB32, the Global Warming Solutions Act and SB375, Redesigning Communities to Reduce Greenhouse Gases Act

The SGC currently awards program funding for urban greening, planning for sustainable communities and modeling incentives proposals geared towards improving regional transportation network efficiencies.

The California Outdoor Recreation Plan (CORP) is a statewide master plan developed with a multi-agency public participation process led by the California State Parks' Planning Division (http://www.parks.ca.gov/?page_id=23880). CORP provides guidance to agencies, from federal to local, involved in planning and implementing recreational lands, facilities and services. CORP also is the primary means of prioritizing Land and Water Conservation Fund Act grant allocations for local governments.

Private Groups—Land Use Policy and Regulation and Purchase of Land or Conservation Easements

As of 2005, nearly two hundred land trusts were operating in California, with about 1.73 million acres acquired, under easement or re-conveyed to another land holding agency. Most of these land trusts operate at a local or regional level, such as the Sonoma Land Trust or Save the Redwoods League, with the

View of the Verdugo Mountains.The city of Glendale, California is visible in the foreground.

area each has conserved ranging from a few hundred to many tens of thousands of acres. Some, like The Nature Conservancy and the Trust for Public Land, are active in the state and across the entire country. Recent years have seen strongly increasing trends in both the number of smaller land trusts and their activity levels, driven by bond and tax funded measures.

The private non-profit Local Government Commission provides "inspiration, technical assistance, and networking to local elected officials and other dedicated community leaders who are working to create healthy, walkable and resource-efficient communities." Members of this group authored the Awhanee Principles, which outline a set of guidelines for communities that have influenced city and county planning since their creation in 1991.

The community activist organization Greenbelt Alliance has been working for 50 years to influence policy and regulations to conserve high value landscapes in the impacted Bay/Delta bioregion. Their 2006 report provides detailed maps of landscapes at risk of development across the bioregion (Greenbelt Alliance, 2006).

The severe contraction in the economy and state budgets since 2008 has decreased the activities of private organizations involved in land conservation and management. Many are dependent in large part on bond measures and local taxes, which have fallen off dramatically in recent years. Although the economic downturn has diminished the cash donations to land trusts overall, a countering effect has been reduction in the price of land. In California the cost of real estate has decreased to the point where some areas are much more affordable, and some well-endowed land trusts are now taking advantage of this opportunity.

Coalitions, Consortia, and Initiatives

In some areas, land trusts are partnering together in their efforts to conserve land. For example, the North Sierra Partnership is a joint effort of the Sierra Business Council and four land trusts (two regional and two national): Feather River, Truckee-Donner, The Nature Conservancy and the Trust for Public Land.

With shared planning and resources, a partnership can plan more efficiently to acquire lands and allocate financial and other resources. A southern Sierra partnership is now under development.

The Southern California Association of Governments (SCAG) unites a number of municipalities across six counties, from Ventura in the northwest to Imperial in the southeast, excluding San Diego County. Cities and towns in San Diego County belong to San Diego Association of Governments, similar in mission to SCAG. The Association of Bay Area Governments has one hundred member municipalities in nine Bay Area counties. Regional planning among neighboring communities has the advantage of providing a more synoptic view of growth, and looking at potential problems caused by pushing development into the outreaches of metropolitan areas.

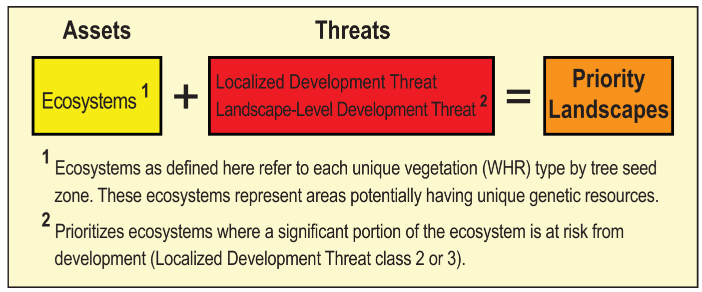
In addition to the direct efforts to conserve lands, there are coalitions and initiatives which include both public agencies and private organizations working together to promote policies for better development and land use planning. The Smart Growth Network is comprised of 40 public and private institutions nationwide, and promotes rebuilding vital communities in city centers and older suburbs. Among their principles, Smart Growth lists preserving “open space, farmland, natural beauty, and critical environmental areas.” The Bay Area Open Space Council has over one hundred member organizations from both the public and private sector working to “foster an interconnected system of healthy communities with parks, trails, agricultural lands, and natural areas throughout the region.”

These many organizations work, plan and promote development that maintains landscapes with high value ecosystems. Taken together, they represent a movement towards growth that is based on a thorough examination of the land, its resources and values, and the needs of communities to grow and develop. Balancing these competing goals is a difficult task. The strategies for dealing with the threat posed to ecosystems by development are likely to involve the empowerment and support of such institutions, initiatives and coalitions.

POPULATION GROWTH AND DEVELOPMENT IMPACTS

Analysis

The analytical framework used to identify ecosystems at risk from development is shown in the below diagram. Development threats and the ecosystem asset were combined to identify the priority landscape.



Assets

As shown in the above diagram, to represent the ecosystem asset, digital spatial data of California Wildlife Habitat Relationships (WHR) vegetation types (Mayer and Laudenslayer, 1988; DFG, 1988–1990) were used. WHR types were originally developed to help biologists and planners determine the suite of animal species that may use a given habitat or cover type. Sixty-five land habitat and cover types are in the WHR system, 43 of which are of natural vegetation (Statewide Land Use / Land Cover Mosaic, FRAP (2006)). A statewide map of WHR types can be found on the FRAP website (http://frap.fire.ca.gov/data/frapgismaps/select.asp?record=fvegwhr_map).

A Geographic Information Systems (GIS) layer of the 87 tree seed zones in California was used to capture regional variations within each WHR type. The U.S. Forest Service and the California Department of Forestry and Fire Protection (CAL FIRE) developed these zones as guides to seed collecting and planting of native tree species to help maintain their geographic genetic diversity and integrity (Buck, et al., 1970). Figure 1.1.2 shows the delineations of the 87 zones and the total number of natural vegetation WHR types that occur within each. For the purposes of this model, each WHR type in each tree seed zone is considered equally important to protect.

Threats

Two GIS data layers were combined to create the composite future development threat.

Localized Development Threat
The threat to a specific small area from future development was represented by the spatial data created for the EPA Integrating Climate and Land Use (ICLUS) program that modeled increasing housing densities in California projected for the years 2010, 2020, 2030 and 2040 (EPA, 2009). Housing density changes from lower densities to more than one house per five acres were termed 'converted', and sparser densities moving up to one house per 20 acres were defined as 'parcelized'. The threat ranks were then derived according to the projected change in housing density and the decade for which the change was projected. In general, the higher projected densities and closer dates were rated higher threats, and for sparser densities and more distant future decades the threat was downgraded. Threat ranks of zero were assigned to all lands off-limits to private residential and commercial development due to federal management, ownership, easements or other legal restrictions.

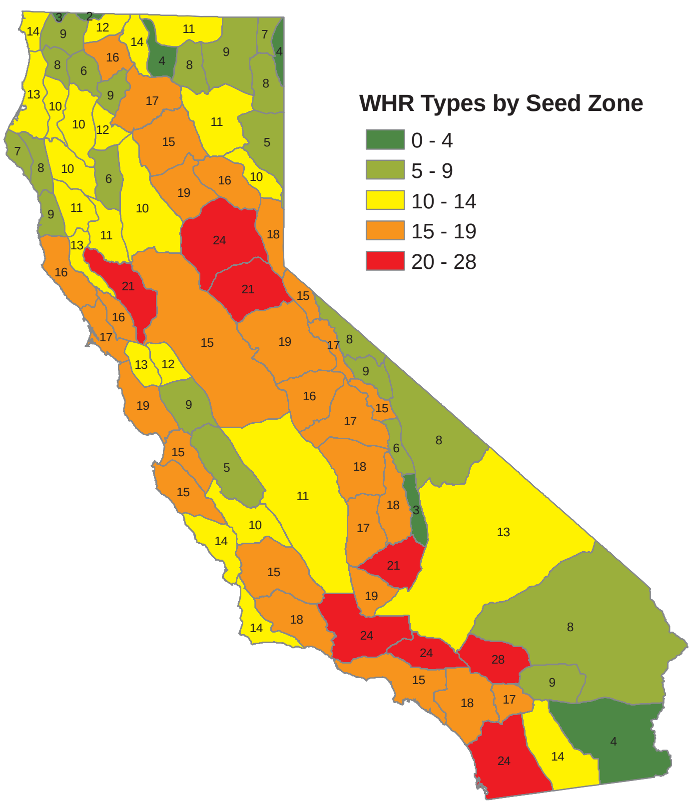


Figure 1.1.2.
U.S. Forest Service and CAL FIRE tree seed zones, with the shading and labels indicating the number of natural vegetation WHR types found within each zone.
Data Sources: Statewide Land Use / Land Cover Mosaic, FRAP (2006); California Tree Seed Zones, Buck, et al. (1970)

The resultant threat ranking data was modified according to a statewide GIS data layer of county general plan zoning (Commission on Local Governance for the 21st Century, 2000), reducing threat ranks in areas where current zoning ordinances prohibit the near-term level of development projected in the ICLUS data. The mapped results of projected development risk are shown in Figure 1.1.3.

Landscape Level Development Threat
The threat to ecosystem values posed by projected future development at landscape scale was expressed by taking the percentage of the total area of each WHR type within each seed zone that was shown to be under medium to high risk of development. Medium risk was defined as where 10 percent but less than 25 percent of the area of WHR type was shown as likely to be developed, whereas high risk were those types with 25 percent or more of their area in that category.

Results

High priority landscapes, shown for the state in the map in Figure 1.1.4, are areas with significant threats at both the localized and landscape level and identify the most at risk stands within the most at risk ecosystems.

The number of acres of high priority landscape is summarized by WHR type and bioregion in Table 1.1.1. The analysis indicates the WHR type with the most area at risk is Annual Grassland, followed by Coastal Scrub and Montane Hardwood. Annual

Grassland is typically dominated by species such as wild oats, soft chess, ripgut brome and others. Coastal Scrub is made up of a number of shrub species including California sagebrush, California buckwheat, black and purple sages, coyotebush, coffeeberry and various kinds of ceanothus. Montane Hardwood habitat type areas are often comprised of oaks (interior live, coast live, canyon live, California black, Oregon white, tanoak), and in some areas with giant chinquapin, Pacific madrone and California laurel (DFG, 1988). For each of these, more than a half million acres is at risk across the state. Bioregionally, the largest areas of WHR types at risk occur in the Sierra, South Coast and Bay/Delta bioregions, each with well over a million acres.

Area at risk totals for the top ten counties are shown in Table 1.1.2. With the exception of Ventura County, each has about 200,000 acres or more in high priority. Riverside County heads this list, with over 464,000 acres, followed by Los Angeles and San Bernardino. Along with San Diego, four of the top five counties are in the South Coast bioregion. Four of the top ten counties are all or partly in the Sierra bioregion: El Dorado, Madera, Placer and Nevada counties. Sonoma County is the sole representative of the Bay/Delta bioregion in this list. However, this bioregion faces a significant development threat but contains small counties that cannot compete when using total acres as the measure.

Discussion

In general, development can negatively affect natural habitats in several ways depending on the intensity of the conversion. Areas converted to high density housing, for example, typically have high impacts by removing most or all of the natural vegetation cover, which eliminates habitat for native animals and plants. Less impacting parcelization can leave some natural vegetation structure intact, but often affects the natural processes that maintain these habitats. Management of the latter, as required for safety from wildfires, can involve clearing and removal of most or all understory plants. This may locally simplify the native species composition, eliminate some native plant species and the cover they provide to small animals, and can also inhibit recruitment of young trees that would eventually replace the older canopy dominants. Vegetation removal also reduces the total carbon sequestered in the area.

Given the patterns of projected future development, the areas of threatened ecosystems identified are for the most part expected. In general, projected development is most likely to occur in close proximity to areas that are already urbanized, especially along major transportation routes. The nearness to urban development in many cases has already compromised the ecosystem values that are most likely to be developed in the near-term. High levels of fragmentation, relative isolation and negative impacts spilling over from surrounding development often characterize these areas.

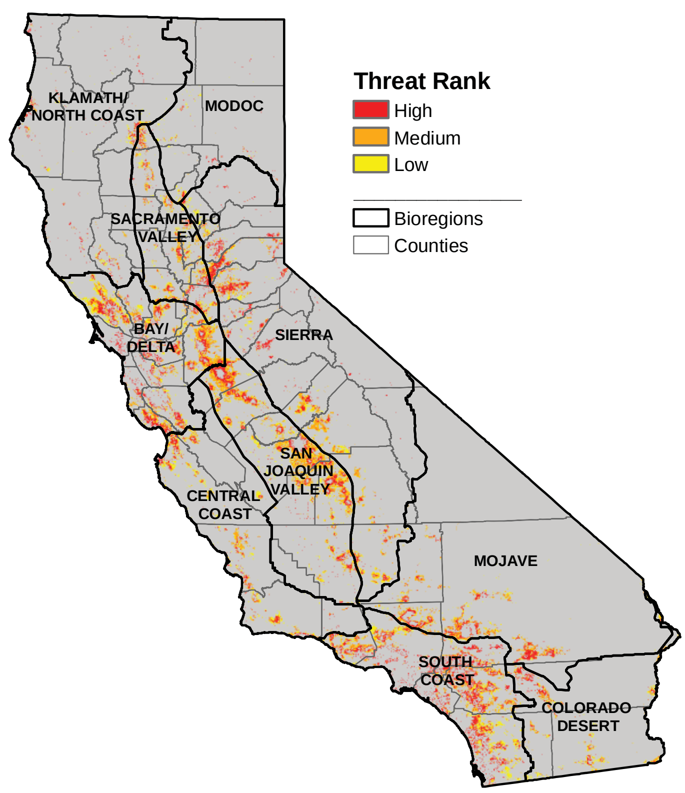


Figure 1.1.3.
Localized development threat.
Data Sources: U.S. Census Bureau (2000); ICLUS, U.S. Environmental Protection Agency (2009); Commission on Local Governance for the 21st Century (2000)

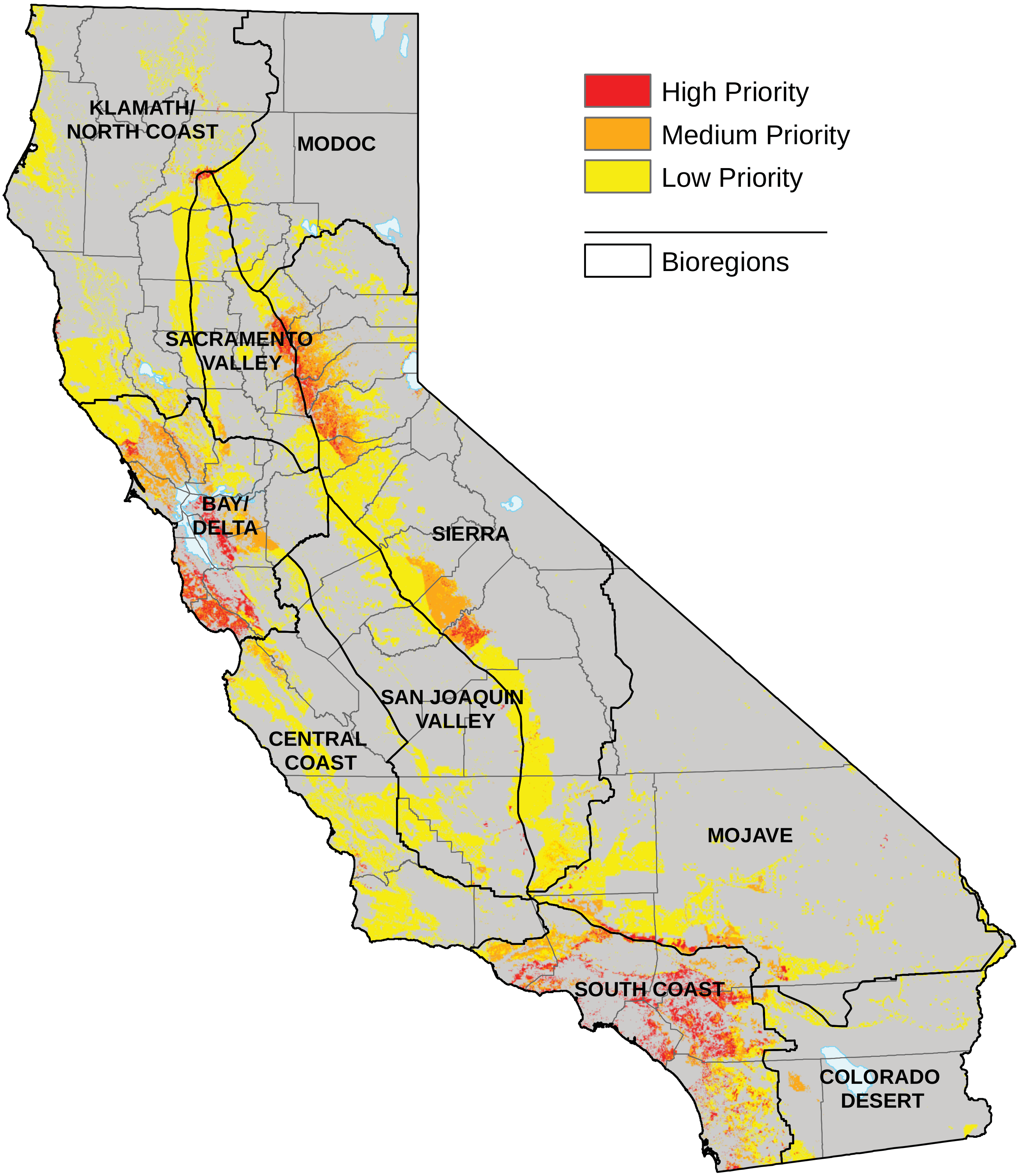


Figure 1.1.4.
Population growth and development impacts priority landscape.
Data Sources: Commission on Local Governance for the 21st Century (2000); California Tree Seed Zones, Buck, et al. (1970); Statewide Land Use / Land Cover Mosaic, FRAP (2006); ICLUS, U.S. Environmental Protection Agency (2009)

Table 1.1.1. High priority landscape – acres potentially at risk (high or medium) from development – WHR types by bioregion (acres rounded to nearest hundred)

WHR Natural Vegetation Types	Klamath /North Coast	Modoc	Sacra-mento Valley	Sierra	Bay/ Delta	San Joaquin Valley	Mojave	Central Coast	Colo-rado Desert	South Coast	State Total
Annual Grassland	42,200	500	144,300	297,400	601,600		600	100	2,800	323,500	1,413,000
Coastal Scrub					33,200	1,500	7,500	5,500	900	578,000	626,600
Montane Hardwood	600		9,800	493,000	102,600		200	500		7,300	614,000
Blue Oak Woodland	8,300	2,400	64,900	324,100	5,900		3,500	6,200			415,300
Coastal Oak Woodland	1,600				139,900			62,200		71,600	275,300
Montane Hardwood–Conifer				107,300	79,900		4,000		100	9,200	200,500
Mixed Chaparral			100	40,100	20,800					132,800	193,800
Desert Scrub							130,700		7,700	47,200	185,600
Blue Oak–Foothill Pine	9,400	1,900	30,200	61,400			300				103,200
Redwood					100,900						100,900
Chamise–Redshank Chaparral				100	18,300		6,100		200	71,500	96,200
Alkali Desert Scrub				300		13,600	65,600		700	1,000	81,200
Ponderosa Pine	2,900			68,200	1,300					400	72,800
Juniper						400	47,400	300		14,800	62,900
Valley Oak Woodland	2,000		12,600	19,600	11,800	2,600	1,100	7,300		800	57,800
Desert Succulent Shrub							17,700		37,700	500	55,900
Montane Riparian	5,500		900	8,000	16,900	100	700	3,000		11,400	46,500
Valley Foothill Riparian			7,000	1,500	500	4,400	500	1,000	500	23,000	38,400
Sagebrush				4,600			14,800			6,600	26,000
Joshua Tree							8,200		7,700	1,600	17,500
Douglas Fir					16,000						16,000
Sierran Mixed Conifer						100				15,800	15,900
Bitterbrush	600			8,000			3,400			200	12,200
Closed–Cone Pine–Cypress	7,100				1,800			3,000			11,900
Jeffrey Pine	400			9,900						700	11,000
Eastside Pine							100			8,900	9,000
Desert Riparian							7,000		300		7,300
Desert Wash							1,500		600	5,000	7,100
Saline Emergent Wetland					4,300			1,100		1,400	6,800
Fresh Emergent Wetland					3,100				300	1,500	4,900
Wet Meadow			300	1,600	100					2,600	4,600
Perennial Grassland				100		2,100				200	2,400
Montane Chaparral	200										200
Aspen				100							100
Palm Oasis									100		100
Bioregional Totals	80,800	4,800	270,100	1,445,300	1,158,900	24,800	320,900	90,200	59,600	1,337,500	4,792,900

The analysis did not take into account some organizations and regulations that operate on a more local basis and may have additional bearing on the likelihood of development. For example, the California Coastal Commission has jurisdiction over development that occurs within close proximity to the coastline, in some areas extending inland up to five miles. The effect of the Coastal Commission was not modeled, and thus there may be some over-prediction of ecosystems at risk in the Bay/Delta and South Coast bioregions.

Continuing past trends, much development is projected on land currently used for agriculture. For example, the map in Figure 1.1.3 shows high risk of development across large extents of the San Joaquin Valley and the Central Valley delta area of the Bay/Delta bioregion. In these areas the impacts to ecosystem values are much less, since land under intensive cultivation in general does not provide high quality wildlife habitat. (An important exception to this are the rice fields of the Sacramento Valley that are flooded in winter for waterfowl.)

A few bioregions stand out as having large areas where the risk of diminished ecosystem values due to development is potentially high. The largest are around the main urbanized areas of the state, in the South Coast and Bay/Delta bioregions, and are most commonly associated with urban sprawl. In the South Coast bioregion the main WHR types at risk are Coastal Scrub, Annual Grassland and Mixed Chaparral. The rate of growth and development in this region is of such magnitude that in Southern California counties many other WHR types are also at risk (Table 1.1.2). Figure 1.1.5 shows the South Coast bioregion priority landscape in greater detail. Annual Grassland also tops the list of at risk habitat types in the Bay/Delta bioregion, with Coastal Oak Woodland and Montane Hardwood types also challenged in the future.

Areas further away from urbanization are under threat of dispersed (rural or exurban) development in several areas of the state. These lands are often in better ecological condition than the above, and further away from, but still within reach of, large urban areas. The lower west slope of the Sierra bioregion has concentrations of high priority landscapes from Butte County in the north, stretching south to Amador County, and in portions of Fresno and Madera Counties. Primary WHR types at risk in the Sierra

Table 1.1.2. Top 10 counties with the highest number of acres at risk, and their most impacted WHR types (acres rounded to nearest hundred)

WHR Natural Vegetation Types	Riverside	Los Angeles	San Bernardino	El Dorado	San Diego	Madera	Sonoma	Placer	Nevada	Ventura	WHR Total Acres
Annual Grassland	128,500	24,800	51,000	65,200	79,000	64,400	126,400	59,100	27,000	7,400	632,800
Coastal Scrub	141,700	117,100	35,800		127,700					133,400	555,700
Montane Hardwood	1,000		6,500	125,800		76,300	61,500	50,300	71,800		393,200
Blue Oak Woodland		300		36,200		96,500	200	44,700	29,300		207,200
Desert Scrub	20,700	86,800	78,100								185,600
Mixed Chaparral	67,600	29,200	600	22,400	11,900		9,400	4,000	7,200	11,000	163,300
Montane Hardwood–Conifer	2,800		10,500	27,100			6,800	23,300	21,100		91,600
Coastal Oak Woodland	7,800	21,600	1,900		2,500		20,800			32,900	87,500
Chamise–Redshank Chaparral	61,800	1,200	12,900		300		600				76,800
Alkali Desert Scrub	1,000	17,500	48,200		600						67,300
Juniper	600	30,900	26,400							200	58,100
Desert Succulent Shrub	1,100	13,600	4,500		36,200						55,400
Ponderosa Pine			400					13,200	36,600		50,200
Blue Oak–Foothill Pine		100		10,800		22,300		4,000	6,200		43,400
Valley Foothill Riparian	7,900	2,000	1,400		9,300	1,100		200		1,200	23,100
Sagebrush	3,700	1,100	16,100								20,900
Montane Riparian	400	3,600	800				6,000	1,200	400	8,000	20,400
Redwood							18,100				18,100
Joshua Tree	7,700	3,700	6,000								17,400
Sierran Mixed Conifer	3,700		12,100								15,800
Valley Oak Woodland		400		3,300		2,500	500	3,600	1,900	400	12,600
Jeffrey Pine	700			5,600				3,600	100		10,000
Eastside Pine		100	8,900								9,000
Douglas Fir							7,700				7,700
Desert Riparian		800	6,600								7,400
Desert Wash	2,000	800	1,600		1,900					700	7,000
Wet Meadow	2,400						100	400	100	100	3,100
Fresh Emergent Wetland	1,000				600						1,600
Closed–Cone Pine–Cypress							1,300				1,300
Bitterbrush		200	500								700
Saline Emergent Wetland		100								600	700
Perennial Grassland			100								100
Palm Oasis	100										100
Total Acres at Risk by County	464,200	355,900	330,900	296,400	270,000	263,100	259,400	207,600	201,700	195,900	

bioregion are Montane Hardwood, Blue Oak Woodland and low elevation Annual Grassland, with Montane Hardwood Conifer coming in a distant fourth.

Future residents will require housing, roads, and places to work, shop and recreate. Redevelopment efforts within cities can absorb some of these people without significantly developing more natural lands (Commission on Local Governance for the 21st Century, 2000). However, if new settlement holds to past patterns of 6.9 people per developed acre, the addition of 3.9 million residents over the next decade could still require developing more than 565,000 acres of land now used for intensive agriculture and wildland, including wildlife habitat. Higher average densities of 15 to 20 persons per acre, now occurring in the urban/suburban fringe areas, would greatly reduce this ten-year estimate to between 195,000 to 260,000 acres of new development.

Recent county-based population data support the analytical findings cited here and the likely spatial impacts anticipated from future development. Table 1.1.3 shows population increases from 2000 to 2008 for the fastest growing counties in California. In terms of number of residents added, the top-ranked 18 counties absorbed more than 90 percent of the total population growth statewide. Six of the top seven – Riverside, Los Angeles, San Bernardino, San Diego, Orange and Kern – are in Southern California, and taken together these account for nearly 59 percent of all growth over the period. Along with Sacramento, these seven counties account for nearly two-thirds of all state population growth. However, the land use impacts will depend not only on the increase in population but also on the average land consumption per person.

This analysis examined where new land development is most likely to occur over the next 10 years in California and the likely impacts from parcelization and conversion on the ecosystem and habitat values. In some regions, working forests and rangelands are at risk. Since the changes brought by new land development are usually permanent and irrevocable, a statewide perspective on growth in relation to ecosystem

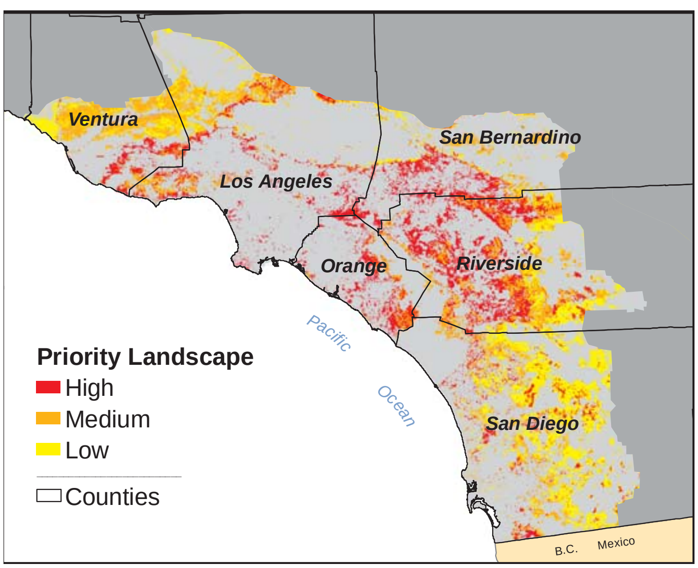


Figure 1.1.5.
Priority Landscapes of WHR types at risk from projected future development in the South Coast bioregion, due mainly from suburban sprawl.
Data Sources: Commission on Local Governance for the 21st Century (2000); California Tree Seed Zones, Buck, et al. (1970); Statewide Land Use / Land Cover Mosaic, FRAP (2006); ICLUS, U.S. Environmental Protection Agency (2009)

Table 1.1.3. Eighteen top state counties of population growth, 2000–2008 (Population in thousands)

County	Year 2000	Year 2008	Newly Added 2000–2008	Percent Change 2000–2008
Riverside	2,100.5	1,559.3	541.2	34.7
Los Angeles	9,862.0	9,544.1	317.9	3.3
San Bernardino	2,015.4	1,718.7	296.7	17.3
San Diego	3,001.1	2,825.4	175.7	6.2
Sacramento	1,394.2	1,230.2	164.0	13.3
Orange	3,010.8	2,856.9	153.9	5.4
Kern	800.5	663.5	137.0	20.6
Fresno	909.2	802.1	107.1	13.3
San Joaquin	672.4	568.0	104.4	18.4
Placer	341.9	251.3	90.6	36.1
Santa Clara	1,764.5	1,686.2	78.3	4.6
Contra Costa	1,029.7	953.3	76.4	8.0
Stanislaus	510.7	449.7	61.0	13.6
Tulare	426.3	368.7	57.6	15.6
Ventura	797.7	756.4	41.3	5.5
Merced	246.1	211.6	34.5	16.3
San Francisco	809.0	777.5	31.5	4.0
Yolo	197.7	169.9	27.8	16.4

Data Source: Commission on Local Governance for the 21st Century, 2000 and habitat values can assist planners, agencies and officials seeking to minimize values lost.

This analysis used one approach to characterize the threat level to regional ecosystems, through examining impacts of projected development to wildlife habitats. Not included in this approach were other important factors, including the parcel size of the habitat and its distance and connectivity to others of its kind in the neighborhood. The analytical complexity required for such an approach exceeded the scope of this report. However, the Areas of Conservation Emphasis (ACE) program of the Department of Fish and Game is slated to include these factors in its future spatial analysis results.

Forests and Rangelands

The Forest and Range 2003 Assessment provided a summary of past and current effects of development pressures on forests and rangelands in the state. The current analysis looked at statewide prospects for these lands in terms of future development. An area of predominantly forest and rangeland that stands out as showing an abundance of high and medium priority landscapes is the west slope of the northern Sierra bioregion (Figure 1.1.6).

Heavy development pressure due to access to major highways (e.g., I-80, US 50) and urbanized areas of greater Sacramento have compromised ecosystem values on these lands. These results are generally consistent with those reported in the previous assessment of California forests and rangelands (CAL FIRE, 2003).

Tools

Tools are described in the current status and trends section of this chapter.

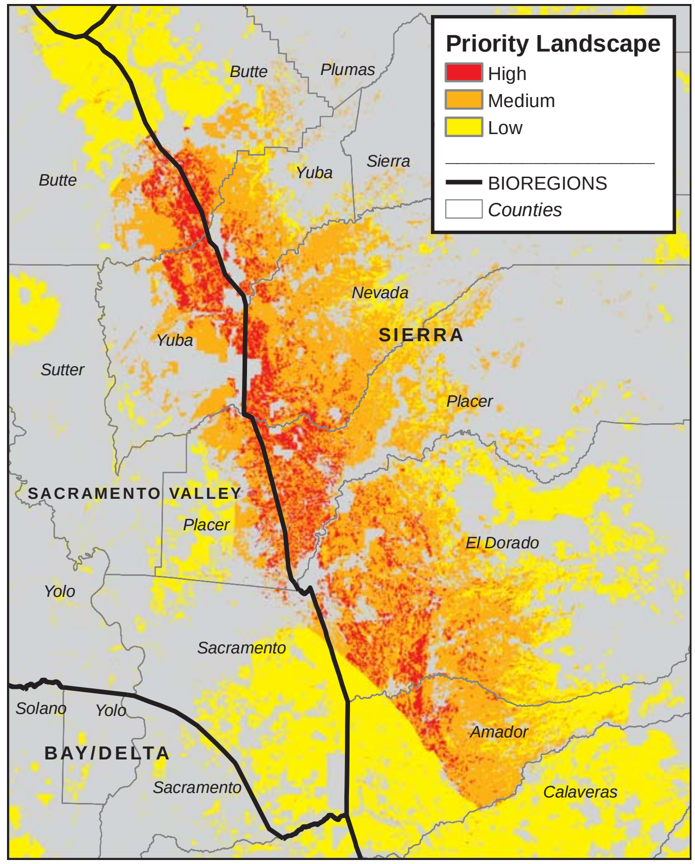


Figure 1.1.6.
Priority landscape in the northern Sierra bioregion, of predominantly working forest and rangeland use.
Data Sources: Commission on Local Governance for the 21st Century (2000); California Tree Seed Zones, Buck, et al. (1970); Statewide Land Use / Land Cover Mosaic, FRAP (2006); ICLUS, U.S. Environmental Protection Agency (2009)

Chapter 1.2
Sustainable Working Forests and Rangelands

Forestry agencies and partners can provide landowner assistance and incentives to help keep working forests working. Providing forestry assistance to landowners can improve the economics of, and encourage sustainable forest management. In urban and suburban areas, forest agencies can assist communities to develop sustainable forest management and green infrastructure programs. Assessments and strategies can identify viable and high potential working forest landscape where landowner assistance programs, such as Forest Stewardship can be targeted to yield the most benefit in terms of economic opportunities and ecosystem services. Assessment and strategies can also identify opportunities for multi-landowner, landscape scale planning and landowner aggregation for access to emerging ecosystem service markets (excerpted from the U.S. Forest Service State and Private Forestry Farm Bill Requirement and Redesign Strategies).

KEY FINDINGS

Land Use and Land Cover Impacts

- Permanent land cover change occurs most often (47,000 acres a year) in grassland/shrubland types, most dramatically in grazing lands along the edges of the Central Valley.
- Forest disturbance from harvest peaked between 1986 and 1992, with fire-caused disturbance most common in forests from 1992–2000. Most fire-related disturbance was in the chaparral and oak woodlands of the Sierra Nevada ecoregion.
- Monitoring of Best Management Practices on private and public forestlands shows generally high compliance with implementation, and effectiveness when implemented properly.
- Unmanaged outdoor recreation may adversely impact natural resources by causing erosion, spread of invasive weeds, compaction, plant damage, wildlife disturbance,

damage to cultural resources and others impacts.

Forests and Woodlands

- Both private and public forestlands appear to continue to build inventory volume.
- A recent U.S. Forest Service analysis indicates that while carbon sequestration is occurring, long-term carbon storage will be a function of management inputs over the next 100 years.
- A carbon sequestration and storage analysis of California's private timberlands suggests that less total storage and sequestration is occurring relative to public lands, but given management inputs may be more sustainable in the long-run.
- The propensity for the conversion of working forests and woodlands is increasing due to pressures from high costs, low income, infrastructure loss and generational turnover.

Forest Products Sector

- The softwood sawmill capacity in California shrank by 25 percent in the last few years, which is indicative of the overall contraction of the sector in jobs, capacity and overall economic activity.
- Ownership patterns have changed for large industrial landowners; they are now all privately held firms.
- Individual Timber Harvesting Plans (THPs) have increased in acreage (before 2009 their size was fairly steady). Acres under Non-Industrial Timber Management Plans (NTMPs) continue to rise but with smaller landowners increasing in participation. As of January 1, 2010, there are 711 NTMPs covering 301,598 acres.
- The acres of alternative prescriptions have declined and clearcutting acreage has been generally constant over the last several years.
- Cost reduction and regulatory streamlining is necessary for the forest products sector in California to compete and be sustainable in the long-term.
- The forest products infrastructure of California is declining. Climate change adaptation, biomass energy production and restoration activities depend on that infrastructure, as do many of the rural economies of California.

Rangelands and Range Industry

- Rangeland productivity is highly variable across space and time. Climate change may impact this further. Buffering public lands with grazing helps protect ecosystem health from development and protect development from wildfires originating on public wildlands.
- Like the timber industry, the ranching industry has been in steady long-term contraction. The maintenance of large ranches across California landscapes cannot rely on amenity values alone; these operations must be economically viable to avoid conversion, abandonment or fragmentation.
- The propensity for the conversion of working rangelands is increasing due to pressures from high costs, low income, infrastructure loss and generational turnover.

Landowner Assistance

- Addressing risk reduction on forestlands, high priority landscapes with significant timber or biomass energy assets at risk from wildfire or forest pests were found primarily in the Klamath/North Coast, Modoc and Sierra bioregions.

- High priority landscapes with rangeland productivity at risk from wildfire were found primarily in the Bay/Delta, Central Coast, Sierra and South Coast bioregions. Bioregions with smaller acreages of high priority landscapes or extensive areas of medium priority included the Klamath/North Coast, Modoc and Sacramento Valley bioregions.
- Regarding restoration, extensive areas of high and medium priority landscapes representing areas with significant timber or biomass energy assets that have been damaged by past wildfires or forest pest outbreaks are found in the Klamath/North Coast, Modoc and Sierra bioregions. Bioregions with smaller acreages of these priority areas include the South Coast and Bay/Delta bioregions.
- A clear opportunity exists to implement strategies for improving forest conditions across California. The costs and benefits are variable, but competing for resources to implement stand improvement projects often benefits from both matching resources and economies of scale. Opportunities to tie projects to landscape plans are currently limited, especially across public/private boundaries. Examples of successful landowner aggregation are with existing watershed and firesafe groups and CFIP projects that aggregate landowners with less than 20 acres.

KEY CONCEPTS

The concept of "working landscapes" was developed to encompass the idea that lands used for commodity production also produce crucial ecosystem goods and services, and that future demands make it essential that these systems are managed for joint production of ecosystem services and food and fiber (Huntsinger and Sayre 2007).

The sustainability of working landscapes broadly has many environmental, economic and social dimensions. These were discussed at length in the previous forest and rangeland assessment. However, within this chapter the topic is addressed by examining a variety of issues under land use and land cover impacts, cultural resources, pesticide use, the condition of the forests and rangelands, their associated economic sectors, current and developing policy, and assistance to landowners and communities.

CURRENT STATUS AND TRENDS

Overview of Management Context

Management activities (or lack of them) can affect (positive, neutral or negative) land cover condition, forest health, soils and protection of special sites or qualities, such as habitat, scenic views or cultural resources. All of these things are elements that relate to overall sustainability.

In the case of forest management, possible impacts on land cover come from such things as site preparation, harvesting, regeneration activities (including application of herbicides), fuel reduction and fire suppression. Range effects can come from grazing intensity and other practices, water pollution from livestock and related factors. In the case of recreation, site disturbance and compaction can take place. Other impacts can spread exotic species and cause loss of or damage to historical and cultural resources.

There are many laws, policies and programs (both regulatory and non-regulatory) across a number of agencies that address conditions and impacts of land uses on forests and rangelands. The overarching laws are federal and state statutes that deal with clean air, clean water and endangered species. There are other federal and state laws that deal with development of plans or permits and emphasize advance public outreach, evaluation of project design, possible impacts and their mitigation.

Federally-owned forests and rangelands are managed by agencies such as the U.S. Forest Service, Bureau of Land Management, National Park Service, and the Department of Defense (DOD). The largest landowner in California is the U.S. Forest Service, whose Region 5 manages 18 national forests and one grassland comprising 20.4 million acres. The Bureau of Land Management (BLM) and National Park Service are the next largest at 14.6 and 7.2 million acres respectively. Each of the agencies operates under numerous federal laws, regulations and policies that require extensive planning, consideration of wide-ranging impacts, application of sound management practices and evaluation of results.

Focuses of the new federal administration include national forest planning, budgeting for fire protection, biomass and renewable energy supply and state and private forestry assessment. Key areas of concern for the U.S. Forest Service include clean and abundant water, wildlife habitat, recreation and biomass opportunities for local economies and climate change mitigation and adaptation. Restoration, roadless area protection, the loss of private forests to development and fragmentation and the need to keep forest ownership and stewardship economically viable are areas of emphasis (Vilsack, 2009).

Approximately 14 million acres in California are designated as wilderness. Major additions were made in 2006 and 2009. In 2006, President Bush approved a wilderness bill focused on 273,000 acres in Northern California. President Obama signed three bills in 2009 that designated approximately 700,000 additional acres as wilderness in Riverside, Tulare, Mono, Inyo, San Bernardino and Los Angeles Counties. Significant portions were in reserved status already. Wild and scenic river protection was a part of both efforts.

On non-federal forestlands in California, the basic regulatory structure is delineated in the California Forest Practice Act. Detailed forest practice rules have been developed that utilize management practices required under the rules or requested by reviewing agencies. Permits must be obtained based on plans prepared by licensed professional foresters. These documents cover planning, operational and post-harvest (such as reforestation) aspects of harvesting. They are reviewed by other state agencies such as the Department of Fish and Game (DFG), the California Geological Survey and Regional Water Quality Control Boards (RWQCBs). Both DFG and the RWQCBs have additional permit authorities that cover areas of concern to these agencies.

Management of non-federal rangelands is less regulatory. For example, water quality is largely addressed through education and voluntary practices. Information sharing and monitoring occurs through the California Rangeland Water Quality Management Plan. This was developed in collaboration with state and federal agencies, cooperative extension and landowners to provide for development and implementation of ranch water quality plans on a voluntary basis (SWRCB, 1995).

Herbicide use is regulated by the U.S. Environmental Protection Agency (EPA) and by the California Department of Pesticide Regulation (DPR). Under state and federal law, only certain herbicides are approved for use in forestry, rangeland and noxious weed control. The application requires a permit and a written recommendation of a pest control advisor and must be done under the supervision of state-certified applicators. DPR provides oversight that includes product evaluation and registration, environmental monitoring, residue testing of fresh produce and local use enforcement through County Agricultural Commissioners. See the DPR website for additional information (http://www.cdpr.ca.gov/index.htm).

Overview of Land Use and Land Cover Impacts on Forests and Rangelands

Land use and land cover (LULC) are commonly considered together when analyzing impacts and trends over time. Land cover refers to the physical material at the surface of the earth including water, rock, grass, forest, shrub, and constructed attributes such as pavement and buildings. Land use may be defined as the use that humans put to land. Note that land use is also a term used in zoning. The sustainability of forest and rangeland ecosystems and economies in California is a function of both land cover changes and land use impacts. Land use practices and measures that contribute to sustainability include Best Management Practices (BMPs), monitoring, balancing forest harvest and growth over time and other management practices.

Land cover change in California from 1973 to 2000 was examined as part of the U.S. Geological Survey Land Cover Trends research (Loveland et al., 2002; Sleeter et al., 2010). Sleeter et al. (2010), reporting by ecoregions, found that the greatest net loss occurred in grassland/shrubland types with a loss of 5,131 square kilometers over the 27 years (73.4 square miles per year or 47,000 acres per year). This loss occurred most dramatically in grazing lands within the Chaparral and Oak Woodland types and along the edges of the Central Valley due to conversion to vineyards, orchards and large housing tracts. While losses in forest cover were observed to be as high as seven percent in the Coast Range, most losses were considered temporary as they were attributed to natural (e.g., fire, drought, pests) and man-made disturbances (e.g., harvest).

Agricultural net land losses in the Chaparral and Oak Woodlands were estimated to be 858 square kilometers over the 27 years (12.3 square miles per year or 7,850 acres per year). Forest cutting was the largest conversion of type class identified, but peaked between 1986 and 1992 (Sleeter et al., 2010). Fire disturbance surpassed harvest between 1992 and 2000 with 60 percent of all fires mapped occurring in this time period. Most fire-related disturbance was in the Chaparral and Oak Woodlands and Sierra Nevada Mountain ecoregions. Developed land increased by over a third from 1973 to 2000 with 97 percent of the new developed lands coming from three ecoregions: the Central Valley, Chaparral and Oak Woodlands, and the Mojave Basin and Range (Sleeter et al., 2010).

Development threats to ecosystems were examined in Chapter 1.1. The land cover types and bioregions most at risk for development in the next 10 to 30 years generally coincide with those areas most impacted in the past. These include South Coast grassland, shrublands and chaparral; Bay/Delta grassland, woodland and hardwood and redwood forestland; and Sierra grassland, woodlands and lower elevation forests. Possible forest and rangeland management impacts are covered briefly later in this chapter.

Effects on forest and rangeland sustainability from LULC vary by bioregion and site-specific geographic factors such as soil type and topography. Recent reductions in economic activity in the forest and rangeland industries translates to reduced activity on the landscape, which may lessen some effects but increase some environmental risks; those associated with road maintenance and fuel loads for example. Permanent conversion resulting from an increasing population remains a major threat to working landscapes and open space and the amenities derived from them. This is likely to most directly affect areas already built up and along major transportation corridors.

Forest and Rangeland Management Impacts on Water Quality and Wildlife

To a large degree these impacts are covered in Chapter 2.1 and Chapter 3.5. However, a brief summary is provided here in the context of land use impacts of forest and rangeland management.

- Based on biotic indicators, a majority of the state's waters are in fair or good condition. Impacts related to rangeland or silviculture sources, as indicted by the 303d list, have not changed significantly from 2002 to 2006. The percentage of impaired streams that have rangeland grazing or silviculture as a factor is highest in the Lahontan and North Coast regions. However, the total impaired stream miles with these factors were greatest in the North Coast region. Cattle and sheep grazing in high elevation areas of the Sierras has been criticized for polluting lakes and streams with suggestions to restrict grazing to lower elevations (Knudson, 2010).
- A number of cooperative instream monitoring projects are under way in coast and inland watersheds including Caspar Creek (USFS-PSW and the California Department of Forestry and

Fire Protection (CAL FIRE)), Little Creek (Cal Poly-SLO), Judd Creek (Sierra Pacific Industries) and South Fork Wages Creek (Campbell Timberland Management). Monitoring activities are addressed by the State Board of Forestry's Monitoring Study Group (MSG). Road crossings have been identified by research and monitoring (Brandow et al., 2006; Cafferata and Munn, 2002; USFS, 2004) as likely potential sources of sediment to watercourses. In response, road inventories that prioritize work and programs to systematically address those priorities have been developed by larger forest landowners.

- Data collected for the MSG found that overall the rate of compliance with forest practice rules designed to protect water quality and aquatic habitat is generally high, and the rules are highly effective in preventing erosion, sedimentation and sediment transport to channels when properly implemented. There are specific areas where improvements in implementation or effectiveness could be made and these are enumerated with specific recommendations.
- In the case of water quality monitoring on national forest lands, results show that while some improvements are necessary, the program performed reasonably well in protecting water quality on national forest lands in California (Brandow et al., 2006). Effects classified as elevated were typically caused by lack of or inadequate implementation of good practices and most elevated effects were related to engineering practices. Roads, and in particular stream crossings, were found to be the most problematic.
- Unmanaged outdoor recreation often occurs near water or other sensitive sites and is associated with one-quarter of all imperiled species in the U.S. (Wilcove et al., 2000). Potential impacts include spread of invasive weeds, erosion, compaction, plant damage, wildlife disturbance and damage to cultural resources (Collins and Brown, 2007). The USFS identified about 14 thousand miles of unauthorized trails created by off-highway vehicle users in 2004 alone. Off-Highway Vehicle use is one of the fastest growing forms of outdoor recreation. Private property is also impacted by unmanaged outdoor recreation. Dumping is also a major problem in many forest and rangeland areas, with concomitant concerns for hazardous materials and impacts to water bodies.
- Impacts on fish and wildlife habitat can be both positive and negative. Management of forests or rangelands can enhance or recreate habitat or habitat elements required by individual or groups of species. Examples of negative impacts can include reduction of biodiversity, simplification or destruction of habitat (such as loss of seral stages or areas directly providing or linking habitats), removal of key habitat elements (such as nesting or feeding components), decreased connectivity of habitat, and increased threats to remaining habitats from fire, insects, disease and sedimentation. A detailed analysis is not covered by this statewide assessment, but can be found in documents such as the California Wildlife Action Plan (DFG, 2007a) or recovery plans for threatened and endangered wildlife or fish species.

Forest and Rangeland Management Impacts on Soils

The soil of forests and rangelands is fundamental to ecological and economic productivity. Erosion potential for timberlands involves such factors as the potential for surface erosion, debris slides and landslides. The Forest and Range 2003 Assessment identified low to moderate surface erosion and debris slide potentials on private timberlands with the Coast and Klamath regions tending to moderate. The area of highest landslide potential on private timberlands exists in the Coast Range Province. In the Klamath Province, the erosion potential is highly varied while in the Sierra Nevada, Modoc and Cascade Provinces, the potential generally is low. The Natural Resource Conservation Service has estimated erosion due to wind on non-federal pasture land in California at 0.4 tons per acre per year. Most rangeland management depends on monitoring the condition of rangeland vegetation and distributing animals to reduce grazing impacts.

Wildfire also can increase the chance of erosion due to wind and rain by removing vegetation, litter, and even creating a burned layer on top of the soil that resists penetration by water. Significant landslide activity from fire areas has impacted homes and infrastructure, most recently in Southern California. Post-fire mitigation practices reduce risk, but may be overwhelmed by severe storms in combination with topographic and edaphic factors.

There has been a growing consensus that better measures are needed concerning the impact of management activities on soil biota and other factors related to soil productivity. This has led to the creation of the North American Long-Term Soil Productivity cooperative research program. The objectives of the program are to:

- define how site carrying capacity is related to changes in soil porosity and organic matter,
- develop an understanding of the controlling natural process,
- produce practical, soil based measures for monitoring changes in site carrying capacity and
- develop generalized estimation models for site carrying capacity, subject to soil and climatic variables.

Forest and Rangeland Management Impacts on Cultural, Historical and Related Values

Many prehistoric and historic archaeological sites, features and artifacts are found on forests and rangelands. Preservation and protection of such sites is part of sustainability. Examples include Native American villages and campsites, petroglyphs, milling stations, housepits and places of cultural importance to Native California Indians such as gathering areas, dance grounds and religious/sacred sites. Historical resources include a variety of structures, buildings, towns, mining features, logging camps, sawmills, cemeteries, trails or roads and artifacts.

No statewide data layer is available that summarizes the location of these resources and from which to create a priority landscape. These resources are a priority to identify and protect as part of any program of sustainable forest and rangeland management. In many cases and for a number of reasons, information on existing prehistoric, historic, ethnographic, and paleontological resources is often limited in its dissemination.

Threats to these resources include the following.

- Resource management and fire suppression activities, as well as development and other land uses.
- Fire under some circumstances can destroy or damage cultural or historic resources and sometimes alter native plant communities and lead to infestation by exotic invasive plants. Increased visibility of the ground surface may expose site constituents to damage or to collection of artifacts by the public.
- Mechanical treatment can dislodge and damage resources.
- Grazing animals, especially large, heavy animals such as cattle can dislodge and damage cultural resources.
- Application of herbicides can harm traditional use plants, or threaten the health of the people gathering, handling or ingesting recently treated plants, fish or wildlife that are contaminated with herbicides (California Indian Basketweavers' Association, 2007).

Some of these impacts can be helpful to the resources. For example, fire can be used to combat the recent invasion of forest or chaparral vegetation into original grassland settings of a region or remove overgrown brush from historic trails. For traditional Native American practices, fire and burning can be essential to the growth of native plants used for food, medicine or craft manufacture.

Cultural and historical resources are managed and protected by various governmental agencies for their cultural, historical, scientific, educational, recreational, and other values in response to a variety of state and federal mandates. For example, CAL FIRE is mandated to identify and protect archaeological, historical and other cultural resources located within its jurisdiction by applicable sections of the Public Resources Code, California Forest Practice Rules, the Government Code, and Health and Safety Code, as well as those of the California Environmental Quality Act (CEQA) Statutes, CEQA Guidelines, and California Executive Order W-26-92 mandate (Foster, 2006).

To varying degrees, governmental agencies collaborate and consult with native peoples and others interested in protection of cultural or historical sites. This outreach is especially critical for understanding needs and in helping to identify and protect key sites. A number of approaches are involved, such as training, education, development of management plans, on-the-ground surveys, specific consultation or notification, pre-field research, development of protective measures, recording of sites, and completion of archaeological reconnaissance reports. Recognition and protection of historic and cultural sites, as well as maintenance and strengthening of associated programs is a key element of sustainable landscapes.

Management activities (or lack of them) can affect (positive, neutral or negative) land cover condition, productivity, and protection of special sites or qualities, such as habitat, scenic views or cultural resources. All of these things are elements that can relate to sustainability.

Forest and Rangeland Herbicide Use

Herbicides are a variety of chemicals used to control brush and grasses and are primarily used for maintenance of areas that have been previously cleared of vegetation. The periodic application of herbicides inhibits or slows the re-growth of vegetation. Herbicides are often used on forests and rangelands to control competing and undesirable plant species and to allow commercially valuable species the opportunity to maximize growth. Pre-emergent herbicides are used to inhibit seed germination or reduce seedling survival. Post-emergent herbicides kill established plants, so that a sufficient dose applied to a part of the plant will kill, or inhibit growth in the entire plant. Aerial herbicide application is sometimes used where broadcast treatment is required to control competition from brush and undesirable species over large areas. Commonly used herbicides in forest and rangeland management include: Glyphosate, Triclopyr, 2,4-Dichlorophenoxyacetic Acid (2,4-D), Atrazine, Hexazinone, Imazapyr and Clopyralid.

Public concern about the toxicity of herbicides and other chemicals potentially used in forest and rangeland applications centers on the effects on non-target organisms. The range of potential impacts and toxicity from herbicide use in forests and rangelands is quite varied. Concerns relate to potential impacts of chemical constituents on: surface water or groundwater; synergistic effects of herbicide mixtures where toxicity of chemicals and additives combine; toxicity of surfactants (additives that increase absorption and adherence to plant material) especially with respect to aquatic organisms; chemical-induced impairment of the nervous system; and disruption of the endocrine systems of organisms. There is also concern over impacts of herbicides on gathering and use of plants for traditional uses by Native Americans.

Concerns over the impact of chemical constituents have been especially at issue in the case of threatened and endangered species. In the last decade, several lawsuits have been filed in California and elsewhere against the U.S. Environmental Protection Agency that raise issues about failure to consult with appropriate agencies over the impacts of pesticides on listed species. Courts have acted to place restrictions on the use of specified pesticides in relationship to species of special concern. For example, in 2004, the U.S. District Court for the Western District of Washington at Seattle imposed no-use buffer zones around salmon-supporting waters in Washington, Oregon, and California for certain pesticides (http://www.cdpr.ca.gov/docs/endspec/salmonid.htm). In 2006, the U.S. District Court for the Northern District of California imposed no-use buffer zones around California red-legged frog upland and aquatic habitats for certain pesticides (http://www.cdpr.ca.gov/docs/endspec/rl_frog/index.htm). In both cases, restrictions and buffer zones applied to some areas with forest and rangeland.

Current herbicide use represents the environmental baseline for forests and rangelands in California. The following paragraphs discuss the extent of herbicide use statewide and by bioregion. The information presented is this section was obtained through the DPR website (http://www.cdpr.ca.gov/docs/pur/purmain.htm). The USFS also provides summaries of pesticide use on national forest lands (http://www.fs.fed.us/r5/spf/publications/pesticide). The amount of herbicide use reported in Tables 1.2.1 and 1.2.2 are in pounds of Active Ingredients (AI). The AI represents the portion of the herbicide that is being applied to vegetation to remove weeds or undesired vegetation.

Commercial pesticide use in California has been estimated by California Department of Pesticide Regulation (DPR) at 150 million pounds in 2008. Agriculture accounts for the predominate use of pesticides, but pesticides are also applied to forests and rangelands and other areas requiring vegetation management. Overall pesticide use varies from year to year; the amount is influenced by current pest problems, weather, types of crops grown, and what new chemicals become available (DPR, 1997).

In 2008, forestry on private lands accounted for 359,147 pounds applied, representing less than one percent of total use statewide. Rangeland use was very small. Year to year variation in herbicide use is shown in Table 1.2.1.

Data on herbicide use was further summarized using county-based bioregions for the entire state (Table 1.2.2). With over 100 million pounds of herbicides applied to predominately agricultural lands (non-forest and range), the San Joaquin Valley bioregion had the highest concentration of herbicide use among all bioregions. Herbicide use on forestlands

Table 1.2.1. Trends in pesticide use from 2005 to 2008

Year	Forestland (lbs)	Rangeland (lbs)	Total Statewide (lbs)	Forestland (Percent)	Rangeland (Percent)
2005	209,672	16,633	136,929,825	0.15	0.01
2006	348,576	12,286	110,100,422	0.32	0.01
2007	1,411,534	19,476	161,362,646	0.87	0.01
2008	359,147	20,764	149,566,938	0.24	0.01

Data Source: California Department of Pesticide Regulation, 2008

Table 1.2.2. Pesticide use on private lands summarized by bioregion based on county data

Bioregion	Forestland (lbs)	Rangeland (lbs)	Region Total (lbs)	Forestland (Percent)	Rangeland (Percent)	Region Total (Percent)
Bay/Delta	633	1,132	6,531,690	0.01	0.02	4.37
Klamath/North Coast	256,401	206	2,976,390	8.61	0.01	1.99
Central Coast	42	5,153	22,765,030	0.00	0.02	15.22
South Coast	575	144	4,598,151	0.01	0.00	3.07
Modoc	3,172	2,818	500,309	0.63	0.56	0.33
Sacramento Valley	40,026	855	14,581,711	0.27	0.01	9.75
San Joaquin Valley	255	2,887	91,171,557	0.00	0.00	60.96
Sierra	57,790	59	531,456	10.87	0.01	0.36
Mojave	252	1,704	2,391,062	0.01	0.07	1.60
Colorado Desert	0	5,806	3,519,582	0.00	0.16	2.35
Total	359,147	20,764	149,566,938	0.24	0.01	100.00

Data Source: California Department of Pesticide Regulation, 2008 was concentrated mainly in the North Coast, Sierra, and Sacramento Valley bioregions. These three bioregions collectively accounted for over 98 percent of all herbicide use associated with forestry in 2008. Within the North Coast bioregion 256,401 pounds of pesticides were used in 2008. The Sierra bioregion also had significant herbicide usage with 57,790 pounds applied. The Sacramento Valley bioregion accounted for 11 percent of the pesticide usage in forestry.

The U.S. Forest Service annually reports data on pesticide and herbicide use on national forests and rangelands. However, the most recent estimate compiled by CAL FIRE was for 2004. In this year, the U.S. Forest Service reported that herbicides totaling 17,247 pounds of active ingredients were applied on 4,419 acres of forests and rangeland. The most commonly used herbicide was Glyphosate (99 percent of herbicides applied) comprising 93 percent of the area treated. The most common herbicide treatment on national forests in California in 2004 was for conifer release (70 percent) aquatic weed control (13 percent) and site preparation (11 percent).

The Bureau of Land Management also uses herbicide for vegetation management on public lands in California. Between 2002 and 2005 BLM treated an average of 2,245 acres annually using an average 2,079 pounds of herbicides.

FORESTS AND WOODLANDS

Forestland Condition

Ownership and Net Volume

The basic source of information on forests and woodlands is the Forest Inventory and Analysis Program (FIA) of the U.S. Forest Service. This program has been fundamentally restructured and this complicates decadal trend analysis. However, FIA has published information (Christensen et al., 2008) on the first five years of annual plot measurements done under the restructure.

The estimated area of forestland by ownership class is shown in Table 1.2.3 based on 2001–2007 FIA data. Timberland is a subset of forestland and is defined as lands capable of producing in excess of 20 cubic feet/acre/year at its maximum production. Non-industrial private forestland is about two-thirds of the private forestland, or about 8.5 million acres.

Adding two additional years of plots in the 10-year inventory cycle of FIA (Forest Inventory Data Online (FIDO)) caused a revised estimate of net cubic volume of 99,203 million cubic feet from 95,547 million cubic feet (Christensen et al., 2008). Using the online FIDO query with two more years of data, the standard error improved from 2.1 percent of the estimate to 1.7 percent. Table 1.2.4 shows the net cubic volume estimates by ownership class and reserve status. About two-thirds of the volume is on public lands, mostly federal.

Table 1.2.3. Estimated area of forestland, by owner class and forestland status, 2001–2007 (acres in thousands)

	Unreserved Forests			Reserved	
Owner Class	Timberland	Other Forest	Total	Forests	Total
National Forest	9,794	2,516	12,310	3,611	15,921
National Parks	0	0	0	1,312	1,312
BLM	471	892	1,363	277	1,640
Other Federal	44	143	187	111	298
Total Federal	10,309	3,551	13,860	5,311	19,171
State	138	118	202	509	711
Local	110	156	266	108	374
Total Private	8,780	4,351	13,131	0	13,131
All Owners	19,337	8,122	27,459	5,928	33,387

Data Source: USFS Forest Inventory and Analysis, 2001–2007

Table 1.2.4. Net tree volume (in millions of cubic feet) on forestland by ownership and reserve status

Ownership	Not Reserved	Reserved	Total
National Forest	41,817	13,041	54,858
National Parks	0	5,907	5,907
BLM	1,308	196	1,504
Other Federal	116	355	471
Total Federal	43,241	19,499	62,740
State	898	3,532	4,429
Local (county, municipal, etc)	579	388	967
Total Private	31,066	0	31,066
All Owners	75,784	23,419	99,203

Data Source: USFS Forest Inventory and Analysis, 2001–2007

Estimated Carbon

A 100-year projection of alternative carbon inventory scenarios, assuming various management inputs, was conducted for U.S. Forest Service lands in California (Goines and Nechodom, 2009). Results from this report provide estimates of expected and potential carbon sequestration and storage on U.S. Forest Service lands in California. The carbon analysis conducted on Forest Service lands in California (Goines and Nechodom, 2009) estimates that in 2007, 20.2 million acres held nearly 620 million tons of carbon in live tree biomass. The standing stocks in 2100 could be lower or higher than current levels depending on policy alternatives (Figure 1.2.1). In most cases there is active sequestration over the next 50 years before a decline to near current levels.

To estimate the current carbon storage and sequestration on forestlands in California, the following analysis was conducted. FIA plots (USFS, 2008) from seven years of annual inventories (2001–2007) were processed to calculate current carbon storage and sequestration on all forestlands, both private and public, and private non-reserved timberlands. The four variants of the Forest Vegetation Simulator (FVS) were used to estimate growth and mortality of plots (Ritchie, 1999). The plots were grown for the standard 10-year increment. Carbon storage and change were calculated for live tree, above and below ground portions for trees greater than or equal to five inches diameter at breast height using the FIA regional volume and biomass functions (USFS, 2009a and 2009b). While this analysis contains many of the key elements, this analysis is not a full forestry sector inventory.

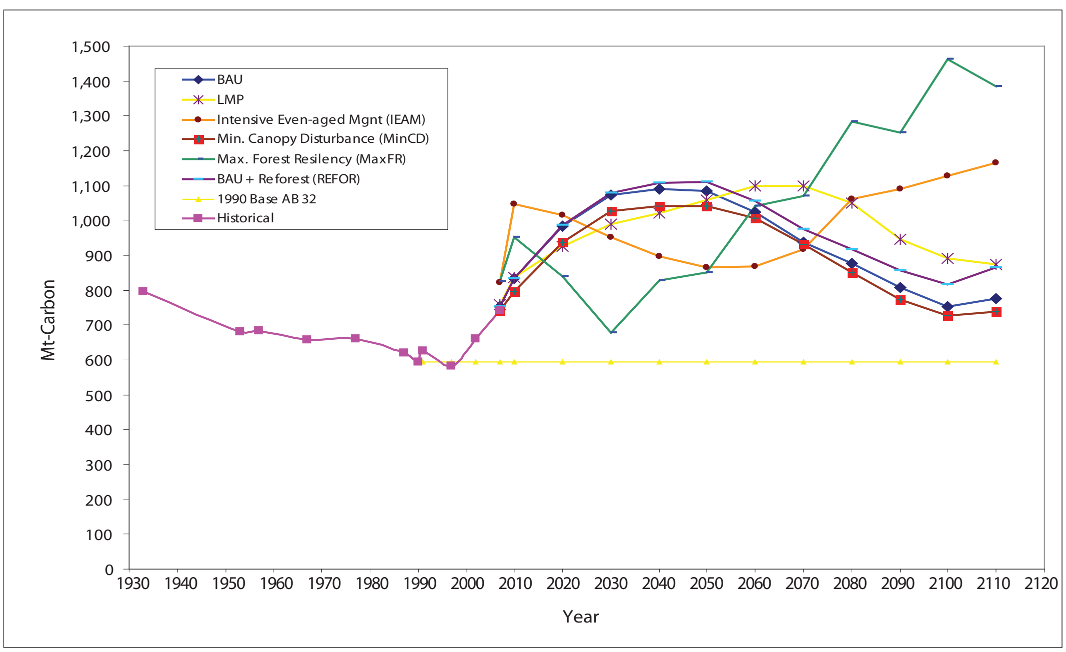


Figure 1.2.1.
Results from U.S. Forest Service analysis of projected carbon stocks on national forests in California.
Source: Goines and Nechodom, 2009

Emissions were estimated for mortality, wildfire, and harvest. Wildfire emission estimates were based on California Air Resources Board (ARB) emissions estimates that were prorated to private/public and forest/non-forest categories using 10-year fire history data. A CO2/CO ratio of 13 was used (Klaus Scott, personal communication). Harvest emissions from bole wood were estimated from 10-year average Board of Equalization data and U.S. Department of Energy (DOE) 1605(b) conversion factors. Non-merchantable emissions were estimated using harvest efficiency along with top, stump and root relationships to the bole (Cairns et al., 1997; Christensen et al., 2008). Storage due to wood products in-use and landfill were calculated based on the 10-year average storage from the DOE 1605(b) emission inventory technical guidelines for voluntary reporting of greenhouse gases (DOE, 2007 Part I). The results of the carbon stocks and sequestration analysis are presented by land base type in Tables 1.2.5 through 1.2.8.

Tables 1.2.9 and 1.2.10 show the total and per acre values of carbon dioxide equivalent (CO2e) and other measures, respectively, of storage and net annual change from tree growth and mortality (Table 1.2.10).

This analysis is an inventory compilation and modeling exercise with unknown error. Christensen et al. (2008) estimated the aboveground live tree carbon per acre as 33.7 tons (30.6 metric tons). The estimate of aboveground live tree carbon from this analysis is 31.1 metric tons of carbon per acre, which compares favorably as a check on the analysis. Hudiburg et al. (2009) estimate average stocks of 6.5 to 19 kilograms per square meter across Northern California and Oregon, which equates to 96.5 to 282.2 metric tons CO2e per acre. This estimate brackets the values in this report. The FVS growth models used in this analysis were developed primarily from data on national forests and are used for long-term planning on national forests. Intensively managed forests, as found on many private timberlands, will likely have growth underestimated and mortality overestimated. Coast redwood, which is primarily

Table 1.2.5. Carbon sequestration analysis results for all forestlands (32,114,317 acres)

Source	Type	Carbon (metric tons)	CO2e (metric tons)
Growth	Storage	-16,367,285	-60,067,936
Model Mortality	Emission	5,455,351	20,021,137
Wildfire	Emission	1,719,915	6,312,087
Harvest (merch)*	Emission	565,315	2,074,706
Harvest (non-merch)	Emission	791,776	2,905,819
WP (in-use)	Pool	-389,436	-1,429,231
WP (landfill)	Pool	-48,796	-179,081
Net		-8,273,161	-30,362,499

*Reduced by 22.8% for salvage (10-yr avg) duplication

Table 1.2.6. Carbon sequestration analysis results for public forestlands (19,467,566 acres)

Source	Type	Carbon (metric tons)	CO2e (metric tons)
Growth	Storage	-12,660,007	-46,462,226
Model Mortality	Emission	4,319,121	15,851,175
Wildfire	Emission	1,415,436	5,194,651
Harvest (merch)*	Emission	40,703	149,379
Harvest (non-merch)	Emission	57,008	209,219
WP (in-use)	Pool	-28,039	-102,905
WP (landfill)	Pool	-3,513	-12,894
Net		-6,859,292	-25,173,600

*Reduced by 22.8% for salvage (10-year average) duplication

Table 1.2.7. Carbon sequestration analysis results for private forestlands (12,646,761 acres)

Source	Type	Carbon (metric tons)	CO2e (metric tons)
Growth	Storage	-3,708,104	-13,608,743
Model Mortality	Emission	1,136,233	4,169,977
Wildfire	Emission	304,478	1,117,436
Harvest (merch)*	Emission	524,612	1,925,327
Harvest (non-merch)	Emission	734,768	2,696,600
WP (in-use)	Pool	-361,397	-1,326,326
WP (landfill)	Pool	-45,283	-166,188
Net		-1,414,691	-5,191,917

*Reduced by 22.8% for salvage (10-year average) duplication

Table 1.2.8. Carbon sequestration analysis results for private timberlands (7,647,009 acres)

Source	Type	Carbon (metric tons)	CO2e (metric tons)
Growth	Storage	-3,603,556	-13,225,049
Model Mortality	Emission	1,010,508	3,708,564
Wildfire	Emission	184,106	675,670
Harvest (merch)*	Emission	524,612	1,925,327
Harvest (non-merch)	Emission	734,768	2,696,600
WP (in-use)	Pool	-361,397	-1,326,326
WP (landfill)	Pool	-45,283	-166,188
Net		-1,556,240	-5,711,402

*Reduced by 22.8% for salvage (10-year average) duplication

Table 1.2.9 Total live tree stocks and estimated annual change from tree growth and mortality

		Stocks				Change, Net of Mortality			
Landbase	Acres	CO2e (metric tons)	Cubic Feet (thousands)	Board Feet (thousands)	Number of Trees	CO2e (metric tons)	Cubic Feet (thousands)	Board Feet (thousands)	Number of Trees
All Forestlands	32,114,317	5,099,162,048	113,695,755	447,709,621	10,058,521,955	40,046,799	1,419,806	5,764,470	-58,328,612
Public Forestland	19,467,566	3,343,515,541	76,368,749	340,794,682	5,685,834,310	30,611,051	751,107	3,438,690	-38,089,971
Private Forestland	12,646,761	1,755,647,124	37,327,502	106,914,068	4,372,687,646	9,438,766	668,726	2,325,853	-20,237,568
Private Timberland	7,647,009	1,418,463,058	31,054,447	103,118,272	4,364,675,374	9,516,486	591,411	2,242,743	-17,094,787

Table 1.2.10. Per acre live tree stocks and estimated annual change from tree growth and mortality

	Stocks					Change, Net of Mortality				
Landbase	CO2e (metric tons)	Cubic Feet (thousands)	Board Feet (thousands)	Number of Trees	Stand Density Index	CO2e (metric tons)	Cubic Feet (thousands)	Board Feet (thousands)	Number of Trees	Stand Density Index
All Forestlands	158.8	3.5	13.9	313.2	214.1	1.247	0.044	0.179	-1.816	2.422
Public Forestland	171.7	3.9	17.5	292.1	225.1	1.572	0.039	0.177	-1.957	2.015
Private Forestland	138.8	3	8.5	345.8	197.1	0.746	0.053	0.184	-1.6	3.05
Private Timberland	185.5	4.1	13.5	570.8	258	1.244	0.077	0.293	-2.235	4.189

privately owned, is missing from FVS; the other softwoods category was used as a surrogate. Therefore, the private lands estimates should be considered a lower range of possible results, particularly for the coast redwood region and for plantations.

The differences in the public and private lands may be a function of stand age as well as productivity. Hudiburg et al. (2009) showed that there are marked differences in stand age distributions, with private lands having substantially younger stands. A recent U.S. Forest Service analysis (Goines and Nechodom, 2009) showed that while national forests are currently sequestering a substantial amount of carbon, there are long-term risks associated with storage given disturbance and management assumptions. Consideration should be given to both the amounts of carbon sequestered and the probability of long-term storage. Potential long-term sustainable carbon storage on private lands needs further analysis. Hudiburg et al. (2009) estimates that total landscape stocks in Oregon and Northern California could theoretically be increased by 46 percent. The relative amount of currents stocks to long-term sustainable stocks is of considerable policy interest and needs further study.

Growth and Harvest

One key indicator of forest sustainability is the growing stock and removals relative to growth over time. Estimates of growth, mortality and removal based on FIA data collected from 2001 to 2005 showed that growth was statistically the same or exceeded mortality and removals for public and private landowner classes (Christensen et al., 2008). The largest increase in inventory was on national forest lands although on the average they tend to be less productive. Improved estimates of changes in growth, mortality and removal will be available in the next few years as remeasurements of plots are completed and analyzed.

While only a partial measure, another possible indicator is the amount and type of timber harvesting occurring. Relatively little harvesting has taken place on federal lands. Table 1.2.11 shows the average annual acres of even-aged, intermediate, uneven-aged, and total silviculture by county. The groupings of silviculture are done to be consistent with the classifications in the California Forest Practice Rules. Counties with total harvesting over three percent included Glenn, Modoc and Sierra Counties, which had mostly intermediate harvest types in aggregate. Overall, the average annual harvest covered 1.64 percent of private timberland acres with even-aged, intermediate and uneven-aged silvicultural practices

Table 1.2.11. Acres and percent of silvicultural type by county for private timberland harvest averaged over 10 years (2000–2009).

	Acres of Timberland					Percent of Timberland			
County	Even-Aged	Intermediate	Uneven-Aged	Total	Private	Even-Aged	Intermediate	Uneven-Aged	Total
Alpine		10	18	28	11,678	0.00	0.09	0.15	0.24
Amador	669	243	176	1,088	120,344	0.56	0.20	0.15	0.90
Butte	2,404	677	441	3,523	265,310	0.91	0.26	0.17	1.33
Calaveras	1,373	350	818	2,541	210,304	0.65	0.17	0.39	1.21
Del Norte	880	216	234	1,329	106,023	0.83	0.20	0.22	1.25
El Dorado	3,618	863	732	5,213	369,048	0.98	0.23	0.20	1.41
Fresno		110	1,683	1,792	95,663	0.00	0.11	1.76	1.87
Glenn	320		16	336	5,381	5.95	0.00	0.30	6.24
Humboldt	8,965	2,611	4,226	15,802	1,234,885	0.73	0.21	0.34	1.28
Kern		267	767	1,034	149,044	0.00	0.18	0.51	0.69
Lake	278	104	282	664	100,104	0.28	0.10	0.28	0.66
Lassen	4,262	1,681	5,001	10,944	369,109	1.15	0.46	1.35	2.97
Madera		10	164	174	88,006	0.00	0.01	0.19	0.20
Marin	200	93	372	664	35,850	0.56	0.26	1.04	1.85
Mendocino	6,031	2,611	7,463	16,105	1,408,582	0.43	0.19	0.53	1.14
Modoc	2,320	5,732	2,755	10,807	224,758	1.03	2.55	1.23	4.81
Napa	2	64	29	95	108,598	0.00	0.06	0.03	0.09
Nevada	1,268	766	1,553	3,586	288,256	0.44	0.27	0.54	1.24
Placer	1,619	1,193	1,457	4,269	239,259	0.68	0.50	0.61	1.78
Plumas	1,301	1,600	2,463	5,364	309,628	0.42	0.52	0.80	1.73
San Bernardino		16		16	48,325	0.00	0.03	0.00	0.03
San Mateo		5	496	501	40,342	0.00	0.01	1.23	1.24
Santa Clara			261	261	43,223	0.00	0.00	0.60	0.60
Santa Cruz		15	1,047	1,062	114,380	0.00	0.01	0.92	0.93
Shasta	9,295	4,026	8,982	22,304	832,702	1.12	0.48	1.08	2.68
Sierra	834	1,077	1,746	3,657	110,625	0.75	0.97	1.58	3.31
Siskiyou	8,867	5,483	5,431	19,780	836,828	1.06	0.66	0.65	2.36
Sonoma	399	213	828	1,440	433,352	0.09	0.05	0.19	0.33
Tehama	3,400	575	1,407	5,382	259,027	1.31	0.22	0.54	2.08
Trinity	5,414	760	871	7,045	428,952	1.26	0.18	0.20	1.64
Tulare		227	182	409	94,992	0.00	0.24	0.19	0.43
Tuolumne	934	407	1,010	2,351	159,905	0.58	0.25	0.63	1.47
Yuba	955	576	575	2,107	85,066	1.12	0.68	0.68	2.48
Total	65,608	32,580	53,487	151,675	9,227,549	0.71	0.35	0.58	1.64

Data Source: CAL FIRE Forest Practice Database, 2009

accounting for 0.71, 0.35 and 0.58 percent respectively. 1.64 percent harvest coverage approximately equates to an average 61-year return interval.

Stand Condition

The 2001–2007 FIA data for California was queried (FIDO, 2010) to produce a graph (Figure 1.2.2) of forest biomass by landowner and stand age classes and a table on snag density by landowner and diameter classes (Table 1.2.12). This information is presented in a statewide aggregated form across reserve status, ecological types and management history, which is useful for general use and is not specific to individual ownership.

Private forestlands have an age distribution that is generally younger than public lands. This is a function of historic logging, forest types, productivity and current management objectives. Correlation of stand structural elements and stand age is expected, resulting in lower densities in more intensively managed forests. This generalization is confirmed in Table 1.2.12. Private forestlands have on average about half the snag density as Forest Service lands. The relative distribution of snags across tree sizes is similar

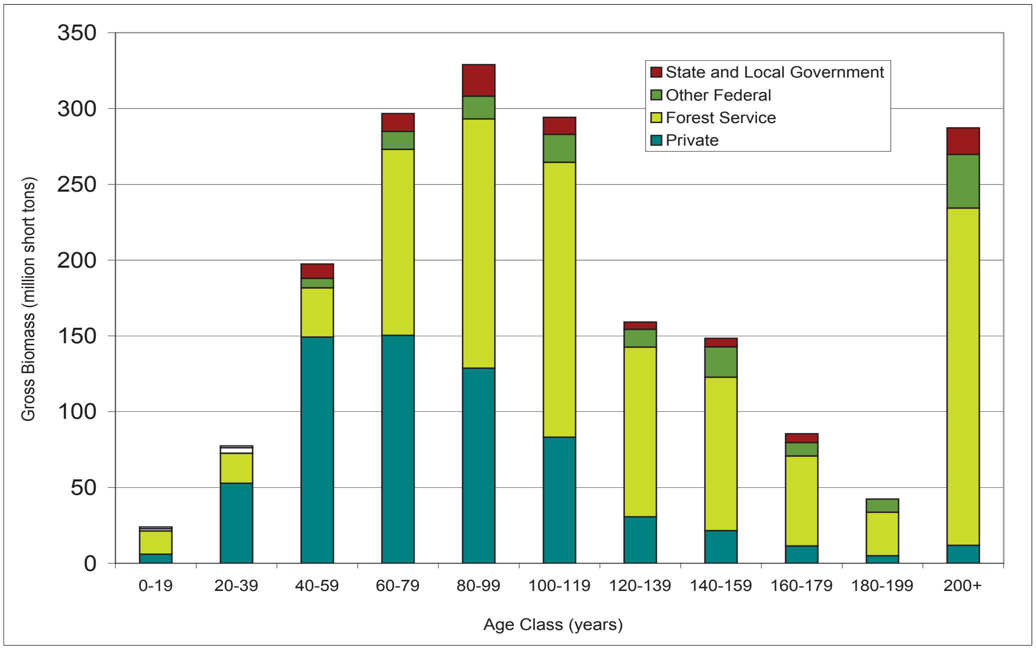


Figure 1.2.2.
Gross tree biomass by stand age class and ownership group.
Data Source: USFS Forest Inventory and Analysis, 2001–2007

across all ownership categories. Snags and other dead wood perform as both an asset (e.g., nutrient cycling, habitat) and as a risk factor (e.g., fuel, brood material) to a particular stand. Reconciling these competing functions with landowner objectives presents a management and regulatory challenge at the landscape planning and project levels.

Condition of the Forest Products Sector

Timber production in California had stabilized in the early part of the last decade but has experienced a significant decline in the last few years (Table 1.2.13, Figure 1.2.3). This trend is expected to continue into 2010 due to the economic slowdown. The proportion of volume from public lands appears to have stabilized at a relatively low level (Figure 1.2.4).

The bankruptcy and transfer of the Pacific Lumber Company (PALCO) to the Mendocino Redwood Company in 2008 marked the end of a change in ownership configuration of large industrial forestlands in California from publicly traded to privately held companies. A national trend has been for integrated forest products companies to divest of their timberlands, often selling to timberland investment management organizations (TIMOs) or real estate investment trusts (REITs). These organizations manage the lands as an investment rather than as a raw material source for sawmills and may therefore have a higher propensity to subdivide and sell parcels for development. About 10 percent of private corporate forestlands, or 344,000 acres, in California are held by TIMOs or REITs (Christensen et al., 2008).

The National Woodland Owner Survey, which is a mail-in form-based survey by FIA, was last conducted in 2004. A summary of results is presented on page 18 of Christensen et al. (2008). For landowners with 500 acres or less, which fits many recent Non-Industrial Timber Management Plan (NTMP) sizes, timber, firewood or other forest product harvests were a significant activity for many. Three-quarters use their land as part of their primary residence and have lived there for many years. Significantly, 84 percent were over 55 years of age and were concerned with passing the land to their heirs. Fire, trespassing, exotic plants and property taxes were the other top concerns.

Table 1.2.12. Snag density (trees per acre) by tree diameter class and ownership group

Tree Diameter Classification	Ownership Group				Average of all Ownerships
	U.S. Forest Service	Other Federal	State and Local Government	Private	
5.0–6.9	11.4	9.6	9.8	7.2	9.5
7.0–8.9	10.0	9.9	6.0	5.1	7.8
9–10.9	2.6	1.8	1.8	1.4	2.0
11–12.9	1.9	1.5	1.6	0.9	1.5
13–14.9	1.5	1.3	0.9	0.6	1.1
15–16.9	1.2	1.1	1.3	0.6	0.9
17–18.9	1.0	0.9	0.5	0.3	0.7
19–20.9	1.0	0.7	0.5	0.3	0.7
21–28.9	2.5	2.2	1.4	0.9	1.8
29+	2.3	2.3	1.9	1.3	2.0
Total	17.8	12.4	12.5	9.3	13.7
Data Source: USFS Forest Inventory and Analysis, 2001–2007					

Table 1.2.13. Volume (million board feet) and value from timber production in California

Species	2000	2001	2002	2003	2004	2005	2006	2007	2008
Douglas-fir and Larch	1,080	922	825	761	889	871	770	630	545
Hemlock-Fir	774	650	685	753	781	713	709	682	532
Other Mixed Softwood	741	672	570	609	545	628	557	565	553
Redwood	578	488	554	532	548	476	554	433	290
WWPA Volume	3,173	2,732	2,634	2,655	2,763	2,688	2,590	2,310	1,920
BOE Volume	1,966	1,603	1,690	1,663	1,706	1,725	1,631	1,626	1,372
WWPA Value (wholesale)	$1,362	$1,128	$1,114	$1,015	$1,287	$1,248	$1,186	$1,040	$508
BOE Value (stumpage)	$909	$575	$452	$448	$501	$547	$534	$475	$323
Data Sources: 2008 Statistical Yearbook of the Western Lumber Industry (WWPA) and California State Board of Equalization, 2009.									

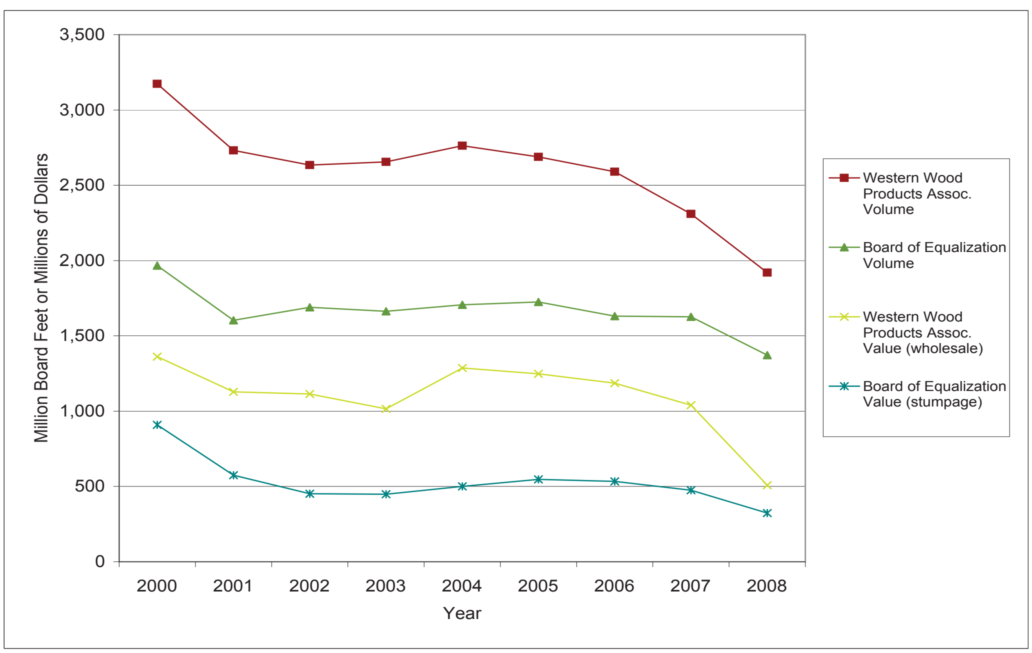


Figure 1.2.3.
Volume and value trends for California timber products.
Data Sources: Western Wood Products Association, 2009; California State Board of Equalization, 2009

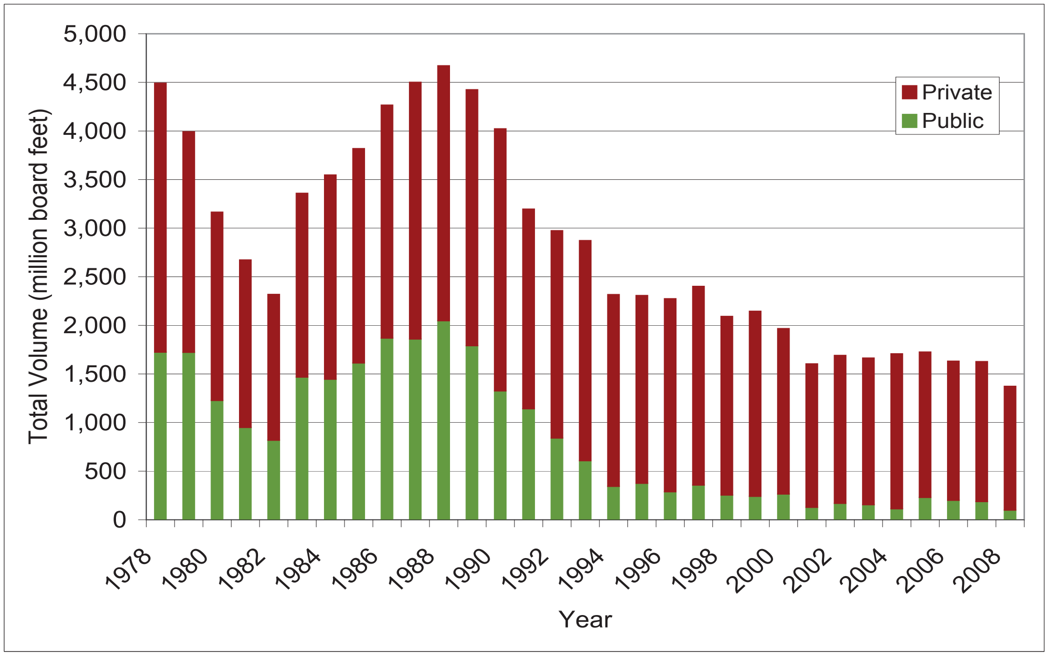


Figure 1.2.4.
Annual timber volume from private and public lands.
Data Source: Timber Tax Program, California State Board of Equalization, 2009

On non-federal lands, harvesting permits are tied to the approval of a harvesting plan. The most common plan is the Timber Harvesting Plan (THP). The other plan, that is used by ownerships of 2,500 acres or less and is more long term, is the NTMP. Costs of preparing both of these kinds of plans have risen dramatically in the last decade. At the same time, both THP and NTMP numbers have been decreasing. The size of THPs has been increasing with a fairly constant number of acres under plan, although 2009 has seen a dramatic drop-off in THPs due to the economic recession. NTMP average size has been decreasing over the last decade.

Data is available that shows what silvicultural prescriptions have been used in THPs over time in the state by CAL FIRE forest region. There are standard silvicultural prescriptions and alternative prescriptions, which are defined to be closest to a given standard prescription. Table 1.2.14 shows the statewide trend in use of standard silvicultural prescriptions over the last decade. Standard prescriptions show a relatively constant level of clearcutting, group selection, single tree selection and conversion. Commercial thinning acres dropped significantly in 2005 and have stayed low. Rehabilitation, sanitation/salvage, seed tree removal, shelterwood removal, and transition have declined in acreage over time. Variable retention, which was a newly adopted practice in 2000, has recently been around 1,100 acres per year.

Jobs associated with the forest products industry are tied to economic cycles and also show a downward trend (Figure 1.2.5) associated with a decline in capacity and increases in mill and logging efficiency. Softwood sawmill capacity in the western United States declined approximately eight percent from 2007–2009 with the permanent loss of 25 sawmills and the opening of three large sawmills in the Pacific Northwest (Spelter et al., 2009). In California, the loss in capacity during this time was 25 percent.

Discussion

California's forests are as diverse as their ecosystems. These forests include coastal rainforests, oak savannas, mixed conifer, high elevation fir, dry pine, and unique communities including pigmy forests on coastal terraces, giant sequoias in the Sierras (the largest trees on earth), subalpine bristlecone pine (the oldest trees), and coast redwoods (the tallest

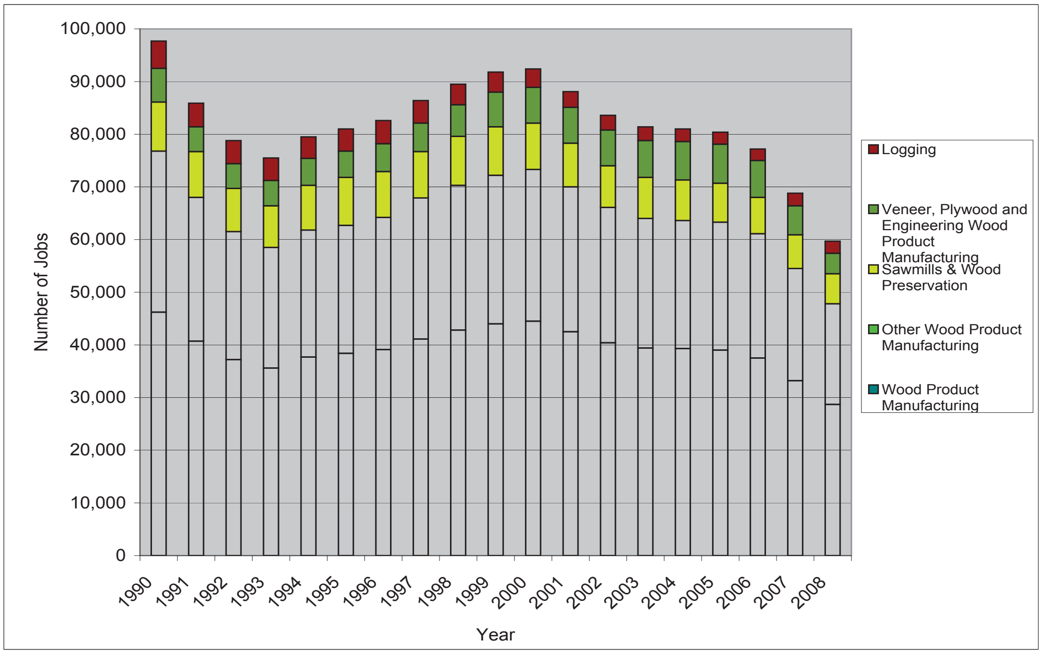


Figure 1.2.5.
Jobs associated with the forest products industry in California.
Data Source: California Employment Development Department, 2009

estate planning factors such as the federal estate tax, will all affect the ability of these owners to retain their lands as working landscapes. Woodlands, in particular, are affected by this class of landowner and may intersect both forest and rangeland ownerships.

Statewide, the best estimates are that standing stocks of trees are stable or increasing. Estimates are problematic due to changes in design of the national FIA inventory, but will improve in time. Carbon stock change estimates indicate that the AB32 Scoping Plan 2020 objective of no net loss in sequestration, which is estimated to be five million metric tons of CO2e a year, will likely be met and exceeded. This assumes that current sequestration rates will continue for the next ten years and that no catastrophic changes occur in that time frame.

RANGE

Rangelands are defined as lands on which existing vegetation, whether it grows naturally or through management, is suitable for grazing or browsing of domestic livestock for at least a portion of the year. Rangeland vegetation types in California include any natural grasslands, savannas, shrublands, deserts, wetlands, or woodlands that support a vegetative cover of native and non-native grasses, grass-like plants, forbs and shrub species. Rangelands may also include forested land that contains grazing resources, although these are viewed as secondary to the primary rangeland base. At 57 million acres, primary rangelands make up 57 percent of the lands of California, providing ecological, economic and other services. Approximately 34.1 million acres or 34 percent of California is actually grazed and most of this is on private lands. The BLM leases 1.8 million acres for grazing in California (BLM, 2009). In California, the U.S. Forest Service has 8.3 million acres within active grazing allotments, which includes waived private lands (Anne Yost, personal communication).

Based on work done under contract by researchers at the University of California, Berkeley (UCB), Department of Environmental Science, Policy and Management (Huntsinger and Romanek, 2009), the following section is primarily a summary of their work and uses the language from their report, including imbedded draft papers.

trees). The forests of California are relied upon for a vast array of ecological services and commodities. California is one of the top wood products producing states (Adams et al., 2006). Non-reserved private and public forestlands are about equally represented at 13 million acres each. Most of the wood supply from California forestlands, however, is from private lands.

California forests produce relatively high quality softwood products, such as dimensional lumber, molding and decking. Many of the large forestland ownerships are part of integrated operations that include sawmills and sometimes secondary manufacturing, although timberlands may be held by separate companies than mills. The national trend of the disposition of timberlands from formerly integrated forest products companies is not as common in California. Large industrial timberland ownership in California is concentrated in long-term family oriented corporations, which appears beneficial to long-term forest and rural economic sustainability. The concentration of milling facilities and general reduction in production capacity, however, will continue to limit the economic feasibility of operations over increasing geographic areas of the state. This may in turn affect the ability to conduct beneficial treatments, increasing risk over landscapes. Revenue reductions to landowners may impact working landscapes by increasing the economic attractiveness, or necessity, of alternative uses.

Private non-corporate forest landowners control a quarter of the state's timberlands. The size of these properties makes them particularly sensitive to costs and geographically dependent on local revenue opportunities. The stabilization of the existing wood products infrastructure, increased opportunities from emerging ecosystem services markets, regulatory compliance costs, and

Table 1.2.14. Acres of standard silvicultural prescriptions on private timberlands in THPs by year

Year	Clearcut	Commercial Thin	Conversion	Fuelbreak/ Defensible Space	Group Selection	Rehabilitation	Right-of-Way (Road Construction)	Sanitation-Salvage	Seed Tree Removal	Seed Tree Seed Step	Selection	Shelterwood Prep Step	Shelterwood Removal	Shelterwood Seed Step	Special Treatment Area Prescription	Substantially Damaged Timberland	Transition	Variable Retention	Total
1990	14,279	18,079	0	0	0	11,458	0	14,710	8,764	1,117	41,173	1,810	77,224	1,449	155	0	66,722	0	256,940
1991	7,751	28,761	163	0	0	4,614	0	6,824	5,976	1,317	50,099	1,970	42,415	2,819	120	0	53,358	0	206,187
1992	10,578	40,728	0	0	0	7,520	0	14,171	5,357	791	86,941	2,874	25,353	1,075	111	0	51,161	0	246,660
1993	11,303	28,225	54	0	0	7,510	0	48,171	7,877	1,873	70,612	1,769	28,690	3,093	284	0	27,589	0	237,050
1994	11,892	20,729	1,347	0	47	6,977	59	10,838	6,638	1,849	71,326	1,924	27,218	1,059	355	0	11,078	0	173,336
1995	13,025	25,923	833	270	1,530	16,681	84	11,218	16,076	2,207	63,881	1,098	24,411	79	476	0	5,038	0	182,830
1996	20,468	61,336	1,169	0	4,205	18,082	18	18,158	20,840	1,666	106,103	1,241	40,979	479	970	114	4,049	0	299,877
1997	23,236	28,734	1,044	716	5,908	12,739	101	11,849	15,087	1,133	68,338	302	27,772	262	144	0	5,243	0	202,608
1998	25,287	33,009	1,201	474	8,002	5,261	303	12,854	10,709	906	55,951	1,440	32,466	267	162	198	2,454	0	190,944
1999	37,316	27,322	689	2,838	15,789	7,553	559	14,932	12,597	783	52,059	1,718	42,409	382	277	444	3,471	0	221,138
2000	23,628	9,878	2,075	257	5,303	6,299	403	10,603	9,934	707	42,790	1,257	19,737	65	737	3	2,927	38	136,603
2001	22,307	25,253	376	1,057	7,241	8,013	466	3,816	7,826	260	33,135	755	13,082	73	352	2,705	5,209	0	131,926
2002	26,090	20,488	2,286	1,625	15,613	3,787	542	4,122	4,326	810	45,781	230	15,982	10	157	19	2,759	0	144,627
2003	23,561	20,093	365	1,192	16,510	1,513	592	4,990	7,971	357	41,064	355	12,785	68	163	127	2,003	0	133,709
2004	26,301	24,946	1,082	2,543	16,595	1,739	481	9,421	4,668	541	53,404	99	16,915	7	307	0	2,225	2,003	161,274
2005	24,319	6,825	646	841	15,086	1,837	508	5,138	5,808	636	19,772	348	11,574	6	558	0	1,527	743	95,429
2006	21,320	9,299	1,460	1,094	13,773	1,689	353	6,689	1,567	226	34,987	166	7,765	8	236	0	1,908	1,231	102,540
2007	22,840	8,450	1,101	152	12,807	2,140	368	5,613	5,169	159	32,004	236	6,950	68	524	0	3,310	1,132	101,891
2008	21,919	4,934	556	3,273	22,390	1,717	469	6,963	2,664	67	41,225	220	6,987	30	260	0	5,500	1,128	119,174
Total	387,420	443,012	16,447	16,332	160,799	127,129	5,306	221,080	159,854	17,405	1,010,645	19,812	480,714	11,299	6,348	3,610	257,531	6,275	3,344,743

Data Source: CAL FIRE Forest Practice Database http://www.fire.ca.gov/resource_mgt/resource_mgt_forestpractice_thpstatus.php

Rangeland status was considered by examining rangeland productivity, management, environmental services and wildland urban interface issues. The status of rangeland enterprises was examined by focusing on what constitutes working landscapes, considering trends in oak woodland use and management, a rangeland enterprise risk analysis, ownership considerations on livestock production, the role of amenity values and a livestock inventory.

Rangeland Condition

Rangeland status was examined a variety of ways, starting with an analysis of statewide rangeland productivity and capacity for modeling change. A nonparametric regression modeling technique (CART) was used to construct a means to predict forage productivity from simple climate, habitat and bioregion inputs. Using climate variables including temperature and precipitation, the model facilitates predicting low and high production years from recent climate conditions. The projected impact of climate change on forage productivity was also examined by inputting future temperature and precipitation estimates into the forage productivity model.

Figure 1.2.6 shows the average forage productivity for California, which ranged from zero to 5,200 pounds per acre per year. A draft climate change scenario indicated that forage productivity impacts may be positive or negative, depending on geographic location.

Rangelands provide a wide variety of ecosystem services. Fragmentation and poor management can reduce the capacity of rangelands to produce clean water, habitat, viewshed and livestock products. Ranches tend to be on watered sites with better soil and have less human disturbance to wildlife, relative to land preserves (Lenth et al., 2006; Maestas et al., 2001; Maestas et al., 2003). The avoidance of conversion appears to be influenced by the ability to bolster the amenities of ranching with the income to maintain working landscapes. Clustering rural development does not appear to reduce impacts (Lenth et al., 2006). Grazing in California is seen as a more socially preferable alternative to reducing fuel loads in some areas.

While some impacts of grazing may be negative, they should be taken in the context of alternative land uses and their impacts. Avoided conversion through conservation easements and fee title acquisitions by conservation groups has been increasing, which keeps working landscapes contributing to local economies while protecting ecosystem values. A study by the California Rangeland Conservation Coalition of the Central Valley and surrounding foothills (Kroeger et al., 2009,) identified high priority landscapes for conservation. The linking of private ranches to public land leases has the benefits of habitat linkages and discouraging development adjacent to public lands.

Over 100,000 acres of grazing lands were lost to urbanization between 1990 and 2004 with an estimate of 750,000 additional acres by 2040 (Kroeger et al., 2009). Conserving the ecological integrity of

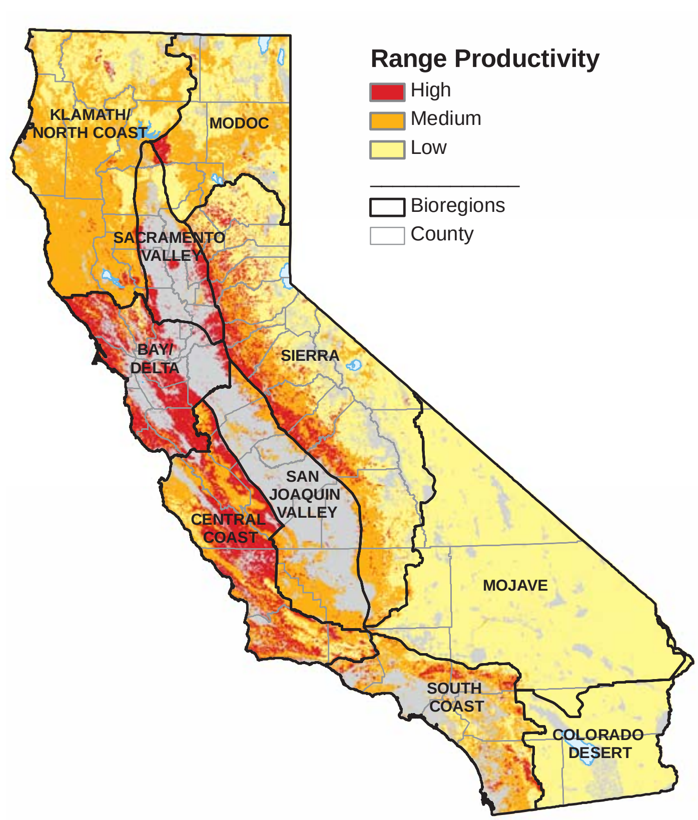


Figure 1.2.6.
Estimated average forage productivity.
Data Sources: Forage Productivity (derived from NRCS Forage Production and Soil Survey (SSURGO) data), UC Berkeley (2009 v1)

an ecosystem means maintaining the processes that create structural and biological diversity and enable plant communities to persist. These processes include the way that plants, animals and the environment interact and influence one another. Exurban development changes plant habitats profoundly by introducing new species or changing habitat, adding barriers to movement or dispersal, introducing new herbivores and changing competitive dynamics among species. Exurban developments favor species that are adapted to human-altered environments so that exotic and weedy species generally increase (Hansen et al., 2005). Effects on biodiversity are cumulative and often nonlinear, and continue to emerge for decades after the development occurs.

A study of ranching in the Sierra Nevada found that while adjacent public forests were profoundly changed by fire suppression, ranchers had maintained relatively fire resilient open woodlands through grazing, brush control, prescribed burning and tree thinning. Once houses are introduced into the mix, vegetation management priorities and options are changed forever. Prescribed burning and grazing are often lost as management options.

Condition of the Range Industry

The concept of "working landscapes" encompasses the idea that lands used for commodity production also produce crucial ecosystem goods and services, and that future demands make it essential that we learn to manage these systems for joint production of ecosystem services and food and fiber (Huntsinger and Sayre, 2007). In addition to open space and habitat provided by rangeland, livestock grazing can be used as a tool to reduce exotic plants and manipulate vegetation in a now-changed ecosystem that cannot return to its original state. In the course of 200 years of livestock grazing, some wildlife species, even some endangered ones, have adapted to and may to some extent be dependent on the landscape characteristics and management practices of livestock producers, for example in the construction and maintenance of stock ponds.

Ranches require access to veterinarians, packing houses, processing facilities and agricultural advisory services (Huntsinger and Hopkinson, 1996). As lands are developed, there are fewer rural enterprises to support this infrastructure. In one study of exurbanizing communities, ranchers had seen an average of 10 neighboring ranches sold for development, and stated that this was an important reason they might sell their ranch (Sulak and Huntsinger, 2002). Exurban residents may quickly outnumber rural residents and change the economics and politics of a region (Gosnell and Travis, 2005; Sheridan, 2007). In-migrants may bring with them particular 'aesthetic' or 'consumption' views of landscape that long-time residents with continuing ties to the production landscape view as political threats.

Public rangelands often support private ranch operations and when access to public lands is lost an enterprise often becomes unsustainable. This can encourage development adjacent to public lands, diminishing ecological values across the landscape.

California has millions of acres of privately owned rangelands that are crucial reservoirs of biodiversity. Ranchers are in large part motivated by their enjoyment of the environment and ranching as a way of life. Outside income is often required to maintain ranching enterprises. There is growing interest among ranchers in potential markets for ecosystem services from ranch lands. Because land conservation on private lands relies to a certain extent on landowner choice, it is important to understand landowner motivations for participation. Landscape level conservation strategies on private rangelands must consider public land and development linkages and pressure.

Ecosystem services that can be marketed, such as carbon, may benefit both landowners and society without significant direct subsidy. Range management practices that may provide carbon benefits are shown by Kroeger, et al. (2009). Support of market development, such as protocol development, and the dissemination of technical information may be the most useful role for government agencies and universities in these cases. Ecosystem services that do not lend themselves to markets, such as threatened and endangered species habitat conservation, may best be addressed through payment programs (Kroeger et al., 2009).

A longitudinal study of California hardwood rangeland owners indicated significant change in landowner characteristics and goals. The three surveys, from 1985 to 2004, showed a significant reduction in oak cutting and an increase in oak planting. This time period coincided with the creation of the Integrated Hardwood Range Management Program, co-sponsored by UCB and CAL FIRE. Unfortunately, the program was disbanded in 2009 due to budget cuts. The number of oak woodland landowners engaged in the production of crops or livestock continues to decline. Recent changes include the increased use of land trusts for consultation by landowners and an increased number of landowners, including ranchers, reporting they live in the oak woodland to benefit from environmental services such as natural beauty, recreation and lifestyle. Property size remained significantly related to landowner goals, values and practices, with those producing livestock owning most of the larger properties.

Oviedo and Huntsinger (2009) conclude that woodland owners in California are willing to pay for the amenities derived from living there, but that each additional acre in property size saw a reduction in willingness to pay, approaching a saturation point. Conversely, commodity production was constant per acre. Sustainably retaining larger ranch sizes on the landscape requires both an amenity and a commercial production component.

An economic simulation of three cow-calf ranches in California found low market risk and a low cost of capital approximately equal to the risk-free rate of return, which averaged 4.8 percent over the last 20 years, but ranged from 0.9 to 9.7 percent (Brownsey et al., 2009). This was much like other agricultural enterprises. However, this cost of capital was still significantly greater than the historical return on cow-calf ranching in the western United States of two to three percent, implying that ranchers are receiving benefits from their business beyond financial returns.

More than 60 percent of oak woodlands are owned by those who produce livestock for sale, and another 10 percent of owners produce livestock only for their own use. Another 10 percent of oak woodland owners graze stock on their property by leasing out their land to ranchers. County tax assessor data shows that many acres of California oak woodlands and annual grasslands are owned by corporations and investment groups. A significant portion of these are holding land as an investment, anticipating continued rising land values. Maintaining grazing on these properties reduces fire hazard, and qualifies the land for tax benefits based on agricultural use. The great majority of livestock producers live on their properties and manage the land themselves. What ranchers say makes ranching worthwhile is experiencing the lifestyle, raising a family on a ranch, working with livestock and enjoying the natural environment. On the other hand, most consider land appreciation an important, long-term financial asset, and have planned retirements and estates accordingly. As a result they strongly defend their right to market their land at a good price.

California livestock production is not diverse, with the vast majority of ranchers producing cattle only. About 720 thousand beef cows grazed California rangelands in 2005, down from a million in 1985, with half a million to a million weaned calves, known as “stockers”, also using rangeland resources, depending on markets, rainfall and other factors (Figure 1.2.7). In 2005, there were 275,000 ewes in California, the mature female sheep of the kind likely to use rangelands, down from 776,000 in 1985. Dairy cattle are rarely grassland-based, except in parts of the northern coastal counties.

The majority of ranchers voluntarily participate in a land conservation incentive program through the California Land Conservation Act (CLCA, Williamson Act) of 1965, which allows them to pay property taxes at a rate based on the land's agricultural value as

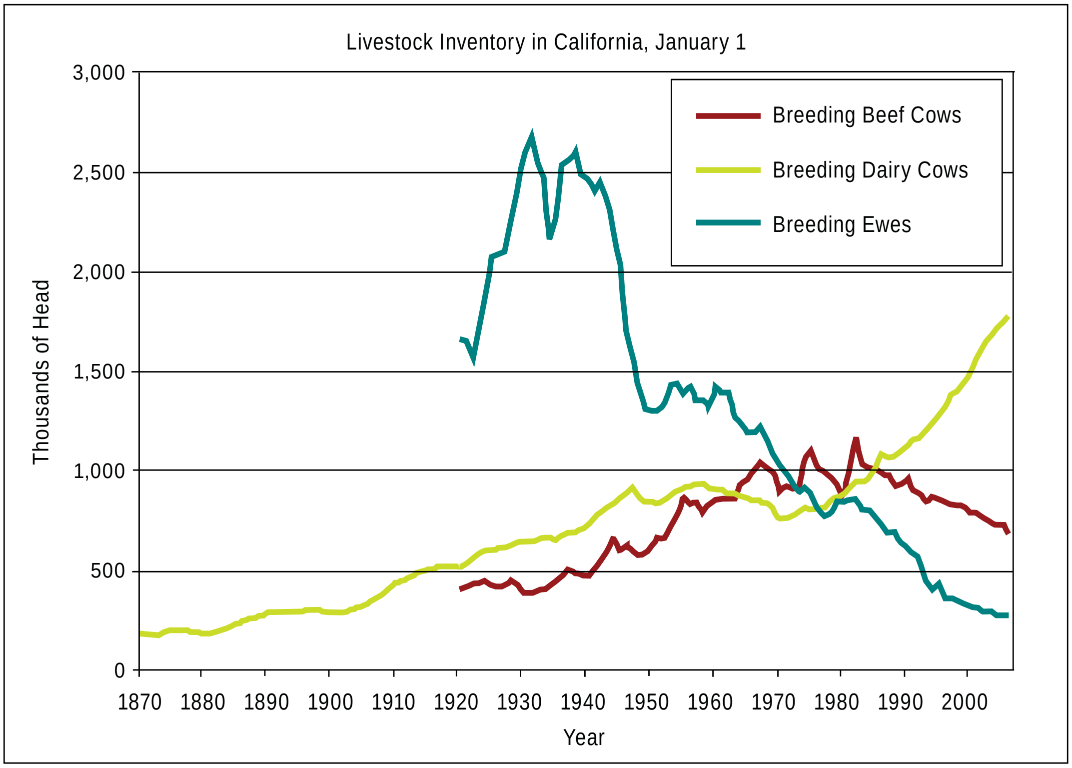


Figure 1.2.7.
Inventory of breeding beef cows, dairy cows and ewes over time.
Data Source: USDA National Agricultural Statistics Service, 2009

long as they commit to keep the land in agriculture for ten years into the future. In exchange for much needed cash, or tax relief, a small but growing number of ranchers have acquired conservation easements, which in general puts a restriction on the title regarding development.

A diverse array of public agencies lease public rangelands for grazing, including the BLM, Department of Defense, U.S. Forest Service, water districts and local and regional parks. Competition for grazing leases has been augmented by the administrative withdrawal of millions of acres of federal lands from grazing, and the continued decline in grazing permit issuance. Declining public forage supply puts stress on the industry, and on the private lands associated with public leases (Sulak and Huntsinger, 2002). In California, in the last decade, although “permitted use” has not changed much, the amount of authorized grazing, or the amount actually allowed, has been lower on both U.S. Forest Service and BLM land.

Traditionally in California, calves are produced on rangelands in cow-calf operations, spending their early life on these rangelands. However, as the current breeding beef cow inventory is about 700,000 head and the current breeding diary cow inventory is 1.1 million (as of January 1, 2006, USDA-NASS), the majority of calves entering the beef production process in California are coming from dairies. As these calves become stockers, they may then stay on rangelands, move to pasture, get shipped to the Intermountain West to graze on rangelands or pasture or get shipped to feedlots in the Midwest or California, depending on the supply and cost of forage from each source. Stockers also enter into California from the Intermountain West, Hawaii and Mexico. Table 1.2.15 lists the top six trading states with California for cattle leaving and entering the state. The stockers that are in California may be finished on feedlots in California or the Midwest. A small but growing number of stockers remain on rangelands or pasture to be finished and marketed as “grassfed beef”, a niche market that can produce value-added profits for ranchers.

The sheep ranching industry in California (and the entire U.S.) has seen even more dramatic declines in inventories as the beef ranching industry. The drop in sheep ranching is likely due to the higher labor costs for grazing sheep and a decline in consumer preference for lamb meat. Increasing immigration of people from non-Western cultures with stronger preferences for lamb meat into the U.S. may help to offset this trend.

Discussion

Over one-half of California is classified as rangelands, including substantial amounts of woodlands. The amenities that these lands provide the people of California rely on working landscapes to finance their management. Biodiversity is especially enhanced by the larger tracts. Larger tracts of rangelands require economically viable livestock operations to remain in an undeveloped condition.

Maintaining rangelands as working landscapes is challenging due to the relatively low economic returns of livestock production, a shrinking industry, and the proximity of some rangelands to developed areas. The loss of tax incentives, such as funding of the CLCA and federal estate tax limits, may have a substantial impact on long-term ranching viability. Opportunities may exist to retain viable operations with public-private partnerships where the objectives of fuels management, open space and management costs converge. Programs that monetize the ecosystem services of rangelands may provide the incomes necessary to retain some working landscapes that will otherwise be lost.

Table 1.2.15. Number of cattle imported and exported between California and top six trading states, 2001

State	Leaving California	Entering California
Idaho	109,781	39,682
Colorado	101,452	14,242
Oregon	92,455	22,026
Kansas	597,892	2,997
Nevada	50,638	44,703
Arizona	0	16,836
Total	481,032	247,852

Data Source: Shields and Matthews, 2003

LANDOWNER ASSISTANCE

The potential for various landowner assistance programs to contribute to forest and rangeland production and sustainability was analyzed. Four unique categories for private landowner assistance were identified in order to more specifically target unique landowner needs and opportunities for improving current conditions:

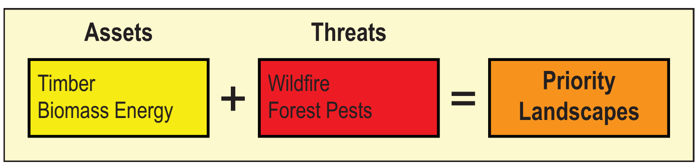
- Risk reduction: Forests and rangelands face a variety of threats that can impact production and sustainability, including wildfire, insects and disease and forest pests. Landowner assistance can facilitate application of various pre-fire management tools to reduce threats to the priority landscapes.
- Restoration: Extensive areas of forest and rangelands have already been impacted by past wildfire events, insect outbreaks or diseases. This has a direct impact on production and sustainability and can also increase the threat of future impacts. Landowner assistance can facilitate application of tools such as reforestation to restore impacted areas, improve productivity, and reduce susceptibility to future threats. Lack of spatial data related to impacted rangelands precluded a spatial analysis to determine priority rangeland landscapes for restoration. However, there are notable areas that should be prioritized for restoration such as riparian areas or oak vegetation or eradication of exotic invasive species.
- Stand improvement: California has extensive areas of suboptimal stands in terms of current timber and carbon growth versus what is possible optimally stocked conditions. This represents unutilized capacity – sites capable of fast-growing valuable coniferous species are currently dominated by non-commercial hardwoods, shrubs or slow-growing overstocked conifers. These are the areas where landowner assistance could facilitate application of stand

improvement tools such as reforestation, species conversion, and thinning to improve growth, species composition, and thus future timber and carbon yields.

- Technical and financial assistance: This includes various forms of assistance that could be particularly beneficial to nonindustrial landowners. Technical assistance can be important for developing management plans or timber harvest plans, meeting compliance with various regulations, forming multi-landowner cooperatives for more effective marketing, and providing estate planning tools.

Analysis: Risk Reduction on Forestlands

The diagram below shows the analytical model for risk reduction on forestlands, which includes the economic values timber and biomass energy that are threatened by wildfire and forest pests.



Assets

Two assets are included in this analysis.

Timber
Areas were ranked based on standing volume of commercial species. Counties without a viable timber processing capacity were excluded (counties south of Santa Cruz on the west and Kern on the east).

Biomass Energy
Areas were ranked based on the biomass, exclusive of merchantable timber, that is potentially available (see Chapter 3.4 for more detail). For non-timber counties, we assumed all material from trees is potentially available for biomass energy.

The composite asset was derived by combining the assets with a weight of two for timber, given its economic value relative to biomass energy.

Threats

Two threats are included in this analysis, wildfire and forest pests. These correspond to the "stand-level" threats described in detail in following chapters. The composite threat was derived by combining the two threats with a weight of two for wildfire, given the severity of the damage it can cause to forest economic assets.

Results

Combining the composite asset and threat with equal weights creates the priority landscape (Figure 1.2.8). Almost all of the high priority landscape areas are a result of high timber assets coinciding with medium threat.

Analysis: Risk Reduction on Rangelands

The diagram below shows the analytical model for risk reduction on rangelands, which includes the

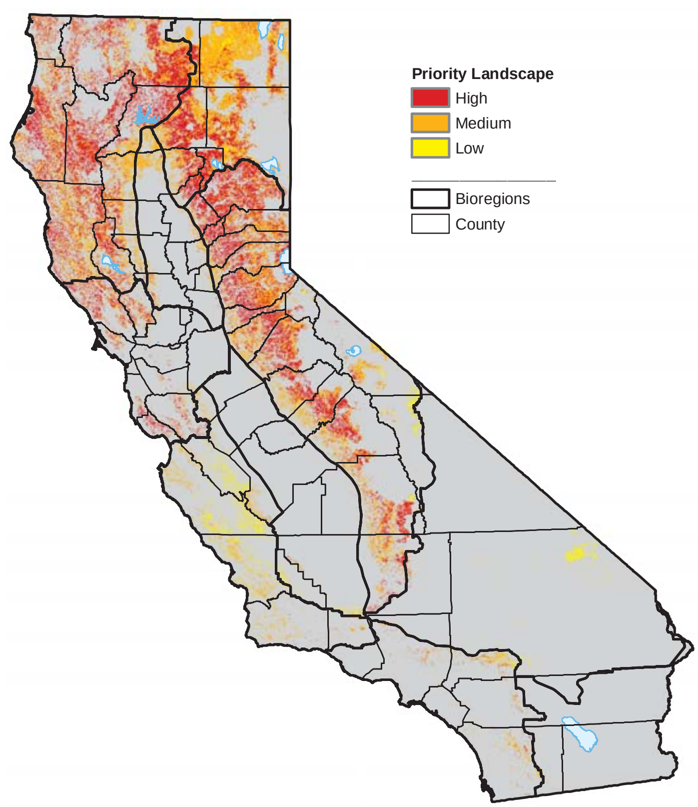
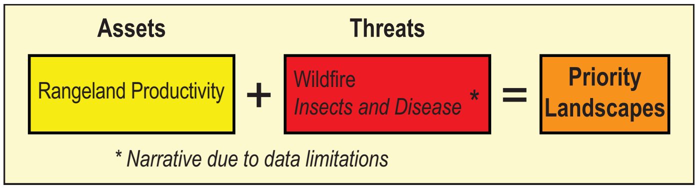


Figure 1.2.8.
Priority landscape for risk reduction on forestlands.
Data Sources: Fire Threat, FRAP (2005); Forest Biomass and Biomass Potentials, FRAP (2005); Statewide Land Use / Land Cover Mosaic, FRAP (2002); Forest Inventory and Analysis, USFS (2000); Forest Pest Risk, USFS FHP (2006 v1)

rangeland productivity asset that is threatened by wildfire and insects and disease.



Assets

The rangeland productivity asset (UC Berkeley, 2009) is shown in Figure 1.2.6.

Threats

The wildfire threat is described in Chapter 2.1, where it is called "stand-level wildfire threat."

Results

Combining the rangeland productivity asset and wildfire threat with equal weights creates the priority landscape (Figure 1.2.9).

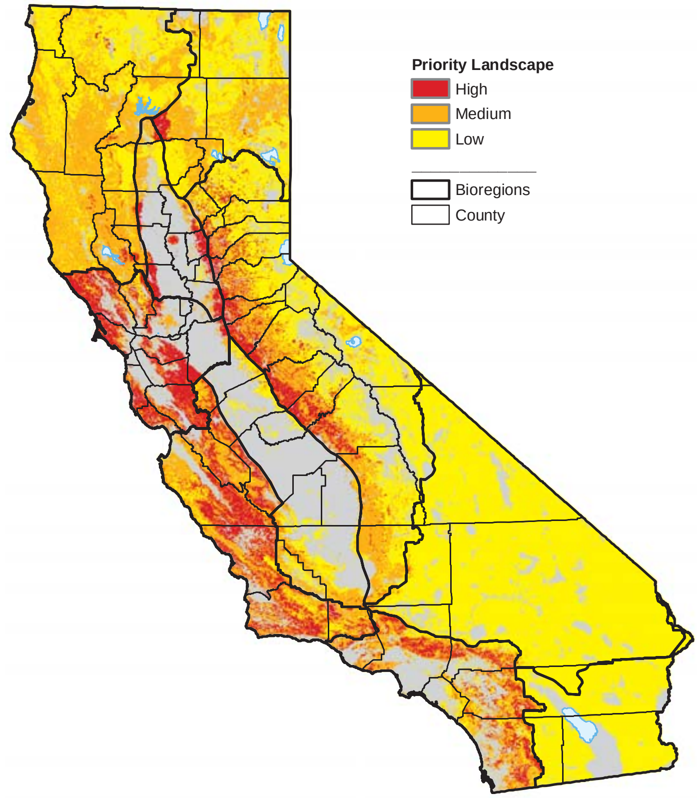
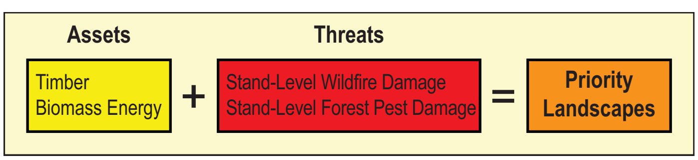


Figure 1.2.9.
Priority landscape for risk reduction on rangelands.
Data Sources: Fire Threat, FRAP (2005); Forage Productivity (derived from NRCS Forage Production and Soil Survey (SSURGO) data), UC Berkeley (2009 v1)

Analysis: Restoring Impacted Timberlands

The diagram below shows the analytical model for restoring impacted timberlands. This includes the same economic assets as the first analysis. The threats represent areas impacted by past wildfires or forest pest outbreaks.



Assets

The forest economic assets were described in the first analysis.

Threats

This analysis includes two threats.

Stand-Level Wildfire Damage
Areas are ranked based on how recent the wildfire event occurred, and the burn severity, which affects the degree of economic loss.

Stand-Level Wildfire Damage
Areas are ranked based on the level of mortality due to past forest pest outbreaks.

The composite threat was derived by combining the two threats, and assigning the highest threat rank from the two threat inputs. This ensures that an area heavily impacted by either type of past event receives a high composite threat rank.

Results

Combining the composite asset and threat using equal weights creates the priority landscape (Figure 1.2.10).

Analysis: Stand Improvement

An analysis was conducted on private and public forestlands in non-reserve status to identify gross opportunities for stand improvement. FIA data (2001–2007 annual inventory) was used to:

Step I: Screen plots without trees to determine if they could potentially support forestland and identify potential productivity from site class.

Step II: Identify understocked stands that might benefit from improved stocking from inter-planting or treatments to encourage natural regeneration.

Step III: Identify overstocked stands that would benefit from thinning to improve forest health and resilience.

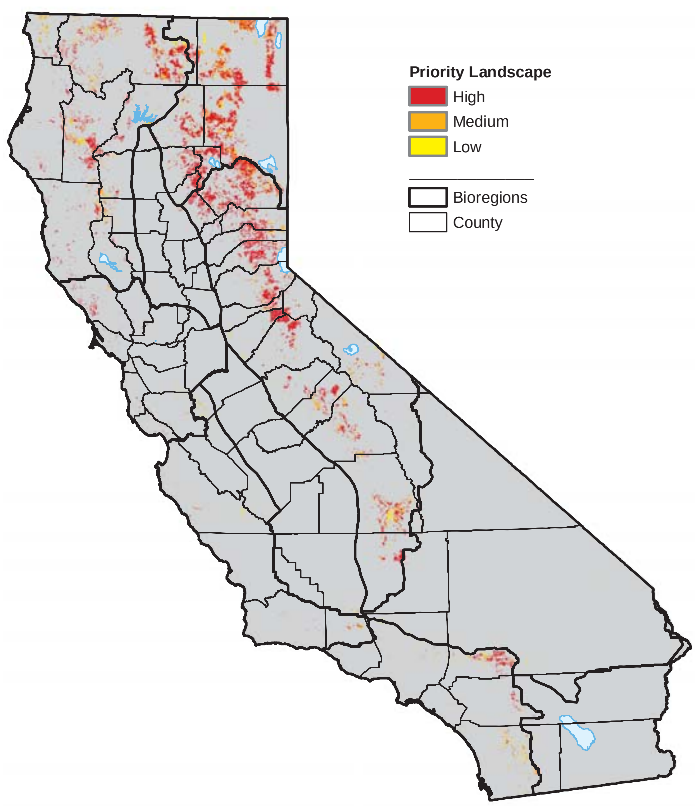


Figure 1.2.10.
Priority landscape for restoring impacted timberlands.
Data Sources: Fire Perimeters, FRAP (2005); Forest Biomass and Biomass Potentials, FRAP (2005); Statewide Land Use / Land Cover Mosaic, FRAP (2002); USFS Forest Inventory and Analysis (2000); Burn Severity, USFS (2009); Aerial Detection Surveys, USFS FHP (2008 v1)

The results are summarized for public and private forestlands by acres showing FIA site class (1=highest, 7=lowest) and other factors.

Results

These results indicate possible opportunities for stand improvement, that would need to be evaluated on the ground in the context of multiple objectives and constraints. The reforestation results are provided in Table 1.2.16 for non-reserved public forestlands and Table 1.2.17 for private forestlands. The relatively small number of stands makes it likely that significantly more acreage may exist suitable for reforestation that is associated with recent wildfires. These stands are devoid of trees entirely; understocked stands (Table 1.2.18) shows that considerable acres exist for improving stocking and the overall growth of trees statewide. The site classes of un- and understocked stands tend to be medium to low site quality, reflecting the difficulty to realize a return on investment from slower growing stands. This presents opportunities where public benefits might be enhanced through public investments and ecosystem service markets.

Table 1.2.19 shows that there is over one million acres of overstocked forests that may benefit from thinning. These stands tend to be on mid-site quality where prior management has occurred. Opportunity exists to use treatments to improve forest health and protect existing stocks from damage by wildfire and pests. Given that these stands already contain significant carbon and timber stocks and that they are productive sites, investments in these stands may provide a high return on investment for both public and private good.

Technical and Financial Assistance

A variety of state and federal programs exist to assist forest and range landowners. These programs provide both technical or financial assistance to landowners and are offered through University extensions, and state and federal programs. In addition, Resource Conservation Districts (RCDs) are local non-governmental organizations that work between

Table 1.2.16 Acres of reforestation opportunities on non-reserved public forestlands (78 plots)

	FIA Site Class							
Slope Class	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
0–30	1,810	0	19,858	6,747	15,356	48,082	92,444	184,296
31–60	0	0	12,471	4,343	3,318	15,455	38,971	74,558
>60	0	0	0	0	8,679	0	10,067	18,746
Total	1,810	0	32,329	11,090	27,353	63,537	141,482	277,600

Data Source: USFS Forest Inventory and Analysis, 2001–2007

Table 1.2.17. Acres of reforestation opportunities on private forestlands (57 plots)

	FIA Site Class							
Slope Class	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
0–30	3,983	2,924	41,891	18,644	47,271	2,623	107,496	224,831
31–60	0	589	7,898	192	3,012	9,341	4,368	25,401
>60	0	0	0	0	0	273	2,159	2,432
Total	3,983	3,513	49,790	18,836	50,283	12,237	114,023	252,664

Data Source: USFS Forest Inventory and Analysis, 2001–2007

landowners and government programs, facilitating the delivery of technical assistance to landowners. Assistance to communities is addressed in the next section of this chapter.

Cooperative Extension

Land grant colleges and the U.S. Department of Agriculture cooperate in agricultural and forestry extension services to landowners going back to the Hatch Act of 1887, but formalized by the Smith-Lever Act in 1918. The University of California, as the land grant institution in California, manages a cooperative extension service (UCCE) that serves forest and range landowners. UCCE is part of the Division of Agriculture and Natural Resources within the University of California. Extension agents may be found in county offices and at the campuses of Berkeley, Davis and Riverside. UCCE outreach includes web-based publications, meetings, conferences, workshops, demonstrations, field days, video programs, newsletters and manuals. Forestry subjects covered by UCCE include maintaining healthy forests, woodlands and rangelands, reducing fuels and fire hazard, restoration following wildfire, and estate and financial planning.

California Department of Forestry and Fire Protection Programs

Pest Management Program

Forest pests (insects and diseases) annually destroy 10 times the volume of timber lost due to forest fires. Native bark beetles took hold in Southern California forests following severe drought years and caused unprecedented tree mortality. The introduced pitch canker disease has attacked Monterey pine along the coast. Sudden oak death (SOD), caused by Phytophthora ramorum (a fungus), has been found in 14 counties in California and has killed millions of oaks and tanoaks. CAL FIRE's forest pest specialists (four statewide) help protect the state's forest resources from native and introduced pests, conduct surveys and provide technical assistance to private forest landowners and promote forest health on all forestlands throughout the state.

Annual aerial surveys are conducted by the U.S. Forest Service over the entire forest landscape of California. Outbreaks of bark beetles and defoliating insects are reported to the landowners and assistance offered for identification and control. Potential spots of SOD are ground checked. Control and suppression of SOD sites outside of the general infestation are conducted in cooperation with multiple landowners to attempt to slow the spread of the disease. Cooperative programs exist for suppression of bark

Table 1.2.18. Understocked stands with regeneration opportunities on non-reserved public (371 plots) and private (167 plots) forestlands

Ownership	Condition	Structure	Managed	Average FIA Site Class	Acres
			Y	4.6	41,982
		Even-aged	N	4.8	36,115
		Two-storied	Y	3.0	8,062
	Grass-forb	Uneven-aged	Y	4.2	19,690
			Y	4.5	38,150
		Even-aged	N	4.4	32,074
		Two-storied	N	7.0	5,674
	Shrub	Uneven-aged	N	3.0	9,525
			Y	4.6	382,282
		Even-aged	N	5.0	205,521
			Y	4.9	143,064
		Two-storied	N	5.5	92,252
			Y	5.0	503,873
	Sapling to Sawtimber	Uneven-aged	N	5.7	378,864
Public	Subtotal				1,897,127
		Even-aged	Y	3.8	43,465
		Two-storied	N	5.0	9,840
			Y	3.0	7,509
	Grass-forb	Uneven-aged	N	7.0	15,283
		Even-aged	Y	2.3	13,405
			Y	3.0	3,944
	Shrub	Uneven-aged	N	4.0	9,514
			Y	4.3	321,130
		Even-aged	N	4.7	93,151
			Y	4.4	173,014
		Two-storied	N	5.1	18,478
			Y	4.2	463,513
	Sapling to Sawtimber	Uneven-aged	N	4.0	54,489
Private	Subtotal				1,226,734
Total					3,123,862
Data Source: USFS Forest Inventory and Analysis, 2001–2007					

Table 1.2.19. Overstocked stands with thinning opportunities on non-reserved public (144 plots) and private (83 plots) forestlands

Ownership	Condition	Structure	Managed	Average FIA Site Class	Acres
	Grass-forb	Even-aged	N	7.0	5,681
			Y	3.0	4,044
	Shrub	Even-aged	N	3.0	4,517
			Y	3.4	103,209
		Even-aged	N	4.0	102,128
			Y	3.6	37,274
		Two-storied	N	4.0	87,133
			Y	3.9	101,096
	Sapling to Sawtimber	Uneven-aged	N	4.4	209,522
Public	Subtotal				654,605
	Grass-forb	Even-aged	Y	2.0	3,575
	Shrub	Even-aged	Y	3.0	9,840
			Y	3.5	197,871
		Even-aged	N	3.4	59,288
			Y	3.1	107,693
		Two-storied	N	4.5	18,467
			Y	3.9	131,447
	Sapling to Sawtimber	Uneven-aged	N	5.3	37,499
Private	Subtotal				565,681
Total					1,220,286
Data Source: USFS Forest Inventory and Analysis, 2001–2007					

beetles throughout the Southern California outbreak region. Zones of Infestation can be declared for both native and exotic insects and diseases to help in pest management, procurement of funds for control efforts and region-wide planning for management efforts. Landscape planning often occurs through the California Forest Pest Council, a volunteer cooperative organization that links together state, federal and local government agencies, universities, forest industry, non-profit organizations and concerned individuals on forest pest issues. Specific insect and disease issues covering large areas are often handled through task forces under the Pest Council, for example the Pine Pitch Canker Task Force and the Oak Mortality Task Force.

Forest Stewardship Program (FSP)
The purpose of the Forest Stewardship Program (FSP) is to encourage the long-term stewardship of non-industrial private forestlands (NIPF). In achieving that purpose, the program helps California's NIPF landowners, either individually or collectively with their NIPF neighbors, to more actively manage their forests, watersheds and related resources, and keep those lands and watersheds in a productive and healthy condition for present and future generations. California's FSP is also designed to assist California communities to increase the economic and environmental benefits associated with their watershed resources through locally led programs with active participation of individual forestland owners.

The primary emphasis of the program is technical assistance, forest landowner education and assisting in developing multi-resource planning documents such as a Forest Stewardship Plan.

The State Forest Stewardship Coordinating Committee
Federal law requires that any state that wishes to participate in Farm Bill programs such as the FSP must have a State Forest Stewardship Coordinating Committee (SFSCC) to serve as an advisory group to that state's State Forester. The SFSCC must:

- provide advice and recommendations to the State Forester concerning implementation of the Forest Stewardship Program, and other associated landowner assistance and cost-share programs,
- provide assistance and recommendations concerning the development, implementation, and updating of the statewide assessment and resource strategy,
- make recommendations to the Secretary concerning those forestlands that should be given priority for inclusion in the Forest Legacy Program.

California Forest Improvement Program (CFIP)
The goal of the program is to improve the timber productivity of non-industrial private forestlands while also improving other forest resources, such as fish and wildlife habitat and soil resources; the overall effect is to improve the total forest resource system. Funded practices include management planning, reforestation, site preparation, thinning, land conservation (erosion control, forest road rehabilitation, revegetation), and fish and wildlife habitat improvement. Cost-share rate is generally 75 percent up to $50,000 per contract. Rehabilitation after natural disasters such as fire can qualify for up to 90 percent cost-share. Demand for CFIP funding always exceeds the funding available.

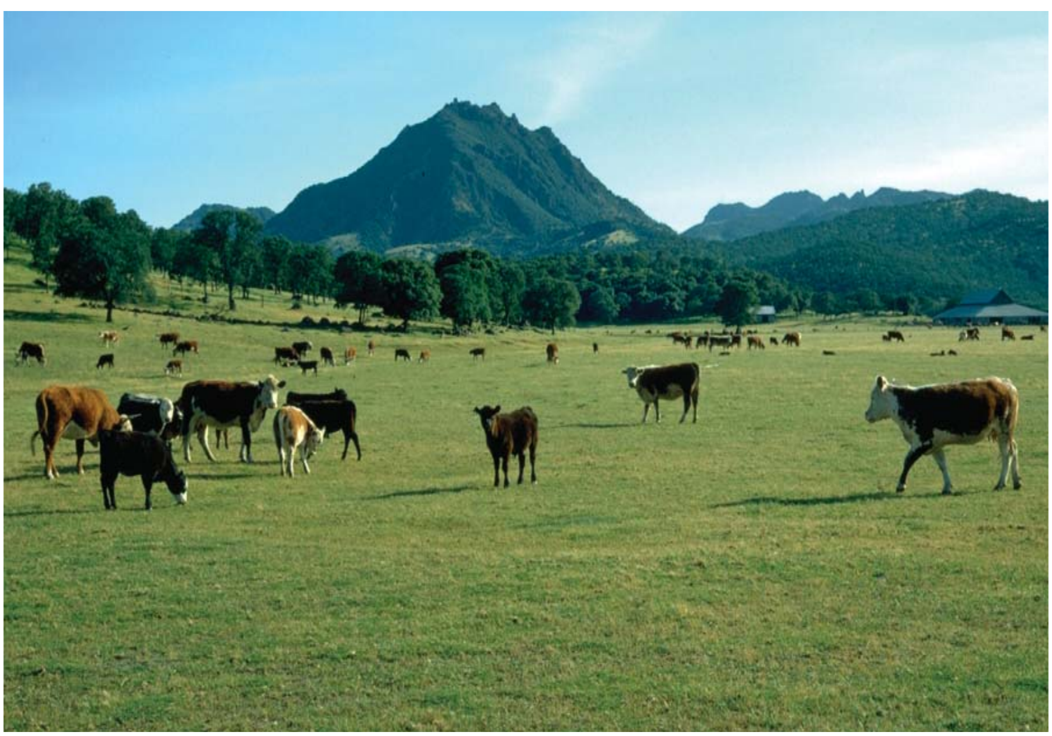
Forest Legacy Program (FLP)
The objective of the Forest Legacy Program (FLP) is to identify and protect environmentally important forestlands that are threatened by present or future conversion to non-forest uses by either purchasing the land or purchasing the development rights through deed restrictions such as a conservation easement. Priority is given to lands that can be effectively protected and managed and that have important scenic, recreational, timber, riparian, fish and wildlife, threatened and endangered species and other cultural and environmental values. In California, the program emphasizes purchasing conservation easements that restrict development and maintain the forests intact and provide such traditional forest benefits as timber production, wildlife habitat,

watershed protection or open space. These forests remain in private ownership.

The federal Forest Legacy Program was part of the 1990 Federal Farm Bill. It recognized that private forestland owners were facing increased pressure due to greater population densities and users' demands to convert their forestlands to other uses, such as housing subdivisions, rural lots and vineyards. In 2000, Governor Gray Davis signed into law the California Forest Legacy Act (SB 1832) which allows the California Department of Forestry and Fire Protection to acquire conservation easements, and permit federal and state agencies, local governments, and nonprofit land trust organizations to hold conservation easements acquired pursuant to the California Forest Legacy Program. An Assessment of Need (AON) was developed in 1995 and was amended in 2000. Specific program goals and objectives as well as Forest Legacy Areas (FLAs) are identified in the AON, which is incorporated by reference into this assessment.

Federal funds are limited to 75 percent of the value of the conservation easement with the remaining portion contributed by non-federal matching funds. Money to fund the program may come from a variety of sources: gifts, donations, federal grants and loans, other appropriate funding sources, and from the sale of bonds pursuant to the Safe Neighborhood Parks, Clean Water, Clean Air, and Coastal Protection Bond Act of 2000.

Federal funding is allocated to potential Forest Legacy Program (FLP) projects based on a national ranking system. All project applications are ranked on Importance, Threat, Strategic and Readiness. The FLP uses owner aggregation to increase "strategic" value in applying for federal funding. For example, the Six Rivers to the Sea FLP Initiative seeks to recruit landowners in the southern Humboldt County area who are willing to sell a "working forest" conservation easement to the state. This approach has been extremely effective and California has garnered funding for projects in the Six Rivers to the Sea Initiative every year that requests were submitted. To date successful transactions have closed on four ranches, one small industrial property, and another ranch in December of 2009.



Cattle grazing can be an effective means of invasive weed control on grasslands.

Five CAL FIRE foresters supported the delivery of the FSP, CFIP and FLP programs in 2009.

California Department of Fish and Game

Two programs, the Fisheries Restoration Grant Program and the Private Lands Wildlife Habitat Enhancement and Management Program (PLM) are of particular importance. The Fisheries Restoration Grant Program assists with watershed planning and restoration including fish habitat improvement projects, watershed organization support, training and education. The PLM seeks to enhance and safeguard much-needed habitat for California wildlife while improving profits for landowners. A five-year commitment and habitat plan are required. Fishing, hunting and other recreational activities may be developed outside normal season and modified bag limits are allowed. Fees charged by the landowner can improve the sustainability of an enterprise.

Federal Programs

Many of federal programs are delivered by state agency programs or cooperative extension.

U.S. Forest Service

The U.S. Forest Service, State and Private Forestry, is composed of Forest Health Protection (FHP) and Cooperative Forestry programs. FHP is responsible for technical assistance for forest health activities and monitoring and reporting on the health of all forestlands in California. They have specialists in forest pathology, forest entomology, pesticide use and safety, remote sensing and GIS. They are active in the California Forest Pest Council and specific organizations that target individual pests.

Cooperative Forestry provides assistance in education, economic action, landowner assistance and urban and community forestry. Economic action has been implemented through community action plans to diversify local economies dependent on national forests. Landowner assistance is implemented through CAL FIRE. Forest Legacy, forest management and reforestation programs benefit from Cooperative Forestry investments. Chapter 3.2 addresses urban and community forestry.

USDA Natural Resources Conservation Service (NRCS)

The Natural Resources Conservation Service (NRCS) has two forest and range landowner assistance grants programs created by the 2008 Farm Bill. The Conservation Stewardship Program (CSP) targets agricultural, rangeland and non-industrial forestlands. Activities supported by CSP include conservation activities associated with erosion control and wildlife habitat. On rangeland, vegetation health and livestock watercourse access is managed. On forestland, certification is encouraged as are implementation of management plans (such as fuel breaks, thinning and Integrated Pest Management (IPM)) and native tree use. Payments are estimated to be $6 to $12 per acre for forestland and $5 to $10 for rangeland. Five year contracts are required under CSP. The other program, the 2009 Environmental Quality Incentives Program (EQIP), focuses on erosion control, IPM and forestry. The program assists, up to 75 percent, with the development of forest management or IPM plans. The 1996 Farm Bill created the Wildlife Habitat Incentives Program (WHIP) to improve habitat on private lands, which is still an ongoing program funded at about $1.3 million a year.

Community Assistance

Assistance to communities may include grants and technical assistance directly to local governments or non-profit organizations. Addressed here are fire prevention projects, payments to counties that include federal lands, and stream restoration activities. Urban forestry, which has area service foresters and community grants programs, is addressed in chapter 3.2. Green infrastructure programs are covered in chapter 3.6.

Projects to reduce wildland fire hazards by treating fuels may be funded through a variety of sources. The National Fire Plan, Healthy Forests Initiative and other related federal initiatives have treated (prescribed fire and mechanical) between 230,000 and 275,000 acres a year since 2004 in California. Firewise Communities is a multi-agency program to engage communities in planning for wildfires through design, emergency response and home design landscaping and maintenance. Rural Fire Assistance (RFA) was a pilot effort from 2001–2005 to augment rural fire department firefighter safety and wildland fire protective capabilities. Currently, direct assistance to communities near DOI-managed lands is delivered through firefighter training.

The federal State Fire Assistance (SFA) program assists states and local fire departments in developing preparedness and response capabilities for wildland fire management. SFA had private lands grant amounts of $2.3 million in 2007 and $3.2 million in 2008, with $23 million available in 2009. BLM Community Assistance grants had $3 million available in 2008 and $1.6 million in 2009. State funds were available from Proposition 40 for fuels reduction projects in the Sierra Nevada, but funding was suspended in 2009.

Payments in lieu of taxes (PILT) are federal payments to local governments that help offset losses in property taxes because of federal ownership within their boundaries. This includes federal parks, forests and other lands. The formula for PILT incorporates population, receipt sharing payments and the amount of federal land within an affected county. Annual PILT amounts in California were about $19 million in 2003–2005, $21 million in 2006–2007, $33 million in 2008, and $34 million n 2009.

In addition to PILT, the Secure Rural Schools and Community Self-Determination Act (SRS), which was authorized in 2000 and reauthorized in 2008, provides funding to counties with federal lands. Payments from SRS to 38 California counties were between $65 and $67 million from 2002 to 2005. Most of this funding was allocated to roads and schools (about $56 million) with the rest going to projects either supporting or on national forests. Fourteen resource advisory committees (RACs) have been established in California to assist with identifying funding priorities. The total SRS budget for California was $58 million in 2008 and $61 million for 2009. Funding is projected to decrease each year and be $40 million for California counties in 2011. The 2008 reauthorization changed some program structure including having RACs involved in project monitoring, use of funds for the Firewise Communities program, reimbursement for emergency services and development of community wildfire protection plans.

Urban, agricultural and wildland stream restoration activities are funded by a variety of agencies and programs. Propositions 13, 40 and 84, for example, have provided over $25 million for urban stream restoration grants. CALFED grants fund projects that affect the Sacramento River delta. These include Watershed Coordinator grants (Proposition 50) and Watershed Program grants to advance sustainable watershed-based management through community-based strategies, both managed by the Department of Conservation. The Department of Fish and Game manages the Fisheries Restoration Grant Program, which has invested over $180 million to support projects from sediment reduction to watershed education since 1980. A variety of federal grants are managed by the National Oceanic and Atmospheric Administration, the U.S. Environmental Protection Agency, the U.S. Fish and Wildlife Service and others. Non-profit organizations also fund stream restoration projects.

Discussion

The maintenance of working landscapes may be facilitated by landowner assistance programs. The analysis of risk reduction on forestlands highlighted much of the Klamath/North Coast and Sierra bioregions. Rangeland risk reduction highlighted lands bordering the Sacramento and San Joaquin Valleys, Bay/Delta, Central and South Coast bioregions. Measures that enhance forest and rangeland health may have multiple benefits in reducing risk. Biomass markets may assist by offsetting some treatment costs where appropriate.

The analysis on restoring impacted timberlands highlighted areas primarily in the Sierra bioregion with some in the Klamath area, a result of where fire activity has been recently. Post-fire restoration may mean speeding up the natural cycle of reforestation or retaining the site in forest where climate stress may cause a type conversion without intervention. This generally means preparing the site and planting locally sourced seedlings. Site preparation and potential soil impacts, may be minimized by replanting within a year of the fire before competing vegetation dominates the site.

The stand improvement analysis relied on FIA plot data, rather than a geospatial analysis, to get an estimate of the statewide potential for reforestation, increased forest site occupancy, and thinning opportunities in overstocked stands. Many of these acres will overlap with those identified in the spatial analyses. The acres identified in all analyses are potential acres before the consideration of site-specific aspects such as habitat use in a landscape context, or the feasibility of treatments either economically or due to logistical constraints. Substantial acres are available for consideration of landowner assistance treatments where public benefits would result.

Protect Forests and Rangelands from Harm

The U.S. Forest Service State and Private Forestry Program (S&PF) in 2008 "redesigned" its approach to reflect these plans and funding strategies, and Program Redesign has strongly shaped the approach CAL FIRE has taken with the California 2010 Assessment.

The 2010 effort covers two components of the Redesign approach:

- Statewide Assessment of Forest Resources – provides an analysis of forest conditions and trends in the state and delineates priority rural and urban forest landscape areas.
- Statewide Forest Resource Strategy – provides long-term strategies for investing resources to address priority landscapes identified in this assessment, focusing where federal investment can most effectively stimulate or leverage desired action and engage multiple partners.

The Redesign approach emphasizes, where possible, use of available data and of a spatial framework for analysis and to delineate priority landscapes. The focus is on incorporating existing plans and information within states. Some categories of plans are specified, such as the state wildlife plan and community wildfire protection plans. Outreach to stakeholders is encouraged, though the outreach process and extent is left to the states. However, a requirement exists to seek input from specified stakeholder categories or entities such as federal management agencies, the state wildlife agency, the urban forest council and others.

MEETING BOTH MANDATES: ASSESSMENT TOPICS

This document presents the 2010 statewide assessment. It is intended to meet both the California and federal assessment requirements. A separate strategies document addresses approaches to dealing with issues raised in this assessment.

This assessment presents an analysis of trends, conditions and the development of priority landscapes. It is organized around topics (themes) presented in related federal assessment and strategy Redesign guidance documents (http://www.fs.fed.us/spf/redesign/index.shtml). Three general themes and related subthemes are covered in both this assessment and the strategies document. They are:

1. Conserve Working Forest and Range Landscapes

1.1 Population Growth and Development Impacts
1.2 Sustainable Working Forests and Rangelands

2. Protect Forests and Rangelands from Harm

2.1 Wildfire Threat to Ecosystem Health and Community Safety
2.2 Forest Pests and Other Threats to Ecosystem Health and Community Safety

3. Enhance Public Benefits from Trees, Forests and Rangelands

3.1 Water Quality and Quantity Protection and Enhancement
3.2 Urban Forestry for Energy Conservation and Air Quality
3.3 Planning for and Reducing Wildfire Risks to Communities
3.4 Emerging Markets for Forest and Rangeland Products and Services
3.5 Plant, Wildlife and Fish Habitat Protection, Conservation and Enhancement
3.6 Green Infrastructure for Connecting People to the Natural Environment
3.7 Climate Change: Threats and Opportunities

There is an additional chapter relating to Bordering States and associated issues as well as an appendix that describes Data and Analytical Needs. Additional information is provided on the FRAP website regarding assessment methodologies and other background (http://frap.fire.ca.gov/assessment2010.html).

These themes and subthemes generally cover the same topics that were presented in the Forest and Range 2003 Assessment prepared by CAL FIRE. The last assessment was organized around seven general topics ranging from biological diversity to socio-economic benefits and governance. The 2003 assessment emphasized consistency with international work being done on possible indicators to measure sustainable forest and rangeland management in temperate forests (called the Montreal Process).

For a variety of reasons, little work has been done by CAL FIRE since that time to refine or focus these indicators. While it covers status and trends for each of the issues, the 2010 assessment does not delineate specific indicators; rather, the topic is covered in the strategies document.

RELATED EFFORTS AND SUPPORTING DOCUMENTS

Consistent with U.S. Forest Service Redesign instructions, the 2010 assessment takes into consideration various existing planning efforts; these range from local plans such as Community Wildfire Protection plans to statewide plans, like California's Wildlife Action Plan, the State Water Plan and the Outdoor Recreation Plan. In California, a large amount of work has been completed, and more is ongoing, that is related to the focus of various state programs on increased use of renewable energy and to climate change. To the extent feasible, this assessment uses results of these efforts, especially those of the California Energy Commission, the Air Resources Board, the Department of Fish and Game, the Department of Water Resources and various academic institutions.

Additionally, the content of the Forest Legacy Program's Assessment of Need was integrated into many chapters because of its focus on conservation easements, which is a proposed tool for the protection of many priority landscapes. Many other reports were used in the preparation of this assessment, including the most recent report from the Forest Inventory and Analysis (FIA) program "California's Forest Resources, 2001–2005." For a complete list of sources used in this document, please refer to the References Section.

Finally this assessment and the strategies document reflect input taken from other agencies and stakeholders. The U.S. Forest Service, in particular, has provided ongoing support and review of draft documents. CAL FIRE has been holding outreach efforts since mid-2009. This has included focused interviews, webinars, public meetings, briefing sessions, presentations and other efforts. Information on the 2010 assessment, including general and issue-specific surveys, has been available at the Fire and Resource Assessment Program of CAL FIRE website. Draft results of both this assessment and strategies document were available for public comment for 30 days during March and part of April, 2010. As much as possible, the final documents seek to address agency and public comments.

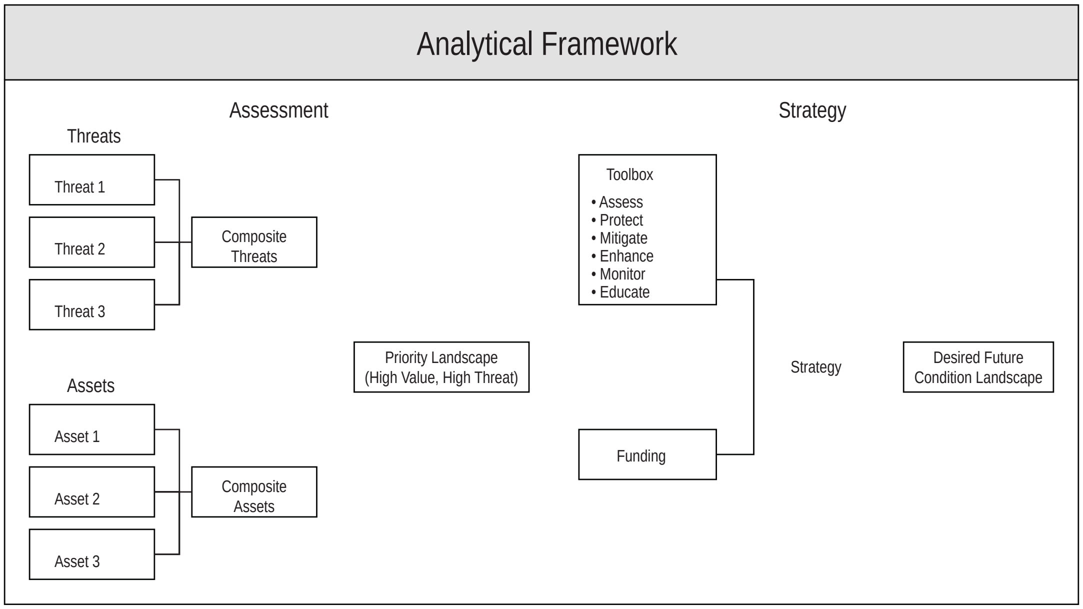
OVERALL ASSESSMENT AND STRATEGIES FRAMEWORK

As conceived by CAL FIRE, the relationship of this assessment to the strategy document is indicated in the Analytical Framework diagram below.

By delineating and comparing threats with assets for each subtheme, this assessment identifies priority landscapes. The strategies document then describes approaches (tools) and funding that define various strategies to address concerns reflected by the priority landscapes.

ASSESSMENT APPROACH

Each subtheme in this assessment contains two basic elements: a summary of statewide or regional status and trends on forests and rangelands across all ownerships, and one or more spatial analyses using geographic information systems (GIS) techniques, which suggest priority landscapes where additional resources are most likely needed. Prior to conducting the analysis, assets and threats were identified for each subtheme. The selection of assets and threats



was based on the results of extensive outreach to experts in the subject areas as well as the availability and completeness of data.

Assets and threats were represented in the analyses by GIS data layers assigned rankings of low, medium or high to delineate areas of varying asset value or threat level. The data layers were then combined in an overlay operation to highlight the pertinent priority landscapes.

The chapters in this assessment present 23 spatial analyses and their resultant priority landscapes, spread across 11 issues that correspond to Redesign subthemes (Table I.1). The number of priority landscapes presented reflects the diversity of issues, ecosystems, and values at work in California.

Priority landscapes are purposely kept separate to illustrate the particular issue being modeled. In reality, issues and priority landscapes cross over each other; multiple priority landscapes can be relevant to different landscapes and issues. This is explored in the strategies document.

RANKING ASSETS AND THREATS

GIS data inputs and their ranking methodology are described in detail in each chapter's methodology document (http://frap.fire.ca.gov/assessment2010.html). For purposes of illustration, an example follows for the Preventing Wildfire Threats for Community Safety analysis (Table I.2). This analysis identified human infrastructure potentially threatened by large damaging wildfires.

The assessment subthemes include a variety of assets such as commercial timber, watersheds that contribute to municipal water supplies, and wildlife habitat. Examples of subtheme threats include development, forest pests and climate change.

DATA AND ANALYTICAL LIMITATIONS

In some cases the most appropriate and definitive data on status and trends was not available. In other cases, statewide spatial information for assets and threats needed to develop priority landscapes was not available, was incomplete or could not be compiled into a statewide layer. Especially given short time frames for completion of required documents, the federal Redesign guidance documents recognized

Table I.1. Chapter topics/issues and priority landscapes

Chapter	Chapter Topics/Issues	Priority Landscapes (PL)
1.1	Population Growth and Development Impacts	PL 1 – Population Growth and Development Impacts
1.2	Sustainable Working Forests and Rangelands	PL 2 – Risk Reduction on Forestlands PL 3 – Risk Reduction on Rangelands PL 4 – Restoring Impacted Timberlands
2.1	Wildfire Threats to Ecosystem Health and Community Safety	PL 5 – Preventing Wildfire Threats to Maintain Ecosystem Health PL 6 – Restoring Wildfire Impacted Areas to Maintain Ecosystem Health PL 7 – Preventing Wildfire Threats for Community Safety
2.2	Forest Pests and Other Threats to Ecosystem Health	PL 8 – Restoring Forest Pest Impacted Areas to Maintain Ecosystem Health PL 9 – Restoring Forest Pest Impacted Communities for Public Safety PL 10 – Preventing Forest Pest Outbreaks to Maintain Ecosystem Health PL 11 – Preventing Forest Pest Outbreaks for Community Safety
3.1	Water Quality and Quantity Protection and Enhancement	PL 13 – Water Supply PL 13 – Water Quality
3.2	Urban Forestry for Energy Conservation and Air Quality	PL 14 – Urban Tree Planting PL 15 – Urban Tree Maintenance
3.3	Planning for and Reducing Wildfire Risks to Communities	PL 16 – Evaluating Communities for Wildfire Risk
3.4	Emerging Markets for Forest and Rangeland Products and Services	PL 17 – Biomass Energy for Ecosystem Health PL 18 – Biomass Energy for Community Safety
3.5	Plant, Wildlife and Fish Habitat Protection, Conservation, and Enhancement	PL 19 – Wildfire Threat to Areas Protected for Habitat
3.6	Green Infrastructure for Connecting People to the Natural Environment	PL 20 – Conserving Green Infrastructure PL 21 – Managing Green Infrastructure
3.7	Climate Change: Threats and Opportunities	PL 22 – Climate Change –Forest Carbon, Wildfire and Forest Pests * PL 23 – Climate Change –Forest Carbon and Development *
* includes PL for multiple years (2010, 2020, 2050, 2100)		

Table I.2. Example of ranking methodology used in the preventing wildfire threats for community safety analysis in Chapter 2.1

GIS Input	General Definition	Example	Example Ranking Method
Asset	Provides societal value in terms of economic, environmental, or social benefit	Structures	High: > 1 HU/AC * Medium: 1 HU/AC to 1 HU/5 AC * Low: 1 HU/5 AC to 1 HU/40 AC * None: less than 1 HU/40 AC *
Threat	Change agent that can negatively impact the asset	Community Wildfire Threat	High: areas identified as Very High Fire Hazard Severity Zones (PRC 4201-4204 and Govt. Code 51175-89)
* HU/AC = housing unit (as defined by the U.S. Census) per acre			

that this would be the case for all states and stressed the use of existing GIS data or of available federal GIS data layers. Issues with data found in California are treated in the Appendix under Data and Analytical Needs.

REPORTING UNITS

Reporting units are used to spatially summarize priority landscapes and are typically at the bioregion, county, watershed or community scale. Reporting units are chosen based upon what is most appropriate for the subtheme. For example, bioregions are an appropriate reporting unit for the impacts of climate change, while communities are more appropriate for urban forestry issues. Reporting units form the basis for building strategies that apply strategic tools to address one or more issues identified by priority landscapes. For example, communities with large areas of suggested highly ranked priority landscape are deemed focal places for additional investments to apply tools such as tree planting to address urban heat islands.

Bioregions

The California Biodiversity Council (CBC) has referred to ten unique bioregions (Figure I.1) defined by the Interagency Natural Areas Coordinating Committee. These bioregions were defined based on "...unique mixes of biodiversity and public agency responsibilities" (http://biodiversity.ca.gov/Bioregions/INACC.pdf).

Watersheds

Watershed boundaries are defined by hydrology and are used as a reporting unit for water quality and quantity issues. These boundaries, which are shown in Figure I.2, are defined using the Watershed Boundaries Database (WBD), which provides a national database of nested watershed units.

Varying WBD units were used for these analyses, depending on the nature and resolution of the data being summarized. For example, forest meadows are generally small in scale and affect localized watersheds. Therefore, the appropriate unit of analysis is the smallest WBD unit, hydrologic unit 12, which averages around 34 square miles. Conversely, water storage facilities in California often collect water from an entire river system and the effects are spread across the entire system. For this reason, the appropriate unit of analysis is the WBD unit 8, which represents large river systems such as the North Fork of the Feather River, the Russian River or the Upper Consumnes, and average around 1,000 square miles.

Results of the analyses were also reported with varying WBD unit types. Combined threats and combined assets were reported at the WBD unit 8 scale representing large river systems. This is to facilitate understanding the health and challenges to easily identifiable watersheds. Priority landscapes were reported at a hydrologic region scale, such as the Sacramento, North California/Klamath and Lahontan.

Counties

County boundaries were determined to be the appropriate reporting unit for various issues such as development impacts, where county zoning policies guide future development. California's 58 counties are shown in Figure I.3.

Communities

Communities were used as the most appropriate reporting unit for issues such as urban tree planting and community wildfire planning. Communities were defined based on incorporated cities and unincorporated Census Designated Places from the 2000 census. Figure I.4 shows an example of communities for El Dorado County.

This county includes two incorporated cities, Placerville and South Lake Tahoe, unincorporated communities of moderately dense development such as Eldorado Hills and Cameron Park, as well as smaller, more rural communities such as Pollock Pines. The county also has other small clusters of development that were not captured as communities, such as Kyburz, Meeks Bay and Coloma.

Figure I.1.
California bioregions as defined by the Interagency Natural Areas Coordinating Committee
Data Source: California Bioregions, FRAP (2004 v1)

Figure I.2.
Watershed boundaries
Data Source: Watershed Boundaries Database for California, NRCS (2009)

Figure I.3.
California counties
Data Source: County Boundaries, FRAP (2009 v1)

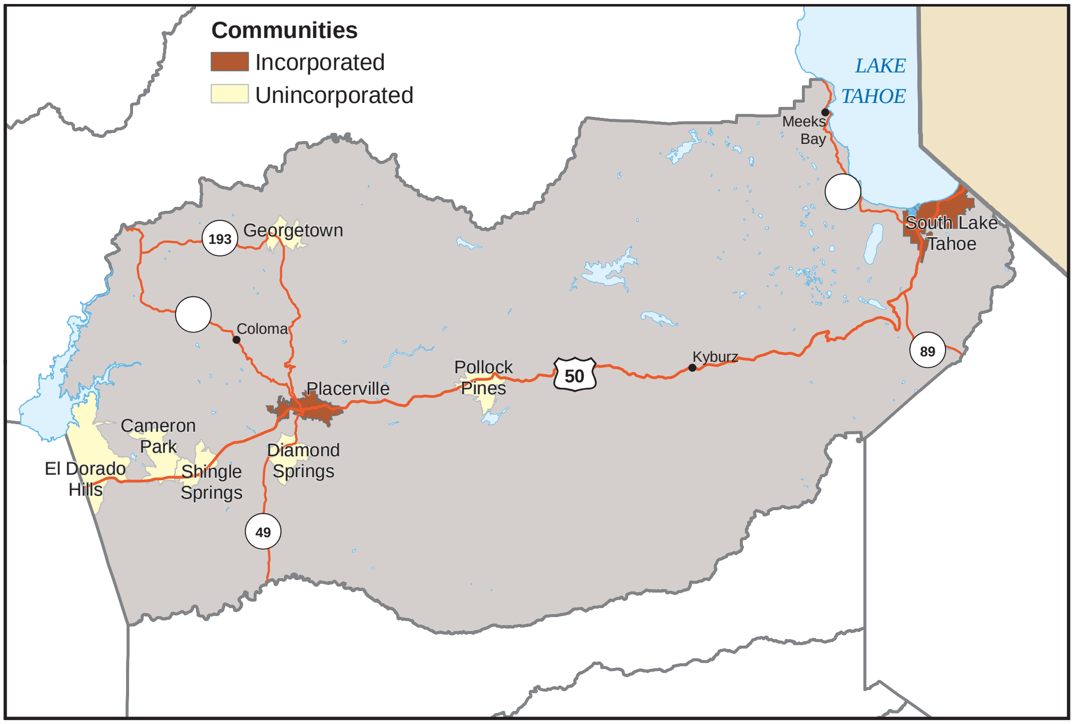


Figure I.4.
Communities in El Dorado County.
Data Source: Communities, FRAP (2009 v1)

GEOGRAPHIC SCOPE

California has a diverse natural landscape which ranges from conifer and hardwood forest and woodlands in the mountain and coastal areas, to shrub and herbaceous rangelands in the south coast, north interior and Central Valley, to desert habitats in the southeast (Figure I.5).

Forests (including woodlands) occupy almost one third of California (Figure I.6). This includes almost 20 million acres of timberlands, defined as lands capable of producing in excess of 20 cubic feet of commercial species per acre per year, where harvest is not legally prohibited (PNW-GTR-763). Together, forest and rangeland cover types occupy over 80 percent of California.

OWNERSHIP

Over half of California is publicly owned (52 percent) with the remaining lands owned by individuals, corporations or conservancies (Table I.3). Sixty percent of the 80 million acres of forests and rangelands are publicly owned, including over 40 million acres owned by the federal government (Figure I.7). The pattern is similar when we examine the ownership of forestlands in California, where over 55 percent of forestlands are publicly owned, the vast majority of which are owned by the federal government, and only 45 percent are privately held.

BIOREGIONAL DIVERSITY

The great diversity of natural land cover in California varies by region of the state, which makes it difficult to use statewide averages to understand and prioritize issues in California. Table I.4 and Table I.5 quantify bioregional ownership patterns for California's forestlands, and forests and rangelands, respectively.

ONGOING ASSESSMENT EFFORTS

This is the fifth assessment of forest and rangeland resources done under the California mandate. While basic subjects treated in past state assessments are covered in this document, the analytical approach

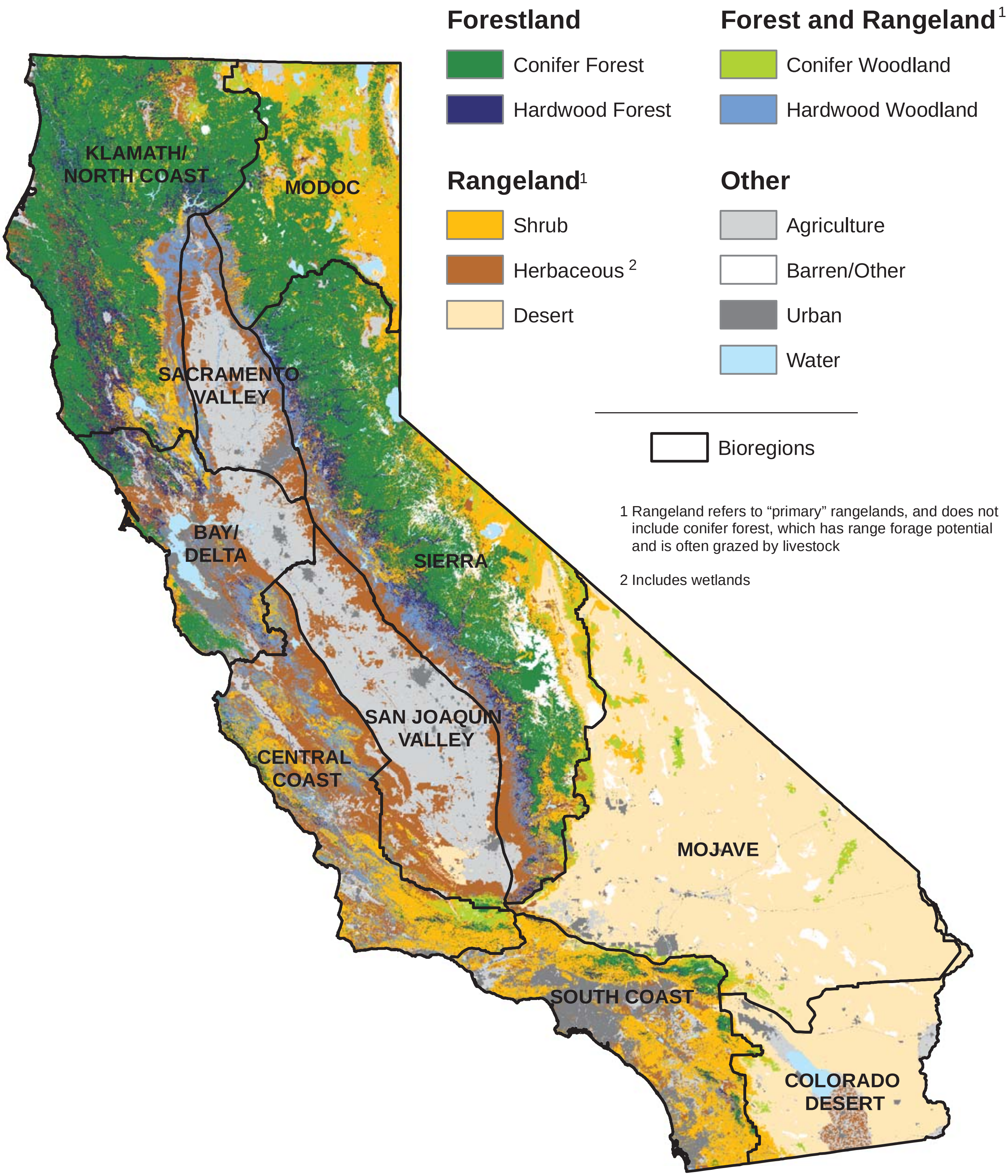


Figure I.5.
Forests and rangelands of California.
Data Sources: Statewide Land Use / Land Cover Mosaic, FRAP (2006)

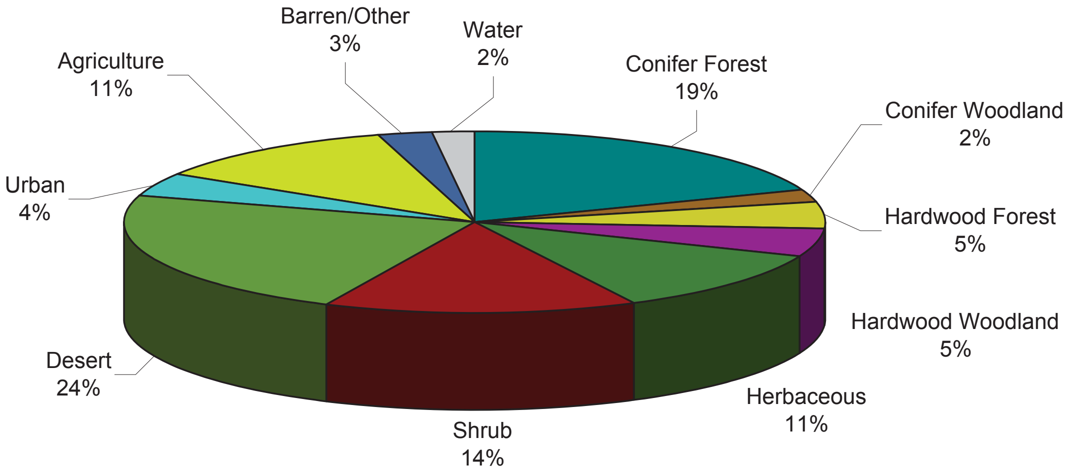


Figure I.6.
Percentage area of land cover classes, statewide.
Data Source: Statewide Land Use / Land Cover Mosaic, FRAP (2006)

Table I.3. Area of land cover type by owner group (acres in thousands)

WHR Vegetation Type	Private	USFS	BLM	NPS	Other Public	NGO	Total[1]
Forestland							
Conifer Forest	6,653	10,762	346	1,106	434	34	19,335
Hardwood Forest	2,828	1,305	194	104	151	12	4,594
Forest and Rangeland							
Conifer Woodland	466	989	469	317	137	21	2,399
Hardwood Woodland	4,296	284	193	19	456	45	5,292
Rangeland[2]							
Shrub	4,842	5,806	2,353	282	1,180	60	14,522
Herbaceous[3]	9,525	376	433	82	831	159	11,407
Desert	3,540	137	10,450	4,772	4,325	27	23,251
Total Forest and Rangeland							
	32,151	19,658	14,438	6,682	7,512	358	80,799
Other							
Agriculture	11,336	3	39	1	237	24	11,639
Barren/Other	358	841	428	760	324	3	2,714
Urban	3,897	6	27	5	221	3	4,159
Water[4]							1,916
All							
Total	47,742	20,508	14,932	7,449	8,294	387	10,1227

[1] Totals may not add up due to rounding
[2] Rangeland refers to "primary" rangeland, and does not include conifer forest, which has rangeland forage potential and is often grazed by livestock
[3] Includes wetlands
[4] Areas classified as water are not assigned an ownership
USFS – United States Forest Service, Department of Agriculture
BLM – Bureau of Lands Management, Department of the Interior
NPS – National Park Service, Department of the Interior
NGO – non-governmental organizations (e.g., The Nature Conservancy)
Data Sources: California Protected Areas Database, GreenInfo Network (2009); Statewide Land Use / Land Cover Mosaic, FRAP (2006)

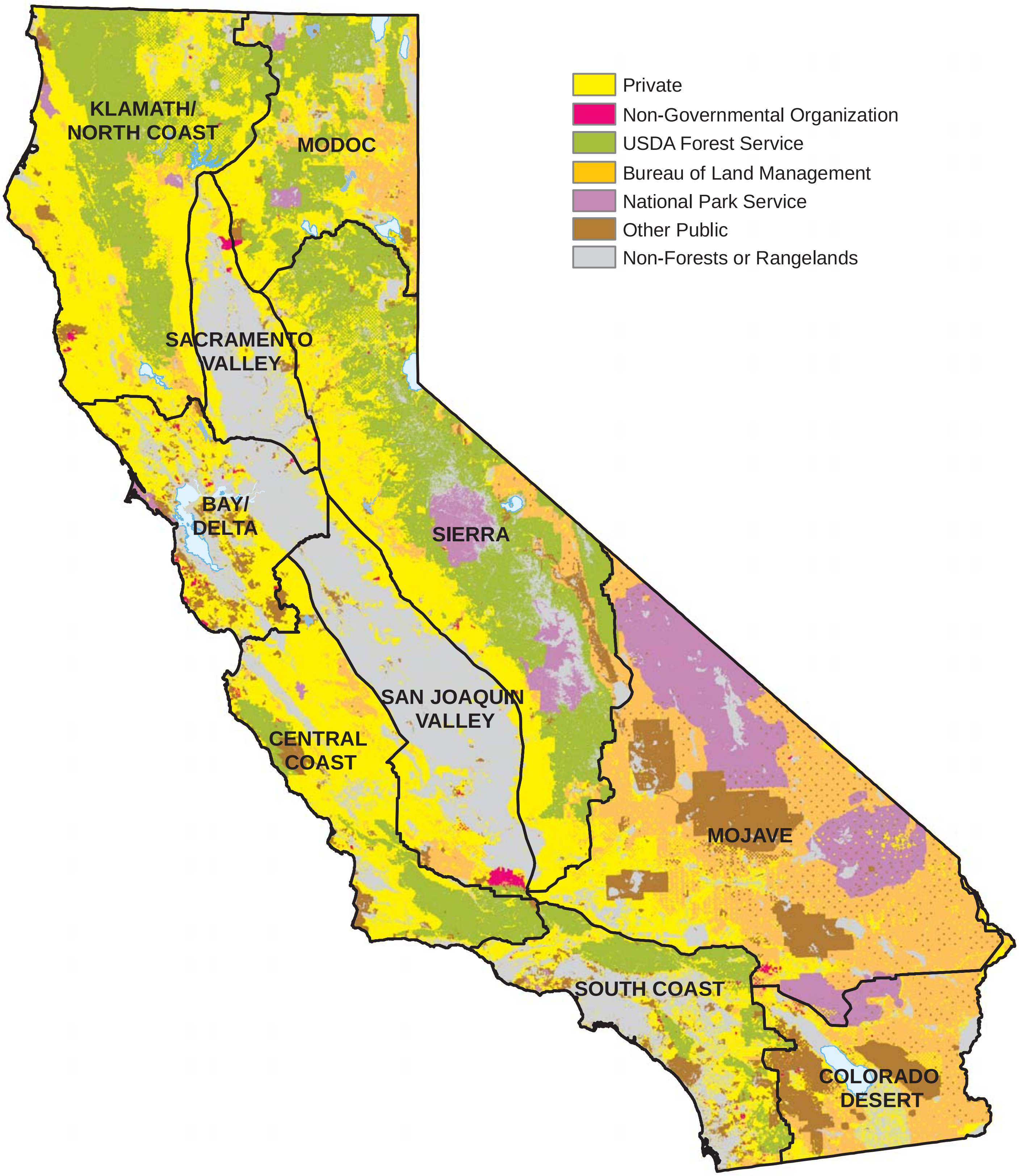


Figure I.7.
Major ownership of forests and rangelands in California.
Data Sources: Protected Areas, Department of Defense and Bureau of Indian Affairs lands from California Protected Areas Database (CPAD),GreenInfo Network (2010)

Table I.4. Forestland area by owner and bioregion (acres in thousands)*

Bioregion	BLM	NGO	NPS	Other Public	Private	USFS	Total
Bay/Delta	14	25	30	374	1,251	0	1,695
Central Coast	75	8	5	155	1,354	515	2,113
Colorado Desert	12	2	<1	74	20	2	110
Klamath/North Coast	352	18	108	224	5,415	4,941	11,058
Modoc	271	7	88	45	1,654	1,770	3,835
Mojave	450	13	760	105	214	30	1,571
Sacramento Valley	11	14	0	32	490	<1	547
San Joaquin Valley	23	13	0	10	77	60	183
Sierra	264	9	1,026	131	3,532	5,498	10,460
South Coast	8	6	2	91	309	527	942
Total	1,479	115	2,020	1,241	14,317	13,343	32,514

*Some lands are considered both forest and rangeland

Data Sources: California Protected Areas Database, GreenInfo Network (2009); Statewide Land Use / Land Cover Mosaic, FRAP (2006)

Table I.5. Forest and rangeland ownership by bioregion (acres in thousands)*

Bioregion	BLM	NGO	NPS	Other Public	Private	USFS	Total
Bay/Delta	48	76	83	826	3,685	0	4,719
Central Coast	297	15	25	496	4,728	1,663	7,224
Colorado Desert	2,741	22	338	1,609	1,375	9	6,094
Klamath/North Cost	602	20	120	284	7,220	5,724	13,970
Modoc	1,387	15	140	259	3,136	2,821	7,759
Mojave	7,820	27	4,812	3,083	3,035	83	18,860
Sacramento Valley	29	35	0	117	1,710	<1	1,891
San Joaquin Valley	314	106	0	141	2,242	73	2,875
Sierra	1,155	13	1,181	599	6,017	7,751	16,716
South Coast	108	31	23	815	3,809	1,724	6,511
Total	14,502	361	6,721	8,228	36,958	19,848	86,618

*Some lands are considered both forest and rangeland

Data Sources: California Protected Areas Database, GreenInfo Network (2009); Statewide Land Use / Land Cover Mosaic, FRAP (2006)

differs. This assessment represents the California piece of a larger ongoing effort by states under the federal 2008 Farm Bill to track condition and trends, develop priority landscapes, explore policy options and monitor the effectiveness of existing policies and programs. As such, for California, this document is a starting point for future refinements and related efforts over time to update assessments under the Farm Bill framework. It has inherent limitations, in large part due to data and analytical needs, and the fact that some issues cross state borders. In addition, a number of entities and stakeholders in California have jurisdictions or interests in forest and rangeland that may not be fully captured or represented in this assessment.

The limitations of the assessment data, methods, and results will no doubt be more fully explored as they are reviewed and used by a wider audience of stakeholders. This is an important part of the process of improving the assessment capacity over time. Towards this end, assessment materials such as the individual chapters in pdf format, methods documents, complete enumeration tables and GIS data and maps can be found on the FRAP website (http://frap.fire.ca.gov/assessment2010.html).

Conserve Working Forest and Range Landscapes

Chapter 2.1
Wildfire Threat to Ecosystem Health and Community Safety

The strategic management of wildfires is crucial to the health of our nation's forests, the safety of our citizens and the contributions of forests to our economy. Assessments should identify areas where management can significantly reduce the risk of catastrophic wildfire while enhancing multiple associated forest values and services (excerpted from the U.S. Forest Service State and Private Forestry Farm Bill Requirement and Redesign Strategies).

KEY FINDINGS

Current Trends in Wildfire

- California is a complex wildfire-prone and fire-adapted landscape. Natural wildfire has supported ecosystem health and is critical to maintaining the structure and function of California's ecosystems. As such, the ability to use wildfire, or to mimic its impact by other management techniques, is a critical management tool and policy issue.
- Simultaneously, wildfire poses a significant threat to life, public health, infrastructure and other property, and natural resources. The threat will remain significant, or grow worse, due to factors such as continued population growth, changing land use, and drought or other shifts in climatic conditions. Addressing wildfire as a threat is also a major management and policy issue.
- The innate complexities associated with ecosystem dynamics in California make it difficult for statewide and even regional generalizations to capture specific conditions unique to particular areas. Local conditions may vary considerably within the scope of classifying fire regimes and effects.

- Data suggests a trend of increasing acres burned statewide, with particular increases in conifer vegetation types. This is supported in part by the fact that the three largest fire years in the period since 1950 have all occurred since 2000.
- Wildfire related impacts are likely to increase in the future based on trends in increased investment in fire protection, increased fire severity, fire costs and losses, and research indicating the influence of climate change on wildfire activity.

Preventing Wildfire Threats to Maintain Ecosystem Health

- Statewide, there are 21.3 million acres of high priority landscape (HPL), with large concentrations in the South Coast, Sierra and Modoc bioregions, and the northern interior portions of the Klamath/North Coast.
- Key ecosystems at risk include conifer types such as Klamath and Sierran Mixed Conifer and Douglas-fir; shrub systems at risk are Mixed Chaparral, Sagebrush and Coastal Scrub.
- Managing fire risks requires understanding the specific mechanisms that have disrupted the natural fire regimes that once formed the stability of the ecosystem, and determining actions that best mimic or restore these natural processes. As such, tools must be tailored to the specific ecosystem.

Restoring Wildfire Impacted Areas to Maintain Ecosystem Health

- A total of 2.35 million acres are high priority for restoration statewide.
- In the northern portion of the state a total of 456,000 acres of Douglas-fir, Klamath Mixed Conifer and Sierran Mixed Conifer are high priority for restoration. These high priority landscapes highlight the fire-restoration issue. Conifer ecosystems are adapted to a frequent, low-severity fire regime, but are burning under a less-frequent, more severe modern era regime.
- In the southern portion of the state, a large area of Mixed Chaparral is in high priority status (over 750,000 acres) highlighting direct impacts on soils and watersheds due to typical high intensity/high severity fires in this type. In addition, recent findings implicate re-burning at immature seral stages may pose the threat of type conversion in this type.
- The 200,000 acres of Coastal Scrub in HPL deserve special attention due to loss of key ecosystem components and the apparent trend in increased fire frequency, increased non-native invasive dominance, and loss of ecosystems due to land use practices.

Preventing Wildfire Threats for Community Safety

- Community areas of high and high and medium priority are scattered throughout the state, occurring in at least modest (500 acres) abundance in 46 of 58 counties.
- Areas of HPL concentration occur in the South Coast and Sierra bioregions, and other isolated urban areas near significant wildland high-threat areas, such as the east San Francisco Bay Area and Redding.
- Los Angeles and San Diego are by far the largest communities in terms of high priority landscape acres.
- Many rural counties have significant numbers of communities and acreage in medium priority landscape, a result of extensive low density housing areas in high threat landscapes.
- A total of 390 communities were identified as meeting a basic priority threshold for significance. A total of 508 communities had at least some high priority landscape.
- There are many additional areas of human settlement that were not identified as meeting the definition of a community that also contain areas of high priority, reinforcing the widespread pattern of the problem.

CURRENT AND HISTORICAL TRENDS IN WILDLAND FIRE

California is recognized as one of the most fire-prone, and consequently fire-adapted landscapes in the world. The combination of complex terrain, Mediterranean climate, and productive natural plant communities, along with ample natural and aboriginal ignition sources, created a land forged in fire. Excluding fires that occurred in the desert, estimates of annual acreage burned prior to the arrival of European settlers range between 4.5 and 12 million acres annually (Stephens et al., 2007), 4.5–12 percent of the land area burning every year. These findings support the dramatic influence of natural wildfire that supports and maintains ecosystem structure and function in California's wildlands; this includes fostering maintenance of timing and extent of vegetation, enhanced site productivity, and elements of habitat and wildlife species diversity.

Dramatic changes in fire activity accompanied the European settlement of California, partly due to land use practices such as agriculture, grazing, logging and mining. In the modern era these changes have been magnified through land use practices that remove natural fuel systems (agriculture, urbanization) and beginning after the turn of the 20th century, organized fire suppression designed to protect people and assets from damage.

Using data on fire records and perimeters from 1950–2008, the Fire and Resource Assessment Program (FRAP) has compiled a variety of measures of fire activity to examine modern trends. Figure 2.1.1 shows the distribution of burn frequency over this time period. As is evident, the Central and South Coast bioregions dominate the frequency surface, but the western front of the Sierra bioregion and the northwest Klamath Province also show concentrated fire activity.

Trends of annual acres burned over time and by life form were assessed by overlaying fire perimeter data on current land cover types. Examining these data from a time series perspective offers insight into fire patterns for both the influence of time and the influence of fuel types.

Over the entire period of record, an average of 320,000 acres burned annually, but there is very large inter-annual variability, largely attributable to weather conditions and large lightning events that result in many dispersed ignitions in remote locations. Annual totals range from a low of 31,000 acres in 1963, to a high of 1.37 million acres in 2008.

Looking at the fire acreage organized by decade and by life form confirms these basic trends. Fire is most common in shrublands across all decades, with a large spike in this decade (Figure 2.1.2) Conifer, hardwood, and herbaceous (grassland) all burned at relatively similar amounts through the 1970s, 1980s and 1990s, after which conifer also shows a very large increase in annual acres burned in the most recent decade, averaging 193,000 acres per year, compared to an average of 48,000 acres over the previous four decades.

While high annual variation makes it statistically difficult to determine actual long-term trends, looking at data from 1990 and applying trend analysis techniques to look at time-dependence renders a reasonable fit to a log-linear model of increasing burn acreage (log transformed) over time (Figure 2.1.3). While the goodness of fit to the data represents persistent variation around the modeled mean, the confidence that the trend is upward is very strong ($p = 0.01$). This pattern is also supported by the fact that the three largest fire years were all in this decade (2003, 2007, 2008) and the annual average since 2000 is 598,000 acres, or almost twice that of the 1950–2000 period (264,000 acres).

In addition to these trends, research indicates trends of increased fire severity, particularly in coniferous forest types of the Sierra (Miller et al., 2008; Lutz, et al., 2009), increases in human infrastructure at risk (e.g., the wildland urban interface) (Theobald and Romme, 2007), and climate change increasing hazards and risks associated with vegetation fires (Fried et al., 2006; Lenihan et al., 2006; Westerling

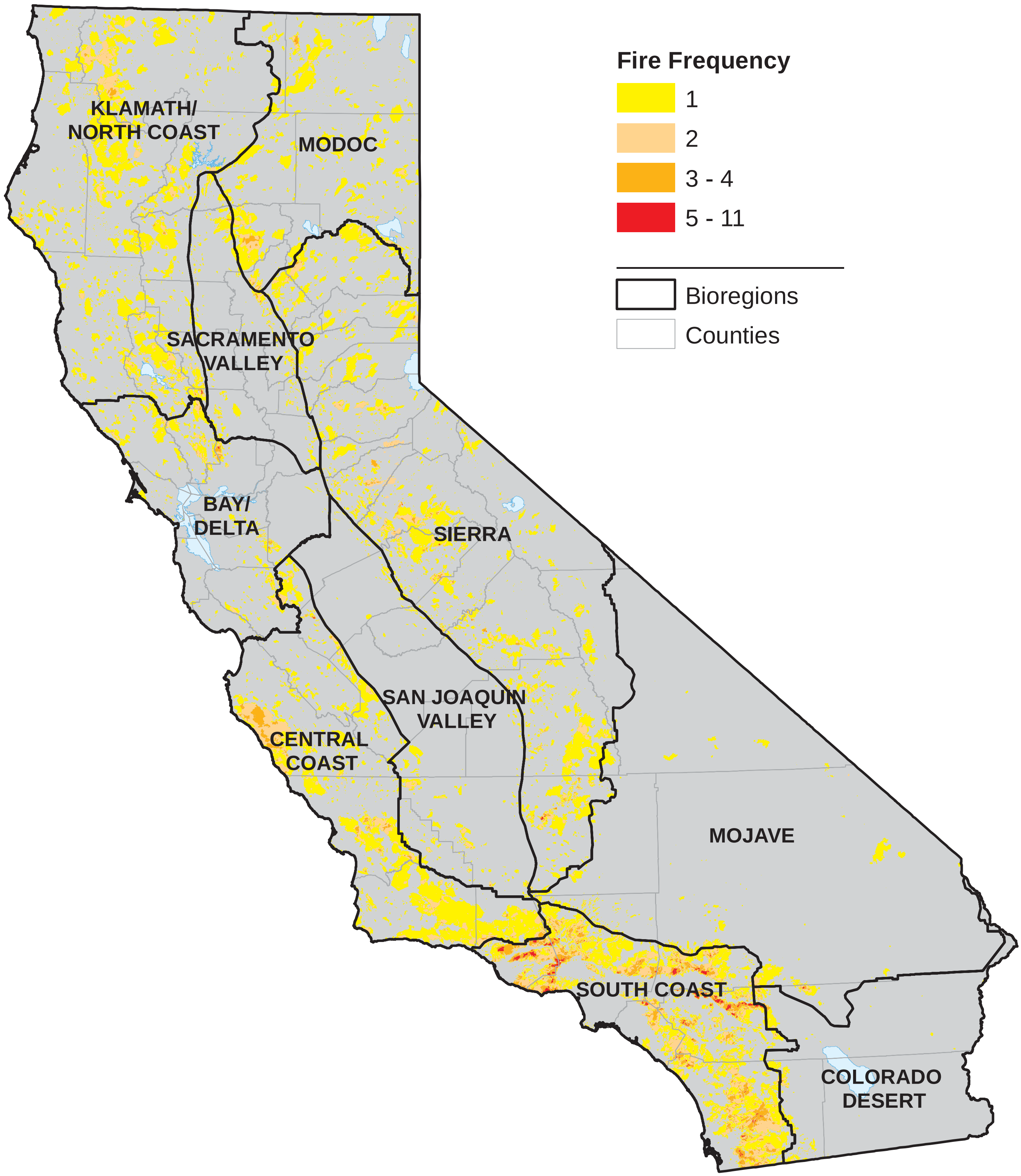


Figure 2.1.1.
Fire frequency (number of times burned) over the period 1950–2008.
Data Source: Fire Perimeters, FRAP (2009 v1)

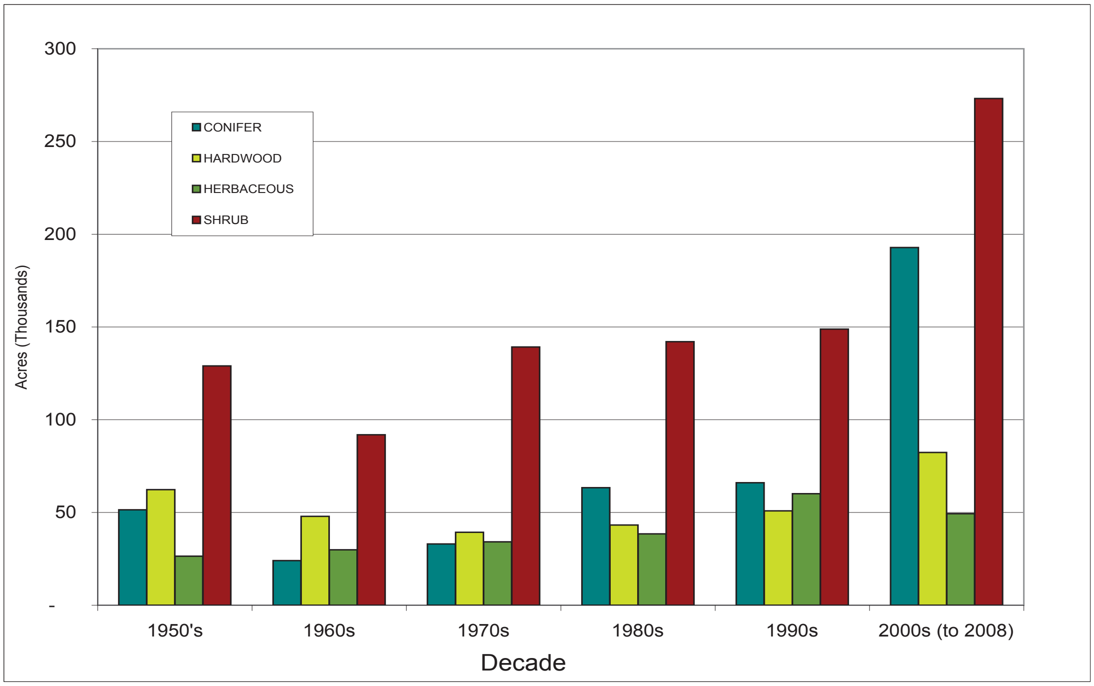


Figure 2.1.2.
Annual acres burned by decade and by life form, 1950s to 2000s.
Data Sources: Fire Perimeters, FRAP (2009 v1); Statewide Land Use / Land Cover Mosaic, FRAP (2006)

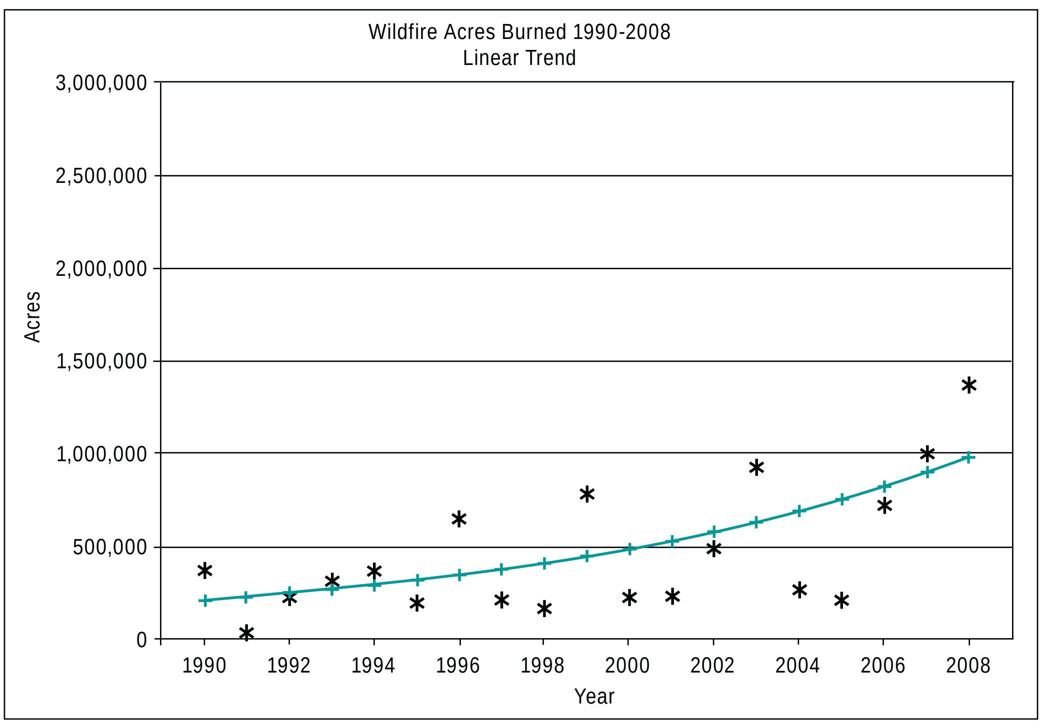


Figure 2.1.3.
Log-linear trend model for annual acres burned as a function of time, 1990–2008.
Data Sources: Fire Perimeters, FRAP (2009 v1); Statewide Land Use / Land Cover Mosaic, FRAP (2006)

et al., 2009). Similarly, a number of studies have shown trends of increasing cost of fire suppression (Calkin et al., 2005; Gebert, 2008) and losses (Bryant and Westerling, 2009). Collectively, research suggests that the patterns exhibited in recent history will increase due to changes in both threats and in assets exposed to damages, magnifying the need for comprehensive planning and strategies designed to effectively mitigate these risks.

Key Concepts

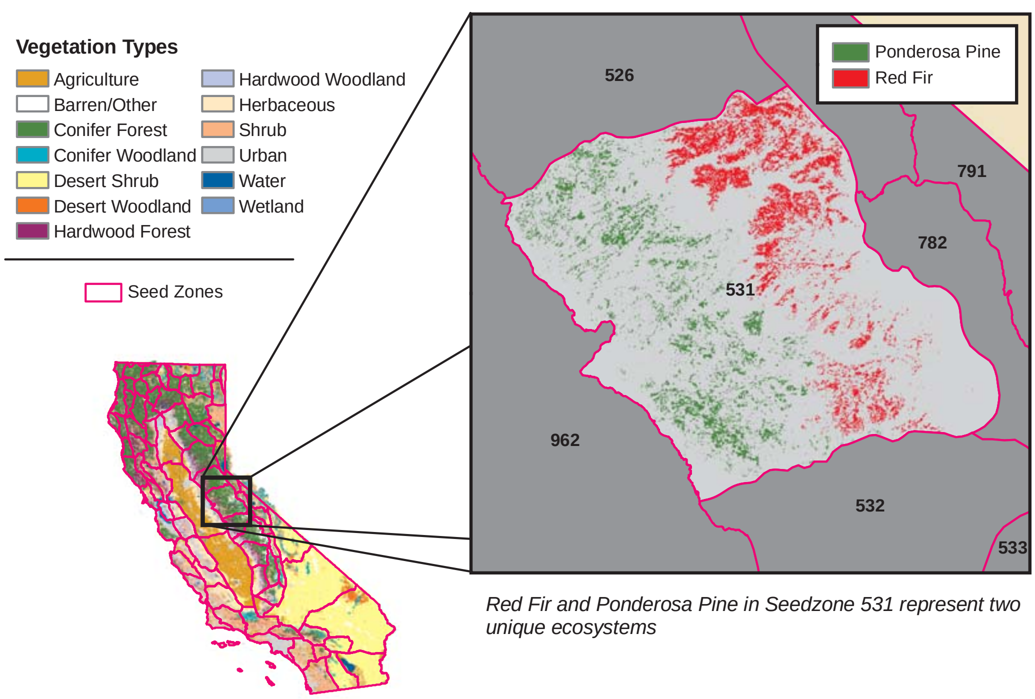
Ecosystems

The California Department of Fish and Game recognizes the following definition of the term ecosystem: "a natural unit defined by both its living and non-living components; a balanced system for the exchange of nutrients and energy."

A more specific working definition that can be mapped for analyses: ecosystems are areas of potentially unique genetic resources as defined by each vegetation wildlife habitat relationships (WHR) type and tree seed zone combination (Figure 2.1.4).

Tree seed zones help determine the suitability of seed for planting and survival in a particular area and are delineated on the basis of collection criteria adopted by the USDA forest seed policy of 1939 (Fowells, 1946). Tree seed zones are used by forest managers to designate and reference seed collection areas for restocking of forest stands. As such, seed zones are a management tool used to help conserve genetic diversity and are important for identifying the local area where the seed naturally originated. When combined with vegetation maps, tree seed zones define one type of ecosystem asset that represents areas potentially having unique genetic resources.

Seed zones also serve as a convenient tool for regionalizing both threats and impacts in a way that allows for discriminating unique relationships between biological assets and physical characteristics influencing fire activity, most notably climate/fire weather. In the analyses presented in this chapter, these "ecosystems" serve as an integrated asset metric for all the resources of concern contained in that land type.



Red Fir and Ponderosa Pine in Seedzone 531 represent two unique ecosystems

Figure 2.1.4.
Land cover and tree seed zones in California, 2008.
Data Sources: California Tree Seed Zones, Buck, et al. (1970); Statewide Land Use / Land Cover Mosaic, FRAP (2006)

Fire Regime

Fire regime is a measure of the general pattern of fire frequency and severity typical to a particular area, type of landscape or ecosystem. In its usage here, fire regime refers to the pre-historic pattern of fire and its suite of effects on the ecosystem, emphasizing impacts on the dominant vegetation present at the site. In many cases ecosystems are highly adapted to a particular fire regime that functions to maintain stability over many disturbance/fire cycles. The regime can include other fire metrics, including seasonality and typical fire size, as well as a measure of the pattern of variability in characteristics.

Fire Severity

Fire severity is a measure of the magnitude of fire impacts on organisms, species and the environment. It is usually broadly classified in terms of direct fire effects on the dominant vegetation present (e.g., percent killed, plant cover change, etc.) and consequently often has a direct linkage to fire intensity, a physical descriptor of a fire's behavior, estimating the amount of heat output in the flaming front of a fire. While in many ecosystems close relationships exist between fire severity and intensity, they are fundamentally different variables of vegetation fires, and should not be used interchangeably.

Fire Threat

Fire threat is a measure of fire hazard that includes components for both probability (chance of burning) and the nature of the fire (fire behavior). Taken collectively, these two features assess the basic threat features of periodic wildfires and their capacity to drive fire effects. It is important to understand that fire threat carries no direct measure of fire effects and associated value change associated with fire risk.

Fire Risk

Typically, risk is a measure of the expected damage that fire may have on assets that hold value to society. In some cases, fire effects may be viewed as beneficial, in which case a negative risk value would be applied. It is important to recognize that a given fire threat will have varying impacts on different assets, and that differing fire threats have different impacts on both individual and collective assets. Thus, fire presents particular challenges when viewed across the spectrum of fire types and probabilities that may occur in an area, and the effects these fires have on the suite of assets (e.g., air quality, wildlife habitat, timber resources, etc.). A comprehensive assessment of the challenges in understanding and managing fire risk in natural ecosystems can be found in Finney, 2005.

Stand-Level Wildfire Threat, Stand-Level Wildfire Damage

The threat to a particular small area is called the stand-level wildfire threat, and is based on current fuel conditions, observed fire frequency and weather conditions. Similarly, stand-level wildfire damage is a measure of wildfire impacts from past events on small areas, based on burn severity and how recent the event occurred.

Landscape-Level Wildfire Threat, Landscape-Level Wildfire Damage

Landscape-level threat includes the influence of the distribution of threat characteristics taken across the ecosystem as a whole. The approach taken in this analysis recognizes that stand-level threats and damages may have added importance if they cumulatively have potential to damage broader landscape-level ecosystems. While stand-level impacts can result in loss of timber volume or wildlife habitat, a landscape-level event can have a significant impact on larger systems, for example loss of genetic diversity for a given tree species, or decline of a particular wildlife species endemic to that ecosystem. Similarly, landscape-level wildfire damage includes the cumulative damage from past fire events across the ecosystem as a whole.

Communities

Communities are a reporting unit for assessing impacts to human infrastructure and are based on both legal jurisdiction areas (incorporated cities) and areas identified as "places" in the 2000 census data.

PREVENTING WILDFIRE THREATS TO MAINTAIN ECOSYSTEM HEALTH

While historically wildfire has been a key component in ecosystem dynamics, a number of factors have disrupted the natural fire regime occurring in many of California's ecosystems. There are many cases where the type of fire and the pattern of its occurrence, when compared to historical conditions, are creating adverse impacts on ecosystem composition, structure and function. Factors such as fire suppression, timber management, grazing, land use, exotic invasive species and climate change all place stress on the manner in which fire interacts with ecosystem health, function (such as biodiversity) and sustainability.

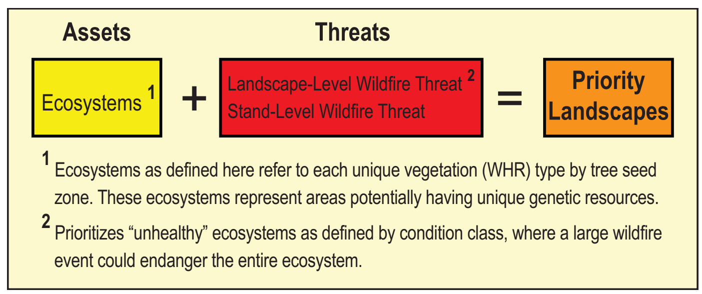
Many ecosystems in California that were previously adapted to frequent low to moderate severity fires have seen shifts in reduced fire frequency (missed fire cycles), associated fuel build-up, and subsequent increases in fire severity when wildfires eventually occur (Miller et al., 2008). At the landscape scale, where natural wildfire took place historically there are commensurate large-scale shifts in the basic manner in which fire affects ecosystems. Fire suppression typically acts to limit extent of low intensity fire, while having little impact on conditions supporting high intensity crown-fire. While most California shrubland ecosystems support stand-replacing crown fires, where ecosystems are commingled across various regime types, there is more uniformity of mixed- and high-severity effects that are not as clearly linked to basic ecosystem function in the absence of human intervention. Thus, in many mixed conifer systems, while the modern trend indicates an increase in fire rates, the type of fire and its typical interval are still significantly departed from the frequent low and mixed-severity fires that dominated low and mid-elevation confer forests throughout California.

Other ecosystems appear to be burning too frequently – a situation facilitated by exotic invasive species that cause fundamental changes to post-fire fuel dynamics (Keeley, 2001; Merriam et al., 2007). These changes facilitate early seral phases to re-burn within a matter of only a couple years, and may reduce or eliminate native species that require time to develop to maturity and assure regeneration.

While these issues are reasonably well-defined from both a broad conceptual framework and a detailed site research perspective, an analytical approach using the concepts to define areas of priority across the state is needed to frame a strategic response to these impending risks.

Analysis

The diagram below shows the analytical framework for identifying the priority landscape to assess the risk and feed the mitigation strategy for dealing with preventing damage to ecosystems as a result of wildfire.



Assets

Ecosystems are areas of potentially unique genetic resources as defined by each vegetation (WHR) type and tree seed zone combination.

Threats

The threat to a particular small area is called the stand-level threat and is derived from FRAP's fire threat data compiled in 2004. It is based on fuel conditions, observed fire frequency and expected fire weather conditions. A detailed discussion of this metric can be found on the FRAP website (http://frap.fire.ca.gov/assessment2003/Chapter3_Quality/wildfire.html).

The landscape-level wildfire threat attempts to capture the threat of damage to ecosystems at the landscape scale. This is derived by calculating the percentage of each vegetation type in each unique tree seed zone that is "unhealthy", based on being in a condition class that indicates significant deviation from historical fire regimes–specifically the proportion of a given ecosystem that is in either condition class two or three. This approach recognizes that stand-level threats have elevated importance if cumulatively they have potential to damage broader landscape-level ecosystems. However, it may understate or not well represent portions of landscapes that can benefit from wildfire. Use of seed zones may also not be the best way to characterize smaller or larger ecological zones. However, the approach best fits available data and does measure a key element of forest function – the uniqueness of seed zones as adapted to regenerate local forest structure.

Results

The priority landscape identifies priority areas within ecosystems that have high levels of threat from future fires, and should be viewed as a basic assessment of need for strategies and adoption of tools to protect these key areas in the future. It is constructed by combining stand- and landscape-level threats to create a composite threat map, and classifying the final product into low, medium, and high priority landscapes.

Statewide, there are 21.3 million acres of high priority landscape (HPL), with large concentrations in the South Coast, Sierra and Modoc bioregions, and in the northern interior portions of the Klamath/North Coast bioregion (Table 2.1.1; Figure 2.1.5). Roughly half of this total (9.3 million acres) is on public lands.

When viewed statewide as a percentage of watershed sub-basin area in HPL, virtually all of Northern California, the Sierra bioregion, and to a lesser extent the South Coast bioregion are at high risk to ecosystem damage from wildfire (Figure 2.1.6).

The distribution of the top five ecosystem types in terms of HPL abundance reinforces the relationship between areas of HPL and the ecosystems most at risk. Almost two-thirds of all HPL are found in just the top five ecosystem types (Table 2.1.2). At the top of the list is Sierran Mixed Confer, with 3.7 million acres in HPL, followed by Sagebrush, Douglas-fir and Mixed Chaparral, all with roughly 2.9 million acres and Klamath Mixed Conifer with one million acres in HPL.

Discussion

While not diminishing the fact that wildfire may be beneficial in places, landscapes that may require protection from wildfire threats to ecosystem health are widespread throughout California, but are concentrated in the South Coast, Sierra, and Modoc bioregions, and the northern interior portions of the Klamath/North Coast bioregion. This pattern is directly attributable to ecosystems that are under the influence of current modern fire regimes and other various disturbances that affect their extent, composition and structure. In these cases wildfires have

Table 2.1.1. Distribution of priority landscape ranks by bioregion, for preventing wildfire threats to maintain ecosystem health (acres in thousands)

Bioregion	None	Low	Medium	High	Total
Bay/Delta	2,911	2,162	1,206	13	6,292
Central Coast	1,265	2,986	2,004	1,731	7,986
Colorado Desert	1,458	5,053	41	206	6,757
Klamath/North Coast	757	4,753	3,310	5,563	14,383
Modoc	1,097	1,043	1,203	4,989	8,332
Mojave	1,751	17,357	460	369	19,937
Sacramento Valley	2,454	1,071	356	72	3,953
San Joaquin Valley	5,978	2,028	129	89	8,224
Sierra	3,004	5,787	4,171	5,341	18,304
South Coast	2,485	853	764	2,957	7,059
Total	23,160	43,091	13,645	21,331	101,227

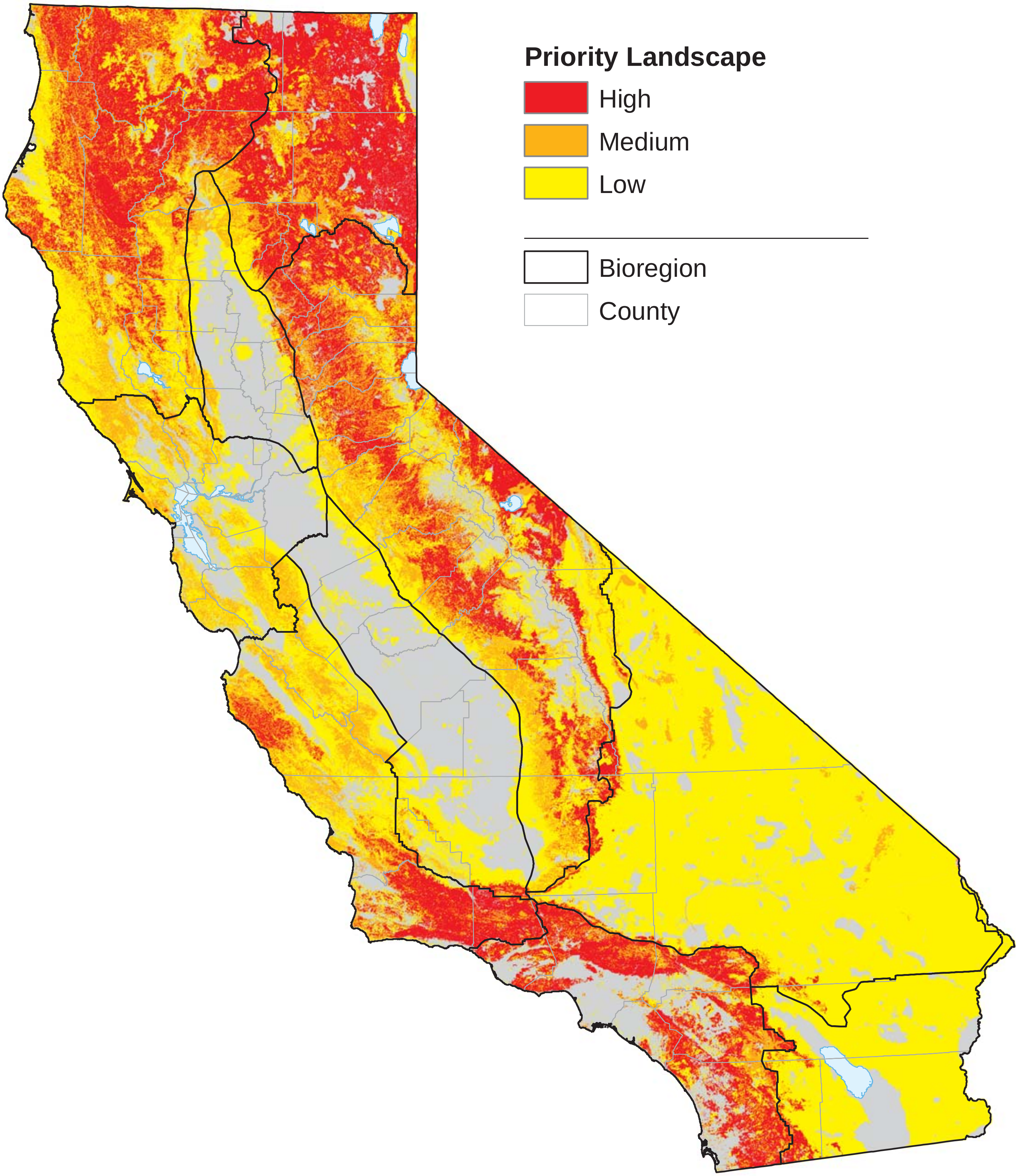


Figure 2.1.5.
Priority landscape for preventing wildfire threats to maintain ecosystem health.
Data Sources: California Fire Regime Condition Class, FRAP (2003); California Tree Seed Zones, Buck, et al. (1970); Fire Threat, FRAP (2005); Statewide Land Use / Land Cover Mosaic, FRAP (2006)

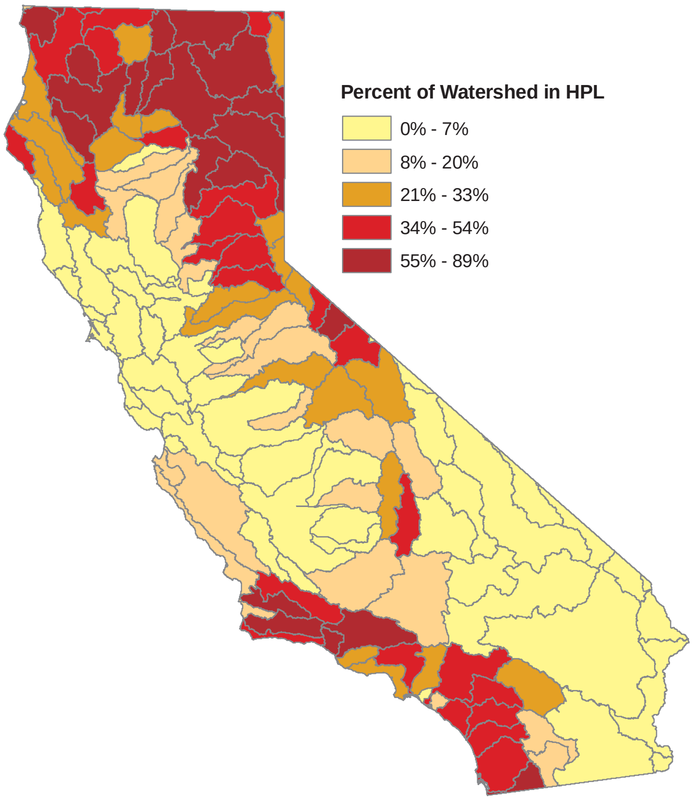


Figure 2.1.6.
Percent of watershed Hydrologic Unit Class 8 (sub-basins) in high priority for preventing wildfire threats to maintain ecosystem health.
Data Sources: California Fire Regime Condition Class, FRAP (2003); California Tree Seed Zones, Buck, et al. (1970); Fire Threat, FRAP (2005); Statewide Land Use / Land Cover Mosaic, FRAP (2006); Watershed Boundaries Database for California, NRCS (2009)

the potential to cause significant ecological damages. Mediterranean climate productive conifer systems, such as Douglas-fir, Ponderosa Pine, Mixed Conifer and Eastside Pine, have all seen significant reductions in fire frequency, with additional stress from logging and grazing also contributing to disruption of natural fuel dynamics.

Similarly, Pinyon-Juniper woodlands, particularly in the more productive and climate-conducive South Coast bioregion, appear to be missing fire cycles in some areas. This allows significant woody plant development that may alter landscape water balance and ultimately affect the ability of surface fire to spread until tree density reaches a point of continuity. That would allow for active crown fire spread, a model of fire relatively rare to that type, and likely causing significant delays in post-fire recovery. Grazing impacts further limit inter-tree herbaceous fuels, enhancing the disruption of the normal fire cycle. In contrast, some intermountain ecosystems of Pinyon-Juniper have burned numerous times over the last 30 years, and seem to be converting to grassland.

Shrubland types of particular concern include the Sagebrush steppe type that dominates much of the northeast plateau in the Modoc bioregion and Great Basin region on the eastern side of the Sierra Nevada Mountains, and extensive Mixed Chaparral and Coastal Scrub most prevalent in the Central and South Coast bioregions. Extensive research implicates alteration of the fire regime from exotic invasive plants that disrupt natural fuel dynamics, cause competitive stress on native plants, and show evidence of type conversion to fire-maintained annual grass dominated seral stages. In addition, climate change, overgrazing and active fire suppression have allowed Juniper encroachment into otherwise brush dominated lands, effectively dominating the site at the expense of less woody plant components, causing not only fire-related changes to system succession, but also soil erosion problems (Pierson et al., 2008).

Tools

Tools to address the role of wildfire depend on many factors, including the type of ecosystem under concern and land management objectives and options. Approaches taken typically aim to mimic the effects of a natural fire regime on a particular ecosystem or indirectly try to either avoid damaging wildfires, or modify the fuel and ecosystem components so they are more resilient to damage. Techniques vary widely and can include use of prescribed fire, mechanical, grazing and other approaches. In some cases (with many limitations), ongoing wildfires can be left to burn with their attendant ecological impacts.

In frequent-fire adapted forested types, like Ponderosa Pine, Eastside Pine and Mixed Conifer, this usually involves fuel treatments designed to reduce surface and ladder fuels, and stand treatments designed to increase mean tree size and favor composition

Table 2.1.2. Top five ecosystem types for area of high priority landscapes, for preventing wildfire threats to maintain ecosystem health

WHR Type	Total
Sierran Mixed Conifer	3,717,600
Sagebrush	2,955,500
Douglas-Fir	2,942,900
Mixed Chaparral	2,846,100
Klamath Mixed Conifer	1,025,700
Total	13,487,800

toward more fire resilient species. With respect to adaptation, often a combination of mechanical treatments in conjunction with prescribed fire will result in significant reduction of wildfire risks to forested ecosystems. For direct mitigation, fire avoidance strategies such as strategic fuel breaks that facilitate wildfire containment can also be employed. A key strategic element to designing treatments under economic constraints is to use strategic analyses to maximize reductions of risk, given the capacity to treat only a portion of the imperiled landscape. In as much as treating forests to improve resilience to wildfire damage costs money, tools that may capture economic value while accomplishing additional social benefits should be promoted. Examples of this type of tool are biomass projects where forest waste recovery for energy production serves two benefits.

Mixed Chaparral, Sagebrush steppe and Coastal Scrub ecosystems are at high risk due to invasive species, notably annual grasses, causing changes in the fuelbed that make them more flammable, and thus supporting short periods between fires that can lead to loss of key native components (Brooks et al., 2004; Keeley et al., 2005). An example of this problem (short intervals between fires) is seen in San Diego County, where large stands of Mixed Chaparral re-burned after only four years, indicating that under the current regime, early seral stages in this type are not effectively non-combustible as was previously believed. Tools for dealing with direct fire impacts could focus on fire prevention and suppression strategies designed to avoid frequent-fire induced type conversion, and may also employ strategic fuel treatments like fuel breaks that assist in fire control.

Techniques that selectively reduce the concentration of exotic invasive elements are worth exploring, although many of the most pernicious weed species (e.g., cheatgrass, yellow-star thistle) appear highly resistant to environmental controls. Ecological recovery tools possibly involve seeding, planting, and creation of fire resilient refugia dispersed throughout sensitive habitats to facilitate natural regeneration.

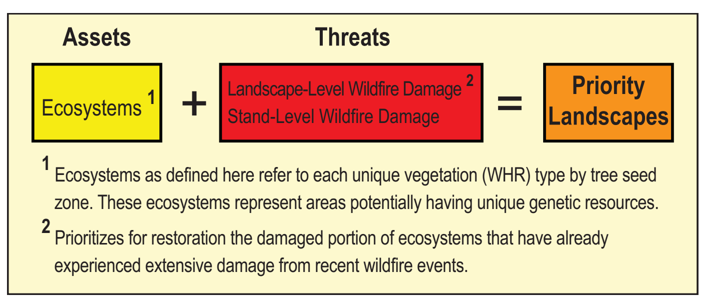
Finally, tactical operations and strategies employed in fire suppression can be used effectively to either alter or significantly redirect fire occurrence in high value/high sensitivity areas.

RESTORING WILDFIRE IMPACTED AREAS TO MAINTAIN ECOSYSTEM HEALTH

Restoring fire damaged lands was analyzed by prioritizing areas that recently have burned in wildfires, and ecosystems that have sustained a cumulatively high level of damage. The objective is to define areas in need of treatments designed to facilitate recovery of ecosystem health and related ecosystem components and public benefits.

Analysis

Similar to the previous analysis, the analytical framework employs developing a composite threat surface that is overlaid on the ecosystem asset to define the priority landscape.



Assets

The asset for this analysis is ecosystems as defined in the Key Concepts section, unique WHR types by tree seed zone.

Threats

The model used two discrete threat layers that were combined to create a single composite threat.

- Stand-level wildfire damage is a measure of past wildfire impact on small areas based on how recent the event occurred and burn severity (Miller et al., 2008). Where severity data were not available, fire severity was based on the pre-fire fuel rank attribute found in the fire threat data model.
- Landscape-level wildfire damage is a measure of ecosystem damage when viewed across the distribution of ecosystem extent. It is based on the percentage of the ecosystem that has recently been damaged, as expressed in stand-level wildfire damage.

These threats were combined to create the composite threat, which prioritized areas based on recent past damage to specific stands and the cumulative damage to entire ecosystems.

Results

Combining the composite threat with the ecosystem asset results in a priority landscape, which defines and ranks areas based on recent wildfire impacts.

There are roughly 2.35 million acres of high priority landscape scattered throughout the state ranging from San Diego to Siskiyou Counties, reflecting areas damaged from recent fires (Figure 2.1.7).

The bioregional summary shows significant damaged lands occur in the Central and South Coast, Klamath/North Coast and Sierra bioregions (Table 2.1.3).

When viewed as a percentage of a watershed in high priority, Figure 2.1.8 illustrates the relative concentration of fire damage across the entire state, ranging from none to about 27 percent of the sub-basin in high priority for restoration.

Discussion

California is under significant fire-ecosystem risk. The impact of modern-era wildfire activity places a high premium on ensuring wildfire-stressed areas receive appropriate attention to restore ecological values, including soil productivity, species richness, watershed integrity, wildlife habitat and scenic conditions. While basic restoration focused on soil and watershed issues continue to be important, an additional issue is broad ecosystem lag or type conversion resulting from wildfire. High severity wildfires in productive conifer ecosystems, such as those HPL areas in the northern part of the state, may suffer a long lag-time for conifer reforestation, and may require active planting efforts to assure continuity of ecosystem attributes over time. Similarly, in response to differing fire regimes and invasive pressures, areas of the South Coast bioregion appear to

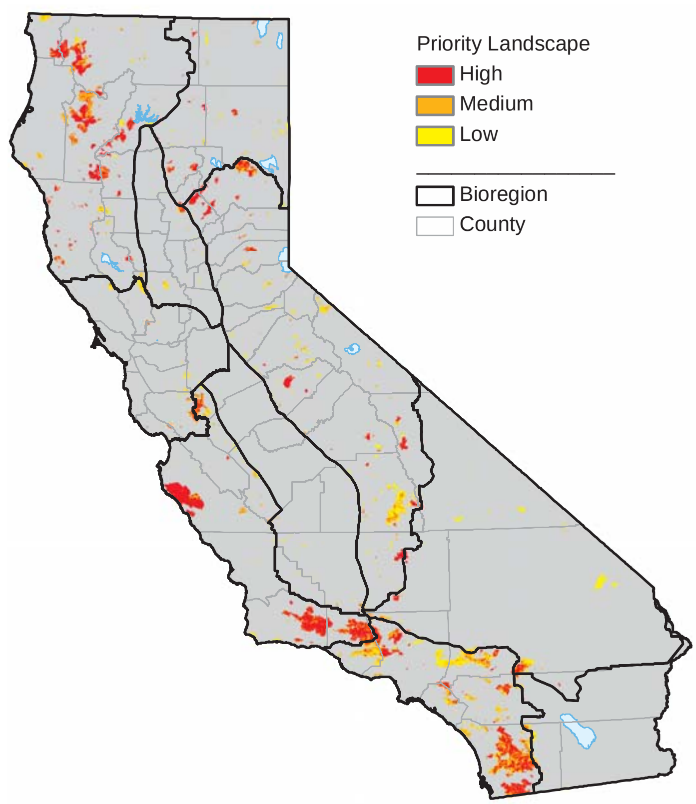


Figure 2.1.7.
Priority landscape for restoring wildfire impacted areas to maintain ecosystem health.
Data Sources: Burn Severity, USFS (2009); California Tree Seed Zones, Buck, et al. (1970); Fire Perimeters, FRAP (2009 v1); Fuel Rank, FRAP (2002); Statewide Land Use / Land Cover Mosaic, FRAP (2006)

Table 2.1.3. Priority landscape ranks for restoring wildfire impacted areas to maintain ecosystem health, by bioregion (acres in thousands)

Bioregion	Non-Wildland	Low	Medium	High	Total
Bay/Delta	6,176	59	32	24	6,292
Central Coast	7,066	87	162	671	7,986
Colorado Desert	6,708	22	19	8	6,757
Klamath/North Coast	13,385	131	279	587	14,383
Modoc	8,181	44	36	71	8,332
Mojave	19,704	132	43	58	19,937
Sacramento Valley	3,905	22	12	13	3,953
San Joaquin Valley	8,195	17	11	2	8,224
Sierra	17,529	291	178	306	18,304
South Coast	5,581	386	483	610	7,059
Total	96,429	1,192	1,255	2,351	101,227

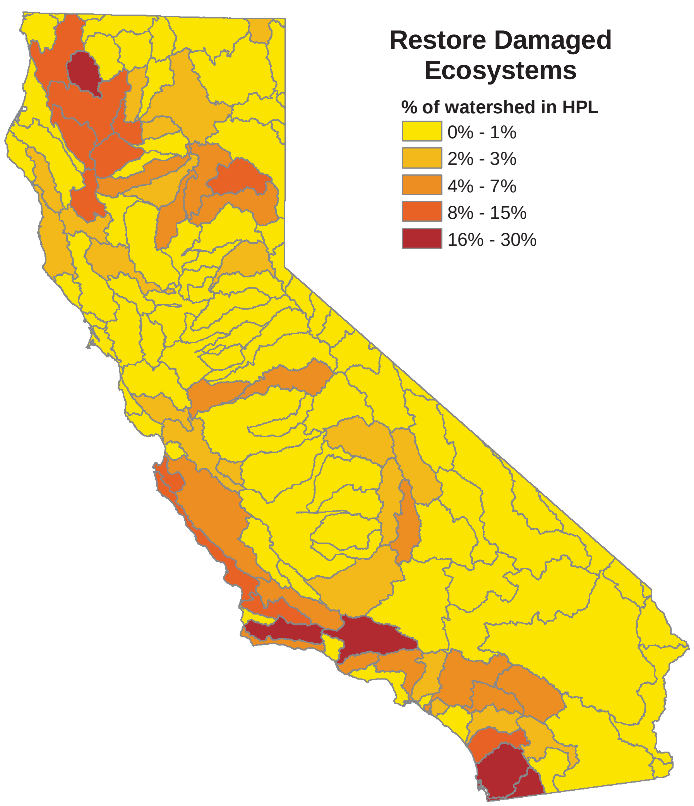


Figure 2.1.8.
Percent of Hydrologic Unit Class 8 (sub-basins) in high priority for restoration from wildfire damage.
Data Sources: Burn Severity, USFS (2009); California Tree Seed Zones, Buck, et al. (1970); Fire Perimeters, FRAP (2009); Fuel Rank, FRAP (2002); Statewide Land Use / Land Cover Mosaic, FRAP (2006); Watershed Boundaries Database for California, NRCS (2009)

be undergoing type conversion to annual grasses and herbs, and maintained in that state by increasingly frequent re-burning, epitomized by areas that burned in 2003 and then again in 2007. Subject to the caveat that wildfire may also serve useful functions, these areas should receive priority for activities designed to promote native plant establishment and reduction in fire frequency though fire prevention and suppression strategies designed to protect increasingly rare ecosystems such as Coastal Scrub.

Tools

A variety of management and policy tools are available to land managers and public agencies to restore fire damaged areas. The Burned Area Emergency Recovery (BAER) Program focuses on the immediate issues associated with soil damage and potential watershed impacts. A variety of tools, including slope stability techniques (e.g., hay bales, hydromulch, fireline rehabilitation), are often implemented soon after fire is controlled. Issues associated with long-term ecosystem recovery are often not part of the BAER process, but should be engaged where appropriate. In particular, reforestation measures in high severity wildfire areas, particularly for ecosystems that are likely to do poorly with natural regeneration (large blocks devoid of natural re-seeding sources), can be an effective tool aiding in ecosystem recovery. However, there is an ecological benefit to allowing some areas of high severity patches to persist, as they provide unique complex and rich habitats through seral development (Swanson et al., 2010).

Finally, efforts at monitoring various restoration tools provide the learning environment for testing new methods to deal with these emerging problems, and form the basis of new opportunities to deal with future fire-impacted areas.

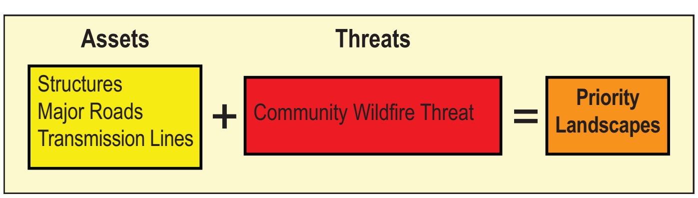
PREVENTING WILDFIRE THREATS FOR COMMUNITY SAFETY

Large damaging fires continue to plague California, reflected in efforts to describe the wildland urban interface (WUI) (CAL FIRE, 2003; Radeloff et al., 2005; Theobald and Romme, 2007), federal, state, and local policy development, and the unavoidable fact of persistent losses; California wildfires destroyed over 2,000 structures in both 2007 and 2008. Future forecasts implicating more fire with expansion of the WUI (Theobald and Romme, 2007; Bryant and Westerling, 2009) portend increasing risk.

This analysis derives the priority landscape as the convergence of areas with high wildfire threat and human infrastructure assets. This is summarized using indicators for prioritizing communities in terms of investments to prevent likely wildfire events that would create the most severe public safety hazards.

Analysis

The analytical framework follows the same pattern of aligning threats with key assets to define the priority landscape. In this case, the threat is specific to the nature of fire that can cause significant losses to human infrastructure, personal property and pose a risk to public safety. The threat-asset data is combined to define the priority landscape, which will feed into a strategy assessment designed to explore policies and tools that reduce risk to communities.



Assets

The housing asset identifies concentrations of human settlement and also serves as a proxy for additional human infrastructure that is at risk to damage from wildfire. Higher housing density results in higher asset ranks.

In addition, a high rank is assigned to 150-foot buffers around major transportation routes, as well as major transmission lines.

Composite Asset
High priority is given to dense housing and medium ranking is given to major roads and transmission line buffers. When generating the composite asset, housing is weighted three times as much as transmission lines and roads.

Threats

The Community Wildfire Threat used in this analysis was derived from a new and unique spatial dataset, Fire Hazard Severity Zones (FHSZ). This dataset was explicitly built for adopting new ignition-resistant building code standards and adopted by the California Building Commission in 2007. It is constructed to describe the nature and probability of fire exposure to structures, including those lands that are highly urbanized, but in close proximity to open wildlands. Details of the FHSZ mapping project are available on the FRAP website (http://frap.fire.ca.gov/projects/hazard/fhz.html). The implementation of final FHSZ maps are jurisdiction specific, and have unique specifications, thus various components were brought together into a single FHSZ threat dataset for use in this analysis. This included State Responsibility Area final adopted data, draft data on federal lands used to map areas required under statute due to proximate effects, and Very High FHSZ lands in Local Responsibility Areas statutorily required under Government Code authority. The latter set of data is in its final stages of completion, with all but five counties finalized for recommendation from CAL FIRE. Areas in the remaining five counties have been based on the original draft data, and will be updated upon finalization. The areas currently reflecting draft FHSZ include Los Angeles, Orange, Mono, Riverside and Ventura counties.

Results

Areas with high threat and high asset value result in high priority landscape ranking. Areas containing no assets or threats were not included in this analysis.

A sample of the priority landscape representing an area in the Sierra bioregion in and around Lake Tahoe is shown in Figure 2.1.9.

All Areas

There are 866,000 acres of high and 2.2 million acres of medium priority landscape statewide. When viewed in terms of population, there are almost 2.5 million people in high priority, and 764,000 in the medium landscapes. Many of the concentrations of risk are found in the South Coast and Sierra bioregions, and isolated high density urban areas immediately adjacent to high threat wildlands (e.g., San Francisco's east bay, Redding). For this analysis, it was important to include areas designated as medium priority to capture an extensive type of land within the wildland urban interface issue – that of rural, low-density housing communities that result in relatively modest asset density but within a high threat landscape.

Counties

Table 2.1.4 lists the top five counties by HPL acres, and Table 2.1.5 lists the top five counties by population in HPL. The South Coast bioregion dominates both summaries.

Communities

Per the discussion of communities in the Key Concepts section, results for communities differ from those for ecosystems because communities are a significant subset of the entire area where assets and threats intermingle. That said, most lands that have significant housing assets are within the communities polygons.

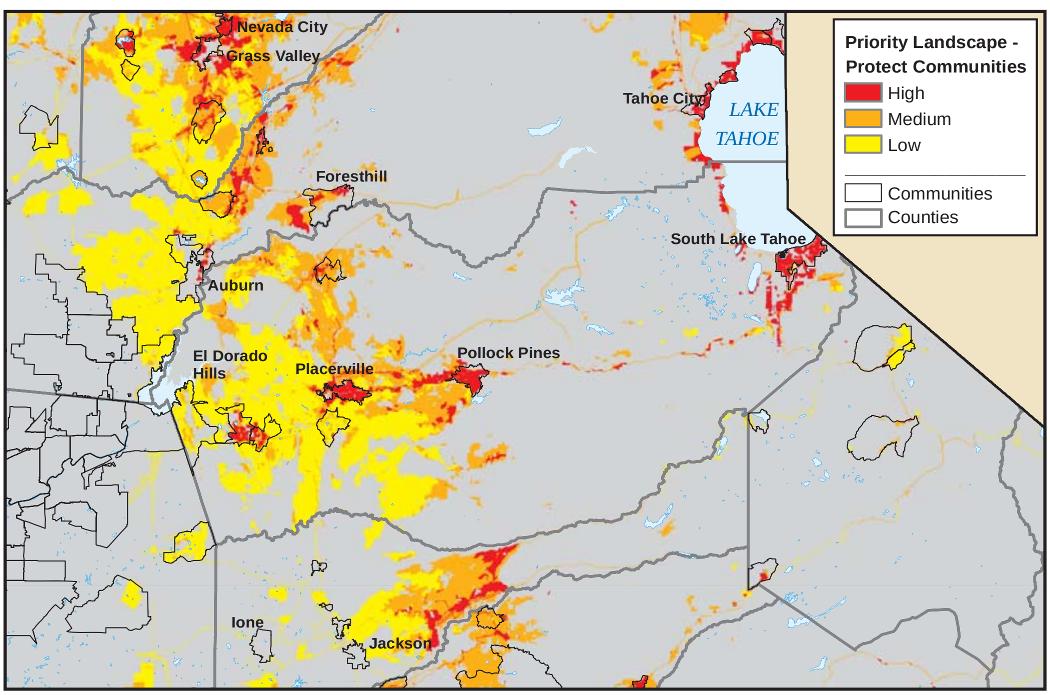


Figure 2.1.9.
Sample priority landscape for preventing wildfire threats for community safety, Lake Tahoe region.
Data Sources: Transmission Lines, California Energy Commission (2007); Communities (FRAP 2009 v1); Fire Hazard Severity Zones for SRA, FRAP (2006); Very High Fire Hazard Severity Zones for LRA, FRAP (2010); Major Highways, TIGER (2000); U.S. Census Bureau (2000); USGS National Land Cover Dataset (2001)

Table 2.1.4. Top five counties, based on acres in high priority landscape for preventing wildfire threats for community safety (acres in thousands)

County	Acres in HPL
Los Angeles	187
San Diego	141
Riverside	49
San Bernardino	48
Orange*	46
*based on DRAFT threat data, subject to change	

Table 2.1.5. Top five counties, based on population in high priority landscape for preventing wildfire threats for community safety (population in thousands)

County	Population in HPL
Los Angeles	813
San Diego	432
Orange*	235
Ventura*	174
San Bernardino	120
*based on DRAFT threat data, subject to change	

Table 2.1.6 lists the top five communities by acres in HPL, and Table 2.1.7 lists the top five communities based on population in HPL.

Figure 2.1.10 shows the county frequency of communities based on significant areas of high plus medium priority landscape (HMPL), where significance is determined by having 500 people or 1000 acres within the community boundary. A total of 404 communities meet the above definition of significance, while a grand total of 508 communities have some lands in high priority. This highlights the mixed pattern of fire risk to communities throughout California, where varying asset density impacts the analysis across a widespread threat level.

While Southern California still dominates the risk surface, many Northern California rural counties have ten or more communities that meet the high and medium definition of significance, emphasizing the rural nature of this particular type of WUI pattern. It should also be noted that there are many additional areas of human settlement that were not identified as meeting our community definition, that also include areas of high priority.

Table 2.1.6. Top five communities, based on acres of high priority landscape*, for preventing wildfire threats for community safety (acres in thousands)

Community	Acres in HPL
Los Angeles	58
San Diego	48
Thousand Oaks	15
Santa Clarita	13
Paradise	10
*based on DRAFT threat data, subject to change	

Table 2.1.7. Top five communities, based on population in high priority landscape*, for preventing wildfire threats for community safety (population in thousands)

Community	Population in HPL
Los Angeles	354
San Diego	268
Santa Clarita	65
Thousand Oaks	59
Oakland	40
*based on DRAFT threat data, subject to change	

Discussion

The high priority communities identified above differ from previous analyses that highlighted communities for National Fire Plan grant opportunities (so called "Communities at Risk") constructed by FRAP in 2000, due to significant differences in the modeling processes. The FHSZ project was designed to accurately capture both wildland fire threats and proximate threats in urbanized areas due to flame propagation and firebrands, and included newly captured data on flammability of the urbanized landscape to meet a statutory requirement for zoning ignition resistant building standards. This is contrasted with simple buffer distances used in previous WUI mapping efforts. The FHSZ effort identified hazard zones within and around community polygons, while the Communities at Risk effort simply identified priority communities by point locations. Detailed methodologies are available for Communities at Risk and FHSZ on the FRAP website (http://frap.fire.ca.gov/projects/wui/525_CA_wui_analysis.pdf and http://frap.fire.ca.gov/projects/hazard/fhz.html).

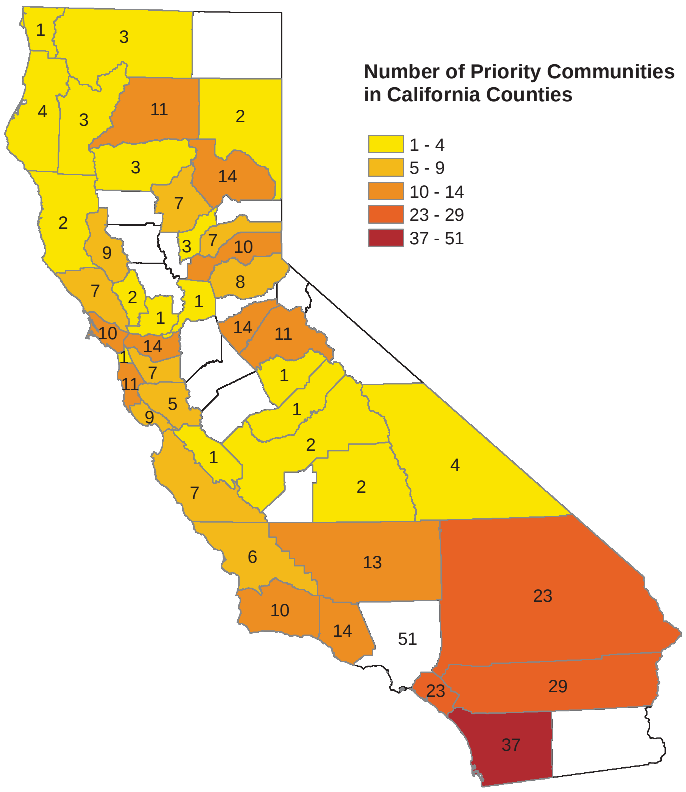


Figure 2.1.10.
Number of communities meeting HMPL thresholds for preventing wildfire threats for community safety.
Data Sources: Transmission Lines, California Energy Commission (2007); Communities, FRAP (2009 v1); Fire Hazard Severity Zones for SRA, FRAP (2006); Very High Fire Hazard Severity Zones for LRA, FRAP (2010); Major Highways, TIGER (2000); U.S. Census Bureau (2000); USGS National Land Cover Dataset (2001)

Tools

Developing coherent strategies involves collaborative planning, given the unique and disparate audience for dealing with the community threat problem (e.g., numerous individual landowners). This is discussed in detail in Chapter 3.3.

Dealing with threatened community infrastructure can involve addressing the wildfire threat, increasing the resilience to damage of assets threatened, or both. Hazard tools outlined in other analyses (fuel treatments, forest thinning, biomass, etc.) are also applicable here, but additional more creative operations may also be feasible given the unique constraints in built-out environments (Ager et al., 2010). Biological control (e.g., use of goats) has proven to be an effective fuel hazard reduction tool in urban areas where prescribed fire and other mechanical types of treatments are viewed as undesirable. Additionally, in many cases, local jurisdictions and state statutes define some elements of hazard reduction required by law (e.g., defensible space ordinances requiring vegetation clearance around residences).

Asset vulnerability can be decreased though various tools such as the ignition-resistant building codes recently constructed by the State Fire Marshal and adopted by the California Building Commission. Similar increases in regulations requiring various fire hazard mitigations and fire reporting requirements are now being addressed to deal with electrical transmission lines by the Public Utilities Commission. Land use planning that clearly articulates the extent of hazards and matches appropriate mitigations regarding development placement and in-place infrastructure/designs is an emerging area of focus, particularly in rapidly expanding areas such as Southern California.

Tools that address fire awareness and prevention strategies, particularly during periods of severe fire weather, improve the ability to avoid community risks and compliment an effective fire protection system. Finally, tactical tools such as evacuations, shelter-in-place, and targeted suppression tactics can all improve the capacity to limit damage from wildfires in communities.

Chapter 2.2
Forest Pests and Other Threats to Ecosystem Health and Community Safety

A healthy forest landscape has the capacity for renewal and for recovery from a wide range of disturbances, while continuing to provide public benefits and ecosystem services. Threats to forest health include insects, disease, invasive plant and animal species, air pollution and climate change. Assessments should identify high value forest landscape areas that are especially vulnerable to existing or potential, forest health risk factors, where forest management practices are most likely to prevent and mitigate impacts. Assessments should also identify areas where management could successfully restore impacted forests (excerpted from the U.S. Forest Service State and Private Forestry Farm Bill Requirement and Redesign Strategies).

KEY FINDINGS

Current Status and Trends

- The term "forest pests," as used in this assessment, refers to both forest insects and diseases.
- Over the past five decades, the number of exotic pests has increased from 10 to 33 percent of pests considered significant in California.
- Native bark beetles and wood borers remain a high priority, however, non-native diseases and insects such as sudden oak death, pitch canker disease, the goldspotted oak borer and the light brown apple moth are currently of major concern to California forest pest management agencies.

- Certain non-native pests may have not impacted large acreages thus far, but have the potential to spread and may already have caused significant local impacts on forest ecosystems.
- Forest pests cause major damage resulting in significant public and private costs and losses. For example, Congress provided over $225 million over three years to address hazards from bark beetle killed trees in Southern California.
- These risks are increasing rapidly and additional resources that work across all lands are needed.
- The goldspotted oak borer (GSOB) is an emerging non-native pest in San Diego County that is of great concern to forest pest management staffs.
- Bark beetles and wood borers (i.e., GSOB) in the South Coast and Sierra bioregions and sudden oak death (SOD) in the San Francisco Bay Area and along the north coast are major issues; Zones of Infestation have been declared to address many of these concerns.

Restoring Forest Pest Impacted Areas to Maintain Ecosystem Health

The priority landscape identified represents forest pest impacted ecosystems where restoration activities are most needed.

- There are over six million acres of priority landscapes that are impacted by forest pests in California, with 31 percent of these ranked as high. Seventy-five percent of priority landscapes are on lands managed by the U.S. Forest Service (USFS) and 18 percent are on privately owned lands.
- Sierran Mixed Conifer (SMC), Eastside Pine (EPN), Red Fir (RFR) and White Fir (WFR) are the habitat types with the most priority acres.
- White Fir had the largest proportion of its habitat identified as a priority landscape (43 percent), and almost 240,000 acres (26 percent) designated as high priority. Twenty-eight percent of RFR was designated as high.

Restoring Forest Pest Impacted Communities for Public Safety

The identified priority landscape represents areas of tree mortality coincident with human infrastructure such as houses, roads and transmission lines, where falling trees are a public safety issue and restoration activities are most needed.

- The South Coast, Bay/Delta and Sierra bioregions comprise 98 percent of high priority areas and 83 percent of priority landscapes.
- San Bernardino, Sonoma, San Diego, Riverside and Placer Counties have over half of the priority landscapes. San Bernardino County alone has almost 60 percent of the highest priority acres.

Preventing Forest Pest Outbreaks to Maintain Ecosystem Health

The priority landscape identified here represents ecosystems most at risk from mortality potentially caused by future outbreaks.

- Almost 95 percent of priority landscape acres are in three bioregions; the Klamath/North Coast (48 percent), Sierra (33 percent) and Modoc (13 percent).
- Two-thirds of areas at risk are U.S. Forest Service lands, one-third are private.
- White Fir (30 percent), RFR (29 percent) and Lodgepole Pine (LPN) (16 percent) are the WHR habitats most at risk (high plus medium priorities) from future tree mortality. These results are partially supported by findings from the previous analysis, which identifies these types as having significant pest activity over the last 15 years.
- Montane Hardwood (MHW), which includes much of the tanoak at risk from SOD, is the habitat with the most total priority landscape acres in the Klamath/North Coast bioregion. RFR, Ponderosa Pine

(PPN), and WFR are the most at risk in the Sierra bioregion.

Preventing Forest Pest Outbreaks for Community Safety

A priority landscape was identified that represents communities most at risk for damage from future outbreaks.

- Over 82,000 acres of community infrastructure are found to be at risk from future forest pest outbreaks.
- Magalia, South Lake Tahoe, Paradise and Truckee are the largest communities identified as priorities for forest pest prevention activities.

Threats from Non-Native Invasive Plant Species

- People are a major conduit for seed movement and the number of non-native weeds found in California has increased with population growth.
- High priority for control or eradication is placed on invasive plants that disrupt ecosystem processes.

Air Pollution Threats to Ecosystems

- The primary air pollutants impacting ecosystems are ozone and airborne fertilizing or acidifying substances.
- These pollutants are generally local in nature and are affecting ecosystems mostly in three bioregions: South Coast, Sierra (southern) and Mojave.
- Trends of these pollutants are decreasing or flat, although many areas still do not meet federal or state air quality standards.

THREATS FROM FOREST PESTS

Current and Historical Trends

The term forest pest, as used in this assessment, refers to both forest insects and diseases. A review of current and historical trends (1949–present) in forest pest outbreaks is helpful in determining priorities for future forest pest management activities.

Native bark beetles, wood borers, defoliators and diseases remain a priority. However, the ratio of exotic (non-native) pests to native pests has been increasing over time (Figure 2.2.1). Currently, up to one-third of the total number of significant pests are now non-native to California. These risks are increasing rapidly and additional resources that can work across all lands are needed.

Movement of both native and non-native pests around the state, and from outside of California into the state, remains a major concern. The unregulated movement of firewood through California, transportation of nursery material, and movement of infested soil on vehicles and hiking boots can transfer forest pests. Damage and mortality caused by forest pests have had significant impacts on ecosystem health, public safety, commercial forests, water, wildlife and wildfire occurrence. Sixty years of data on forest pests in California reveal certain trends among forest pest issues (California Forest Pest Control reports, 1949–2008).

Native Forest Pests

California forests can be affected by many different native forest pests, including the native bark beetles and wood borers, native defoliators and native diseases. For a more complete list of native forest pests in California, see http://frap.fire.ca.gov/assessment2010/2.2_forest_health.html.

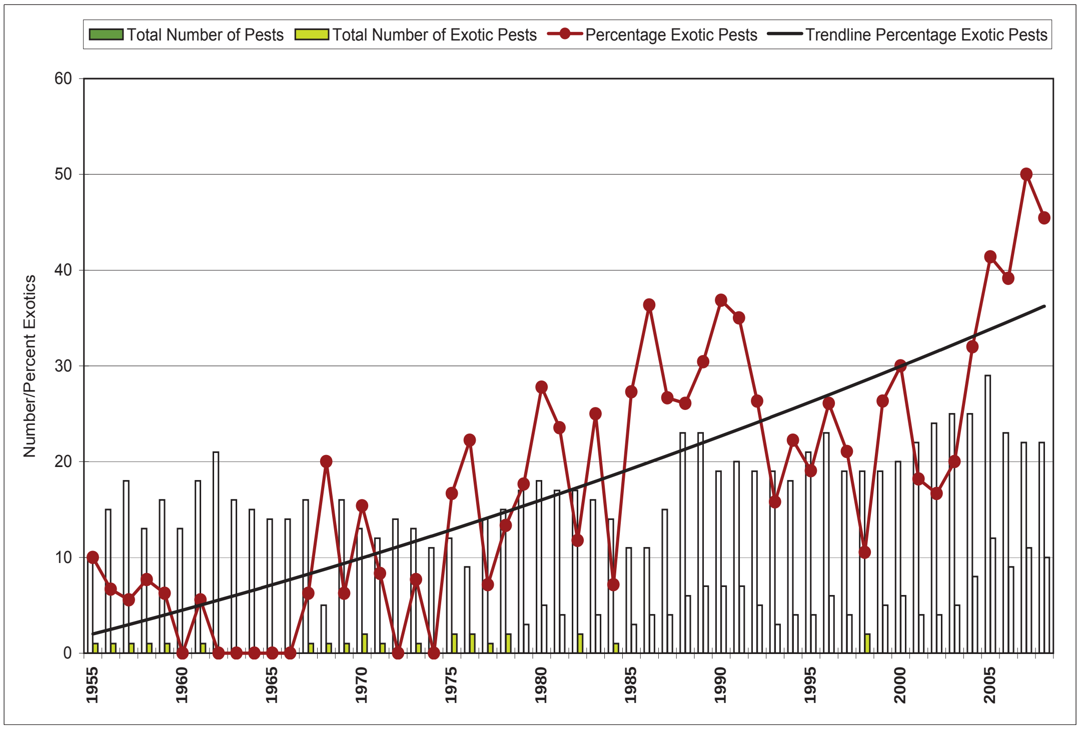


Figure 2.2.1.
Native and exotic pest occurrence in California 1955–2008.
Source: California Forest Pest Conditions Report, California Forest Pest Council, 2009

Native Bark Beetles and Wood Borers

- Bark beetles and wood boring insects have undergone periodic outbreaks nearly every decade, often related to several years of drought (California Forest Pest Conditions Reports 1949–2008).
- Currently there are elevated levels of activity of fir engraver, western pine, Ips and red turpentine beetles throughout the South Coast and Sierra bioregions, and other areas of the state.
- In 2003, Congress provided over $225 million over three years to address hazards from bark beetle killed trees in Southern California, allowing agencies to remove over 1.5 million dead trees.
- Areas of attack tend to be in stands under extreme stress due to root disease, other insect and disease impacts, or severe local soil moisture stress and dense overstocked stands.
- Alterations in forest stand structure and composition away from pine and towards younger true firs, in some areas, have increased the spread of forest pests (Parker et al., 2006).
- Lack of sawmills in some areas and historically low wood prices have left many spot infestations untreated and growing rapidly.

Native Defoliator Insects

- Most outbreaks of defoliators are localized and cyclical in nature and do not occur on a statewide basis.
- Periodic outbreaks have occurred of the Douglas-fir tussock moth, the fruit tree leaf roller, the California oak worm, fall webworms and tent caterpillars.
- Some outbreaks have been nearly continual, such as the ongoing outbreak of the lodgepole needleminer in the Yosemite National Park area and the Modoc budworm in the Modoc bioregion.
- Douglas-fir tussock moth outbreaks recently occurred in the northern end of the state, defoliating true firs in the Mount Shasta area
- A severe outbreak of fruit tree leaf roller recently defoliated thousands of acres of oaks in the San Bernardino Mountains.

Native Diseases

- Root diseases and dwarf mistletoes are found throughout the state's coniferous forests.
- The outbreak of bark beetles in Southern California from 2001 through 2004 has led to an increasing concern about the potential lack of consistent borax stump treatment, which may lead to future root disease pockets in the South Coast bioregion.
- Damage from diseases often leads to attacks by other forest pests that can kill the affected trees more quickly.
- Cytospora canker regularly impacts fir trees infected with dwarf mistletoe but is often not seen until periods of drought stress.
- Needle casts and elytroderma needle blight outbreaks have often been associated with periods of high moisture.

Non-Native Forest Pests

Exotics have killed millions of trees in California, causing significant commercial, aesthetic, economic and environmental impacts. Unlike native pests, non-native insects and diseases have no natural enemies that help control outbreaks, and local host species often have not evolved built-in defenses to repel them. The growing number of non-native introductions of both insects and diseases remains a great concern to ecosystem health in the state. Certain exotic pests may not have impacted large acreages so far but have the potential to spread and may already have significant local impacts on forest ecosystems. Rapid recognition and quick control efforts are key strategies to reduce the impacts from non-native forest pests.

Pitch canker disease, sudden oak death, white pine blister rust and Port-Orford-cedar root disease are examples of non-native diseases currently of major concern in California. The potential for spread and impact of the gypsy moth, the light brown apple moth, the goldspotted oak borer and exotic bark beetles is also a major concern.

Sudden Oak Death

- Sudden oak death has killed millions of tanoak and live oak trees throughout the Zone of Infestation (ZOI) along the coast of California.
- The pathogen that causes SOD can also infect the foliage and twigs of over a hundred other species, which does not kill these species, but can lead to increased spread.
- Sudden oak death continues to slowly spread northward through previously uninfected stands within its potential host range.
- Many species are stressed by the disease, opening up the potential for attack by other pests and building up fuel loads for potential wildfires.

Pitch Canker

- Pitch canker remains an ongoing pest problem in California.
- The disease has killed thousands of Monterey pines as well as bishop pine and knobcone pine along the central coast of California, with isolated infestations in Southern California. Most commonly, however, the disease just kills the terminal leaders of the infected trees.
- The disease continues to spread to stands that were not previously infected with the pathogen.

Light Brown Apple Moth

- This non-native defoliator insect from Australia and New Zealand poses the potential for significant damage, since it has a host range of over a thousand known species that includes most commercial timber species, as well as the majority of commercial crops grown in California.

Other Non-Native Insects and Diseases

- Bark beetles, such as the banded elm bark beetle, the Mediterranean pine engraver beetle and redhaired pine bark beetle, all have potential for spread and impact on California's native and urban forest landscapes.
- The goldspotted oak borer (GSOB) cover an area of about thirty square miles in the interior of San Diego County and has killed over three

quarters of the mature black oak and coast live oak in the impacted area.

- White pine blister rust is thought to be gradually moving south through the range of sugar pine and into higher elevation five needle pine species.
- Port-Orford-cedar root disease has largely filled in its potential range in California, making it an ongoing management challenge.

California Forest Pest Regulations

Regulations governing forest pest management can be found in Sections 4712–4718 of the Public Resources Code (PRC) of California.

- These sections declare that "bark beetles, other insect pests or plant diseases which are harmful, detrimental and injurious to timber or forest growth are a public nuisance."
- In California, non-native forest pests are regulated by the USDA and California Department of Food and Agriculture, who work to keep non-native pests out of the state and attempt to control or eradicate them.
- When exotic forest pests become established or are declared to be not actionable, responsibility for their control often falls to the California Department of Forestry and Fire Protection (CAL FIRE) on state and privately owned lands and the U.S. Forest Service on federal lands.
- Forest Pest Management rules allow or require:
  - — emergency harvesting of infected, infested or damaged timber;
  - — sanitation removal of insect or disease attacked trees to maintain or improve the health of a stand;
  - — salvage removal of trees killed by pests or other causes;
  - — timber operations are to be conducted in a manner that minimizes the build-up of destructive insect populations or the spread of forest diseases;
  - — forest plans include mitigation for pests for properties in a Zone of Infestation.

CAL FIRE, with the approval of the California Board of Forestry and Fire Protection (BOF) can declare a Zone of Infestation for native and exotic insect and disease pests. Within a Zone of Infestation CAL FIRE employees may go on private lands to attempt eradication or control in a manner approved by the BOF. At present, there are Zones of Infestation for bark beetles in the Lake Tahoe basin and the Southern California mountains. Zones of Infestation also exist for the impacted counties in the state where sudden oak death and pitch canker are found (Figure 2.2.2).

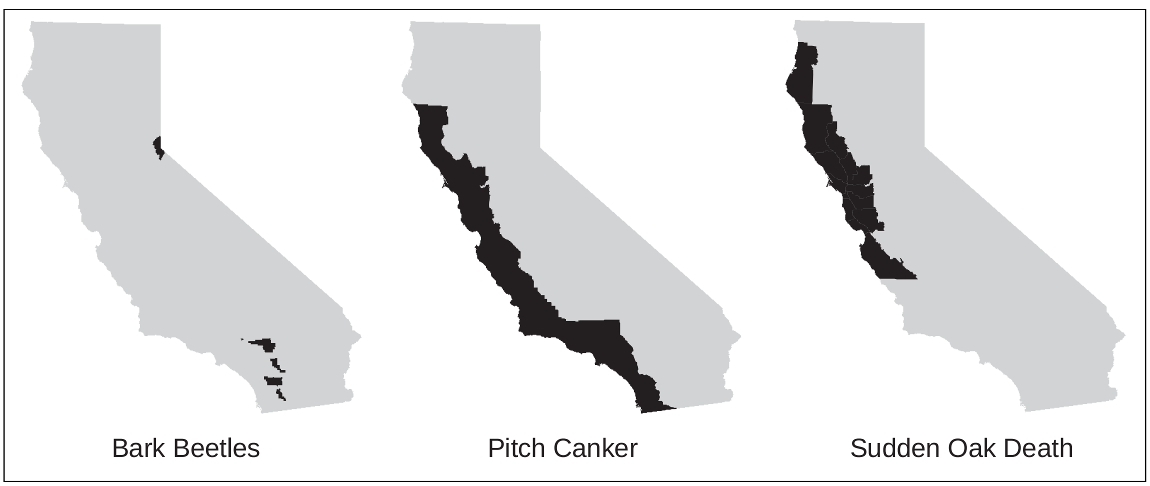


Figure 2.2.2.
State declared zones of infestation.
Data Source: Zones of Infestation, CAL FIRE, 2009

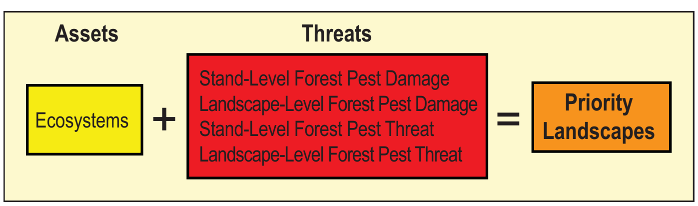
RESTORING FOREST PEST IMPACTED AREAS TO MAINTAIN ECOSYSTEM HEALTH

Prioritizing areas for restoration after major forest pest outbreaks is critical if California is to use scarce resources effectively, given the myriad of forest pests and the large number of host species impacted. This section includes two analyses that identify priority landscapes for restoring forest pest impacted areas. The first is related to ecosystem health, the second to community safety.

The ecosystem health analyses in this document do not differentiate ecosystems based on asset value; the analyses are entirely threat driven. Ideally, each ecosystem could be assigned an asset ranking based on factors such as rarity, sensitivity, habitat value, and level of ecosystem services and public and private benefits provided.

The following analysis identifies a priority landscape that represents areas most in need of treatments to restore ecosystem health.

Analysis



Assets

Ecosystems
The California Department of Fish and Game recognizes the following definition of the term ecosystem:

a natural unit defined by both its living and non-living components; a balanced system for the exchange of nutrients and energy.

To develop a more specific working definition that can be mapped for analysis, ecosystems as defined in this section refer to unique vegetation (WHR) types by tree seed zones (Figure 2.2.3). Tree seed zones help determine the suitability of seed for planting and survival in a particular area and are delineated on the basis of collection criteria adopted by the USDA forest seed policy of 1939 (Fowells, 1946). When combined with vegetation maps, tree seed zones define unique ecosystem assets potentially having unique genetic resources.

Threats

Stand-Level Damage
This threat was mapped and ranked based on current stand-level mortality derived from aerial surveys conducted from 1994–2008 by the U.S. Forest Service Region 5 Forest Health Protection (FHP) staff. The three factors used to rank stand-level damage are severity (the number of dead trees per acre), damage causing agent and time since the outbreak was last observed. Higher ranking is given to more recent and severe outbreaks of pests causing greater than 100,000 acres of damage in the last 15 years.

Landscape-Level Damage
Landscape-level damage captures damage to entire ecosystems, and was derived by calculating the percentage of each ecosystem that has medium or high stand-level damage.

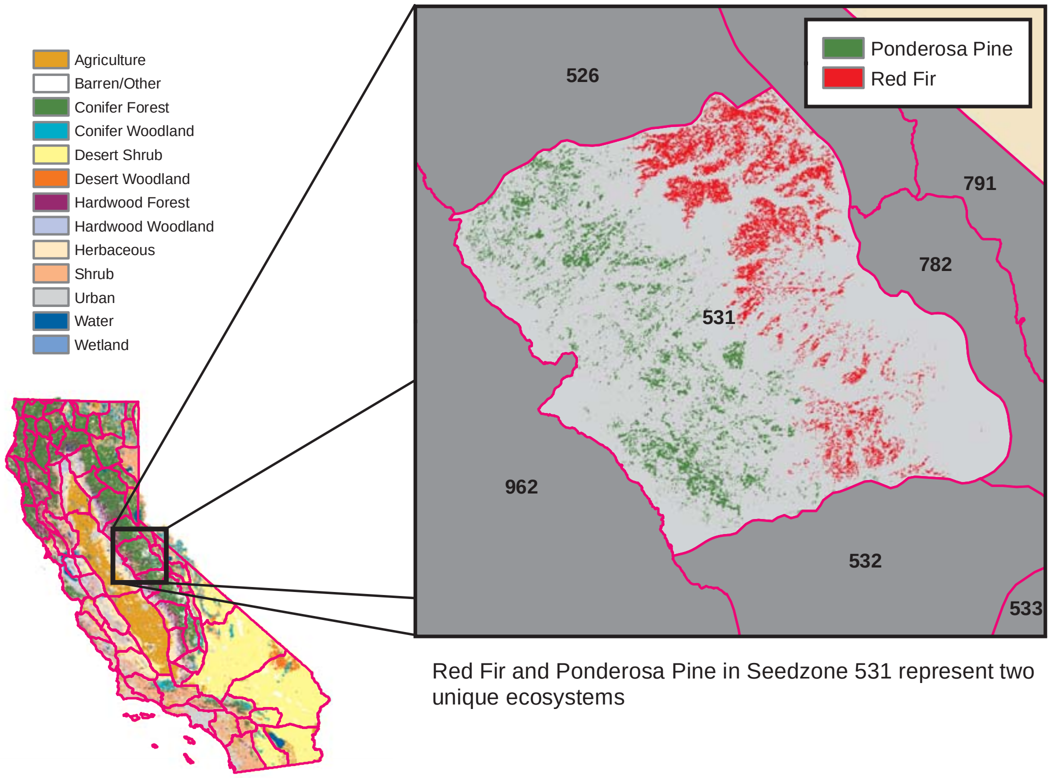
Stand-Level Threat
Forest stands were assigned a threat rank based on expected mortality due to forest pests over the next 15 years, from FHP data.

Landscape-Level Threat
The threat of damage to entire ecosystems at the landscape scale was derived by calculating the percentage of each ecosystem that is expected to have at least 50 percent tree mortality over the next 15 years.

Results

The priority landscape ranks areas impacted by insect and disease outbreaks for restoring ecosystem health (Figure 2.2.4). This involved finding:

1. areas with significant stand-level damage (dead trees),



Red Fir and Ponderosa Pine in Seedzone 531 represent two unique ecosystems

Figure 2.2.3.
Land cover and tree seed zones in California.
Data Sources: California Tree Seed Zones, Buck, et al. (1970); Statewide Land Use / Land Cover Mosaic, FRAP (2006)

2. ecosystems with widespread and significant stand-level damages and
3. potential points of origin for outbreaks in high risk ecosystems (prevent spread).

Priority Landscapes by Owner

There are over six million acres of priority landscapes that are impacted by forest pests in California, with 31 percent of these ranked high. Seventy-five percent of priority landscapes are on lands managed by the U.S. Forest Service (USFS) and 18 percent are on private lands. This ratio is similar when we examine the ownership of the highest priority acres, with 76 percent on USFS lands and 19 percent on private lands.

Priority Landscapes by WHR Type

Sierran Mixed Conifer (SMC) is the most heavily impacted habitat type, with over 1.7 million acres prioritized for restoration, almost 30 percent of all priority landscapes. Over 36 percent of SMC in California is prioritized for restoration.

Eastside Pine (EPN) is second, with just over 600,000 acres in priority landscapes, most of which is in the Modoc bioregion (69 percent). Red Fir (RFR), White Fir (WFR) and Douglas-fir (DFR) were the third, fourth and fifth most heavily impacted habitat types with 501, 404, and 362 thousand acres, respectively.

White Fir had the largest proportion of its habitat identified as a priority landscape (43 percent), and almost 240,000 acres (26 percent) designated as high priority. Twenty-eight percent of Red Fir was designated as high.

Discussion

Bioregional Findings

Over 95 percent of the priority landscapes for restoring forest pest impacted areas are in just four bioregions:

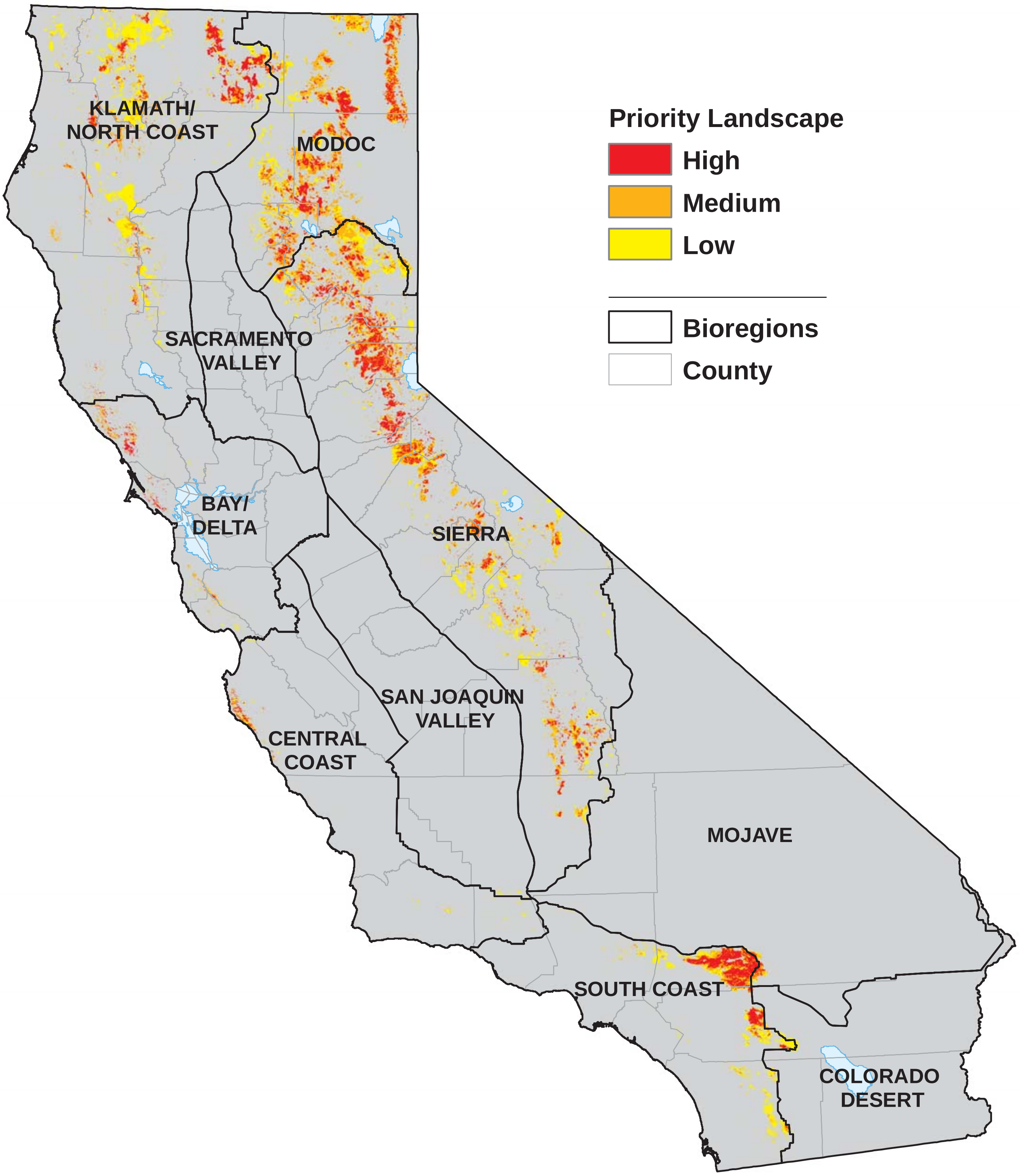


Figure 2.2.4.
Priority landscape for restoring forest pest impacted areas to maintain ecosystem health.
Data Sources: Aerial Detection Surveys, USFS FHP (2008 v1); Statewide Land Use / Land Cover Mosaic, FRAP (2006); California Tree Seed Zones, Buck, et al. (1970)

- Sierra (38 percent),
- Modoc (25 percent),
- Klamath/North Coast (22 percent) and
- South Coast (10 percent).

From a regulatory perspective, declared emergencies in the South Coast bioregion and the sudden oak death Zone of Infestation (ZOI) in the Bay/Delta bioregion already address many of the highest priority habitats identified by this analysis. The goldspotted oak borer is an emerging exotic pest in San Diego County that is of great concern to forest pest management staffs and is not currently addressed by a ZOI. A Zone of Infestation has been declared for the Lake Tahoe basin; however a majority of the Sierra bioregion, with its emerging forest pest related tree mortality is not currently covered under an emergency order or designation. The analysis suggests the need to increase priority for dead tree removal and forest health treatments in this bioregion.

Tools

A variety of forest management tools are available to land managers and public agencies to address forest pest damage to ecosystem health.

- Education and outreach regarding impacts from forest pest killed trees
- Early detection and monitoring of forest conditions and pest activity
- Forestry assistance programs and forest management activities
- State and federal forest policies and declared Zones of Infestation

Within a Zone of Infestation CAL FIRE employees may go on private lands to eradicate or control forest pests. Activities may include:

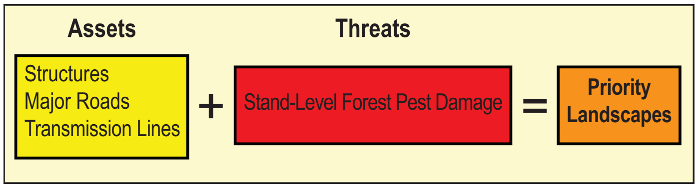
- Removal of dead, dying and diseased trees near community assets,
- Removal of live vegetation directly adjacent to dead or dying trees that is substantially at risk,
- Removal of soil that harbors insects or diseases,
- Eradication or
- Control of forest pest outbreaks that threaten area-wide forest resources.

Enforcement of forest pest regulations often falls under the California Forest Practices Act. The act allows for regulation of commercial timberlands or lands growing commercial timber species around the state. It uses provisions added to timber harvest plans to manage forest pest issues. Management of non-commercial timberlands is more difficult without further action by the state legislature, other state departments or local government regulations. If landowners are not engaged in commercial timber operations, many of the tools available to address forest pest concerns on private lands are limited. Unless a Zone of Infestation or other emergency declaration is made, treatments may only be applied with the consent of private land owners. This can make it difficult for state agencies to react quickly and effectively to prevent and control outbreaks before pests are well established.

RESTORING FOREST PEST IMPACTED COMMUNITIES FOR PUBLIC SAFETY

This analysis identifies priority landscapes in communities already impacted by forest pest outbreaks and most likely to have associated concerns about public safety and human infrastructure. During major outbreaks, large dead trees in populated areas can fall and block major transportation routes, hit power lines (sometimes starting fires) or crush structures. Such events also increase fuel loading, which can create additional fire hazards. Additional threats to public safety outside communities, such as on forest trails and recreation sites are not addressed by this analysis. Although some data on current hazard reduction activities are available for Southern California, these data were not available on a consistent, statewide basis. As a result, ongoing treatment activities to address forest pest threats near communities were not used in this analysis.

Analysis



Assets

High ranking was assigned to dense housing, moderate to major roads and transmission lines. When combining the three assets, housing was weighted three times as much as transmission lines and roads.

Threats

The same stand-level damage threat data based on current tree mortality described in the previous analysis for restoring ecosystem health was used.

Results

The overlay of the threats and assets produces the priority landscape, shown for an example area (Lake Arrowhead) in Figure 2.2.5.

Priority Landscapes by Community

This analysis identified 13 communities with at least 20 percent of their area in priority landscapes (Table 2.2.1). Eight of these are in the South Coast bioregion, which has experienced a high level of tree mortality from drought and subsequent bark beetle (and other forest pests) infestation since 2001. All eight of the South Coast communities are covered by state and county level declared emergencies. Four of the remaining five communities are in the Bay/Delta bioregion and are covered under a Zone of Infestation order, which has been declared by CAL FIRE to address sudden oak death.

Priority Landscapes by County

Over half of the priority acres are contained in just five counties (Table 2.2.2). San Bernardino has over 20 percent of the priority landscape acres and almost 60 percent of the high priority acres. Sonoma County, which has been hit hard by sudden oak death, has over 10 percent of all priority landscape acres.

Discussion

Bioregional Findings

The South Coast, Bay/Delta and Sierra bioregions comprise 98 percent of high priority areas and 83 percent of priority landscapes.

- Bark beetles and wood borers in the South Coast and Sierra bioregions, and sudden oak death in the Bay/Delta and along the North Coast are major issues. Zones of Infestation have been declared to address these concerns.
- The South Coast bioregion has 37 percent of priority landscapes and 74 percent of high priority acres.
- The Sierra bioregion has 27 percent of priority landscapes and 11 percent of high priority acres.

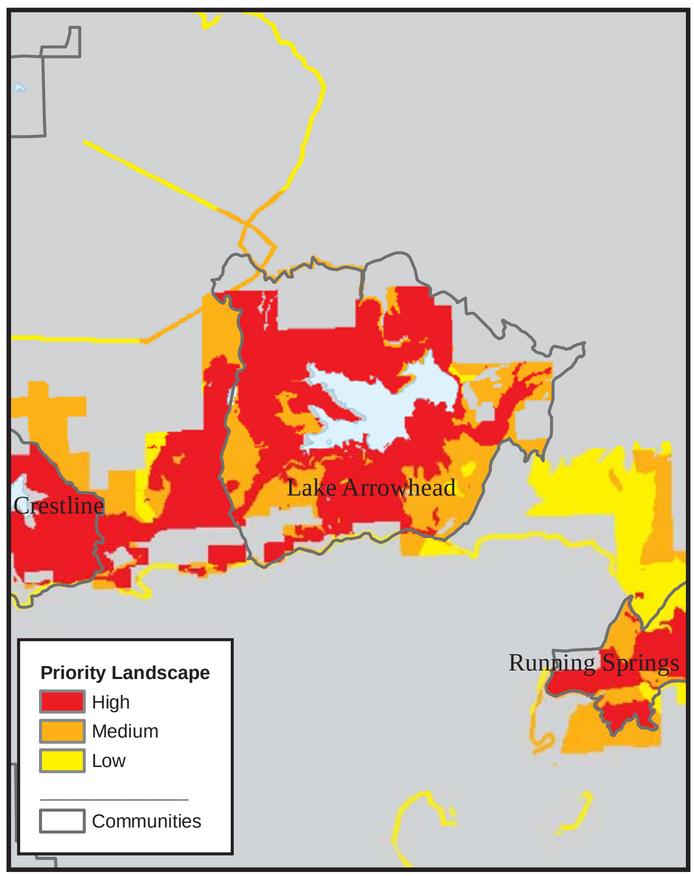


Figure 2.2.5.
Priority landscape (Lake Arrowhead area) for restoring forest pest impacted communities.
Data Sources: Aerial Detection Surveys, USFS FHP (2008 v1); Communities, FRAP (2009 v1); Transmission Lines, California Energy Commission (2007); Major Highways, TIGER (2000); U.S. Census Bureau (2000)

Table 2.2.1. High priority communities for restoring forest pest impacts for public safety (acres rounded to nearest hundred)

Community	Bioregion	Priority Landscape (Acres)	Priority Landscape (Percent of Community)	High Priority Landscape (Percent of Community)	High or Medium Priority Landscape (Percent of Community)
Running Springs	South Coast	2,000	78	55	68
Lake Arrowhead	South Coast	5,400	67	45	66
Wrightwood	South Coast	800	56	46	51
Crestline	South Coast	3,900	55	45	54
Idyllwild–Pine Cove	South Coast	4,700	54	48	54
Big Bear Lake	South Coast	2,400	45	40	45
Monte Rio	Bay/Delta	400	42	42	42
Julian	South Coast	1,800	35	2.5	16
Aromas	Central Coast	900	28	2	28
Big Bear City	South Coast	600	26	26	26
Occidental	Bay/Delta	800	24	5	24
Guerneville	Bay/Delta	500	24	24	24
Inverness	Bay/Delta	800	22	8	22

Table 2.2.2. Priority landscape by county for restoring forest pest impacted communities for public safety

County	Priority Landscape (Acres in Thousands)	Priority Landscape (Percent of County)	Medium Priority Landscape (Acres in Thousands)	High Priority Landscape (Acres in Thousands)
San Bernardino	40	21	16	18
Sonoma	20	10	17	2
San Diego	17	9	2	<1
Riverside	14	7	4	4
Placer	11	6	8	<1

- The Bay/Delta bioregion has 19 percent of priority landscapes and 12 percent of high priority acres.
- The Klamath/North Coast bioregion has seven percent of priority landscapes and one percent of high priority acres.

Declared emergencies in the South Coast bioregion and the declaration of a Zone of Infestation for sudden oak death in the Bay/Delta bioregion already address many of the highest priority communities identified by this analysis, at least from a policy perspective. A Zone of Infestation has been declared for the Lake Tahoe basin, however a majority of the Sierra bioregion, with its emerging forest pest related tree mortality is not currently covered under an emergency order or Zone of Infestation designation and may require additional actions to control the spread early and avoid the most severe consequences to public safety.

Tools

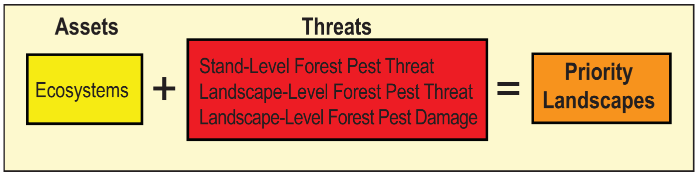
Tools to address forest pest outbreaks near communities are similar to those presented in the previous analysis.

PREVENTING FOREST PEST OUTBREAKS TO MAINTAIN ECOSYSTEM HEALTH

Two analyses were conducted to identify priority landscapes for preventing future damage from forest pest outbreaks. The first was related to ecosystem health, the second to community safety.

The following analysis identified ecosystems at risk from future forest pest outbreaks. The goal is to prevent outbreaks, especially those with the potential to cause widespread damage to entire ecosystems.

Analysis



Assets

Ecosystem
The ecosystem asset used in this analysis was the same as presented in the previous ecosystem health analysis.

Threats

The threats data used in this analysis were the same as presented in the previous ecosystem health analysis.

Results

Areas at significant risk of future forest pest outbreaks are:

- areas with high expected forest pest related tree mortality,
- ecosystems with a high proportion of areas at risk from forest pests (high landscape-level threat) and
- the undamaged portion of heavily damaged ecosystems.

Using this methodology, over 2.5 million acres have a significant level of threat from future forest pest outbreaks (Figure 2.2.6). Highest priority was given to ecosystems with at least half of its area expected to experience volume loss of greater than 50 percent in the next 15 years. Medium priority was given to areas where at least 10 percent of a given ecosystem has expected stand-level volume loss of greater than 50 percent.

Priority Landscapes by Owner

Over 62 percent of threatened areas are owned by the USFS, 33 percent are on privately owned lands.

Priority Landscapes by WHR Type

Together, Montane Hardwood (MHW), Red Fir (RFR), White Fir (WFR), Ponderosa Pine (PPN) and Sierran Mixed Conifer (SMC) habitat types comprise almost 67 percent of all the priority landscape acres. MHW has the largest total priority acres (424,115 acres, about 17 percent of all priority landscapes), although this is less than 10 percent of the MHW habitat in California. RFR (18 percent), Lodgepole Pine (LPN) (10 percent) and WFR (10 percent) had the highest proportions of their habitats identified as high priority for protection. When high priority and medium priority landscapes were combined, WFR (30 percent), RFR (29 percent) and LPN (16 percent) were again identified.

Discussion

Results pointing to WFR and RFR habitats in trouble are supported by findings from the Restoring Forest Pest Impacted Areas to Maintain Ecosystem Health analysis, which identifies these types as having significant pest activity over the last 15 years. Treatment to stand-level threats in high risk WFR and RFR habitats will yield additional ecosystem health benefits away from treatments by reducing the potential for infestation and spread.

Bioregional Findings

- The Klamath/North Coast (48 percent), Sierra (33 percent) and Modoc (13 percent) bioregions comprise almost 95 percent of priority landscape acres
- Montane Hardwood (MHW), which includes much of the tanoak at risk from SOD, is the habitat type with the most priority landscapes statewide and in the Klamath/North Coast bioregion. RFR, PPN, and WFR are the most at risk WHR types in the Sierra bioregion in terms of total priority acres.

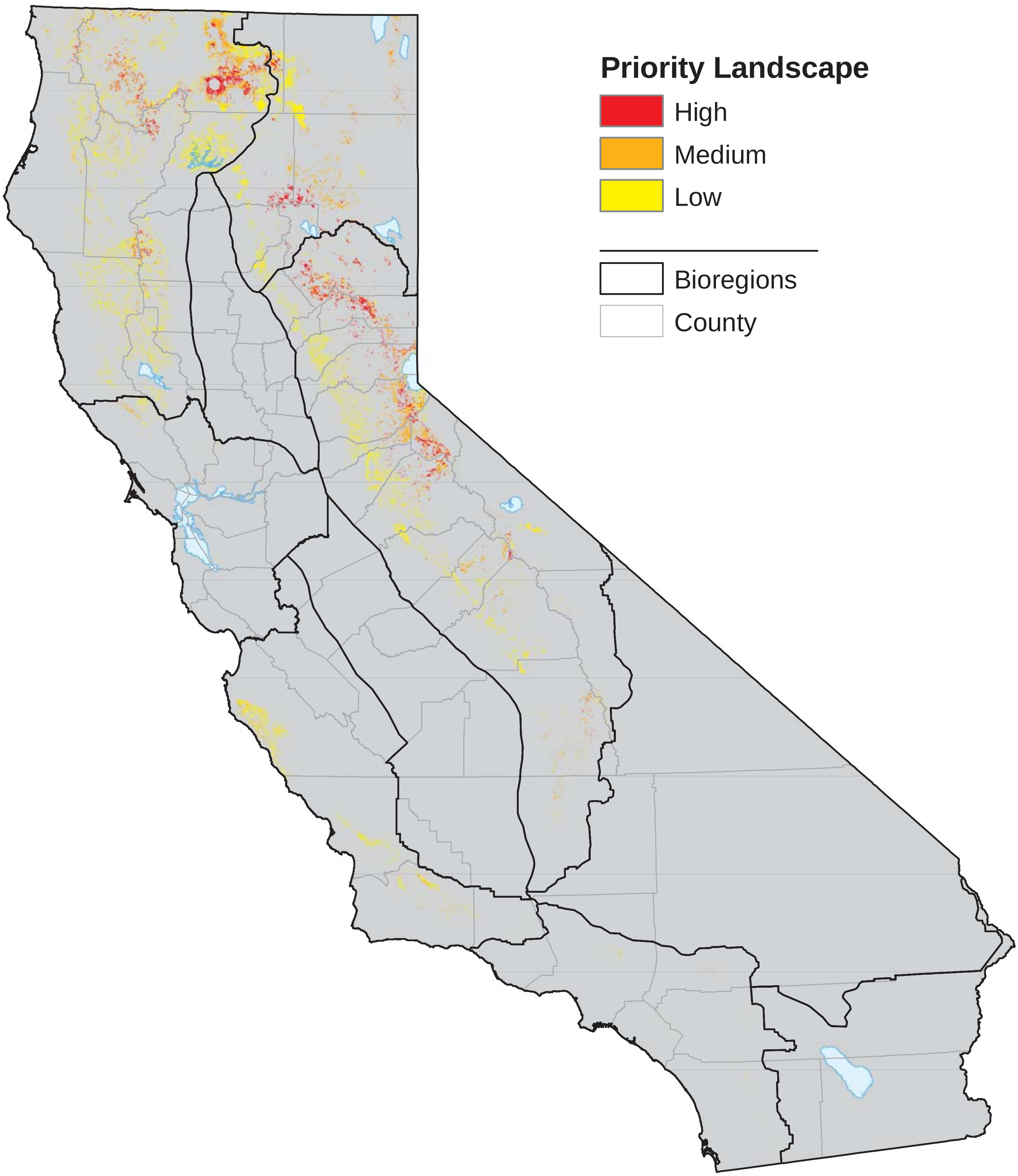


Figure 2.2.6.
Priority landscape for preventing forest pest outbreaks to maintain ecosystem health.
Data Sources: Forest Pest Risk, USFS FHP (2006 v1); Statewide Land Use / Land Cover Mosaic, FRAP (2006); California Tree Seed Zones, Buck, et al. (1970)

These results indicate that the federal government will have a particularly important role to play in protecting ecosystem health from future forest pest outbreaks. Management practices and regulations governing forest policies at the national and regional level will be important in addressing these issues, suggesting that coordination between federal, state and local efforts is critical.

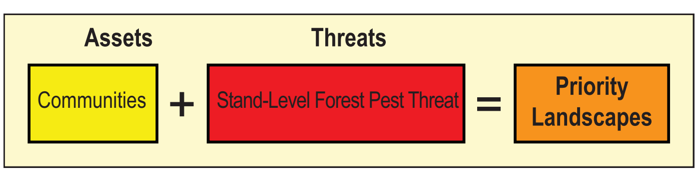
Tools

A variety of forest policy and forest management tools are available to land managers and public agencies to address forest pest risks to ecosystem health. Activities that thin overly dense forests, reduce competition and introduce a mix of tree species that are adapted to the local environment, can help create forests more resilient to disturbances and less susceptible to forest pests. Tools to address forest pest outbreaks are similar to those presented in the previous analysis.

PREVENTING FOREST PEST OUTBREAKS FOR COMMUNITY SAFETY

The priority landscape from this analysis identifies communities potentially impacted by forest pest outbreaks, and that are most likely to have associated concerns for public safety and human infrastructure damage. Additional threats to public safety outside communities, such as on forest trails and recreation sites were not addressed by this analysis.

Analysis



Assets

Communities

The Fire and Resource Assessment Program (FRAP) community data layer identifies incorporated cities and unincorporated Census Designated Places and was used to represent concentrations of people and human infrastructure at risk from forest pests.

Threats

The stand-level forest pest threat data used in this analysis are the same as presented in the previous analysis.

Results

The overlay of the threats and assets produced the priority landscape. Over 82,000 acres of community infrastructure are found to be at risk from future forest pest outbreaks, shown for an example area (Foresthill) in Figure 2.2.7.

Priority Landscapes by Community

Since large communities have very different exposure characteristics than small communities it is useful to discuss these results by community size. There were no communities with populations greater than 50,000 identified by this analysis.

Size Class 4 (Population 10,000–50,000)

Table 2.2.3 lists the five Size Class 4 communities with the most priority acres. Magalia had the most acres with 2,000, which represents 23 percent of the community. This was followed by South Lake Tahoe, with almost 1,600 acres (25 percent) and Paradise, with almost 11 percent.

Size Class 5 (Population < 10,000)

Table 2.2.4 lists the top 20 communities identified by this analysis, in terms of total high plus medium priority landscapes.

Priority Landscapes by County

Table 2.2.5 shows the counties with the most high priority landscape (HPL) and high and medium priority landscape (HMPL) and total priority landscape community acres. Humboldt County had the largest total number of priority landscape acres with almost 20,000 (24 percent of all Size Class 4 community PL acres). Humboldt was followed by Calaveras County, with just over 16,000 acres (20 percent), Tuolumne with over 8,600 acres (10 percent), Shasta County with 6,200 acres (eight percent), Plumas with almost 5,400 acres (seven percent) and Butte County with about 5,000 acres (six percent). Together, these counties comprise 75 percent of all community priority landscapes identified by this analysis (Table 2.2.5).

Areas in the highest priority category are all inside communities and are at risk of losing greater than 75 percent of tree volume over the next 15 years. See Table 2.2.5 for a complete breakdown of high priority acres by county

High and medium priority landscape areas are inside communities and are at risk of losing greater than 50 percent of tree volume in the next 15 years. See Table 2.2.5 for a complete breakdown of HMPL acres by county.

Discussion

Bioregional Findings

- Almost all of the community areas at risk from future forest pest outbreaks identified by this analysis are contained in three bioregions: Sierra, Klamath/North Coast and Modoc.
- Magalia, South Lake Tahoe, Paradise and Truckee are the largest communities identified as priorities for forest pest prevention activities.

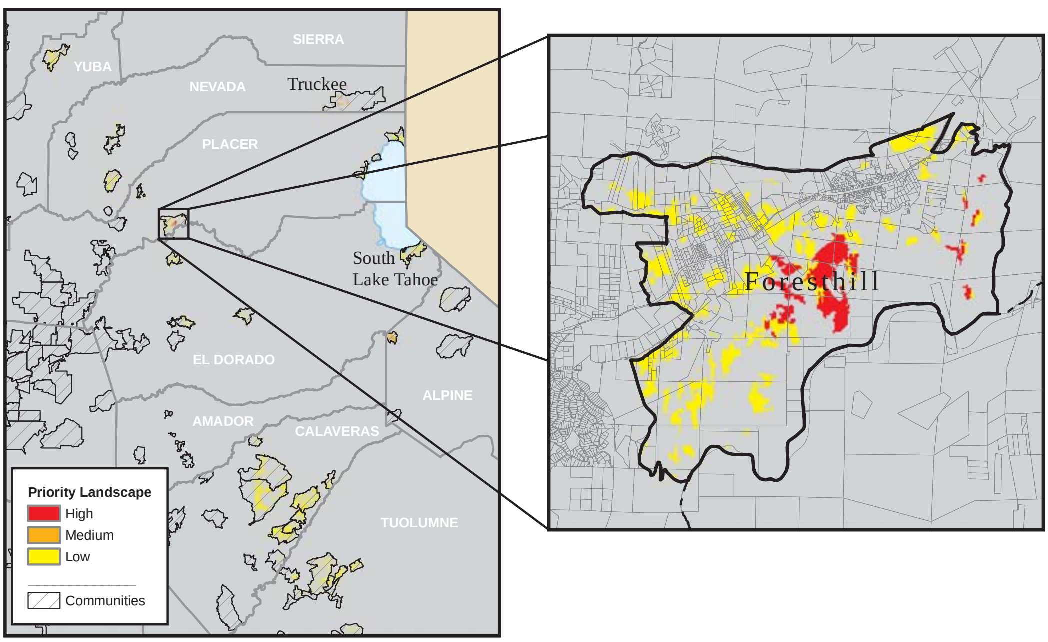


Figure 2.2.7.
Priority landscape for preventing forest pest outbreaks for community safety (Foresthill).
Data Sources: Communities, FRAP (2009 v1); Forest Pest Risk, USFS FHP (2006 v1)

Table 2.2.3. Top five Size Class 4 communities in terms of total priority landscape acres (acres rounded to nearest hundred)

Community	Bioregion	Priority Landscape (Total Acres)	Priority Landscape (Percent of Community)	Medium Priority Landscape (Acres)	High Priority Landscape (Acres)	Percent of Community in HPL or MPL
Magalia	Modoc	2,000	23	0	0	<1
South Lake Tahoe	Sierra	1,600	25	<50	<50	1
Paradise	Sierra	1,200	11	0	0	<1
Truckee	Sierra	700	3	400	100	3
Grass Valley	Sierra	300	8	0	0	<1

Table 2.2.4. Top 20 Size Class 5 cities by HMPL total acres (acres rounded to nearest hundred)

Community Name	Bioregion	Priority Landscape (Acres)	Priority Landscape (Percent of County)	Medium Priority Landscape (Acres)	High Priority Landscape (Acres)	Total HMPL (Acres)
Bucks Lake	Sierra	1,900	28	1,600	<50	1,600
Mineral	Modoc	1,000	4	800	100	800
Kirkwood	Sierra	900	46	600	100	700
Johnsville	Sierra	1,100	12	600	100	700
Mammoth Lakes	Sierra	700	5	400	200	600
Graeagle	Sierra	500	7	300	<50	300
Foresthill	Sierra	1,200	17	0	300	300
La Porte	Sierra	400	14	300	0	300
East Quincy	Sierra	300	4	100	0	100
Meadow Valley	Sierra	300	5	100	0	100
Willow Creek	Klamath/North Coast	20,000	15	<50	10	100
Mount Shasta	Klamath/North Coast	200	9	100	<50	100
Iron Horse	Sierra	100	1	<50	0	100
Weed	Klamath/North Coast	500	17	<50	0	<50
Sunnyside–Tahoe City	Sierra	500	22	<50	0	<50
Lake Arrowhead	South Coast	<50	<1	<50	0	<50
Dollar Point	Sierra	200	16	<50	0	<50
Kings Beach	Sierra	500	21	<50	<50	<50
Mohawk Vista	Sierra	100	2	<50	0	<50
Lakehead–Lakeshore	Klamath/North Coast	2,900	41	0	<50	<50

Table 2.2.5. Top 17 counties by percent of statewide HPL and HMPL and total PL community acres for protection from future forest pest outbreaks (acres rounded to nearest hundred)

County	Priority Landscape (Total Acres)	Priority Landscape (Percent of County)	Medium Priority Landscape (Acres)	High Priority Landscape (Acres)	Percent of HPL in County	Percent of HMPL in County
Placer	2,800	3	100	300	25	5
Mono	700	1	400	200	19	9
Alpine	1,200	1	600	100	14	11
Plumas	5,400	7	3,000	100	13	48
Nevada	2,300	3	400	100	12	9
Humboldt	20,000	24	<50	100	6	2
Tehama	2,400	3	800	100	6	13
El Dorado	2,900	3	<50	<50	2	1
Shasta	6,200	8	<50	<50	1	<1
Siskiyou	1,500	2	100	<50	1	2
Calaveras	16,100	20	0	<50	<1	<1
Trinity	2,100	3	<50	0	<1	<1
Tuolumne	8,600	10	0	0	<1	<1
Butte	5,000	6	0	0	<1	<1
Yuba	1,700	2	0	0	<1	<1
Fresno	1,600	2	0	0	<1	<1
Lake	1,200	1	<50	0	<1	<1

- Sixteen of the top 20 communities with populations below 10,000 are in the Sierra bioregion.
- Humboldt and Calaveras counties have the most community acres identified as a priority; however Plumas has the most acres in high plus medium priority.

These results indicate that a majority of the communities at risk from future forest pest outbreaks are in Northern California counties and have populations of less than 10,000.

Tools

Tools to address forest pest risks near communities are similar to those presented in the previous analysis on preventing forest pest outbreaks to maintain ecosystem health.

THREATS FROM NON-NATIVE INVASIVE PLANT SPECIES

Invasive, non-native plants damage California ecosystems by displacing native species, out-competing native plants, changing plant communities and structure, and reducing the value of habitat for wildlife and stock.

Invasive plants may disrupt physical ecosystem processes such as fire regimes, sedimentation, erosion, light availability, hydrology and nutrient cycling. Some alter soil chemistry, pollute gene pools, suppress native species recruitment and harbor exotic animals. The impact is especially severe in California, with its rich diversity of natural resources. The threat posed by invasive species is second only to habitat loss and is long lasting, difficult to remediate and occurs throughout the state. Many public entities are responsible for the control of invasive plant species in California, and in association with non-governmental organizations (NGOs) and the private sector, a state Noxious and Invasive Weed Action Plan was created (Schoenig, 2005) to coordinate efforts.

Current and Historical Trends of Invasive Plants

Due to geology and climate, California has many different habitats leading to high probability foreign weeds will find a suitable place to become established. People are a prime vector of seeds, as more people came to California, the number of non-native weeds found here has increased (Bossard et al., 2000). As of 2005, approximately 20 million acres of the state were contaminated with noxious or invasive plants (Schoenig, 2005), costing hundreds of millions of dollars. Nearly 30 percent (1,800) of plant species found in the wild are non-native (http://www.cal-ipc.org/ip/inventory/index.php). Approximately 200 are recognized by the California Invasive Plant Council (CAL-IPC) as being invasive.

Many of the 200 invasive plants listed on the CAL-IPC website occur in California's forest and rangeland area. Weed control and restoration are now widely regarded as necessary in many wildlands throughout the state. High priority is placed on invasive plants that disrupt physical ecosystem processes such as fire regimes, sedimentation, erosion, light availability, hydrology and nutrient cycling. Generally these species will act to reduce native species biodiversity and affect wildlife habitat. There are several species or groups of species that may be considered especially troublesome in the forest and rangeland areas of California (Table 2.2.6).

There are unfortunately few statewide comprehensive maps of many of these invasive plant species. However, efforts are underway on several fronts to maintain or develop statewide maps.

Risk of New Non-Native Plant Species Invasions

Human activities, such as urbanization and agriculture, facilitate the initial invasion by non-native plants (Seebloom et al., 2006). People often introduce plants from their homelands when they migrate to new regions, sometimes accidentally. It is generally agreed that areas where the vegetation and soil have been disturbed by humans or domestic animals

Table 2.2.6. Major invasive plant species in California forests and rangelands

Common Name	Scientific Name
Medusahead	*Taeniatherum caput-medusae*
Cheatgrass	*Bromus tectorum*
French Broom	*Genista monspessulana*
Spanish Broom	*Spartium junceum*
Scotch Broom	*Cytissus scoparius*
Portuguese Broom	*Cytissus striatus*
Yellow Starthistle	*Centaurea solstitialis*
Italian Thistle	*Carduus pycnocephalus*
Musk Thistle	*Carduus nutans*
Bull Thistle	*Cirsium vulgare*
Canada Thistle	*Cirsium arvense*
Scotch Thistle	*Onopordum acanthium*
Pampas Grass	*Cortaderia selloana*
Jubata Grass	*Cortaderia jubata*
Giant Reed	*Arundo donax*

are more susceptible to invasion. Grazers introduced by humans often denude large areas of native vegetation, leaving them open to colonization by introduced species adapted to grazing.

Changes in stream flows, the frequency of wildfires or other environmental factors caused by construction, firefighting and other human activities may also hinder survival of native plants and promote invasion by non-natives.

Regulatory Framework for Invasive Plant Species

Many organizations, such as CAL-IPC, publish lists that prioritize which invasive plants need to be addressed. Eleven different federal agencies, ten different state agencies, and as many as four local agencies have invasive, non-native plants as part of their responsibilities. Many of those groups were stakeholders in the 1995 "Strategic Plan for the Coordinated Management of Noxious Weeds in California" which was a broad strategy for cooperation, and increased programs to control noxious weeds. The more action oriented "California Noxious and Invasive Weed: Action Plan" was published with input from many of these same stakeholders. It focused on the overlap of legally defined "noxious" weeds and invasive weeds (recognized by their ability to invade working landscapes or wildlands and to do economic or ecological damage) (Schoenig, 2005). Federal jurisdiction over invasive weeds originates in multiple laws, the most important being the Federal Noxious Weed Act [7 U.S.C. Sections 2801–2813] (Range Management Advisory Committee, 1995). The California Department of Food and Agriculture is the lead agency in noxious weed control in the state and its authority originates in the California Food and Agricultural Code, as does each county Department of Agriculture. These federal, state and local agencies work cooperatively in California's Pest Prevention System to prevent noxious weed and agricultural pest invasions.

AIR POLLUTION THREATS TO ECOSYSTEMS

This section reviews the main effects of lower atmospheric (tropospheric) air pollution on ecosystem health in forests and rangelands in the state. Known or suspected impacts occur from several processes, including ozone (O3) damage to several plant species in areas hard hit by chronic air pollution, and the deposition of fertilizing or acidifying substances in clear mountain waters (e.g., Lake Tahoe) and on mountain and desert soils.

Current and Historical Trends

Air pollution and its gas precursors come from both natural and human-related sources. The single most impacting development in air pollution threats to ecosystems has been the burning of fossil fuels in California, which escalated with industrialization and the invention and use of the automobile in the early 1900s. As such, the most damaging effects to ecosystems typically occur in areas where human activities emit substantial amounts of precursor gases, which contribute to the development of specific damaging air pollutants that impact ecosystem health.

The three bioregions of California that suffer chronically high levels of air pollution affecting ecosystem health are the South Coast, Mojave and southern San Joaquin Valley (and the adjacent Sierra Nevada mountains). These regions all have large urban and agricultural areas surrounded or confined by high mountains. In other areas of the state, the damage from air pollution has thus far been more limited. Table 2.2.7 provides a brief summary of problem air pollutants and their effects.

Fertilizing and Acidifying Effects on California Ecosystems

Fertilization from airborne pollution is a concern in nitrogen-limited ecosystems such as oligotrophic (nutrient limited) waters and desert soils. Lake Tahoe has recorded increases in nitrogen levels, some of which are due to airborne particulates. This has contributed to the diminishing lake clarity. Research is underway in Joshua Tree National Park on fertilization of the soils and its effects. In the long term, this process has the potential to cause changes in dominant vegetation type and fire regimes. However, major impacts from airborne fertilization and acidification substances on these ecosystems have yet to be demonstrated.

Ozone Effects on Ecosystems

Direct damage from chronically elevated, toxic ozone levels occurs mainly to two dominant tree species and several shrub species.

In particular, ozone affects ponderosa pine and its close relative, Jeffrey pine. The gas damages the needles of these trees, especially when the needle stomates are open. The results are dead or dying needles on affected trees and severely compromised tree health. In severe cases it can lead to plant stress and outright tree mortality. Other forest plant species with measurable adverse impacts from ozone are mugwort (*Artemisia douglasiana*), skunkbrush (*Rhus trilobata*) and blue elderberry (*Sambucus mexicana*).

A 2007 estimate suggests 1.3 million acres of California forestlands are at moderate to high risk of impacts from ozone (Campbell et al., 2007). Three air basins are predominantly affected, corresponding to the southern Sierra, South Coast, and Mojave bioregions. Ozone damage to forests has also been recently detected in areas of the Klamath/North Coast and northern Sierra bioregions, though at a much lower level than to the southern bioregions.

Due in large part to reduced emissions of gas precursors, ozone levels statewide have decreased more than 40 percent since 1988, despite the growth in population by 33 percent over that same period.

According to the California Air Resources Board (ARB), other criteria pollutant trends for the past 30 years and their projections are mixed, with some showing improvement across the state (Cox et al., 2009). Emissions of carbon monoxide (CO), nitrogen dioxide (NO2) and reactive organic gases (ROGs) are predicted to continue their long-term decreasing trends. In contrast, particulate matter (PM) has been relatively constant or shows slight increases. Sulfate (SOs) emissions, greatly diminished since the 1970s, have bottomed out and are forecast to increase slightly into the future, especially due to offshore sources such as ships.

Regulatory Environment

The U.S. Clean Air Act of 1963 requires the U.S. Environmental Protection Agency (EPA) to establish

Table 2.2.7. Air pollutants and their effects and trends

Air Pollutant	Documented Effects on Ecosystems	Main Bioregions Affected	Past and Predicted Trends
Ozone	Damages needles of ponderosa and Jeffrey pine, some shrubs	South Coast, Southern Sierra, Mojave	Strong decrease since 1988
Fertilizing substances	Higher than normal soil nutrients and over abundance of nutrients in lakes leading to oxygen depletion	Potentially South Coast, Sierra, Mojave	Trends in precursors are declining
Acidifying substances	Increased acidity in soils and lakes leading to declines in amphibians and other aquatic organisms	Nowhere acute in California	Trends in precursors are declining

National Ambient Air Quality Standards for air pollutants. The federal standards are two tiered: primary standards, designed to protect public health, and secondary standards, designed to protect the environment, such as visibility, damage to property, soil, vegetation, etc. ARB oversees both state and federal air pollution control programs in California and has divided the state into air basins. Authority for air quality management within each basin has been given to local Air Pollution Control Districts, which regulate stationary source emissions and develop local non-attainment plans within their jurisdiction.

When a region falls outside of attainment, individual air districts or groups of air districts prepare air quality management plans designed to bring an air basin into compliance with relevant ambient air quality standards. Those plans, which are submitted to ARB for approval, usually contain an emission inventory and a list of rules proposed for adoption. The districts regulate emissions from stationary sources while the state regulates emissions from mobile sources such as cars and trucks.

Enhance Public Benefits from Trees, Forests and Rangelands

Chapter 3.1
Water Quality and Quantity Protection and Enhancement

Forests and forestry practices can help protect, restore, and sustain water quality, water flows, and watershed health. Healthy urban and rural forested watersheds absorb rainfall and snow melt, slow storm runoff, recharge aquifers, sustain stream flows, and filter pollutants. Assessments should identify watersheds where continued forest conservation and management is important to the future supply of clean municipal drinking water, or where restoration or protection activities will improve or restore a critical water source. Resource strategies should include actions for managing and conserving these priority watersheds for water quality and supply, and other ecosystem services (excerpted from the U.S. Forest Service State and Private Forestry Farm Bill Requirement and Redesign Strategies).

KEY FINDINGS

- The major watersheds across California differ distinctly in climate, geology, ecosystems and land use. Flexible water management tools and policies are needed to account for this tremendous variation.
- Protecting and managing forests in source watersheds is essential to future strategies for providing sustainable supplies of clean water for a broad range of beneficial uses.
- The public is generally unaware of the role forests play in protecting critical water supply assets and of the existing threats to water supplies in headwater regions.

Water Supply

Spatial analysis identified a priority landscape (PL) where water supply would benefit from forest management designed to protect or enhance water resources.

- High priority landscape (HPL) is concentrated in watersheds across the Sierra bioregion. Some watersheds in the Cascade Range also have a high concentration of HPL.

- Projected decreases in snowpack due to climate change are expected to affect the timing and distribution of runoff in watersheds throughout the Sierra bioregion.
- Restoration of mountain meadows offers an opportunity to improve the storage, groundwater recharge and timing of runoff in Sierra upper elevation watersheds.
- The Klamath/North Coast bioregion also has substantial water supply assets, but little storage capacity. These watersheds are predominately rain fed; the water supply impacts from climate change will likely be less dramatic than in the Sierra bioregion. Impacts in the Klamath Mountains are expected to be between those in the Sierra and those in the Coast Ranges.
- Groundwater basins in the Central Valley are an abundant resource heavily threatened due to over pumping.
- Watersheds in South Coast mountain ranges contribute to local municipality water supplies which reduces dependence on imported water from central and northern portions of the state.

Water Quality

The analysis identified locations where high value water assets in watersheds supporting a broad range of beneficial uses coincide with high risks that threaten water quality. The threat to water quality in a watershed was assumed to increase with the number of water quality stressors that are present.

- Water quality impairments from forests and rangelands are most pronounced in watersheds in the Klamath/North Coast bioregion. These watersheds are critical for recovery of state and federally listed anadromous salmonids.
- Watersheds in the Sierra bioregion include a mix of high and medium priority landscape based on an assessment of threats to water quality. The Lake Tahoe basin has the highest priority for watersheds in this region.
- The Central Coast and South Coast bioregio watersheds are mostly ranked as medium priorities. Forest health (see Chapter 2.2) and fire management practices greatly influence water quality conditions in these watersheds.

CURRENT STATUS AND TRENDS

Forested watersheds across California provide clean water that supports a broad range of beneficial uses. Nearly 85 percent of California's average annual runoff is produced from forested watersheds. Forests filter and meter the movement of rainfall, and at higher elevations the forest snowpack acts as a natural reservoir. The rainfall in turn, replenishes aquifers and delivers water to streams. Forest and rangeland vegetation and soils are valuable for absorbing snowmelt and rain, storing moisture, cooling and cleansing water, and slowing storm runoff. Physical and biological processes combine to create the ecological condition of a watershed and define the environmental services that the watershed can support. The natural variability of these processes in space and time gives rise to a diverse array of environmental conditions across a watershed. Over time, environmental conditions vary with disturbance from both natural sources and land management activities. Across California, water resources are under continued stress from multiple sources (Mount, 1995).

California Climate

Precipitation is highly variable by year although the trend line over 120 years of data is flat, showing no distinct trend (Figure 3.1.1). Significant temporal variations in rainfall for California extend from synoptic to intraseasonal, interannual, decadal and longer time scales. Mount (1995) provides a detailed discussion of the factors for this high variability in precipitation for any given year, including sea surface temperatures, El Niño and La Niña events, etc. Given the large variability, the chance of having average precipitation in a given year is extremely low. Water management in California is largely influenced by the highly variable precipitation.

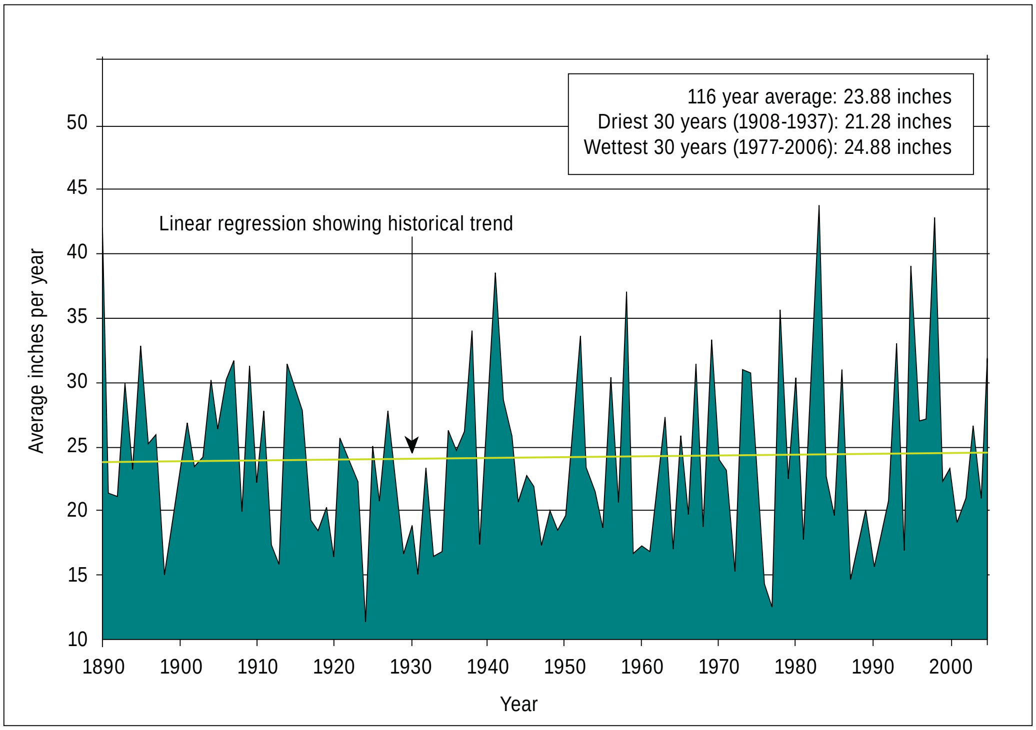


Figure 3.1.1.
Precipitation supporting California's water supply has high inter-annual variability, but the trend line has remained mostly flat over last 100 years.
Source: DWR, Division of Flood Management, 2009

Drought Conditions

As of 2009, California has experienced a third year of drought conditions. Statewide runoff has been approximately 60 percent of the historical average over the past three winters (2006–2007, 2007–2008, 2008–2009) (Department of Water Resources, 2009). In addition, groundwater withdrawals have been occurring at a deficit rate of one to two million acre feet per year. Impacts of drought include decreased availability of water for agriculture and environmental uses. In forested and other vegetated areas, prolonged drought decreases the moisture content of forest fuels and increases the risk of high severity wildfires. Prolonged drought also increases forest susceptibility to pests and can increase tree mortality. For additional information see http://www.water.ca.gov/drought/.

Climate Change

Climate change will likely adversely impact the ability of watersheds and ecosystems to deliver important ecosystem services. There is a broad range of climate change impacts that affect water resources in California (Table 3.1.1). These changes may limit the natural capacity of healthy forests to capture water and regulate stream flows. Peterson et al., (2008) report that Sierra Nevada mountain winters and springs are warming, and on average, precipitation as snowfall relative to rain is decreasing. A warming climate with reduced snowpack will result in earlier snowmelt and will subsequently reduce downstream water availability during summer and early fall.

Water Demand

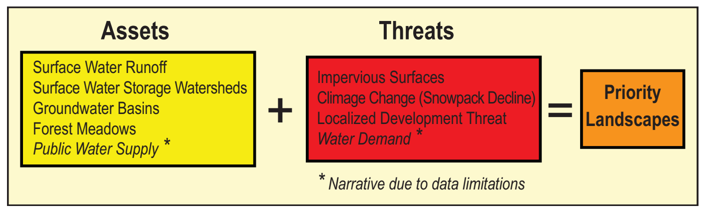
With California's increasing population, currently estimated at 38 million, the demand for water is growing while the supply remains static (Isenberg, 2009; Figure 3.1.2). This has placed a priority on water conservation. Following several consecutive dry years, California has begun to implement water conservation. Through the California Senate Bill No. 7 (2009) urban and agricultural lands have a targeted reduction in water use of 20 percent by 2020.

Table 3.1.1. Summary of climate change impacts on water resources

Resource	Type of Impact	Description
Sea Level	Direct	Sea level is rising and will likely impact coastal areas.
Soil Moisture	Direct	Prolonged dry seasons can lead to decreases in soil moisture; drier vegetation
Vegetation	Indirect	Longer and more intense fire season with increased extent or area burned.
Stream Conditions	Direct	Increases in water temperature; potential effects on fish
Snowpack	Indirect	Increases in temperature will lead to decreases in snowpack
Runoff	Direct	Warmer temperatures are likely to lead to a shift in peak runoff from spring to winter and a likely decrease in summer baseflow.
Hydropower	Indirect	Decreased summer flows resulting from earlier snowmelt and a shift in peak runoff could affect hydropower generation during summer months.
Precipitation	Direct	Warmer winter temperatures will result in a greater percentage of precipitation falling as rain rather than as snow.
Groundwater	Indirect	Reduction in snowpack and extended periods of drought are likely to increase dependency on groundwater.

Ecosystem – Conflicts and Constraints

The watersheds listed in Table 3.1.2 are important to California's water resources and represent current priorities for water management.



WATER SUPPLY

Analysis: Water Supply

A spatial analysis was conducted to identify a priority landscape (PL) where water supply would benefit from forest management designed to protect or enhance water resources. The analysis was based on a geographic information systems (GIS) model that combines threats and assets to produce a priority landscape (see diagram below). This model was used to evaluate threats to water supply assets. The evaluation of threats and assets contains data summaries at multiple watershed scales that are referred to as hydrologic unit codes (HUC). For additional information on watershed units and GIS procedures for ranking threats and assets see the Fire and Resource Assessment Program website (http://frap.fire.ca.gov/) and U.S. Geological Survey website (http://water.usgs.gov/GIS/huc.html).

Assets

Surface Water Storage Watersheds

Surface water storage watersheds are areas that contribute directly to one of the 150 major reservoirs monitored by the California Department of Water Resources (DWR) (http://cdec.water.ca.gov/cgi-progs/reservoirs/STORAGE). Catchment areas were delineated for all of these reservoirs using the Watershed Boundaries Database HUC12 watersheds. Each catchment area was then assigned the average volume of the reservoir it supplied. The catchments for water supply systems, such as the Feather River and the American River, were assigned the combined volume of all reservoirs within the system. These catchments were ranked high, medium and low according to the average reservoir storage volume (Figure 3.1.3).

The majority of the surface water storage watersheds lie in the upper elevations of the Cascade and Sierra Nevada mountain ranges. Many factors in headwater areas affect downstream water supply, water use and water quality. Fire management, land management,

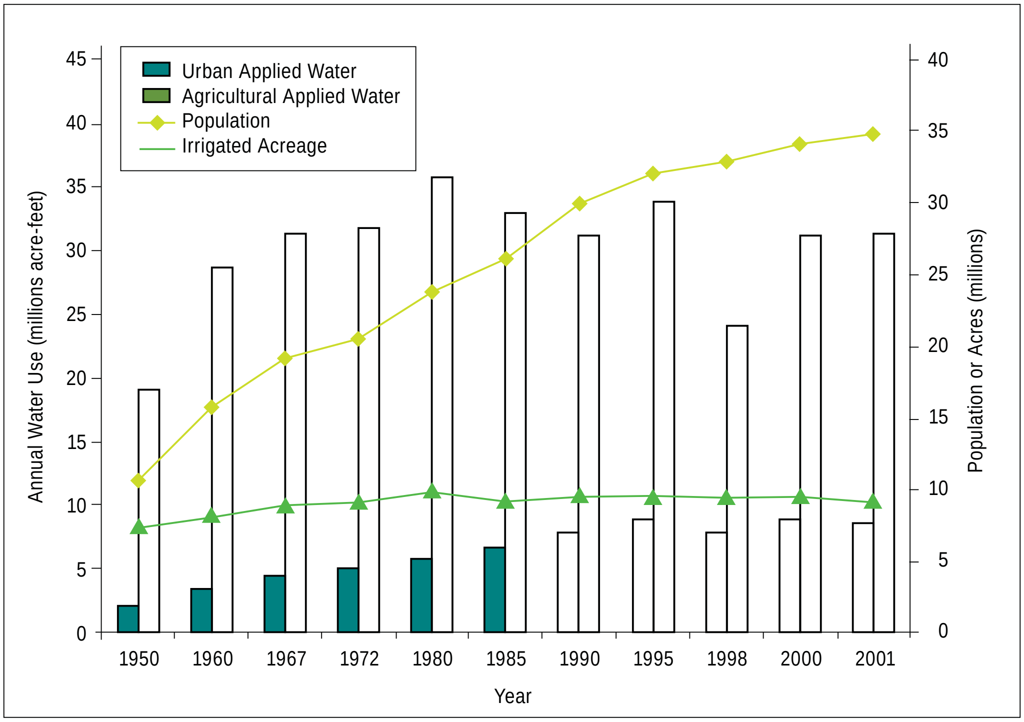


Figure 3.1.2.
Water demand: the relationship between water demand and population growth.
Data Source: Delta Vision Strategic Plan, Blue Ribbon Task Force, 2008

timber harvesting plans, watershed plans and conservancy plans all contribute to watershed health and downstream water supply. The many factors and many actors involved highlight the need for improving coordination between upstream and downstream interests.

Surface Water Runoff

Certain areas of the state rely on surface water runoff for water supply. These are areas with a significant amount of precipitation and thus a high amount of runoff. The data on mean annual runoff was obtained from the U.S. Geological Survey. Mean annual runoff was estimated for HUC 8 watersheds and represents average conditions over a 30 year time period (1970–2000).

Groundwater Basins

Groundwater basins are an important and often overlooked component of water supply in California. Much of the state, including the Central Coast, relies heavily on groundwater rather than surface water for its water supply. There are currently 431 groundwater basins delineated, underlying about 40 percent of the surface area of the state. Of those, 24 basins are subdivided into a total of 108 sub-basins, giving a total of 515 distinct groundwater systems in California (California Department of Water Resources, 2003).

The majority of groundwater used in California is stored in alluvial groundwater basins. In addition to withdrawals of groundwater for domestic, agricultural or industrial uses, groundwater basins also support the natural baseflow of streams during the dry summer months. In some locations the demand and withdrawal for groundwater exceeds the rate of recharge and leads to overdrafting. This has particularly been true for Central Valley basins over the past six years, due to both low precipitation for surface runoff and reduced allocations of river water for Central Valley farmers. The volume pumped for agriculture, cities and industry is not believed to be sustainable if current trends continue.

Table 3.1.2. Current high priority water management issues

Watershed	Bioregion	Water Resource Issue(s)	Resources
Delta	Bay/Delta	An immense estuary spanning 1300 square miles that drains the Sacramento and San Joaquin watersheds; water delivery for Southern California flows through the Delta; conflict between water supply and ecosystem health.	www.deltavision.ca.gov
Sacramento River	Sacramento Valley	Primary river that originates near Mount Shasta and flows through the Central Valley and eventually empties into the delta; historically supported significant salmon runs.	www.sacriver.org
San Joaquin River	San Joaquin Valley	Primary river originating in the high southern Sierra before flowing to the delta near Stockton; historically supported significant salmon runs; conflict over water diversions for agriculture and restoring flows to support salmon runs.	www.restoresjr.net
Klamath	Klamath / North Coast	Large watershed originating in Southern Oregon and crossing through Northern California before draining to the ocean; declining salmonid fish populations, tribal water rights, and water quality impairments have constrained water management options and left the watershed impaired. A recent settlement proposes to remove four large dams as part of a fisheries restoration plan.	
Lake Tahoe Basin	Sierra	This deep Sierra lake is renowned for its clear waters, development pressures, historic timber harvesting, and recreational opportunities. Vehicle emissions, wood smoke, road dust, and development related erosion and runoff contribute to water quality impairment. Fire management and current forest stand conditions in the basin also threaten water quality.	www.tahoescience.org; www.waterboards.ca.gov/lahontan
Colorado River	Colorado Desert	Threats to this ecosystem are numerous. Dams created for irrigation and residential use have altered the water flow blocking migratory paths for fish, and changed water temperatures. Very little of the Colorado River actually flows to the Gulf because much of it is diverted to Arizona and Southern California for residential and irrigation needs. Drought conditions and increased population have amplified the water shortage issue and water disputes have developed as water demands exceed the supply available from the Colorado River.	
Coastal Rivers	Klamath / North Coast; Central Coast	Recovery of 303(d) listed impaired waterbodies for sediment and temperature; recovery of state and federally listed salmonid species	www.swr.nfms.noaa.gov; www.swrcb.ca.gov
Coastal Rivers	Klamath / North Coast; Central Coast	Recovery of 303(d) listed impaired waterbodies for sediment and temperature; recovery of state and federally listed salmonid species	www.swr.nfms.noaa.gov; www.swrcb.ca.gov

Using groundwater basins from DWR and monitoring data from the State Water Resources Control Board (SWRCB), groundwater basins were classified based on use and vulnerability (Figure 3.1.4).

Forest Meadows

Forest meadows in California are mostly found in the higher elevations within the Sierra bioregion. Meadows comprise approximately 10 percent of the land area in the Sierra. Forest meadows play an important role in water supply and quantity, acting as a natural water storage device, holding water and regulating flows in high elevations. They are often located in the upper part of the watershed and can act as a type of sponge, in that they can hold water and slowly release it over time. As snowpack is reduced due

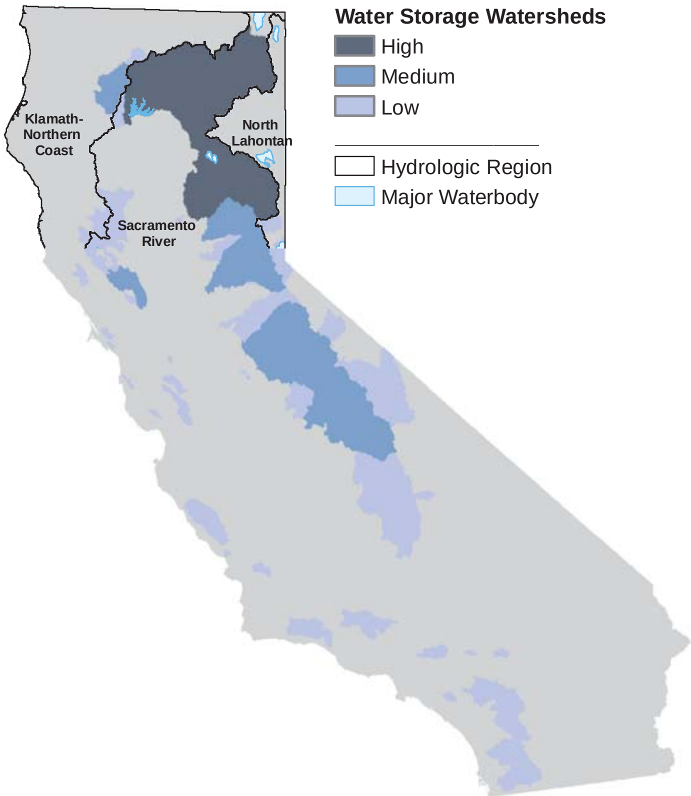


Figure 3.1.3.
Ranking of water supply watersheds. The ranking is based on reservoir storage capacity.
Data Sources: Watershed Boundaries Database for California, NRCS (2009); Monthly Storage in Major Reservoirs, DWR (2009); National Inventory of Dams (NID), U.S. Army Corps of Engineers (2009)

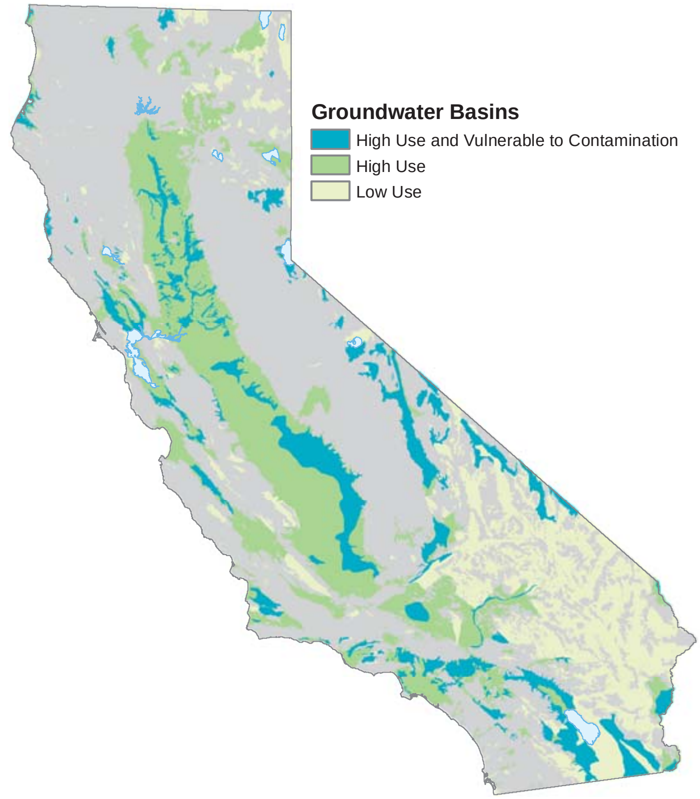


Figure 3.1.4.
Watershed ranking of groundwater basins.
Data Sources: State Water Resources Control Board (2000); DWR Bulletin 118 (2003); USGS (2003)

to climate change, forest meadows may play a more important role in California's water supply. Historically, mountain meadows have been an important resource to Native Americans and currently provide forage for grazing. Meadows provide the bulk of forage on Sierra grazing allotments.

California's montane meadows have been significantly stressed and altered by external pressures for over 100 years. Livestock grazing became widespread in the Sierra during the gold rush era in the mid-1800s and continues through present time. Grazing can have a number of adverse effects on meadows such as defoliation, trampling and soil compaction, mineral redistribution and the introduction of invasive vegetation (Ratliff, 1985). Grazing management practices can be compatible with meadow health if it is restricted to light use, conditions are monitored regularly and include a restoration component (Ratliff, 1985). Other meadow stresses can come from rodent activity, lodgepole pine invasion, erosion and water channeling. Many of these issues are related, and all are accelerated by livestock overgrazing. Meadows have also been stressed by development, road or culvert construction, dams and diversions, homesteading, recreational hiking, camping and fishing. During the peak logging era, they were even a common and convenient site for building railroad beds. Once a meadow has been altered by these pressures its relationship to fire is also changed. Hotter, more devastating fires are more likely in compromised meadows. These types of fires tend to burn mulch and peat, and create sediment deposits that alter the natural state of the meadow even further (Ratcliff, 1985).

As people begin to recognize the benefits of mountain meadows, more effort has been directed towards restoring and reclaiming affected meadows and properly managing meadows in order to enhance their ecological benefits. The results have been positive. The U.S. Forest Service has estimated that there could be an increase of 50,000 to 500,000 acre-feet of groundwater storage per year with proper meadow restoration just within national forest lands in the Sierra bioregion alone (DWR, 2009). Currently California relies heavily on snowpack as its main water source, but as climate change alters the precipitation and snow patterns, meadows may be relied upon more heavily to act as natural water storage.

Forest meadows were evaluated using data from CALVEG and U.S. Forest Service (USFS) vegetation mapping programs. Forest meadows were identified by using all of the meadows mapped by the USFS and located in the Region 5 GIS database. The USFS montane meadow data only includes meadows within USFS lands in the Sierra. To identify montane meadows outside of the USFS dataset, all meadow-related WHR types above 4,000 feet elevation and not mapped as having a land use type of urban or developed, were extracted from the CAL FIRE vegetation database. The CAL FIRE vegetation database is largely based on USFS CALVEG maps. The two datasets were combined, and overlayed with HUC 12 watersheds. The percentage of meadows within each watershed was calculated, and then each watershed was ranked based on the percentage of meadow within the watershed (Figure 3.1.5).

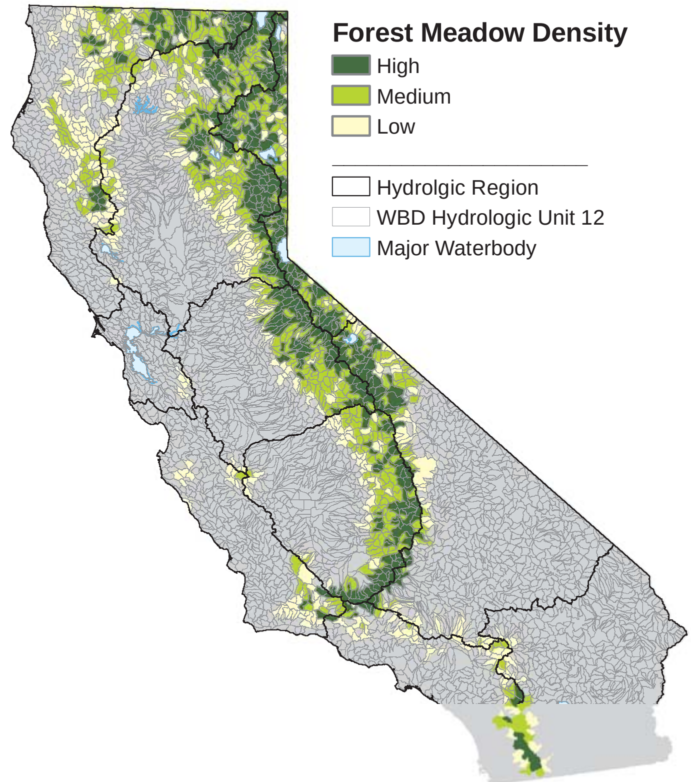


Figure 3.1.5.
Watershed ranking of the density of forest meadows.
Data Sources: Sierra Nevada Montane Meadows, USFS R5 (2000); Statewide Land Use / Land Cover Mosaic, FRAP (2006); Watershed Boundaries Database for California, NRCS (2009)

Composite Assets

Surface water runoff, surface water storage watersheds, groundwater basins and forest meadows were combined to produce the composite landscape for both surface water supply and groundwater assets. The highest ranked assets for surface water supply tend to originate in the North Coast and Sierra watersheds, while the greatest utilization of groundwater resources occurs in Central Valley and other agricultural valleys (Table 3.1.3).

Threats

Disturbance in a watershed comes from both natural events (e.g., intense precipitation, large floods, severe wildfires, earthquake and storm induced mass wasting, etc.) and from land management activities (e.g., mining, grazing, road building, timber harvest, vegetation management activities, developed recreation sites, off-highway vehicle use, etc.). Understanding the timing and frequency of disturbance events places the magnitude from any single event into a watershed perspective (Naiman et al., 1998; Benda, 1998). Stream channels typically exhibit a wide variety of morphologies that result in a broad array of stream types throughout a watershed. Channel classification is performed to take the continuum of conditions that are found in a stream system and group channel segments by function and form. Stream order is one of the commonly used channel classification systems. Stream order correlates with drainage area and can serve as a proxy for stream size. In the Strahler stream order classification system, two first order channels will combine to form a second order channel, second order streams combine to make third order streams, and so on (Strahler,

Table 3.1.3. Watersheds with the highest composite assets to water supply

Sub-basin Name (HUC 8)	Sub-basin Total Square Miles	Percent High	Percent Med	Percent Low	Percent High-Med[1]	Composite[2]
Upper Pit	2,681	100.0	0.0	0.0	100.0	100.0
Lower Pit	2,638	100.0	0.0	0.0	100.0	100.0
McCloud	681	100.0	0.0	0.0	100.0	100.0
Sacramento Headwaters	592	100.0	0.0	0.0	100.0	100.0
North Fork Feather	1,212	100.0	0.0	0.0	100.0	100.0
East Branch North Fork Feather	1,028	100.0	0.0	0.0	100.0	100.0
Middle Fork Feather	1,365	100.0	0.0	0.0	100.0	100.0
North Fork American	1,013	100.0	0.0	0.0	100.0	100.0
South Fork American	850	100.0	0.0	0.0	100.0	100.0
Upper San Joaquin	1,639	100.0	0.0	0.0	100.0	100.0
Upper King	1,544	100.0	0.0	0.0	100.0	100.0
South Fork Kern	981	99.6	0.4	0.0	100.0	99.8
Upper Kern	1,092	97.3	2.7	0.0	100.0	98.6
Battle Creek–Sacramento River	563	94.1	5.9	0.0	100.0	97.1
Butte	596	94.0	5.6	0.4	99.6	96.9
Lost	1,719	90.2	9.8	0.0	100.0	95.1
Upper Yuba	1,345	85.2	14.7	0.1	99.9	92.6
Crowley Lake	1,854	83.3	16.5	0.2	99.8	91.6
Upper Tuolumne	1,873	82.6	17.0	0.3	99.7	91.2
Upper Stanislaus	1,197	82.0	17.9	0.1	99.9	91.0
Upper Merced	1,269	81.8	17.3	0.9	99.1	90.7
Lower American	293	79.4	20.6	0.0	100.0	89.7
Upper Bear	474	77.6	22.1	0.3	99.7	88.7
Applegate	91	77.2	22.8	0.0	100.0	88.6
Putah Creek	654	81.4	7.3	11.4	88.6	87.8
East Walker	504	71.0	27.9	1.1	98.9	85.2
Upper Klamath	852	64.5	35.5	0.0	100.0	82.3
Lake Tahoe	371	64.3	35.7	0.0	100.0	82.2
Truckee	432	62.4	37.6	0.0	100.0	81.2
Upper Calaveras California	529	63.2	32.3	4.5	95.5	80.4
Middle Fork Eel	753	57.6	42.4	0.0	100.0	78.8
Upper Eel	709	53.9	46.1	0.0	100.0	76.9
San Pablo Bay	1,226	53.7	45.6	0.7	99.3	76.7

[1] Percent High-Med = Percent High + Percent Medium
[2] Composite = (Percent High) + (Percent Medium) x 0.5 + (Percent Low) x 0.25

1957). In general, low order streams experience less frequent disturbance, but at a higher magnitude. Higher order streams drain larger catchment areas and thus integrate environmental conditions. This factor results in more frequent occurrence of disturbance, but of a lesser magnitude. The degree of disturbance in a watershed can be influenced by both the continuing impacts from historic management practices and impacts from current management activities.

The analysis used three indicators to model threat to water supply: impervious surfaces, future development, and climate change (snowpack change). Of the factors affecting water supply declining snowpack was considered the most significant threat and has a greater influence in the resulting priority landscape.

Impervious Surfaces

A high degree of imperviousness can negatively impact water quality and limit groundwater recharge. Land use decisions affecting recharge areas can reduce the amount of groundwater in storage. In many basins, little is known about the location of recharge areas and their effectiveness. Protection and preservation of recharge areas are seldom considered in land use decisions. If recharge areas are altered by paving, channel lining or other land use changes, available groundwater will be reduced (DWR, 2003). A GIS layer representing impervious surfaces was used to represent impacts from the current footprint of development. It should be noted that this analysis looks at impervious surfaces over the entire landscape, not just recharge areas. A more refined analysis would separate out recharge areas for special consideration.

Localized Development Threat

Developed areas that were previously forested or rangeland have a limited capacity to capture and promote infiltration and allow groundwater recharge. Disturbance from development modifies the natural pathways of water across the watershed. The decrease in tree cover reduces the rate at which rainfall is intercepted. As infiltration is decreased, surface runoff and the delivery of rainfall to watercourses are accelerated, in turn accelerating channel erosion and gullying.

To prioritize threatened landscapes, watersheds with threats from development were identified in Chapter 1.1 (Figure 1.1.3). The GIS data layer for this analysis uses the projected areas of development, defined in Chapter 1.1, as well as existing areas of development. The GIS analysis displays the percent of each HUC 8 watershed in development or expected development.

Climate Change (Snowpack Decline)

Higher temperatures are expected to bring dramatic changes to California's snowpack and forest hydrology in Sierra watersheds (Peterson et al., 2008). The decline in snowpack is expected to reduce current snowpack by up to 90 percent by 2100 (Anderson, 2008; Mote, 2005). Higher temperatures are likely to have several effects that include:

- Increasing the amount of precipitation falling as rain rather than snow,
- Accelerating the rate of spring snowmelt, and
- Shortening the duration of snow accumulation in mountain watersheds, leading to earlier seasonal runoff and a decrease in summer baseflow.

The objective of this threat layer was to highlight areas that presently support a snowpack, but are expected to experience a declining snowpack under future climate change scenarios (Figure 3.1.6). The analysis highlights watersheds that are likely to shift from snow-dominated hydrology to more rain-based systems. The extent of snowpack was represented using snow water equivalent data developed for the A2 emissions scenario using the Global Fluid Dynamics Laboratory global climate model (Cayan et al., 2006; Cayan et al., 2008). The climate emissions scenario (A2) represents a medium-high emissions scenario with continuous population growth, slower adaptation of technological change, and an increase in carbon dioxide (CO2) that reaches four times the present rate by the end of the century (Cayan et al., 2006). The decline in snowpack was represented by the percentage change over the following future time intervals: 2020, 2050 and 2100. The greatest decline in snowpack is expected in the northern and central Sierra, as well as portions of the Cascades.

Composite Threats

Individual threat layers were combined to represent a composite landscape for threats to water supply. Results were summarized by watershed units (WBD, HUC 8).

Table 3.1.4 lists watershed with the highest composite threat to water supply. Many watersheds had a composite threat rank of over fifty percent. These watersheds tend to be mid to upper watersheds located in the North Coast, Cascade and Sierra regions. These areas have seen an expansion of the wildland urban interface (WUI) which has increased development in fire prone areas. They are also expected to see decreases in snowpack.

Many watersheds had over fifty percent medium ranked threat. These watersheds were predominantly in the North Coast, Cascade and Sierra regions. These areas have seen an expansion of the WUI

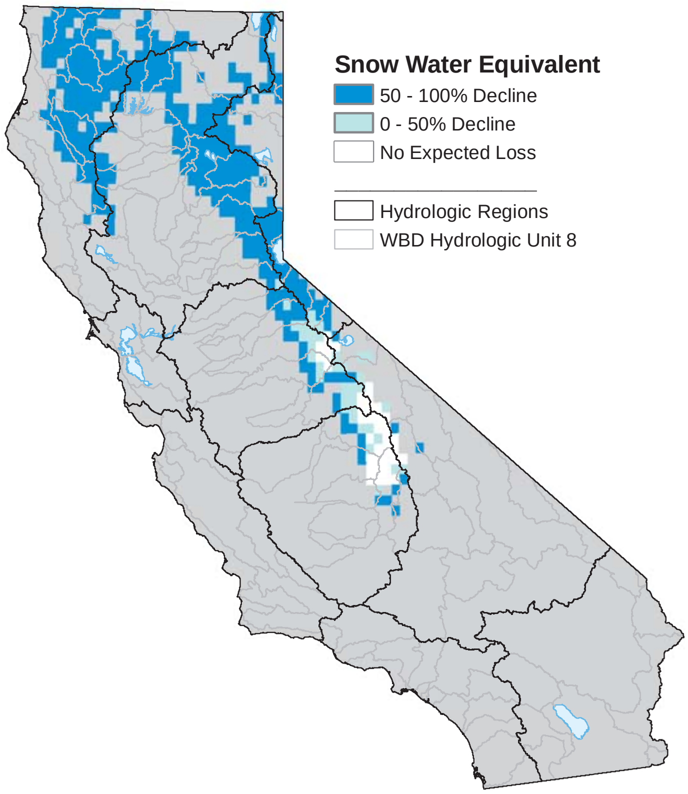


Figure 3.1.6.
Expected changes in April 1 snowpack from 2010 through 2100. The results show significant decreases occurring lower mountain elevations throughout the northern and central Sierra Nevada and Klamath Mountains. The higher elevations of the southern Sierra showed the greatest retention in snowpack.
Data Sources: Climate Change Scenarios and Sea Level Rise Estimates for California, California Energy Commission (2009); Watershed Boundaries Database for California, NRCS (2009)

which has increased development in fire prone areas. They are also expected to see decreases in snowpack.

Results

Combining the composite asset layer with the composite threat layer created a priority landscape layer for water supply. The high priority landscape (HPL) identifies locations where high value water supply coincides with high threats and thus represents areas where stewardship projects are most needed. The results are shown in Figure 3.1.7 and summarized in Table 3.1.5.

Discussion

The results of this analysis suggest that basins in the Northern Sierra and Cascades are facing increasing threats and represent a high priority for water supply. The majority of the forested basins across the Sierra were identified as high priority. Threats from wildfire and development are both substantial in these basins. In addition the threat of diminishing snowpack expected under future climate change scenarios is expected to have significant effect on the hydrology of these watersheds.

Bioregional Findings

- The Sierra bioregion has the greatest concentration of high priority landscape. The watersheds in this region contribute greatly to the state's water supply. They are under threat from climate change, wildfire and development.
- The Klamath/North Coast bioregion has substantial water supply assets. These watersheds are predominately rain-dominated systems; the water supply impacts from climate change are projected to be less dramatic, with the exception of higher elevation areas in the Klamath Mountains.
- Groundwater basins in the San Joaquin Valley and Sacramento Valley bioregions are an abundant resource that is heavily threatened by over pumping.

WATER QUALITY

This section evaluates threats and assets to water quality in California's predominately forested and rangeland watersheds. The analysis identifies locations where watersheds supporting a broad range of beneficial uses and high value water assets coincide with high risks that threaten water quality. (The Forest Management Strategy in the State Water Plan (http://www.water.ca.gov) presents a comprehensive treatment of water resources in California.)

Water quality impacts from forest management can affect a broad range of environmental processes that include: hillslope erosion, stream sedimentation, lack of instream large woody debris (an important fish habitat element in many streams), increased water temperature and hydrologic impacts (higher peak flows and reduced low flows). Some of these water

Table 3.1.4. Watersheds with highest composite threats to water supply

Sub-basin Name (HUC 8)	Sub-basin Total Sq. Miles	Percent High	Percent Medium	Percent Low	Percent High-Med[1]	Composite[2]
Truckee	432	100.0	0	0	100.0	100.0
Salmon	751	100.0	0	0	100.0	100.0
Upper Carson	453	93.3	0.1	0.1	93.5	93.4
East Branch North Fork Feather	1,028	89.8	0.0	0.3	89.8	89.9
South Fork Trinity	932	88.9	0.1	0.6	89.0	89.1
McCloud	681	86.1	0.0	0.4	86.1	86.2
Lake Tahoe	371	83.1	1.7	0.2	84.9	84.1
Trinity	2,038	80.7	0.3	1.0	81.0	81.1
North Fork Feather	1,212	80.3	0.2	2.2	80.5	81.0
Scott	814	76.3	0.1	1.0	76.4	76.6
West Walker	409	54.6	27.0	0.5	81.6	68.2
Lower Klamath	1,527	67.2	0.1	1.2	67.3	67.6
Sacramento Headwaters	592	66.2	0.1	1.5	66.2	66.6
Middle Fork Feather	1,365	55.3	0.2	3.2	55.4	56.2
Lower Pit	2,638	55.5	0.2	1.9	55.7	56.0
Upper Klamath	852	53.7	0.1	2.4	53.8	54.3
Upper Yuba	1,345	49.2	1.7	7.2	50.9	51.9
North Fork American	1,013	48.2	3.0	5.7	51.2	51.1
Middle Fork Eel	753	48.5	0.1	1.8	48.7	49.0

[1] Percent High-Med = Percent High + Percent Medium
[2] Composite = (Percent High) + (Percent Medium) x 0.5 + (Percent Low) x 0.25

quality impacts may also occur on rangelands, along with the possible addition of nutrients from animal waste. The following section provides a brief discussion of the major stressors that management actions can place on water quality.

Background

Stressors on Water Quality

Table 3.1.6 summarizes common water quality stressors in forested watersheds. See State Water Plan (Resource Management Strategies) for additional information of forest management and water quality.

Water Quality Status in California (303d and 305b report)

Operating under authorities from the California Water Code and the state Porter-Cologne Act, the State Water Resources Control Board has primary responsibilities for addressing water pollution and water quality issues in California. Reporting on the conditions of water quality is mandated under section 305b of the federal Clean Water Act. The most recent 305b report for California (2006) indicates that a majority of the California's waters are in fair or good condition based on biotic indicators of water quality (Table 3.1.7). Two biotic indicators were used. The O/E index is a ratio of the taxa observed at a site (O) to those that are expected (E) to occur in the absence of human disturbance. The Benthic Index of Biotic Integrity, which uses counts of macro-invertebrates as a proxy for water quality, was used as a second index (Ode et al., 2005).

Under section 303(d) of the Clean Water Act, the State Water Resources Control Board (SWRCB) and its nine Regional Water Quality Control Boards (RWQCBs) are required to maintain a list of impaired waterbodies. Updated every two years, the 2002 list of impaired waterbodies estimated that California has over 26,000 miles of impaired streams, about 14 percent of the total miles of streams and rivers in California. The current list (2006) shows very little change in the amount of impaired waterbodies associated with silviculture and agriculture.

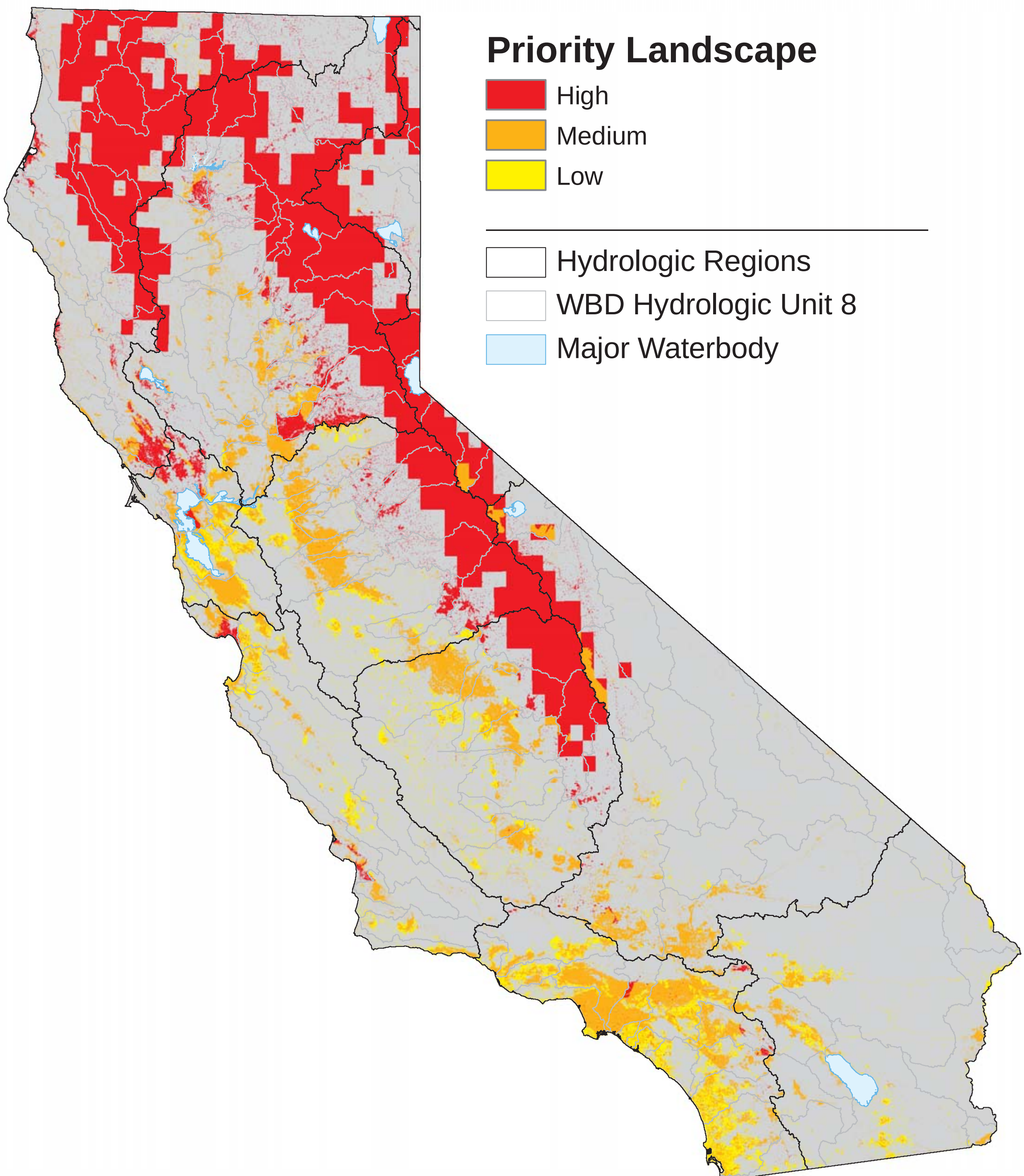


Figure 3.1.7.
Priority landscape for water supply.
Data Sources: Groundwater Basins, DWR (2009); Watershed Boundaries Database for California, NRCS (2009); National Hydrography Dataset, USGS (2009); USGS National Land Cover Dataset (2001); Sierra Nevada Montane Meadows, USFS R5 (2000); Statewide Land Use / Land Cover Mosaic, FRAP (2006); Climate Change Scenarios and Sea Level Rise Estimates for California, California Energy Commission (2009); ICLUS, U.S. Environmental Protection Agency (2009); National Inventory of Dams (NID), U.S. Army Corps of Engineers (2009); Monthly Storage in Major Reservoirs, DWR (2009); Thornthwaite Water Balance Model, USGS (2007); PRISM Climate Data, Oregon State University (2000); Commission on Local Governance for the 21st Century (2000)

Table 3.1.5. Summary of the priority landscape for water supply

Basin Name (HUC 6)	Sub Basin (HUC 8)	Basin Total Sq. Miles	Percent High Priority	Percent Medium Priority	Percent Low Priority
Black Rock Desert	Smoke Creek Desert, Massacre Lake	203	29.2	0.1	0.3
Carson	Upper Carson	453	93.3	0.2	0.0
Central California Coastal	San Lorenzo, Soquel, Pajaro, Carrizo Plain, Estrella, Salinas, Central Coastal, Cuyama, Santa Maria, San Antonio, Santa Ynez, Alisal, Elkhorn Slough, Carmel, Santa Barbara Coastal	11,300	1.1	6.6	6.1
Central Nevada Desert Basins	Fish Lake, Soda Spring Valley, Ivanpah Valley, Pahrump Valley	1,155	0.0	0.5	1.1
Klamath	Lost, Butte, Klamath, Shasta, Scott, Salmon, Trinity	10,023	61.7	0.8	0.1
Laguna–San Diego Coastal	Aliso, San Onofre, Santa Margarita, San Luis Rey, Escondido, San Diego, Cottowood, Tijuana	3,861	0.7	16.4	22.1
Lower Colorado	Havasu–Mohave Lakes, Piute Wash, Imperial Reservoir, Colorado	3,826	0.0	2.3	2.4
Lower Sacramento	Sacramento, Stone Corral, American, Stony, Cache, Feather, Yuba, Bear, Clear, Cow, Cottonwood, Battle, Paynes, Thomes, Big Chico, Butte, Honcutt, Auburn Ravine, Coon, Putah, Cache Slough	20,125	32.6	7.6	0.3
Mono–Owens Lakes	Mono Lake, Crowley Lake, Ownes Lake	4,188	18.6	8.2	0.0
North Lahontan	Suprise Valley, Madeline Plains, Honey Lake, Eagle Lake	3,704	33.5	1.1	0.0
Northern California Coastal	Smith, Mad, Redwood, Eel, Mattole, Big, Navarro, Garcia, Gualala, Salmon, Russian	9,242	20.1	4.4	0.0
Northern Mojave	Eureka–Saline Valleys, Amargosa, Death Valley, Panamint Valley, Indian Wells, Searles Valley, Antelope Valley, Fremont Valley, Coyote–Cuddeback Lakes, Mojave	21,330	0.3	4.8	1.0
Oregon Closed Basins	Warner Lakes	43	19.4	0.5	0.0
Salton Sea	Whitewater River, Carrizo Creek, San Felipe Creek, Salton Sea	7,164	0.0	5.2	4.3
San Francisco Bay	Suisun Bay, San Pablo Bay, Coyote, San Francisco Bay, Tomales Bay, Drakes Bay, South San Francisco Coastal	4,516	6.1	20.6	9.6
San Joaquin	San Joaquin, Chowchilla, Merced, San Joaquin Delta, Fresno, Tuolumne, Stanislaus, Calaveras, Mokelumne, Cosumnes, Panoche, San Luis Resevoir, Rock, French Camp Slough	15,825	22.0	10.0	3.8
Santa Ana	Seal Beach, San Jacinto, Santa Ana, Newport Bay	2,706	1.4	34.8	17.3
Southern Mojave	Southern Mojave	8,867	0.0	1.6	2.5
Southern Oregon Coastal	Applegate, Illinois, Chetco,	168	87.8	0.5	0.0
Truckee	Lake Tahoe, Truckee River	803	93.1	0.0	0.0
Tulare–Buena Vista Lakes	Kern, Tehachapi, Grape, Poso, Deer, White, Tule, Kaweah, Dry, King, Tulare Lakes, Buena Vista Lakes	16,414	15.2	10.2	4.9
Upper Sacramento	Goose Lake, Pit, McCloud, Sacramento Headwaters	6,955	48.9	0.0	0.0
Ventura–San Gabriel Coastal	Ventura, Santa Clara, Calleguas, Santa Monica Bay, Los Angeles, San Gabriel	4,383	0.8	32.2	12.3
Walker	Walker River	913	54.2	11.9	0.0

Table 3.1.6. Summary of water quality stressors in forested watersheds

Stressor	Cause(s)	Primary Response	Secondary Response	Type
Sediment	Hillslope erosion; land disturbance (silviculture, agriculture, etc.); road erosion	Delivery of fine sediment to streams; delivery of sediment from mass wasting associated with the road prism.	Effect spawning gravels; channel morphology; effect stream turbidity	Chronic and Episodic
Stream Temperature	Forest management; agriculture and other land uses	Stream shading; large woody debris	Changes in temperature affecting coldwater fish; change in aquatic habitat	Chronic and Episodic
Nutrients	Land management; wildfires	Increase concentration of nitrogen and phosphorus	Raise nutrient loadings in lakes and streams	Chronic and Episodic
Contami-nants	Land management	Water contamination from application of herbicides, pesticides, or fuel spills	Effects on riparian habitat and aquatic organisms	Episodic

Table 3.1.7. Summary of water quality conditions based on biotic indicators for perennial streams in California

Indicator	Percent Non-Impaired	Percent Impaired
Statewide		
Macroinvertebrate IBI	78	22
Macroinvertebrate O/E	67	33
North Coast		
Macroinvertebrate IBI	94	6
Macroinvertebrate O/E	60	40
South Coast		
Macroinvertebrate IBI	66	34
Macroinvertebrate O/E	67	33

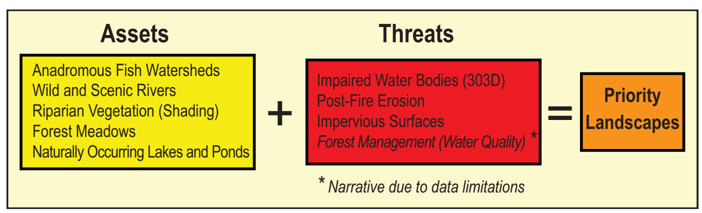
Data Source: State Water Resources Control Board 305b Report (http://www.waterboards.ca.gov/water_issues/programs/tmdl/305b.shtml)

Impairment information for RWQCB basins provides a description of the cause of pollution that results in impairment. Most watercourses have many different potential causes (Table 3.1.8).

Due to differences in how each RWQCB defines impairment, listing whole watersheds versus individual stream segments, it is difficult to assess regional differences in water quality. Impaired waterbodies with silviculture and rangeland activities occur in the North Coast, Central Coast, Central Valley and Lahontan RWQCB regions (Table 3.1.9). For example, over 60 percent of the impaired water bodies in the North Coast list silviculture as one of the causes of pollution. Rangeland grazing activities are one listed cause of impairment on approximately 40 percent of the impaired waterbodies in the Lahontan Regional Water Quality Control Board region, a significant portion of which is in the Sierra region.

Analysis: Water Quality

A GIS based model was developed to evaluate water quality threats and assets (see below). The goal of the analysis was to identify priority watersheds where high value assets (i.e., watersheds supporting a broad range of beneficial uses) are at risk due to water quality threats.



Assets

Anadromous Fish Watersheds

All watersheds support a variety of beneficial uses. These uses are protected by law (see Water Code 13050(f)) against water quality degradation. This analysis used anadromous salmonid watersheds as a proxy for beneficial uses because, in addition to supporting salmonids through cold freshwater habitat, they tend to support a broad range of other beneficial uses. The ranking of watersheds considered both the current and historic extent of salmonids (Figure 3.1.8). For current extent, a GIS layer was developed based on the intersection of watershed boundaries and evolutionary significant units (ESUs) that have

Table 3.1.8. Summary of water quality impairments from 2006 303d list

General Pollution Source	Lakes and Reservoirs	Freshwater Wetlands	Bays and Harbors	Estuaries	Saline Lakes	Rivers and Streams
	Surface Area (Acres)					Miles
Rangeland	108,708		1,922	199		8,002
Agriculture (non-range)	24,688	73,597	159,901	94,758	291,761	9,844
Atmospheric Deposition	109,492		269,224	47,393		87
Construction/Land Development	88,255	62,590	1,922	716	58,421	6,540
Habitat Modification	88,142		2,001	2,934		19,520
Hydromodification	88,362		10,546	199	97,499	14,716
Industrial and Municipal Wastewater	20,868		510,674	97,818	263,551	5,148
Land Disposal	23,436		12,906	1		1,587
Marinas and Recreational Boating	108,682		2,637			
Natural Sources	143,596	62,590	271,146	49,838	98,164	8,135
Resource Extraction	102,982		279,767	91,007		6,672
Silviculture	106,068					13,344
Source Unknown	83,548	11,007	288,726	89,566	72,581	6,889
Urban Runoff	110,538		4,757	47,401		2,294

Data Source: State Water Resources Control Board, Total Maximum Daily Load Program

Table 3.1.9. Impaired miles of streams

RWQCB Region Number	Region Name	Total Miles Impaired Stream	Percent Impaired due to Rangeland Grazing	Percent Impaired due to Silviculture
1	North Coast	19,917	38	66
3	Central Coast	1,050	6	8
5	Central Valley	1,612	10	1
6	Lahontan	318	42	32

Data Source: State Water Resources Control Board, Total Maximum Daily Load Program

been defined by the National Ocean and Atmospheric Administration National Marine Fisheries Service (NMFS). The historic extent of salmonids was identified based on intrinsic potential data (IP) developed by NMFS. The IP data used geomorphic data and other environmental constraints to determine conditions that historically were likely to support salmonids. Using data on current extent and historic distribution, watersheds were ranked as shown in Figure 3.1.8. Under this ranking scheme watersheds that currently support salmonids were given the highest rank.

Wild and Scenic Rivers

Wild and Scenic Rivers are federal and state designations that protect free flowing rivers that possess remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural or other similar values. These rivers contain a range of beneficial uses including recreation and fish habitat. The GIS layer for Wild and Scenic Rivers was developed based on the intersection of watershed boundaries (WBD HUC8) and rivers recognized as Wild and Scenic by state and federal agencies.

Riparian Vegetation (Shading)

This asset layer was used to identify intact riparian areas with tree cover that has the potential to moderate stream temperatures (Figure 3.1.9). Riparian forests were estimated by creating a riparian buffer around perennial and intermittent streams defined from a statewide stream layer (i.e., National Hydrography Dataset, 1:24,000). The riparian buffer was then intersected with a statewide vegetation layer (i.e., National Land Cover Database).

Forest Meadows

Methodology for developing this asset is discussed in the previous section (Figure 3.1.5).

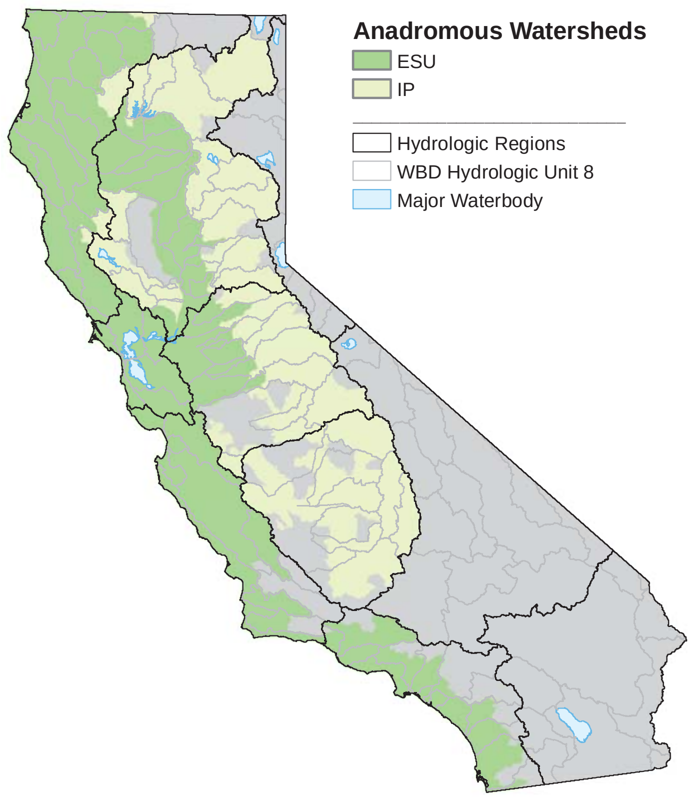


Figure 3.1.8.
Watersheds supporting salmonids where current range is the Evolutionary Significant Unit (ESU) and potential range from an Intrinsic Potential (IP) model. Salmon watersheds were used as a proxy for beneficial uses.
Data Sources: Watershed Boundaries Database for California, NRCS (2009); Evolutionary Significant Units (ESU) for Coho, Chinook, and Steelhead in California, NMFS (2006); Historic Range for Salmonids in California, NMFS (2003)

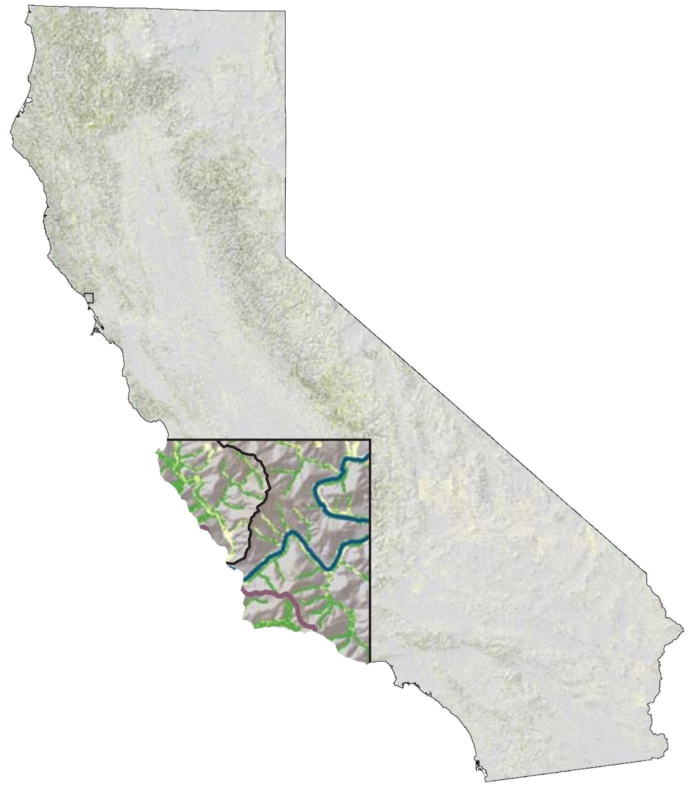


Figure 3.1.9.
Percentage of riparian cover by HUC8 watersheds.
Data Sources: National Hydrography Dataset (NHD), USGS (2009); National Land Cover Dataset, USGS (2001)

Naturally Occurring Lakes and Ponds

Freshwater lakes support a broad range of beneficial uses that can contribute to both water quality and water supply. This asset layer was used to represent natural lakes in California. The data is a subset of the National Hydrography Waterbodies dataset. It was created by limiting the waterbodies dataset to only include lakes and ponds. The lakes and ponds in this data layer correspond to features that would be identified on a U.S. Geological Survey 1:24,000 topographic map.

Composite Assets

An overlay of the water quality assets layers was performed to create the composite asset layer. Assets related to water quality were combined with equal weights for:

- Anadromous Fish Watersheds
- Wild and Scenic Rivers
- Riparian Vegetation (Shading)
- Forest Meadows
- Naturally Occurring Lakes and Ponds

The composite asset layer shows water quality assets were ranked highest in watersheds along the North Coast, along with watersheds in the Sierra. The data used for these ranking places an emphasis on assets for forest and rangeland watersheds and should not be used to infer conditions across all state lands. In addition, monitoring data is generally lacking to identify watersheds that maintain good water quality conditions. Instead, the emphasis is typically placed on monitoring impaired waterbodies.

Threats

There are a number of stressors that can impair water quality. The following threat layers are being used in the GIS-based model to represent threats to water quality.

Impaired Waterbodies (303d)
Information on water quality impairments was derived from the EPA's 303(d) list for California which is developed by the Total Maximum Daily Load Program of the State Water Quality Control Board. For this analysis a data layer was created that summarized causes of impairment by HUC 10 watershed units (Figure 3.1.10). The ranking applied to the HUC 10 watershed units assumes that more causes, or stressors, per watershed implies a higher level of impairment. For additional information on water quality conditions in California see the State Water Resources Control Board's website (http://www.swrcb.ca.gov).

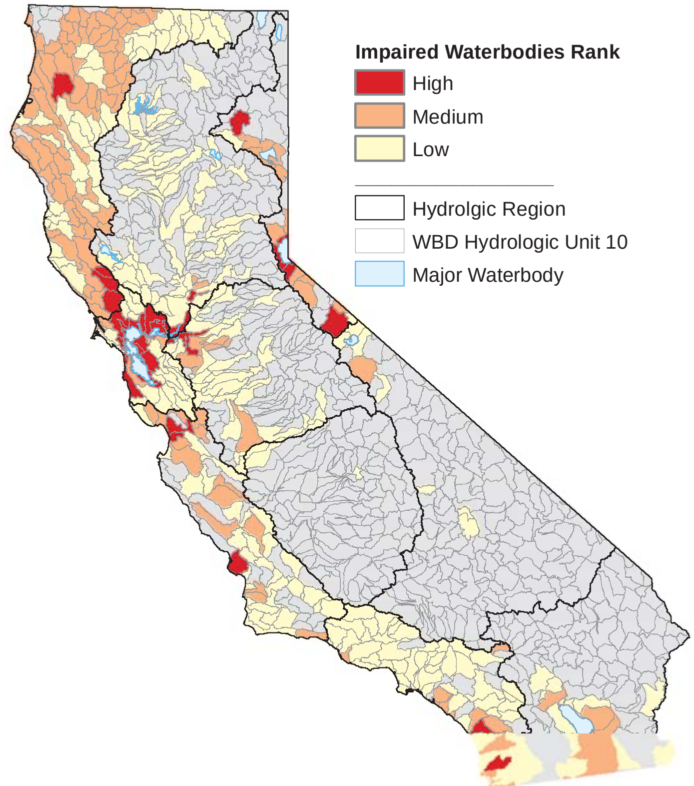


Figure 3.1.10.
Impaired waterbodies by HUC8 watershed units. Watersheds are shown ranked by the number of stressors that occur in a watershed.
Data Sources: Watershed Boundaries Database for California, NRCS (2009); 303(d) List, Total Maximum Daily Load Program, State Water Resources Control Board (2006)

Forest Management (Impacts Related to Timber Operations)
Timber harvesting, road building, and other types of land management activities can have both positive and negative effects on forest hydrology. Watershed studies have typically shown temporary increases in water yield when more than 20 percent of the stand has been harvested. Table 3.1.10 provides a summary of forest management effects on water resources. Timber operations and other types of disturbance from intensive land management can also lead to water quality impairments. Threats to water quality were identified as TMDL watersheds that are listed as impaired from a pollutant where silviculture or grazing was identified as a contributing source. Typical pollutants include sediment, temperature and nutrients.

For additional information on water resources related to forest management throughout California, review the State Water Plan draft section on Forest Management (http://www.waterplan.water.ca.gov/docs/cwpu2009/1009prf/v2ch23-forest_mgt_pf_09.pdf).

Post-Fire Erosion
Potential increases in erosion rates following wildfires can accelerate the delivery of sediment downstream and lead to degraded environmental conditions. Wildfires have been shown to increase both runoff and surface erosion (Larsen et al., 2009). Increases in post-fire erosion rates can adversely affect water quality and aquatic habitat, but can also degrade water supply. Soil erosion from wildfires has the potential to contribute to downstream siltation that may reduce the capacity of water storage facilities. Minear and Kondolf (2004, 2009) found that approximately 200 reservoirs in California have likely lost more than half their initial capacity to sedimentation. Reservoirs with most risk of sedimentation were found to be primarily small reservoirs (<2,500 acre-feet), such as municipal water-supply reservoirs, especially those operated by coastal towns and cities. Reservoirs in the Coast and Transverse Ranges are the most at risk, due to

Table 3.1.10. Potential hydrologic response from changes in forest structure, changes in water flow paths and application of chemicals

Land Management	Potential Response
Forest Canopy Removal	decreased interception or rainfall; net increase in precipitation arriving at the soil surface
	reduced transpiration
	temporary increases in water availability and water yield
	increased soil moisture; potential impacts to root strength
	transpiration rates vary with stand age
Impervious Surfaces	modified flow pathways for runoff and delivery to stream channels
	potential increases for surface erosion and mass wasting
Application of Forest Chemicals	potential adverse affect on aquatic ecosystems particularly when applied near or directly to water bodies
	potential adverse affect on water quality dependent on type of chemical, toxicity, rate of application, etc.
	potential cumulative effects from repeated or chronic treatments

Data Source: Natural Resource Council, 2008

high sedimentation rates, small reservoirs on large watersheds, and older reservoirs. The amount of erosion from wildfire has been shown to be highly variable, depending on the frequency and intensity of storms following wildfires, but have been shown to be greater following high severity burns (Benavides-Solorio and MacDonald, 2001, 2005).

The analysis used the Post-Fire Erosion layer (CAL FIRE, 2003) to represent threat of erosion following wildfires. This data layer estimates an expected erosion rate if an area experiences a high severity fire. This data layer was combined with information on fire rotation (see Chapter 2.1) to better identify those locations that are more likely to experience frequent high severity fires. Based on the existing post-fire erosion layer the percentage of the watersheds with a high post-fire erosion value was estimated and rankings were assigned to produce the threat from wildfire layer (Figure 3.1.11). See Chapter 2.1 for additional information of wildfire threat.

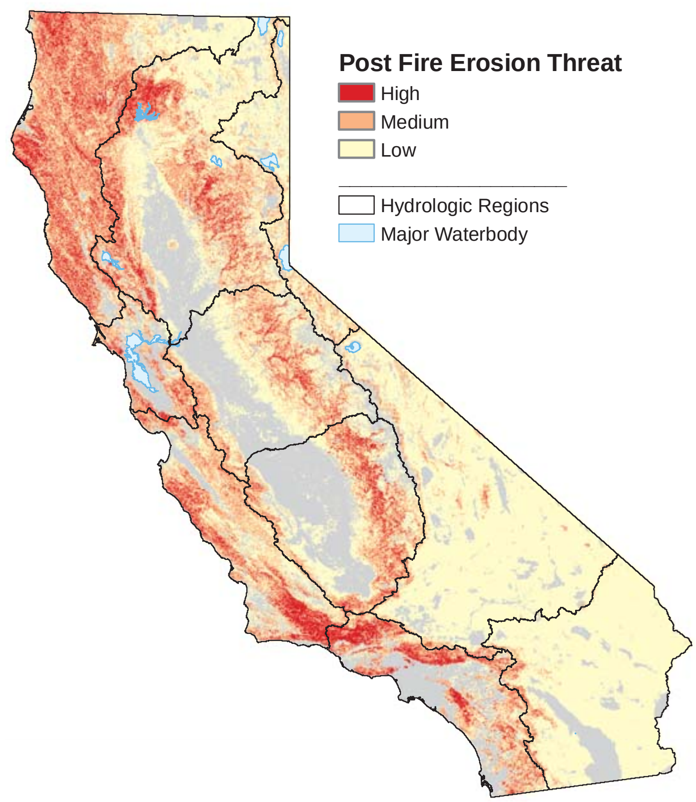


Figure 3.1.11.
Post-fire erosion threat. Soil erosion following wildfires can accelerate sediment delivery to stream courses and through siltation can impact to water storage facilities.
Data Sources: Post-Fire Erosion Potential, FRAP (2004); Fire Threat, FRAP (2005); Statewide Land Use / Land Cover Mosaic, FRAP (2006) Watershed Boundaries Database for California, NRCS (2009)

Impervious Surfaces

Stormwater runoff in developed areas contributes to water quality impairments. The degree of impacts tends to increase with larger areas of paved and impervious surfaces. Using a GIS data layer developed nationally by the EPA, areas were ranked based on the percent impervious surface area.

Composite Threats

The composite threat layer for water quality is based on the overlay of watersheds with water quality impairments. These impairments include forest management-related activities, development, hillslope surface erosion, mass wasting processes and post-fire erosion potential (Table 3.1.11).

Results

The high priority landscape (HPL) identifies watersheds that support a broad range of beneficial uses and coincide with high threats to water quality. The analysis highlights areas where stewardship projects have the highest potential to protect and enhance water quality. Table 3.1.12 displays the results from the GIS-based model and has been summarized by the major hydrologic regions in California. The analysis reported for large watershed units (100,000

Table 3.1.11 Threats to water quality – top watersheds per hydrologic regions

Sub-basin Name	Sub-basin Total Sq. Miles	Percent High	Percent Med	Percent Low	Percent High-Med[1]	Composite[2]
San Francisco Coastal South	257	48.7	44.7	6.7	93.3	85.5
Mattole	500	45	46.7	8.2	91.7	84.1
South Fork Eel	689	35.4	63	1.5	98.5	83.5
Trinity	2,038	35.2	59.8	5.1	94.9	82.5
Lower Klamath	1,527	29.6	69.2	1.2	98.8	82.1
Russian	1,485	34.6	58.5	6.9	93.1	81.9
Lake Tahoe	371	26.2	73.8	0	100	81.5
Upper Eel	709	25	72.6	2.4	97.6	80.7
Mad–Redwood	1,126	18.3	77.2	4.6	95.4	78.4
East Walker	504	22.4	68.5	9.1	90.9	78.3
Upper Klamath	852	9.3	89.2	1.5	98.5	77
Suisun Bay	652	18.4	70.6	11	89	76.8
Newport Bay	158	18.4	70.2	11.4	88.6	76.7
Scott	814	12.9	80.6	6.6	93.4	76.6
Lower Eel	1,529	15.4	70.1	14.5	85.5	75.2
San Pablo Bay	1,226	21.4	57.5	21.1	78.9	75.1
San Francisco Bay	1,333	15.5	68.8	15.7	84.3	74.9
San Lorenzo–Soquel	375	14.2	69.1	16.7	83.3	74.4
Alisal–Elkhorn Sloughs	184	14.3	67.7	17.9	82.1	74.1
Upper Carson	453	3.4	88.5	8.1	91.9	73.8
Gualala–Salmon	494	8	78	14	86	73.5
Big–Navarro–Garcia	1,251	10.5	72.6	16.8	83.1	73.4
Salmon	751	4.5	83	12.5	87.5	73
Middle Fork Eel	753	6.2	76.5	17.3	82.7	72.2
San Diego	1,383	11.7	62.3	26	74	71.4
Seal Beach	88	0	85.6	14.3	85.7	71.4
Tomales–Drake Bays	327	5.4	74.5	20.1	79.9	71.3
Santa Barbara Coastal	378	11.3	61.3	27.4	72.6	71
South Fork Trinity	932	0.4	81.7	17.9	82.1	70.6
San Gabriel	710	0.7	80.5	18.9	81.1	70.5
Santa Monica Bay	575	1.3	78.9	19.8	80.2	70.4
Ventura	266	0.9	75.2	23.9	76.1	69.3
Santa Clara	1,626	0.4	73.6	25.9	74.1	68.6
Coyote	720	0.6	71.8	27.7	72.3	68.2
Los Angeles	831	0.6	71.4	27.7	72	68
Pajaro	1,301	8.5	56.4	34	65	67.9

[1] Percent High-Med = Percent High + Percent Medium

[2] Composite = (Percent High) + (Percent Medium) x 0.5 + (Percent Low) x 0.25

acres or greater in size) and is not likely to adequately represent water quality conditions for smaller sub-basins.

The North Coast hydrologic region has the highest amount of HPL. The majority of forested watersheds in this region are important for recovery of state and federally listed anadromous salmonids and have also been listed for water quality impairments. The watersheds in the Sierra are composed of a mixture of high and medium priority landscape. The Lake Tahoe basin is likely the highest priority for watersheds in this region. The Central Coast and South Coast watersheds are also mostly ranked as medium priorities. Forest health (see Chapter 2.2) and fire management greatly influence water quality conditions in these watersheds. This assessment is not meant to represent conditions in agricultural and urban watersheds. In addition, results from large watersheds are necessarily generalized, and what holds true on average for the large watershed as whole may not be true for some of the smaller watersheds which comprise the larger watershed. Site-specific field checking is needed to determine if generalized conclusions for a large watershed also apply to a specific sub-watershed within the large watershed. For additional information on water quality conditions and priorities, see the Regional Water Quality Control Board's Basin Plans and the State 305(b) Water Quality Report for California.

Discussion

The water quality model resulted in a priority landscape that highlights areas where important water quality assets coincide with high threats to water quality. High priority areas are concentrated in North Coast watersheds and in some basins in the Sierra and parts of the South Coast. The results suggest that water quality impairments in forested watersheds of the North Coast will continue to be a priority issue, as these watersheds support a range of beneficial uses and are of critical importance for restoring habitat for state and federally listed salmonids.

Bioregional Findings

- Water quality impairments associated with forest and rangeland are most pronounced in watersheds in the Klamath/North Coast bioregion and along watersheds in the Central and South Coast bioregions.
- Most water quality impairments in forested watersheds are associated with sediment, water

California Department of Water Resources employees conduct a snow survey

Table 3.1.12. Summary of water quality priorities – the priority landscape from the water quality analysis was summarized for each of the hydrologic regions across California

Hydrologic Region	Basin	Sub-basin	Acres	Priority Rank
Klamath/North Coast (1)	Klamath	Shasta, Scott, Upper Klamath, Lower Klamath, Salmon, Trinity, South Fork Trinity	5,301,783	High
	Coastal	Smith	510,241	High
		Big–Navarro–Garcia	800,505	High
		Gualala–Salmon	316,814	High
		Mattole	320,065	Medium
		Russian	950,344	Medium
		Mad–Redwood	737,035	Medium
		Lower Eel, Middle Fork Eel, Upper Eel, South Fork Eel	2,356,296	High
San Francisco Bay (2)	San Francisco Bay	San Pablo Bay	784,967	Medium
		Suisun Bay	417,503	Medium
		San Francisco Bay	853,238	Medium
Central Coast (3)	Coastal	Santa Maria	437,820	High
		Central Coastal	687,167	High
		San Lorenzo–Soquel	240,261	Medium
		Alisal–Elkhorn Sloughs	117,984	Medium
		Santa Barbara Coastal	242,117	Medium
		Pajaro	832,388	Medium
		Carmel	206,917	Medium
		Salinas	2,130,582	Medium
South Coast (4)	Coastal	Santa Clara	1,040,497	High
		Newport Bay	100,993	Medium
		San Diego	898,735	Medium
		San Luis Rey–Escondido	494,482	Medium
		Ventura	170,651	Medium
		Santa Monica Bay	368,140	Medium
Sacramento River (5)	Upper Sacramento	McCloud	435,718	High
	Lower Sacramento	Lower American, North Fork American	835,282	High
		Lower and Middle Fork Feather	873,423	High
		Upper Yuba	860,738	High
		Battle Creek	360,533	High
		Upper Cache	745,622	Medium
		Auburn Ravine–Coon Creek	277,766	Medium
San Joaquin (6)	San Joaquin	Merced	812,426	High
		Tuolumne	1,198,581	High
		San Joaquin Delta	788,778	Medium
		Middle San Joaquin,Lower Merced, Lower Stanislaus	587,233	Medium
Tulare Lake (7)	Tulare–Buena Vista Lakes	Upper Kern, South Fork Kern	1,327,132	High
Lahontan (8)	Lake Tahoe	Lake Tahoe	324,368	High
	Walker	East Walker, West Walker	1,435,288	Medium
	Carson	Upper Carson	613,469	Medium
	Truckee	Truckee	779,051	Medium

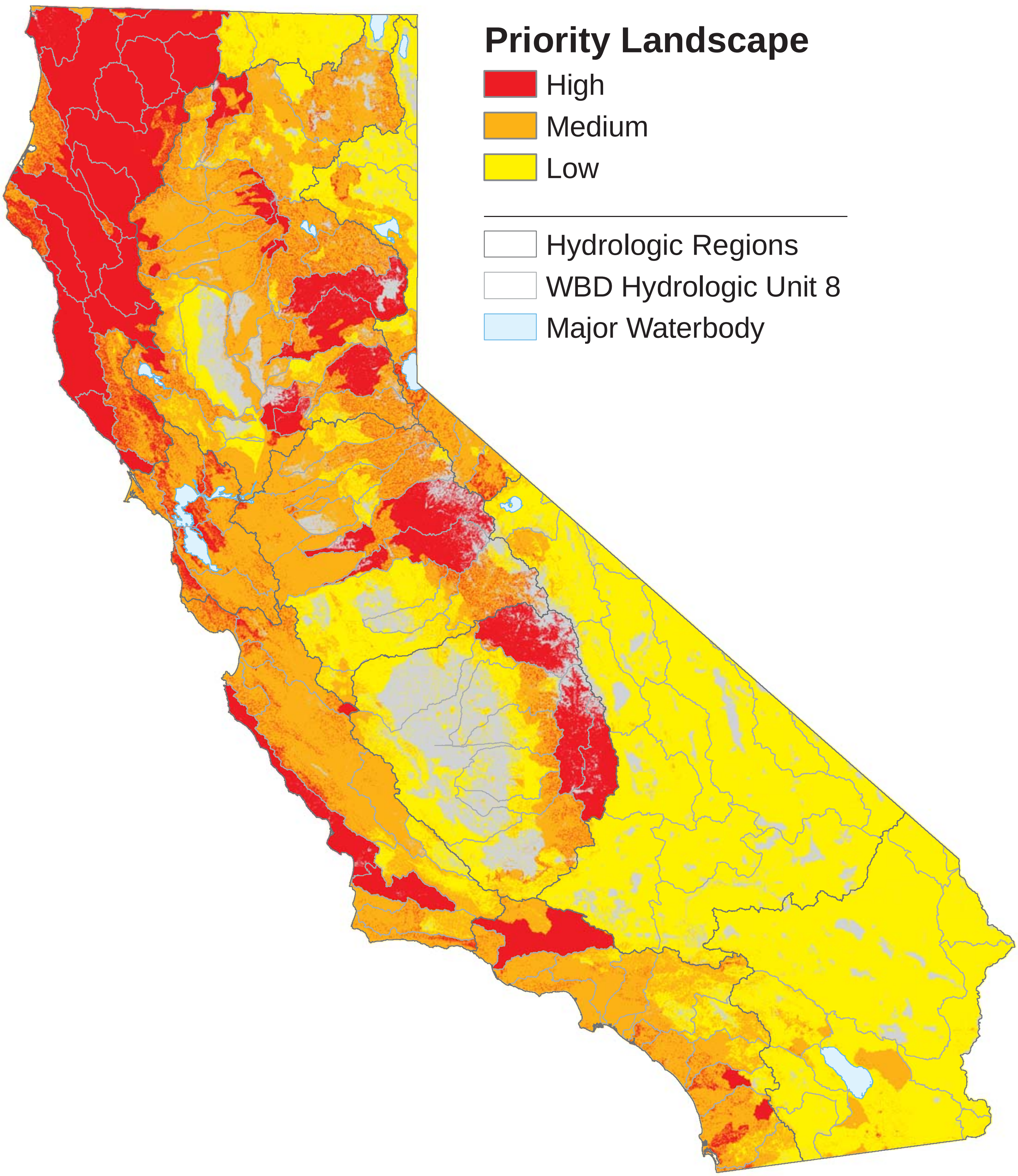


Figure 3.1.12.
Priority landscape for water quality.
Data Sources: Wild and Scenic River Designations, DFG (2008); Evolutionary Significant Units (ESU) for Coho, Chinook, and Steelhead in California, National Marine Fisheries Service (NMFS) (2006); Watershed Boundaries Database for California, NRCS (2009); National Hydrography Dataset, USGS (2009); National Land Cover Dataset, USGS (2001); Historic Range for Salmonids in California, NMFS (2003); 303(d) List, Total Maximum Daily Load Program, State Water Resources Control Board (2006); Post-Fire Erosion Potential, FRAP (2004); Sierra Nevada Montane Meadows, USFS R5 (2000)

temperature or nutrients.

Institutional Setting for Protecting and Enhancing Water Quality

The following programs and approaches are components of an existing strategy to protect and enhance water quality.

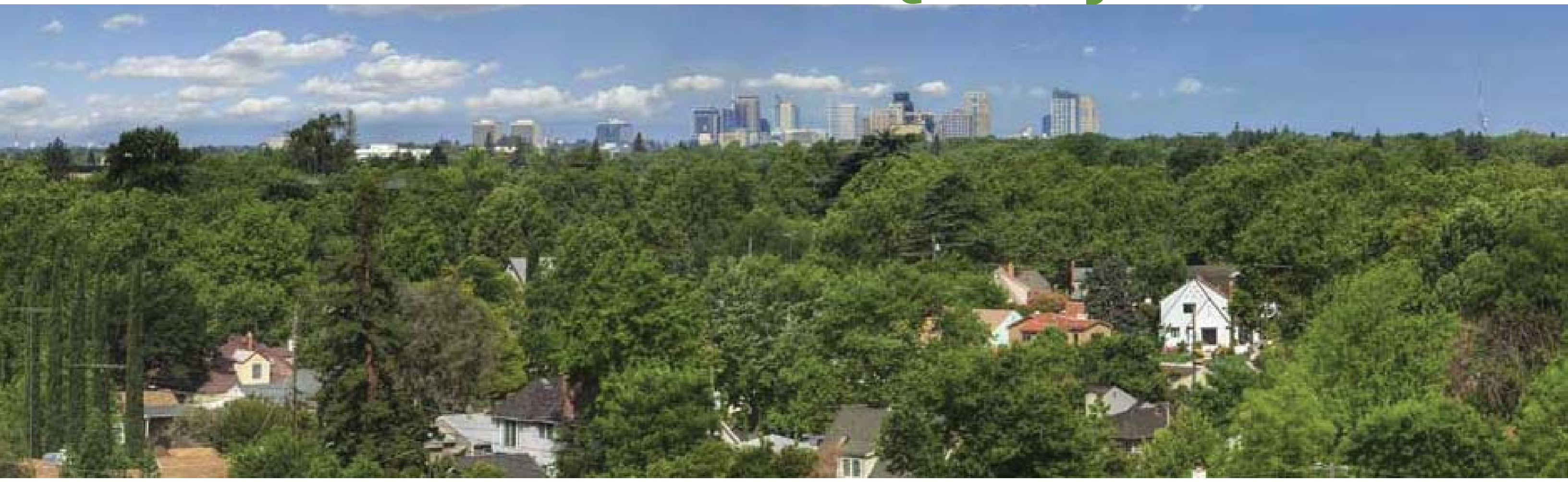
1. *TMDL Implementation* – Through the Porter-Cologne Water Quality Control Act the State Water Resources Control Board (SWRCB) and nine Regional Water Quality Control Boards (RWQCBs) have primary responsibility for developing water quality standards and ensuring that waterbodies are in attainment. As a part of that process, watersheds from the 303d list that have a TMDL developed, represent opportunities to begin to implement pollution load reductions and improve water quality. Watersheds that have an approved TMDL plan have already identified the sources of water quality impairment and have developed strategies to meet water quality objectives. Many of these watersheds represent priorities for implementing restoration projects and improving water quality.
2. *Regulatory* – The California Forest Practice Rules provide water quality protection measures that are designed to ensure that timber harvesting plans do not violate existing water quality standards. In addition, the California State Board of Forestry and Fire Protection (BOF) has implemented additional protection measures for waterbodies that are impaired or contained listed salmonid species.
3. *Watershed Management Plans* – Throughout California many local communities have developed watershed management plans that are designed to identify water quality stressors and to develop restoration plans.
4. *Integrated Regional Water Management (IRWM)* – The Department of Water Resources has developed IRWM planning as a method to prioritize water management needs on a regional level. The goal of IRWM planning is to promote integrated regional water management that improves water supply sustainability, water quality and addresses a range of environmental stewardship issues that affect both water supply and water quality.
5. *USFS Region 5 Water Quality Management Program* – This program provides water quality protection on U.S. Forest Service lands that includes the implementation and monitoring of Best Management Practices (BMPs). The USFS is currently working in collaboration with the State Water Resources Control Board to revise the existing Water Quality Management Plan (http://www.swrcb.ca.gov/water_issues/programs/nps/wqmp_forests.shtml).

TOOLS

Management activities on forests and rangelands can have an affect on both water supply and water quality. The following is a list of tools that can be used to protect and reduce risk to priority landscapes. For additional information on management tools and strategies the reader is referred to the Forest Resource Management Strategy in the State Water Plan (http://www.water.ca.gov/waterplan).

- Low-impact development (enhancing green infrastructure)
- Smart growth to avoid urban sprawl
- Meadow restoration
- Restoring riparian forests
- Fuels management, including prescribed burning and mechanical treatments
- Conservation of water use; see the 20x2020 Water Conservation Plan website (http://www.waterboards.ca.gov/water_issues/hot_topics/20x2020/index.shtml)
- Use of USFS Best Management Practices and BOF Anadromous Salmonid Protection rules for riparian protection and restoration
- Upgrading and decommissioning of forest roads; proper road maintenance
- Rapid and aggressive reforestation of wildfire areas
- Use of zoning (Timberland Production Zones), easements and other incentives to reduce land use conversion, reduce loss of forestlands and strengthen watershed protection.

Chapter 3.2
Urban Forestry for Energy Conservation and Air Quality



Urban and exurban forest cover, including agroforests can improve air quality, reduce energy consumption, and produce biomass for energy production. Assessments should identify areas where management or restoration of the urban or exurban forest canopy will have significantly positive and measurable impact on air quality and produce substantial energy savings (excerpted from the U.S. Forest Service State and Private Forestry Farm Bill Requirement and Redesign Strategies).

KEY FINDINGS

Current Status and Trends

- The urban area (defined by the U.S. Census Bureau) in California encompasses about five percent of land and supports 94 percent of the total population and 93 percent of residential houses. The urban forest encompasses a broad area, including those areas dedicated to high density residential, commercial/industrial, transportation corridors and the wildland urban interface (WUI).
- *The State of the Air Report 2009* ranks counties for years 2005 to 2007 by high ozone days and particle pollution days. Particle pollution data was not reported for nine counties, and annual standards were not met in at least six counties. Thirty-six counties received a failing grade for high ozone when compared to the U.S. Environmental Protection Agency (EPA) ozone pollution standards.
- Urban areas have a high concentration of impervious surfaces and structures that likely contribute to the urban heat island effect.
- Urban forests reduce levels of carbon dioxide and other greenhouse gases and help mitigate the urban heat island effect. The Urban Forest Protocols were approved to benefit local governments and provide incentive to others through offset carbon credits for planting trees in urban settings.
- Many private companies, non-profit organizations and governmental programs have worked hard to sustain and improve California's urban forest. This strong network of organizations

provides many public benefits by improving the urban forest and by increasing public awareness of the importance of urban forests.

- Urban forestry adds jobs and economic value to the California economy. Preliminary data from new research conducted at Clemson University indicates that total output (sales) associated with the urban forestry industry in California was almost $5.4 billion in 2008. Employment totaled nearly 52,000 jobs and generated labor income of over two billion dollars. More economic value is generated through increased tax revenue estimated to be $246 million, and labor income estimated to be $2.9 billion (Templeton et al., 2009).

Urban Tree Planting for Energy Conservation and Air Quality

- About 800,000 densely populated urban acres (15.1 percent of California's urban area) have been identified with high threats from air pollution and urban heat islands.
- Close to 28 percent of the state's population (9.5 million people) live in high threat areas for air quality and urban heat.
- 372 communities have been identified as high priority planting areas to conserve energy or improve air quality.

Urban Tree Maintenance for Energy Conservation and Air Quality

- Close to 217,000 urban acres (about 4.3 percent of California's urban area) has been identified as densely populated with substantial existing tree canopy assets.
- Activities and projects to maintain and protect overall tree canopy would benefit the nearly two million people living in these areas.
- In some cases, a community may be identified as a priority landscape in both urban forest maintenance and tree planting because results are calculated for each quarter acre, but reported at an aggregated community level.

Bioregional Findings

- Extreme hot weather, measured by the number of days over 90 °F (32.2 °C), varies by geographic region. Generally, the Central Valley (interior portion of the Bay/Delta, Sacramento Valley and San Joaquin Valley bioregions) and the southern desert regions (South Coast and Mojave bioregions) are the hottest areas in California, with daytime temperatures exceeding 90 °F for 20 percent or more of the year, on average.
- The urban population continues to grow. Since 2000, the population has increased an average of one percent per year. California is divided into 58 counties with 70 percent of the total population residing in eight counties concentrated in the South Coast, Bay/Delta and Sacramento Valley bioregions. These high population counties include Los Angeles, Orange, San Diego, San Bernardino, Santa Clara, Riverside, Alameda, Sacramento, Contra Costa and Fresno.
- Priority landscapes for urban forestry are concentrated in the Central Valley and the inland southern portion of the state.
- Ranking priority communities can be problematic for resource allocation, given different outcome needs and the many ranking options available. Ranking based on population served may not consider the needs of smaller communities, while ranking based on community size class may not be the most efficient allocation of resources. Different options for community ranking should be considered when addressing specific program and community needs.

CURRENT STATUS AND TRENDS

The California urban forest is found in metropolitan areas that also support 94 percent of the population, and encompass about five percent (7,944 square miles, or approximately five million acres) of the land base. Urban areas are the most populated areas in the state as defined by the U.S. Census Bureau, and community boundaries may include both urban and some rural areas. See Table 3.2.1 for urban and rural population and acres by county.

Urban Forest as Community Infrastructure

The many benefits from urban forests have been well documented, and trees are generally recognized as a highly valued part of community infrastructure and environment. Urban trees benefit areas by providing recreation, pollution reduction, carbon storage, heat island mitigation, stormwater control, noise reduction and increased wildlife habitat. Increased property values and energy conservation are often found in an urban forest setting. Benefits vary with tree size, canopy cover and location, and are generally increased in hotter climates.

Activities associated with urban forestry add jobs and economic value to the California economy. Economic data for 2002 U.S. urban forestry tree sales and tree care services indicate that California led all states with a total output of tree production and care services valued at $2.1 billion and provided over 37,000 jobs. Public awareness and support has increased urban forestry efforts since 2002, providing additional added value in benefits, jobs and increased revenues.

The California Department of Forestry and Fire Protection (CAL FIRE) recently contracted with the Department of Applied Economics and Statistics at Clemson University, South Carolina to quantify the current impacts of urban forestry on the California economy. Preliminary data indicate that total output associated with the urban forestry industry in California was almost $5.4 billion in 2008. Employment totaled 51,971 jobs and generated labor income of more than $2 billion. Economic value added through increased tax revenue was estimated to be nearly $250 million and labor income estimated to be $2.9 billion (Templeton et al., 2009). The final report, expected by late September 2010, will include an

Urban tree cover providing shade in mixed residental/commercial neighborhood in Sacramento, CA
Source: Sacramento Tree Foundation, 2009

Table 3.2.1. Urban and rural areas by county (acres and population in thousands)

	Urban and Rural		Rural		Urban	
County	**Acres**	**Population**	**Acres**	**Population**	**Acres**	**Population**
Alameda	525	1,444	376	8	149	1,435
Alpine	474	1	474	1	<1	<1
Amador	388	35	384	22	4	13
Butte	1,073	203	1,016	37	57	167
Calaveras	663	41	658	33	5	7
Colusa	740	19	739	9	2	10
Contra Costa	514	949	346	20	168	929
Del Norte	649	28	638	9	11	19
El Dorado	1,145	156	1,101	58	44	99
Fresno	3,846	799	3,733	100	113	699
Glenn	849	26	844	12	6	15
Humboldt	2,294	127	2,265	38	29	88
Imperial	2,868	142	2,846	21	22	122
Inyo	6,545	18	6,540	8	5	10
Kern	5,224	662	5,101	78	123	584
Kings	891	130	868	17	23	113
Lake	851	58	837	26	14	32
Lassen	3,021	34	3,017	20	4	14
Los Angeles	2,528	9,512	1,655	68	873	9,444
Madera	1,378	123	1,353	42	25	81
Marin	378	247	315	14	64	233
Mariposa	936	17	936	17	<1	<1
Mendocino	2,248	86	2,230	40	18	46
Merced	1,266	211	1,227	36	39	175
Modoc	2,689	9	2,688	7	1	3
Mono	2,003	13	2,002	7	2	6
Monterey	2,121	402	2,057	44	64	357
Napa	506	124	483	20	23	104
Nevada	624	92	591	40	33	52
Orange	510	2,843	191	5	319	2,837
Placer	960	248	898	53	62	195
Plumas	1,673	21	1,672	18	1	3
Riverside	4,673	1,545	4,332	106	340	1,439
Sacramento	636	1,224	461	30	175	1,194
San Benito	889	53	882	12	8	41
San Bernardino	12,867	1,710	12,303	97	564	1,613
San Diego	2,712	2,811	2,197	110	515	2,701
San Francisco	69	777	38	<1	30	777
San Joaquin	913	564	829	56	83	508
San Luis Obispo	2,124	247	2,066	46	58	200
San Mateo	353	707	252	10	101	697
Santa Barbara	1,633	399	1,531	20	102	379
Santa Clara	835	1,683	640	21	195	1,662
Santa Cruz	286	255	240	38	46	217
Shasta	2,465	163	2,415	51	50	113
Sierra	615	4	615	4	<1	<1
Siskiyou	4,062	44	4,053	29	8	16
Solano	582	395	523	17	60	379
Sonoma	1,026	459	934	66	92	393
Stanislaus	970	447	893	40	77	407
Sutter	389	79	374	12	15	67
Tehama	1,893	56	1,880	28	13	29
Trinity	2,053	13	2,053	13	<1	<1
Tulare	3,099	368	3,032	69	67	299
Tuolumne	1,458	55	1,438	25	20	29
Ventura	1,173	753	1,043	24	130	730
Yolo	653	168	632	16	21	152
Yuba	412	60	401	18	11	42
Total	101,219	33,856	96,135	1,881	5,084	31,975

Note: County totals derived from estimating county total by 2000 Census block and urban data.

estimate of total jobs, value-added to the gross state product and other economic impacts associated with California urban forestry.

Urban Forest and Air Quality

Daily activities, including vehicle driving, mowing lawns, dry-cleaning clothes and natural occurrences such as wind blown dust and fires, cause air pollution. According to the EPA, the average adult breathes over 3,000 gallons of air every day. Children breathe even more per pound of body weight and are more susceptible to ill effects from air pollution. The elderly are also more sensitive to air pollution because they more often have heart or lung disease. The American Lung Association's *State of the Air Report (2009)* found that six out of 10 Americans live in counties where particle or ozone pollution has reached dangerous levels. The report ranked the top 25 most polluted cities in three pollution categories; short-term particulates, long-term particulates and ozone. California has some of the most polluted areas in the nation, holding title to the top four slots in each category and at least 24 percent of each category total.

Particulate matter (PM) in the air varies in size and comes in liquid and solid form. Particles less than 2.5 micrometers (PM 2.5) in diameter, 30 times smaller than the diameter of a single human hair, are called "fine" particles. Sources of PM 2.5 include dust from roads, agricultural operations, construction, wood burning and industrial activities. Exhaust emissions from mobile sources in California contribute a small amount to PM 2.5 emissions (California Air Resources Board, 2007). Recent studies have indicated that the PM 2.5 is considerably more dangerous than previously thought. In fact, researchers at Harvard University and the California Air Resources Board (ARB) have tripled their estimates of the number of deaths that occur each year from particulate matter (American Lung Association, 2009). From 2005 through 2007, at least six counties in California did not meet particulate pollution standards.

Ground level ozone is also a serious pollutant in urban areas, and is formed by chemical reactions between nitrogen oxides (NOx) and volatile organic compounds (VOCs) in the presence of sunlight and heat. Ozone is more likely to form in warmer temperatures (Taha, 2005). For 2005–2007, 36 counties in California did not meet ozone standards according to EPA ozone measurements.

Trees can both add and reduce airborne VOCs. Trees naturally emit VOCs from their leaves, with emission rates varying by species and depending on ambient conditions. In general, the chemical reactions between NOx and VOCs that cause ozone to increase with higher temperatures. However, from the cooling effects of shading and increased evapotranspiration, trees generally lower local temperatures, and the net effect of increased tree canopy is usually to lower overall VOC emissions and ozone levels in urban areas.

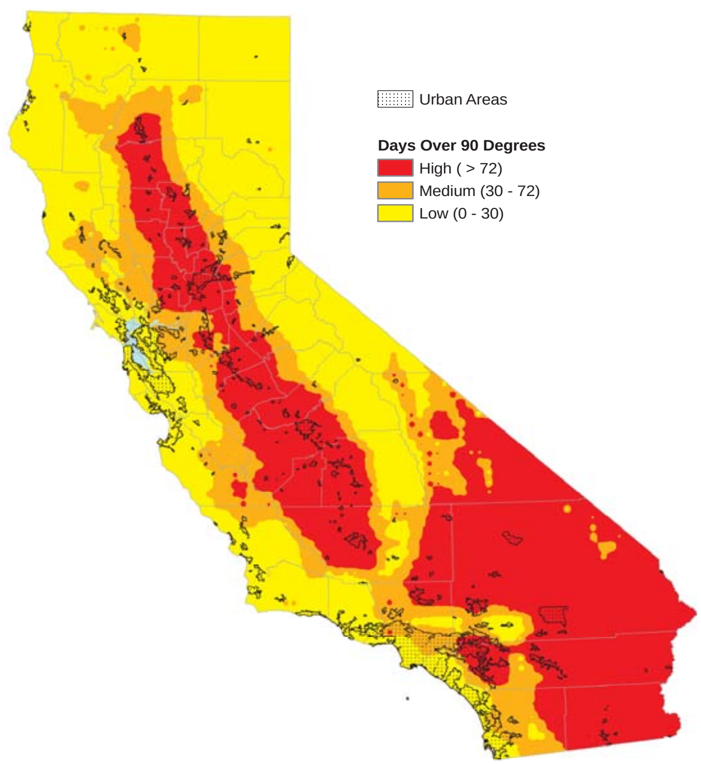


Figure 3.2.1.
California urban areas by annual average days over 90 °F.
Data Sources: Daily Temperatures, California Climate Action Team (2008); Urban Areas, U.S. Census Bureau (2000); USGS National Land Cover Dataset (2001)

Urban forests help filter out air pollutants through the interception of particulate pollutants on canopy leaves, sequestering of carbon dioxide in woody biomass and reducing air temperatures (McPherson, 1999). For example, trees in Sacramento County remove about 665 tons of ozone and 748 tons of particulate matter smaller than 10 micrometers (PM10) annually. The total value of ozone and particle pollution reduction is estimated at $28.7 million (U.S. Forest Service Center for Urban Forest Research, 2006). The value of these benefits is considerable across the state, and maximum results are achieved when the efforts and benefits are focused in highly populated areas.

Urban Forest and Energy Use

Population growth and the trend towards hotter summers have increased the need for electricity in California. In 2006, California produced 78.1 percent of the electricity it used; in 2007, that figure had dropped to 69.5 percent. Energy shortages and urban heat potential increase with urban development that adds impervious surfaces such as asphalt, concrete and roofs, which are estimated to cover 50 to 70 percent of urban areas (Taha et al., 1988).

While the climate varies around the state, the summers are generally hot for most areas away from the coast (Figure 3.2.1). The term "heat wave" is used to describe an event of three consecutive days of maximum temperatures above 90 °F (32.2 °C). Across the state, emergency room visits and hospital admissions increase due to heat related illnesses. Heat waves can be more of a threat to the health of the vulnerable, including children and those over 65 years of age (Natural Resources Defense Council, 2008).

With climate change, scientists are predicting more frequent heat waves for California, leading to increased energy demands and raising the risk of energy shortages and the possibility of rolling blackouts. When projected heat waves and energy demand were mapped with current energy supply, researchers found that shortages could be as high as 17 percent during heat wave periods (DOE, 2008). Shortages could present problems for California's urban population. In addition, impacts are amplified in urban areas because of the high percentage of impervious surfaces that increase local ambient temperatures.

Urban trees reduce summer air temperatures by providing shade and by absorbing water through their roots and evaporating it through their leaves in a process called evapotranspiration. Summer temperatures can be reduced 2–9 °F (1–5 °C) by evapotranspiration alone and shaded surfaces can be 20–45 °F (11–25 °C) cooler than unshaded materials (EPA, 2009; Akbari and Taha, 1992; Rosenfeld et al., 1998; McPherson and Simpson, 2003). Cooler building surfaces and walls then reduce the amount of heat transmitted into the air and the building, thus reducing air conditioning needs and energy demand.

EVALUATING URBAN AREAS FOR ENERGY CONSERVATION AND AIR QUALITY

This section evaluates heat- and pollution-related threats and tree assets in California's urban areas. Communities are identified where high value assets coincide with high threats of urban heat or energy use and air pollution. The high priority landscape (HPL) communities are those that could benefit the most from urban forestry efforts, including planting and maintenance, to improve air quality and reduce energy consumption and urban heat.

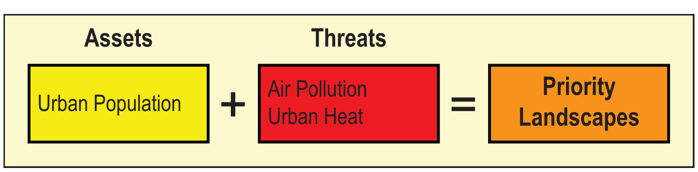
Two geographic information systems (GIS) models were used in this asset-threat based approach. The first model identified priority landscapes that would benefit from urban tree planting efforts. The second model identified priority areas where urban forestry efforts to protect existing tree canopy would be beneficial. The models differed in how tree canopy data was utilized. In the tree planting model, the absence of tree canopy was synthesized as a threat. In the maintenance model, existing tree canopy is synthesized as an asset.

Resulting priority landscapes are concentrated in the Central Valley and inland southern portion of the state. While results are depicted at a community level, ranking the communities for resource allocation is difficult because of different outcome needs and the many ranking options available. Ranking based on population served may not consider the needs of smaller communities, while ranking based on community size class may not be the most efficient allocation of resources. Ranking options should be considered when addressing specific program and community needs.

Analysis: Urban Tree Planting

High priority urban tree planting areas in California are densely populated areas with considerable air pollution, with high summer temperatures and urban heat islands (low tree canopy, high percent impervious surface and many days over 90 °F). Planting efforts can reduce the amount of energy consumption due to indoor cooling needs, help filter air pollutants and provide other public benefits.

Priority areas were identified by merging combined threats and assets. Areas in the high rank, due to the presence of both assets and threats, were considered priority landscape and targeted for urban forestry efforts. To allow the consideration of impacts and opportunities across various community sizes, and distribute resources more equitably, urban communities were sorted into five size class categories based on population. Areas in the highest ranks in each size class are considered priority landscape. To show another ranking option, the top 50 communities by population living in a high priority landscapes are also depicted. These rankings are not meant to be definitive, but rather approximations based on the best data available and the methods used in this analysis.



Assets

To support the goal of enhancing public benefit, the asset was defined as the urban population, representing where public health and energy conservation are significant potential concerns. Densely populated residential areas, those of at least five housing units per acre, were used to represent this. Commercial development also consumes a considerable amount of energy, and was also ranked as a high value asset.

Threats

For the purposes here, threats to the identified asset included air pollution and energy consumption. Data layers included urban areas (U.S. Census Bureau, 2000), air pollution (California Air Resources Board PM2.5 and ozone health data by county, non-attainment days PM10 by air basin), weather (daily temperature data from California Climate Action Team research for number days over 90°), percent impervious surface (National Land Cover Database (NLCD) percent coverage), road density, housing density class (U.S. Census Bureau, 2000) and tree canopy (NLCD percent coverage) for the planting model. Several steps were completed to synthesize this data.

Urban Heat

A single layer, depicting urban heat, representing areas of high energy consumption, was used for the planting model. Ranked data for impervious surface, tree canopy and weather (days over 90°) was combined. The higher ranks represent areas of more demand for energy (days requiring air conditioning) and the largest potential for urban heat.

Air Pollution

Air pollution was derived from PM10 air basin non-attainment days, county PM2.5 and ozone health data which were ranked and merged into one data layer. Health data (PM2.5 and ozone) has a greater overall influence as it presents greater health risks, and was given a weighted final rank. Final ranked data was as follows: high (county exceeds state averages), medium (county does not exceed state average, mid-values) and low (county does not exceed state average, low-values). Air pollution was distributed by road density to create an urban pollution data layer; areas within 300 meters of an interstate, freeway or expressway were ranked high; low ranking areas within 150 meters of an urban principal arterial road were increased to medium rank.

Composite Threats

Urban pollution and energy consumption for interior cooling were merged into a single composite threat and categorically ranked high, medium or low vulnerability. Areas with high threats in both pollution and energy consumption were given the highest threat rank.

Results

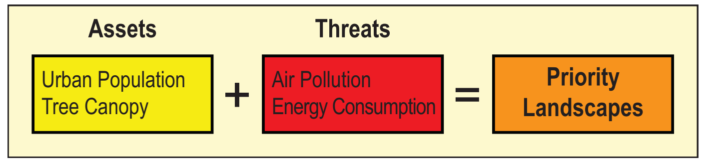
Priority planting areas for energy savings and air pollution reduction are depicted in Figure 3.2.2. Focusing on the 5.1 million acres of U.S. Census Bureau defined urban areas, 15 percent or 766,000 acres have been identified as high priority planting areas. The 2000 population estimates for these high priority landscape (HPL) communities is 9.5 million. Approximately 28 percent of the state population lives in these HPL communities. Most of the 372 HPL communities identified are located in the Central Valley and the inland southern portion of the state. About half of these communities had at least 25 percent of their total acres identified as high priority landscapes (HPL), 65 had more than 50 percent of their total acres in priority landscape and 22 had over 75 percent of their total acres identified as HPL. These HPL communities would benefit from activities and projects that increase overall tree canopy, to reduce energy consumption and improve air quality.

The top five communities for each size class are presented in Table 3.2.2. The communities in this table represent only 40 percent of the planting HPL population. All communities in this category should be considered for urban forestry planting efforts.

Next, Table 3.2.3 depicts the top 50 HPL communities using the population criteria, representing about 65 percent of the total planting HPL population.

Considerable public benefit could also be achieved by urban forest planting efforts in highly populated less threatened communities, and by maintaining existing tree canopy in highly populated communities that have existing tree canopy benefit from previous planting efforts.

Analysis: Urban Tree Maintenance



Assets

The maintenance model also contains the asset urban population, representing public health and energy conservation, which was measured by the proxy variable housing density. Commercial development generally consumes a large amount of energy, and was also ranked high. For the maintenance model, existing tree canopy coverage was combined with housing density to create a composite maintenance asset. Areas with high assets in both housing density and tree canopy were given the highest asset rank.

Threats

For the purposes of the model, threats to identified assets include air pollution and energy consumption. Data layers used included urban areas, air pollution (PM2.5 and ozone health data by county, non-attainment days PM10 by air basin), weather (number days over 90 °F), road density and housing density class. Several steps were completed to synthesize this data.

Energy Consumption

An energy use layer was created by first ranking areas by housing density and weather data. Areas with high housing density and many days over 90 °F were ranked highest.

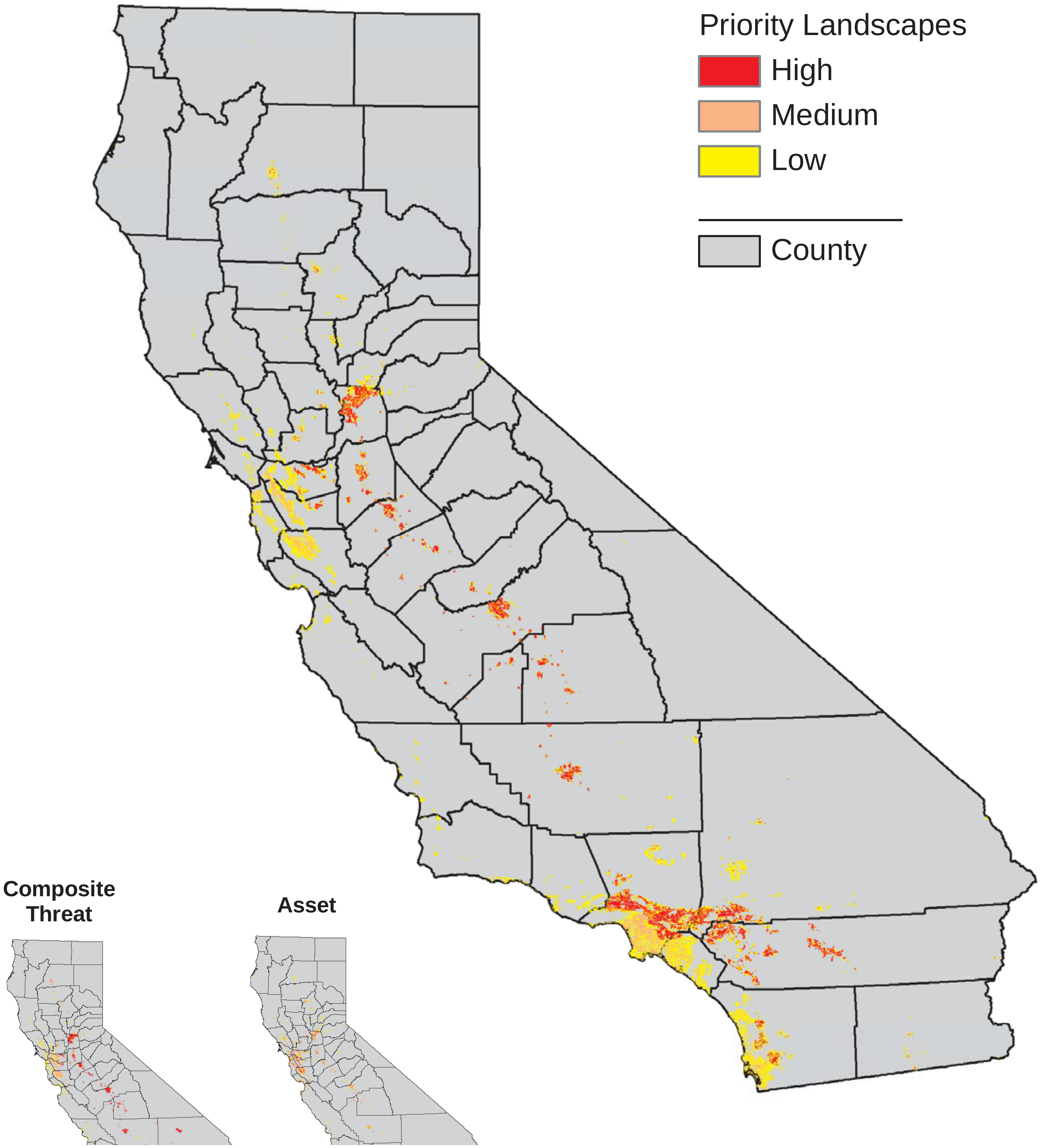


Figure 3.2.2.
Urban forestry planting priority landscape.
Data Sources: PM2.5 and Ozone Health, California Air Resource Board, (2009); Non-attainment Days PM10 by Air Basin, California Air Resources Board (2004-2008); Daily Temperatures, California Climate Action Team (2008); Functional Roads (FUNC), CALTRANS (2004); Urban Areas, U.S. Census Bureau (2000); National Land Cover Dataset, USGS (2001)

Table 3.2.2. Top five communities by size class: population in planting high priority landscape (acres and population in thousands)

Community	Total Acres	HPL Acres	HPL Percent	Population 2000	HPL Population	HPL Population Percent
Size Class 1 (≥ 250,000)						
Los Angeles	301	77	26	3692	1389	38
Fresno	71	33	46	430	378	88
Sacramento	63	26	41	406	306	75
Riverside	52	20	39	257	211	82
San Diego	210	8	4	1224	86	7
Size Class 2 (100,000–249,999)						
Bakersfield	79	20	26	244	209	86
Stockton	38	12	32	244	170	70
Glendale	20	7	34	195	160	82
Modesto	23	13	55	181	151	84
San Bernardino	38	12	31	188	143	76
Size Class 3 (50,000–99,999)						
Rialto	14	7	47	92	84	91
Visalia	23	9	38	95	82	87
El Cajon	9	5	56	95	81	85
Alhambra	5	4	76	85	79	92
Whittier	9	5	50	84	69	83
Size Class 4 (10,000–49,999)						
Manteca	11	4	40	50	43	87
Colton	10	3	32	48	42	87
Covina	5	3	71	48	41	87
Indio	19	4	23	50	41	83
La Mirada	5	3	58	47	41	87
Size Class 5 (< 10,000)						
Charter Oak	<1	<1	90	9	9	92
E. La Mirada	<1	<1	80	9	9	91
Canyon Lake	3	1	39	10	8	82
Exeter	2	1	55	9	8	85
Bystrom	1	1	48	9	8	84

Air Pollution

The air pollution threat data used here is the same as that used in the previous analysis, described above.

High Priority Maintenance Landscapes

Priority areas were identified by merging combined threats and assets, utilizing the same method as the planting model. High priority maintenance areas in California are those densely populated with people and trees, with many days over 90 °F and exceeding air pollution standards. Protecting the existing tree canopy in these areas provides public benefit.

Results

The priority landscape for urban forestry maintenance efforts are depicted in Figure 3.2.3. Focusing on the 5.1 million acres of U.S. Census Bureau defined urban areas, 217,000 acres or 4.3 percent has been identified as priority maintenance areas. Many of these communities already have areas with considerable tree canopy assets and urban forestry activities. Projects to maintain and protect overall tree canopy would be of benefit to the close to two million people living in these areas. Additional tree planting efforts should be targeted for areas of special concerns and to maintain overall health and canopy coverage of community trees.

Table 3.2.3. Top 50 communities by population in planting high priority landscape (acres and population in thousands)

Community	Total Acres	HPL Acres	HPL Percent	Population 2000	HPL Population	HPL Population Percent
Los Angeles	301	77	26	3,692	1,389	38
Fresno	71	33	46	430	378	88
Sacramento	63	26	41	406	306	75
Riverside	52	20	39	257	211	82
Bakersfield	79	20	26	244	209	86
Stockton	38	12	32	244	170	70
Glendale	20	7	34	195	160	82
Modesto	23	13	55	181	151	84
San Bernardino	38	12	31	188	143	76
Ontario	32	8	26	158	129	82
Moreno Valley	33	11	32	141	125	89
Fontana	26	9	36	142	122	85
East Los Angeles	5	4	76	125	116	93
Pomona	15	7	47	150	115	77
El Monte	6	4	70	115	105	91
Corona	25	8	32	128	100	78
Escondido	24	6	27	133	93	70
Burbank	11	5	47	100	89	88
Norwalk	6	4	69	103	87	84
San Diego	210	8	4	1,224	86	7
Santa Clarita	34	7	21	152	86	57
Pasadena	15	5	34	134	85	64
Rancho Cucamonga	26	8	29	128	85	66
Rialto	14	7	47	92	84	91
Visalia	23	9	38	95	82	87
West Covina	10	6	59	103	82	79
El Cajon	9	5	56	95	81	85
Alhambra	5	4	76	85	79	92
Whittier	9	5	50	84	69	83
Baldwin Park	4	3	72	76	68	90
Citrus Heights	9	7	74	84	67	80
Antioch	17	6	33	91	66	73
Arden–Arcade	12	7	53	97	66	68
Elk Grove	27	7	26	81	65	80
Clovis	14	6	45	69	59	86
Merced	13	5	40	64	58	91
Livermore	15	5	35	73	57	78
Pico Rivera	6	3	55	64	57	89
Montebello	5	3	55	62	55	89
Concord	20	5	26	121	55	45
Monterey Park	5	3	64	60	54	89
Hemet	18	6	35	59	52	88
La Habra	5	3	70	59	51	87
South Whittier	3	3	87	55	51	94
Turlock	10	5	48	56	50	89
Rosemead	3	3	78	53	50	93
Redlands	23	5	23	64	49	77
Temecula	19	5	27	67	49	73
Chino	19	3	18	70	47	68
Downey	8	3	39	107	46	43
Upland	10	4	42	69	45	65

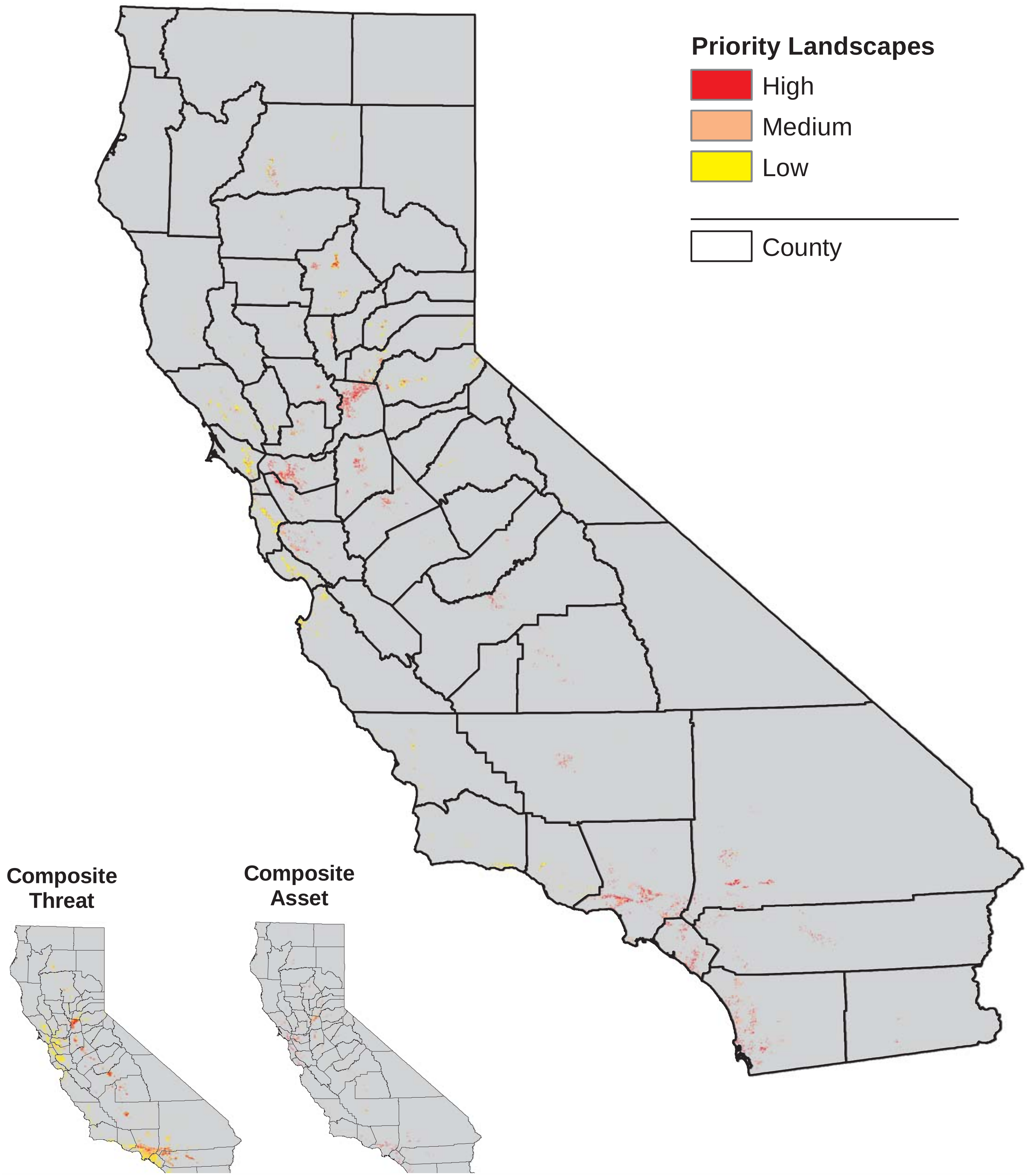


Figure 3.2.3.
Urban forestry maintenance priority landscape.
Data Sources: PM2.5 and Ozone Health, California Air Resource Board, (2009); Non-attainment Days PM10 by Air Basin, California Air Resources Board (2004-2008); Daily Temperatures, California Climate Action Team (2008); Functional Roads (FUNC), CALTRANS (2004); Urban Areas, U.S. Census Bureau (2000)

Table 3.2.4 depicts the top five maintenance HPL by community size class and population in HPL.

Table 3.2.5 depicts the top 50 priority areas for activities and projects to maintain overall tree canopy which can improve energy conservation and air quality.

Discussion

Priority landscapes for both models are concentrated in the Central Valley and inland southern portion of the state. While results are depicted at a community level, giving an ordinal rank to the communities is problematic for resource allocation because of the many ranking options. This chapter has depicted two of many options. Future strategies and policy will need to address how to allocate limited resources equitably and efficiently for maximum public benefit. A summary of population percent in each priority category by county is in Table 3.2.6 for county level comparison.

Past efforts appear to track along the priority landscape fairly well. With the exception of a few projects which may have focused on achieving other urban forestry benefits, a large percentage of past efforts has been focused in areas identified for planting effort to enhance public benefit while conserving energy and improving air quality. Figure 3.2.4 depicts past urban forestry efforts by tree planting priority landscape.

Table 3.2.4. Top five communities by size class: population in maintenance high priority landscape (acres and population in thousands)

Community	Total Acres	HPL Acres	HPL Percent	Population 2000	HPL Population	HPL Population Percent
Size Class 1 (≥ 250,000)						
Sacramento	63	12	18	406	156	39
Los Angeles	301	16	5	3,692	96	3
San Diego	210	9	4	1,224	62	5
Oakland	36	4	11	398	28	7
Fresno	71	2	3	430	25	6
Size Class 2 (100,000–249,999)						
Stockton	38	5	14	244	76	31
Modesto	23	3	12	181	35	19
Bakersfield	79	2	3	244	25	10
Pasadena	15	2	16	134	22	17
Berkeley	7	2	22	102	18	18
Size Class 3 (50,000–99,999)						
Arden–Arcade	12	5	39	97	41	42
Citrus Heights	9	2	27	84	25	30
Chico	21	2	10	76	23	30
Mission Viejo	12	2	19	88	19	22
Davis	6	1	22	60	18	30
Size Class 4 (10,000–49,999)						
Carmichael	7	3	39	50	21	43
Parkway–S. Sacramento	3	1	31	37	15	42
Paradise	12	4	36	26	15	56
Woodland	10	<1	10	49	13	27
North Highlands	8	<1	11	44	13	29
Size Class 5 (< 10,000)						
Lake Arrowhead	8	3	34	9	7	74
Country Club	1	<1	37	10	5	53
Placerville	4	<1	20	10	4	46
Lincoln Village	<1	<1	58	6	4	68
Running Springs	3	<1	34	5	4	73

Table 3.2.5. Top 50 communities in urban forest maintenance high priority landscape by percent of population (acres and population in thousands)

Community	Total Acres	HPL Acres	HPL Percent	Population 2000	HPL Population	HPL Population Percent
Sacramento	63	12	18	406	156	39
Los Angeles	301	16	5	3,692	96	3
Stockton	38	5	14	244	76	31
San Diego	210	9	4	1,224	62	5
Arden–Arcade	12	5	39	97	41	42
Modesto	23	3	12	181	35	19
Oakland	36	4	11	398	28	7
Fresno	71	2	3	430	25	6
Citrus Heights	9	2	27	84	25	30
Bakersfield	79	2	3	244	25	10
Chico	21	2	10	76	23	30
San Jose	113	2	2	894	23	3
Pasadena	15	2	16	134	22	17
Carmichael	7	3	39	50	21	43
Mission Viejo	12	2	19	88	19	22
Berkeley	7	2	22	102	18	18
Davis	6	1	22	60	18	30
Laguna Niguel	9	2	25	62	17	28
Fairfield	24	1	5	95	17	18
Lodi	8	1	14	57	17	30
Rancho Cordova	21	1	6	54	16	31
Walnut Creek	13	2	17	64	16	25
Parkway–S. Sacramento	3	1	31	37	15	42
Paradise	12	4	36	26	15	56
Redding	39	2	6	81	14	18
Woodland	10	<1	10	49	13	27
North Highlands	8	<1	11	44	13	29
Roseville	23	1	5	80	13	16
Riverside	52	2	3	257	13	5
Palo Alto	16	1	8	59	12	21
Vacaville	18	<1	5	88	12	13
Victorville	47	1	3	64	12	18
West Sacramento	15	<1	5	32	11	36
Elk Grove	27	1	4	81	11	14
Altadena	6	1	25	43	11	26
Fair Oaks	7	2	27	28	11	39
San Francisco	30	<1	2	777	10	1
Yuba City	9	<1	9	49	10	21
Anaheim	32	2	5	328	10	3
Glendale	20	2	8	195	10	5
Lake Forest	11	<1	7	78	9	12
Lafayette	10	2	20	24	9	39
Orinda	8	2	30	18	9	50
Pleasant Hill	5	1	24	33	8	26
Concord	20	<1	4	121	8	7
La Canada Flintridge	6	1	26	20	8	41
Folsom	14	1	8	52	8	16
Danville	12	1	12	42	8	19
Escondido	24	1	5	133	8	6
Oceanside	27	1	4	161	8	5

Table 3.2.6. Priority landscapes by percent of county population (population in thousands)

	Percent of Population in Planting Priority Landscapes				Percent of Population in Maintenance Priority Landscapes				
County	Very Low	Low	Medium	High	Very Low	Low	Medium	High	County Population
Alameda	4.2	33.7	57.3	4.8	94.0	0.0	0.5	5.5	1,444
Alpine	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	1
Amador	90.2	9.8	0.0	0.0	94.7	4.1	0.0	1.1	35
Butte	50.2	33.8	8.5	7.4	63.0	6.9	3.9	26.2	203
Calaveras	96.7	3.3	0.0	0.0	98.5	1.0	0.0	0.4	41
Colusa	63.5	36.5	0.0	0.0	85.1	8.5	1.4	5.0	19
Contra Costa	8.3	44.6	21.9	25.2	84.9	0.2	3.1	11.8	949
Del Norte	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	27
El Dorado	75.8	22.1	1.5	0.6	63.8	18.0	1.6	16.6	156
Fresno	17.4	8.7	0.0	73.9	91.6	0.2	3.4	4.8	799
Glenn	54.8	43.0	2.2	0.0	87.0	6.8	3.1	3.1	26
Humboldt	88.1	11.9	0.0	0.0	97.9	1.8	0.0	0.3	127
Imperial	31.9	40.1	17.7	10.3	85.0	0.3	0.6	14.1	142
Inyo	81.8	18.2	0.0	0.0	96.1	3.8	0.0	0.1	18
Kern	19.2	15.7	1.0	64.1	87.6	0.4	5.0	7.0	662
Kings	24.1	11.0	0.0	65.0	97.6	0.1	1.5	0.8	129
Lake	86.6	13.4	0.0	0.0	96.0	3.1	0.0	0.9	58
Lassen	97.5	2.5	0.0	0.0	97.4	2.0	0.0	0.5	34
Los Angeles	4.0	18.6	38.2	39.2	96.9	0.0	0.6	2.5	9,514
Madera	44.0	13.4	0.0	42.6	94.8	0.2	3.1	1.9	123
Marin	44.4	50.3	5.3	0.0	65.4	25.2	0.2	9.2	247
Mariposa	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	17
Mendocino	82.0	17.2	0.8	0.0	96.0	3.0	0.0	0.9	86
Merced	23.0	9.8	0.0	67.2	94.8	0.3	3.4	1.6	211
Modoc	100.0	0.0	0.0	0.0	99.8	0.2	0.0	0.0	9
Mono	100.0	0.0	0.0	0.0	88.7	11.3	0.0	0.0	13
Monterey	29.6	61.1	8.8	0.4	91.6	6.0	0.3	2.1	402
Napa	33.2	61.4	5.5	0.0	92.7	4.5	0.1	2.8	124
Nevada	94.3	5.0	0.8	0.0	78.8	17.1	0.0	4.1	92
Orange	3.7	48.0	44.7	3.5	95.4	0.0	0.5	4.0	2,845
Placer	41.8	40.7	12.6	4.9	75.7	6.0	4.7	13.5	248
Plumas	100.0	0.0	0.0	0.0	99.7	0.3	0.0	0.0	21
Riverside	12.8	14.8	0.4	72.1	96.7	0.0	0.5	2.8	1,545
Sacramento	5.8	20.5	0.0	73.7	55.9	0.6	12.7	30.7	1,224
San Benito	91.1	8.9	0.0	0.0	100.0	0.0	0.0	0.0	53
San Bernardino	12.4	28.1	2.8	56.7	94.5	0.2	0.6	4.7	1,710
San Diego	9.4	44.3	33.1	13.2	93.8	0.0	1.4	4.8	2,813
San Francisco	3.9	54.5	41.6	0.0	98.2	0.4	0.0	1.3	777
San Joaquin	15.6	20.0	2.2	62.2	68.3	0.7	9.2	21.9	564
San Luis Obispo	41.3	49.8	8.6	0.3	92.4	5.1	0.2	2.3	247
San Mateo	19.8	64.1	16.1	0.0	85.9	9.9	0.1	4.1	707
Santa Barbara	22.8	64.7	12.5	0.0	94.9	3.9	0.2	1.0	399
Santa Clara	5.7	47.6	46.7	0.0	95.0	0.0	1.0	4.0	1,683
Santa Cruz	39.8	52.2	8.1	0.0	82.9	13.4	0.5	3.2	256
Shasta	48.6	39.5	4.7	7.2	80.2	5.3	2.5	12.0	163
Sierra	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	4
Siskiyou	93.1	6.6	0.3	0.0	98.0	1.4	0.0	0.5	44
Solano	17.0	56.1	19.3	7.7	82.5	4.1	3.2	10.2	395
Sonoma	36.8	57.2	5.1	0.9	88.5	8.0	0.2	3.4	459
Stanislaus	13.9	11.3	0.6	74.2	80.6	0.4	8.1	10.9	447
Sutter	27.5	47.7	18.6	6.3	68.3	2.7	13.1	15.9	79
Tehama	65.3	34.1	0.6	0.0	90.9	4.0	1.1	4.0	56
Trinity	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	13
Tulare	25.1	9.9	0.0	65.0	92.0	0.3	4.1	3.6	368
Tuolumne	96.7	3.3	0.0	0.0	84.9	12.0	0.0	3.0	54
Ventura	16.7	71.6	11.6	0.0	96.4	2.7	0.1	0.7	754
Yolo	23.7	36.1	25.4	14.8	64.1	0.2	9.8	25.9	168
Yuba	46.9	48.0	5.1	0.0	84.5	7.6	3.8	4.1	60

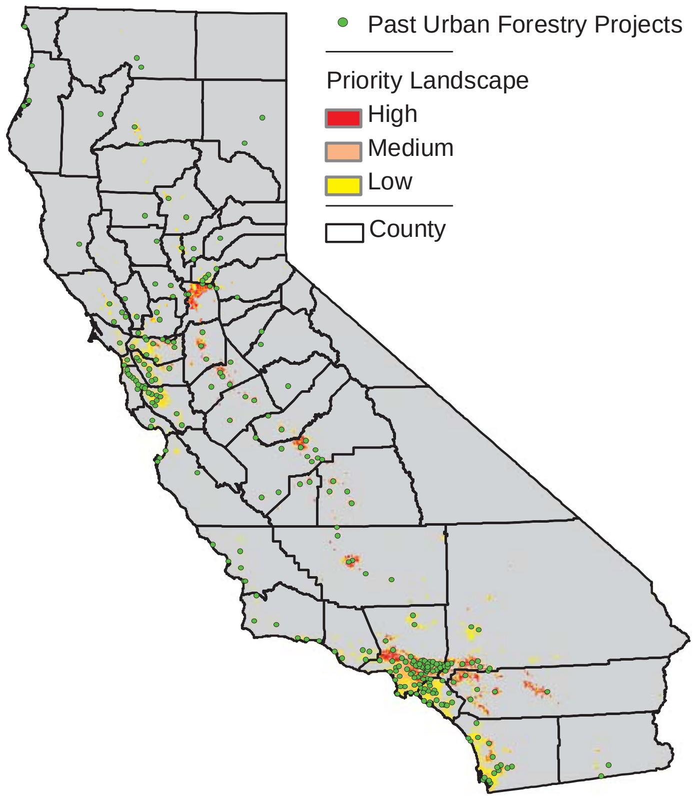


Figure 3.2.4.
Past urban forestry projects by tree planting priority landscape (Tree City USA 2006–2008 and CAL FIRE Urban Forestry Program 2002–2008).
Data Sources: PM2.5 and Ozone Health, California Air Resource Board, (2009); Non-attainment Days PM10 by Air Basin, California Air Resources Board (2004-2008); Daily Temperatures, California Climate Action Team (2008); Functional Roads (FUNC), CALTRANS (2004); Urban Areas, U.S. Census Bureau (2000); USGS National Land Cover Dataset (2001); Tree City USA (2008); CAL FIRE Urban Forestry Program (2008)

Tools

A wide range of approaches and programs now exist to deal with urban forests. For example, the purpose of CAL FIRE's Urban and Community Forest Program is to create and maintain sustainable urban forests to help improve the quality of urban environments and the quality of life of urban citizens.

Regional field specialists promote communication and cohesiveness. Working with local entities to establish integrated projects with multiple benefits, they are a key component to the efficient allocation of funds and the success of the program. They will also be the regional contacts for future Urban Forestry and Community Program tools which includes three broad categories: expansion/reforestation, maintenance/management and public outreach and support.

Expansion and Reforestation
Urban forest expansion is the planting of trees and associated vegetation in urban areas that will increase economic, environmental and social benefits to urban residents. Priority areas with considerable urban heat islands and low tree canopy should be targeted with planting and management efforts. Locating suitable tree planting sites becomes more challenging as open space and forests are lost to development as our population grows. Development without guidelines to conserve urban forests leads to decreased natural resources, and the increasing potential for urban heat islands, air pollution and increased stormwater flow associated with decreased water quality. American Forests, the nation's oldest nonprofit citizens' conservation organization, recommends an average 25 percent tree canopy for the dry west. Specifically, 18 percent tree canopy goal for urban residential, 35 percent suburban residential and nine percent commercial (Kollin, 2006). Expansion efforts can start with setting individual community tree planting goals and striving to meet them through various planned events such as Arbor Day, the Tree City USA campaign or a grant project. However, scarcer planting locations in both private and public areas have created a need to identify new expansion opportunities.

Expansion opportunities may be found by using urban forestry to support other planning goals. For instance, modifying traditionally impervious surfaces with pervious pavers and bioswales in parking lots; planting trees along road medians; adding green space above structures, such as green roofs and parks, all of these strategies help with stormwater runoff and reduce the urban heat island effect. As outdated urban areas and infrastructures are renovated and improved, the area can be retrofitted to accommodate some large-scale trees. Urban area freeway sound walls can become green walls that filter pollutants and noise.

Management

The urban forest encompasses a broad area including areas dedicated to high density residential, commercial/industrial, transportation corridors and wildland urban interface areas. Most definitions of urban forests now include both public and privately owned trees. Different management approaches can be utilized to manage and maintain this expanded urban forest. These approaches should be based on community goals, ownership, vegetation and risk assessment.

The loss of forests to urban development has had considerable environmental impacts including: loss of open space, wildlife habitat loss, water runoff, soil erosion, increased temperature and an increase in air pollution. Urban sprawl contributes to air pollution issues. Increase in the area of impervious surface due to new roadways and building hardscapes creates more water runoff, higher peak flows and soil erosion. Grading activities in conjunction with new development amplify the issue. Habitat is lost with urban development and infill housing projects. Management and maintenance of an urban forest is very complex because each community has goals and environmental concerns. Policies and ordinances that recognize the value of trees by providing guidance for inclusion, preservation and protection, are among the best means for managing and maintaining tree canopy cover.

Management tools also focus on environmental justice among communities to reduce inequitable distributions of environmental burdens, such as, pollution and heat islands caused by a lack of urban forests. Economically disadvantaged communities generally have fewer environmental amenities, more environmental burdens and less access to the decision making processes. Establishing plans in these communities often require more effort from the Urban and Community Forestry Program, because community leaders are often inundated with other issues, such as lack of resources and high crime and don't perceive planting trees a priority. However, increasing the urban forest in these areas can reduce energy bills, incidents of asthma and crime (Kuo and Sullivan, 2001a and 2001b).

Public Outreach and Support

Californians are increasingly aware of the importance of maintaining the environment and the state's natural resources, and actively support efforts to sustain our forestlands. In addition to the Urban Forestry Act of 1978, protection activities and awareness have increased and methods to protect and sustain our natural resources have been defined. Over the past decade, several propositions have been passed to ensure these resources are protected. In addition, Urban Forest Protocols were approved in 2008 to benefit local governments and provide incentive to others through offset carbon credits for planting trees in urban settings.

For any program to succeed and thrive it must have substantial support. This is especially true of the urban forestry program, which needs support from both private and public sectors. Communication, education and collaboration are key components to efficiency, and the planning of multiple benefit projects that endure future impacts and maximizes public benefits.

For urban development, this type of planning is referred to as "smart growth." Smart growth communities promote dense housing and walkable communities with the preservation of open space and planning of urban forest elements prior to development. The American Planning Association published a "Smart Growth Code" guide in 2009, which can be used by local governments, policymakers and developers interested in implementing smart growth strategies. Urban forestry tools of the future will support the smart growth concept, and promote policy to protect areas from being developed as sprawl. Small changes to development codes can have enormous impacts in an urban setting. Standards for minimum landscape requirements and impervious surface coverage allowance would be optimal, but hard to obtain. More achievable would be requirements for adequately sized planting strips on all new public development that accommodate appropriate trees and shrubs and landscape requirements for residential projects.

Urban forestry tools of the future also include the support of new green industry jobs to aid conservation and sustainability, such as opportunities in generating and storing renewable energy, recycling materials and urban biomass and energy efficient and sustainable product development.

Chapter 3.3
Planning for and Reducing Wildfire Risks to Communities

Some communities are especially prone to loss of life and property from wildfire. Local or state laws, regulations and ordinances, landowner attitudes and priorities, and public policies all play important roles in managing fire risk near communities. Assessments should identify communities where State and Private programs can substantially mitigate the risk of catastrophic wildfire occurrence and associated risks to human safety and property (excerpted from the U.S. Forest Service State and Private Forestry Farm Bill Requirement and Redesign Strategies).

KEY FINDINGS

Current Status and Trends

- California's long history of wildfire and population growth has led to a set of state laws, regulations and programs that address community wildfire safety. These include state and local planning laws, Fire Hazard Severity Zones and related building standards, defensible space requirements, various fuel reduction programs, the California Fire Plan and CAL FIRE Unit Fire Plans and the State Hazard Mitigation Plan.
- Community fire protection is also addressed by federal laws and programs such as the Disaster Mitigation Act, National Fire Plan, Healthy Forests Restoration Act, and Firewise Communities Program.
- Local agencies and non-profits play a key role in community fire protection planning through county fire plans, county general plan safety elements, and through involvement of local fire districts, Fire Safe Councils, the California Fire Alliance, and also consortia such as the Forest Area Safety Taskforce (FAST) and Mountain Area Safety Taskforce (MAST) in San Diego, Riverside, and San Bernardino Counties.

- Community planning is a collaborative effort that typically includes various federal, state and local agencies, CAL FIRE units, Resource Conservation Districts, local fire districts and private organizations.

Community Analysis

In the analysis presented here, the priority landscape was identified where wildfire threat coincided with human infrastructure such as houses, transmission lines and major roads. The priority landscape was summarized to identify priority communities. The analysis then examined which priority communities are currently covered by a Community Wildfire Protection Plan (CWPP). In addition, the analysis looked at which priority communities not covered by a CWPP have the necessary planning resources to create one. The area of priority landscape was identified for each community as a starting point for further determination of the extent of wildfire risk and subsequent fine-scale assessments of fuel hazard reduction needs and treatment types. From the analysis:

- It is estimated there are at least 317 communities protected by Community Wildfire Protection Plans throughout California. Even more are covered by a countywide CWPP.
- A total of 404 priority communities were identified, representing about 2.6 million people living on about 1.1 million acres in high or medium priority landscapes. With the assumption that all priority communities in a county with a countywide CWPP are covered by that CWPP, at least 234 (or about 58 percent) of the priority communities are covered by a Community Wildfire Protection Plan (see Data and Analytical Needs in the Appendix).
- About 250 Fire Safe Councils or their equivalent were identified (which included homeowner associations, resource and fire protection districts, local government organizations, advisory groups, CAL FIRE units, Indian Tribes and others). Of these, 47 are countywide in geographic scope. Others are community-centric or regional. There are 38 recognized Firewise Communities. These numbers are growing.
- Priority communities were present in all bioregions, with 62 percent occurring in the South Coast and Sierra bioregions.

CURRENT STATUS AND TRENDS

California's long history of wildfire and population growth has led to a multi-faceted set of laws, policies and programs addressing community safety and wildfire risk. These include:

- Federal government (particularly since 2000) and interagency efforts
- State and local agencies/communities
- Non-profit organizations

The current status of wildfire planning, community wildfire planning in particular, can be described generally by this extensive set of resources.

Federal and Interagency Efforts

Federal agencies administer about 46 percent of the land surface area of California (GreenInfo Network, 2009), with substantial portions in a "checkerboard" of public and private land ownership. This interwoven ownership pattern underscores the need for interagency wildfire planning and cooperative fire agreements. There are many components at work, including the following key elements.

Disaster Mitigation Act (2000–present)

Section 104 of the Disaster Mitigation Act of 2000 (Public Law 106-390) enacted Section 322, Mitigation Planning of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, which created incentives for state and local entities to coordinate mitigation planning and implementation efforts, and is an important source of funding for fuels mitigation efforts through hazard mitigation grants.

California updates its Multi-Hazard Mitigation Plan in accordance with mitigation planning regulations cited in the Code of Federal Regulations (CFR) Title 44, Chapter 1, Part 201 (44 CFR Part 201).

Feinstein – Herger/Quincy Library Group (1998, 2003, 2007)

The Feinstein-Herger Quincy Library Group Forest Recovery Act is being implemented across approximately 1.5 million acres in the northern Sierra bioregion as a demonstration of community-based consensus forest management. It covers much of the Lassen and Plumas National Forests and the Sierraville Ranger District of the Tahoe National Forest. The Quincy Library Group, a grassroots citizen group that helped author and promote the act, was formed to promote local economic stability, forest health and fire resiliency.

Communities at Risk (2001)

At the request of Congress, states submitted lists of all communities within their borders where there was a high level of wildfire risk from adjacent federal lands. A national list of "Communities at Risk" was published in the Federal Register in 2001. California's analysis (CAL FIRE, 2001) included the entire extent of the state's wildland urban interface (not just those adjacent to federal lands). A list is available from the California Fire Alliance website (http://www.cafirealliance.org/communities_at_risk/).

There are currently 1,272 communities at risk in California, ranging in size from large cities such as San Diego and Los Angeles, to small unincorporated areas with few residents (Figure 3.3.1). Bioregionally, 78 percent of these communities are found in the Sierra, South Coast, Klamath/North Coast and Bay/Delta bioregions (Table 3.3.1).

National Fire Plan (2002–present)

The extensive wildland fires of 2000 led to the request and submittal of a report by the Secretaries of the Interior and Agriculture entitled *Managing the Impact of Wildfires on Communities and the Environment, A Report to the President In Response to the Wildfires of 2000*. Following this report were substantial new appropriations for wildland fire management, resulting action plans and agency strategies, and the Western Governors' Association's *A Collaborative Approach for Reducing Wildland Fire Risks to Communities and the Environment – A 10-Year Comprehensive Strategy-Implementation Plan*. Collectively, this is known as the National Fire Plan. This Plan addresses the issues of firefighting and wildfire preparedness, rehabilitation and restoration, hazardous fuels reduction, community assistance and accountability.

Healthy Forests/CWPPs (2003–present)

The Healthy Forests Restoration Act of 2003 (HFRA) was a response to the widespread forest fires during the summer of 2002. Since passage of the HFRA, federal land management agencies have treated about 26 million acres of federal lands for fuel hazard reduction, in the wildland urban interface and beyond (Healthy Forests Report, June 2008).

Placing a renewed emphasis on community planning, the HFRA extended benefits to communities that prepare a CWPP in collaboration with public fire agencies and affected non-governmental interests (especially local community residents). CWPPs identify hazardous fuel reduction treatment priorities, recommend measures to reduce structural ignitability and address issues such as wildfire response, hazard mitigation, and community preparedness and structure protection. CWPPs must be approved by the California Department of Forestry and Fire Protection (CAL FIRE), local government and local fire authorities (National Wildfire Coordinating Group, 2009).

The California Fire Alliance and others endorse the creation of CWPPs through community grassroots organizations, such as local, county, and regional Fire Safe Councils. CAL FIRE Unit and County Fire Plans can serve as a de facto CWPP if they meet the collaborative requirements for community involvement. CWPP workshops are taking place throughout

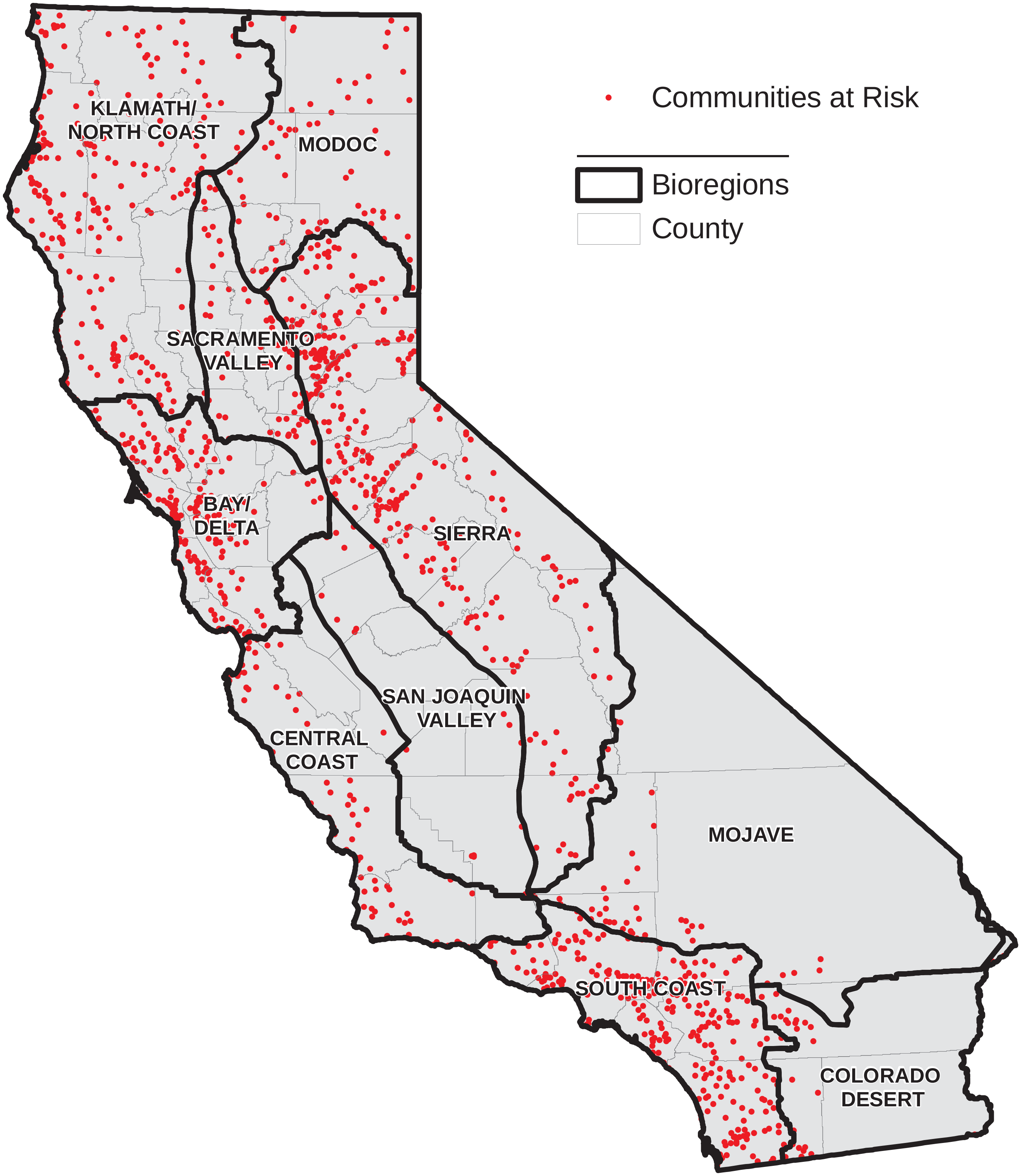


Figure 3.3.1.
Communities at risk (2001) by bioregion.
Data Source: Communities at Risk, FRAP (2009 v1)

Table 3.3.1. Communities at risk by bioregion

Bioregion	Number of Communities at Risk	Percent of Communities at Risk
Sierra	314	25
South Coast	269	21
Klamath/North Coast	226	18
Bay/Delta	177	14
Central Coast	72	6
Modoc	66	5
Sacramento Valley	61	5
Mojave	41	3
Colorado Desert	28	2
San Joaquin Valley	18	1
Total	1,272	100

the state. Conservation principles, in addition to fire safety, can be considered, and materials are available to guide the creation of "Conservation Community Wildfire Protection Plans" (http://www.forevergreenforestry.com/fire.html). Currently, work on a large scale CWPP for the Santa Monica Mountains region in Southern California draws from these conservation principles.

According to a survey by the National Association of State Foresters, CWPP coverage of Communities at Risk was substantially higher in the west, as compared to the south or northeast regions of the United States (National Association of State Foresters, 2010).

The 2001 FRAP analysis identified 317 communities by name on the California Fire Alliance website as having a CWPP. Many others are covered by countywide CWPPs. Reporting is voluntary and new CWPPs are forming continually. CWPP coverage is now found in every bioregion in California.

Although there are a number of countywide CWPPs, individual communities are still encouraged to create their own local CWPPs. For example, in El Dorado County, which has a countywide CWPP, some 17 communities have been creating their own CWPPs supported by the El Dorado County Fire Safe Council (Joint Fire Science Program, 2009).

Joint Fire Science Program

This interagency program conducts various research projects, and has studied communities that are developing CWPPs. Through case studies, they look for insights into collaborative efforts and community strategies. In their report entitled *Community Wildfire Protection Plans: Enhancing Collaboration and Building Social Capacity*, the Joint Fire Science Program found a need for "a significantly higher quality of CWPP monitoring...at the state level."

Firewise Communities (2003–present)

The Firewise Communities program (http://www.firewise.org/) is part of the National Wildland/Urban Interface Fire Program and directed by the National Wildfire Coordinating Group's Wildland/Urban Interface Working Team. The interagency consortium includes numerous federal agencies as well as state forestry organizations. The program reports that as of November 9, 2009 there are 535 Firewise Communities recognized sites in 38 states. Of the 535 Firewise Communities, thirty-eight are in California (Table 3.3.2). These communities are found clustered in the Klamath/North Coast, and also in the Bay/Delta, South Coast, Modoc and Sierra bioregions (Figure 3.3.2).

U.S. Forest Service

The national forests in California are involved with local communities in addressing regional and local wildfire issues and promoting volunteerism. The U.S. Forest Service is investigating mitigation of impacts on rural communities and economies (Thompson, 2007). In cooperative programs with the State of California and many other private and government entities, federal grant money is leveraged in programs for timber and other forest products, wildlife, water resources, rural economies and conservation practices (CFR, 2007).

Forest Legacy Program

The federal Forest Legacy Program partners with states to protect environmentally sensitive forestlands by focusing on the acquisition of partial interests in privately owned forestlands, and by helping

Table 3.3.2. Firewise Communities in California

Community	Firewise Community
Auburn Lake Trails	Cool
Beverly Hills	Beverly Hills
Big Bar and Big Flat	Lewiston
Big Bear City	Big Bear Lake
Big Bear Lake	Big Bear Lake
Carbon Canyon	Chino Hills
Circle Oaks	Napa
Coffee Creek	Lewiston
Concow/Yankee Hill	Yankee Hill
Day Lassen Bench	McArthur
Douglas City	Lewiston
Fawnskin	Fawnskin
Forest Meadows	Murphys
Fountaingrove II	Santa Rosa
Grizzly Flats	Grizzly Flats
Hawkins Bar	Lewiston
Hayfork	Lewiston
Hyampom	Lewiston
Janesville	Susanville
Junction City	Lewiston
Lake of the Pines	Nevada County
Lake Wildwood Association	Penn Valley
Lewiston	Lewiston
Logtown	El Dorado County
Mad River	Lewiston
Marinview	Mill Valley
Nashville–Sandridge	El Dorado
Post Mountain	Lewiston
Salyer	Lewiston
Sea Ranch	Sonoma County
Stones–Bengard	Susanville
Susanville	Susanville
Talmadge	San Diego
Trinity Center	Lewiston
Volcanoville	Georgetown
Walden Woods	Granite Bay
Weaverville	Lewiston

the states develop and carry out their forest conservation plans which generally involve conservation easements which restrict development, require sustainable forestry practices and protect other values.

Bureau of Land Management (BLM)

The BLM's grants for wildfire protection projects totaled $3 million in 2008, and grant applications exceeded $20 million. To date, BLM has assisted more than 450 communities at risk in 51 of California's 58 counties (BLM Fire Protection, 2009)

The Bureau of Land Management's "Take Responsibility" Campaign emphasizes stakeholder involvement and community outreach, and promotes the development of information resources. The priority areas include Trinity, Shasta, Butte, Nevada, Placer, El Dorado, Amador, Calaveras, Tuolumne, Mariposa, San Benito and Kern counties (http://www.firesafecouncil.org/articles.cfm?article=344).

Secure Rural Schools and Community Self Determination Act (2000)

Title II and Title III funds from the Secure Rurals and Community Self Determination Act (HR 2389) funded Fire Safe Councils in certain counties, helping to cover staff, operations and outreach.

Emergency Economic Stabilization Act of 2008

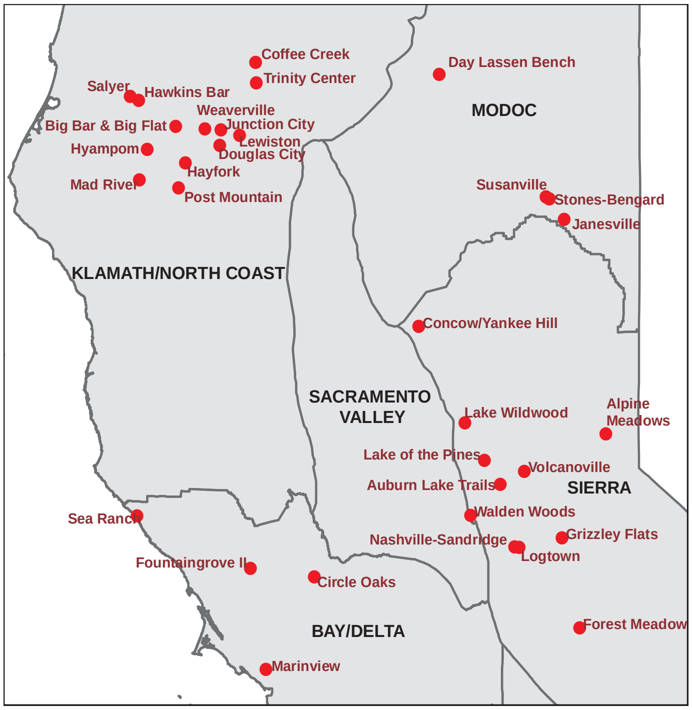
The Emergency Economic Stabilization Act of 2008 reauthorized the Secure Rural Schools and Community Self Determination Act through 2012. However, changes reduced the funding, and monies can no longer be used to cover the administrative costs of Fire Safe Councils. Several councils that depended on this funding are now struggling to survive.

American Recovery and Reinvestment Act (2009)

This federal legislation will result in four projects located in forested lands in California receiving $10.7 million for forest health protection. This funding, which totals $89 million for 78 projects in 20 states, will be used to restore forest health conditions on federal, state and private forests and rangelands recovering from fires and forest insects and disease outbreaks.

FAST/MAST – Bark Beetle Infestation in Southern California, Sierra

Over the past decade, increasing damage from a major bark beetle infestation has alarmed private landowners over the number of dead and dying trees on their property and in their communities. The outbreaks, occurring mainly in Southern California and the Sierra, are being addressed by a dozen land management agencies ranging from federal, state, county and local municipalities.



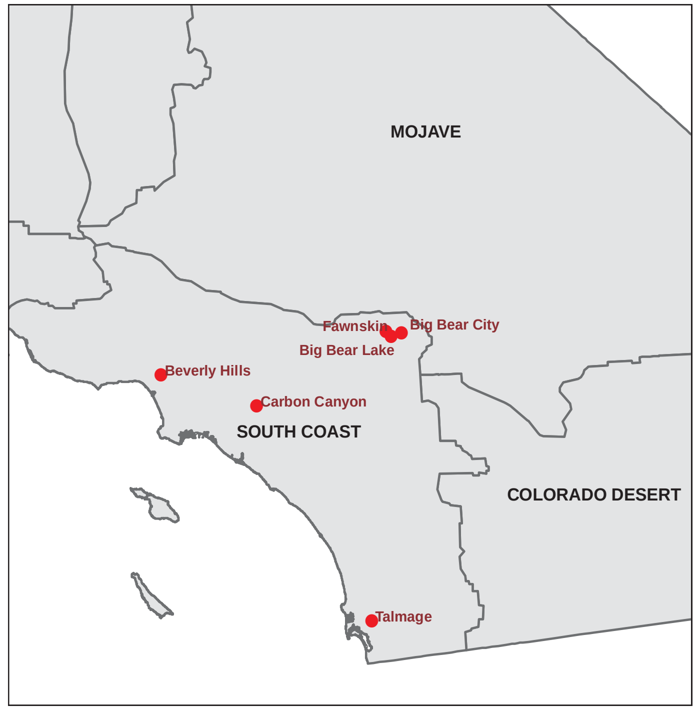


Figure 3.3.2.
Firewise Communities in a) Northern and b) Southern California.
Data Source: Firewise Communities / USA, 2009

Foresters have issued a “call to action” to prevent further spread of a major bark beetle epidemic, with targeted land including the Lake Tahoe area and other parts of the Sierra bioregion. About 2.4 million acres of “high priority” landscapes are at risk of being overrun by beetles and have been identified for potential treatment by the Council of Western State Foresters. Much of the land is near communities where widespread tree mortality could produce extreme fire danger.

In Southern California, the counties organized into Mountain Area Safety Task Forces (MAST) in San Bernardino and Riverside counties, and the Forest Area Safety Task Force (FAST) in San Diego County. The FAST and MAST efforts were originally developed to address significant threat posed by bark beetle infestations through the removal of dead trees. They have since taken on a much broader role in hazardous wildlands fuels management, including identification of priority landscapes for treatment using an “all lands approach”, treatment and maintenance of priority landscapes, and education for communities and homeowners with respect to defensible space and fire resistant building materials. For more information on MAST and FAST, see http://www.calmast.org and http://www.sandiegofast.org.

State and Local Efforts

Various state laws and policies establish a framework that largely utilizes local planning and citizen action.

General Plan Safety Element

Each city and county in California must prepare a comprehensive, long term general plan. The general plan expresses a community’s development goals. Mandated elements listed in Government Code Section 65302(g) include a Safety Element, which aims to reduce the potential risk of death, injury, property damage and economic and social dislocation resulting from fires and other hazards. The Safety Element reflects input from public health and safety agencies and includes substantial public review and comment.

California Environmental Quality Act (1970)

Projects undertaken by a public agency, such as state and local agencies and special districts, are subject to the California Environmental Quality Act (CEQA). CEQA requires an Environmental Impact Report be created where a project may significantly affect the environment, or to adopt a negative declaration if the project will not have significant impacts.

Categorical Exemption
As documented in a Notice of Exemption, CEQA's Categorical Exemption requires limited analysis and restrictions to ensure that environmental impacts will not occur. The following classes of activities are generally considered to be exempt from the requirement to conduct further environmental analysis. An abbreviated checklist is used to document the steps taken to ensure that impacts will not occur.

Examples of fuels treatment projects found to be Categorically Exempt in the past:

- Existing Facilities (e.g., maintenance or re-establishment of existing fuel breaks)
- New Construction (e.g., new fuel breaks)
- Minor Alterations to Land (e.g., minor vegetation removal, shaded fuel breaks)
- Information Collection (e.g., environmental studies prior to project implementation)
- Inspections (e.g., for project compliance)
- Actions to Protect Resources/Environment (e.g., chipper programs)

Fire Hazard Severity Zones, Building Codes (1985–Present)

Fire Hazard Severity Zones (FHSZ) define the application of various mitigation strategies such as building standards to reduce risk associated with wildland fires. California Public Resources Code 4201-4204 and Govt. Code 51175-89 direct CAL FIRE to map areas of significant fire hazards based on specified factors. These zones are delimited for areas where the state has financial responsibility for fire protection, State Responsibility Areas (SRA) and areas where local governments have responsibility for fire protection, Local Responsibility Areas (LRA). CAL FIRE updated FHSZ in SRA in 2007 and will have completed revised recommendations for Very High FHSZ in LRA by early 2010. These updates use models that include the spread of wildfire from wind-driven embers.

Since 2005, building codes have established minimum standards for materials and material assemblies, and provide a reasonable level of exterior wildfire exposure protection for new structures in SRA and where local governments have adopted ordinances for Very High FHSZ in LRA.

Defensible Space (and related laws)

California Public Resources Code 4290 sets the requirements for the creation and maintenance of defensible space, building standards and vegetation management guidelines for wildfire prevention and risk reduction on State Responsibility Area (SRA) lands. The guidelines include regulations on road standards for fire equipment access, standards for signs identifying streets, roads and buildings, minimum private water supply reserves for emergency use and standards for fuel breaks and greenbelts.

The requirement of a defensible space is mandated by California Public Resources Code 4291. Effective January 1, 2005, minimum clearance (defensible space) for structures is 100 feet.

Fuel Reduction Programs

Hazardous fuels reduction programs are administered and implemented at many of the same levels as the defensible space programs.

CAL FIRE's Vegetation Management Program is a cost-sharing program that uses prescribed fire and mechanical means to address wildland fuel hazards and other resource management issues on State Responsibility Area lands.

California Forest Improvement Program provides cost-share assistance to private forest landowners, Resource Conservation Districts, and non-profit watershed groups. Cost-shared activities include management planning, site preparation, tree purchase and planting, timber stand improvement, fish and wildlife habitat improvement and land conservation practices.

Additionally, CAL FIRE utilizes local government agencies or nonprofit organizations, (any California corporation organized under Section 501(c)(3)) to implement Community Assistance Grants. CAL FIRE assists local agencies and councils in the wildland urban interface grant process.

California State and Related Local Fire Plans (1996–present)

The California Department of Forestry and Fire Protection, in cooperation with the State Board of Forestry and Fire Protection (BOF), produces the statewide California Fire Plan. The focus is on reducing the risk of wildfire in the State Responsibility Area, reducing firefighting costs and property losses, firefighter safety, and protecting watershed values and ecosystem health. The Fire Plan is now being updated by the BOF and CAL FIRE, with input from stakeholders, and is scheduled for public release in 2010.

There are 27 Unit Fire Plans, one for each of the 21 CAL FIRE Units and the six counties with which the state contracts for wildland fire protection on State Responsibility Areas (Kern, Los Angeles, Marin, Orange, Santa Barbara and Ventura). The unit plans vary in level of detail and stakeholder involvement. Typically they identify assets at risk, areas of concern and focus of fuels reduction and other efforts. In some cases, the Unit Fire Plan can function as the CWPP.

State Hazard Mitigation Plan (2007–present)

Updated every three years by the California Emergency Management Agency, the State Hazard Mitigation Plan outlines California's evaluation of hazards and the plans to address them and is consistent with a federal requirement under the Disaster Mitigation Act of 2000. The next update will be finished in 2010. California receives federal funds from various disaster assistance grant programs.

Local Hazard Mitigation Plans

Through the preparation and adoption in the past several years of over 400 Federal Emergency Management Agency (FEMA) approved Local Hazard Mitigation Plans, local governments have encouraged grassroots organizations, public and private agencies, and the general public to directly participate in planning for increased safety and sustainability of their own communities (Governor's Office of Emergency Services, 2007).

Role of Resource Conservation Districts

A number of the 100 Resource Conservation Districts (RCDs) are involved in fire planning. For example, the Resource Conservation District of Santa Cruz County and the San Mateo Resource Conservation District are both on a steering committee to coordinate CWPP development as an update to the CAL FIRE San Mateo-Santa Cruz Unit Fire Plan.

Local Fire Districts

The majority of SRA lands have local fire districts that provide life and property protection and other public safety services (CAL FIRE, 2003). Fire districts play an important role in community wildfire planning, in addition to traditional urban fire services. Fire district approval is required for a federally recognized Community Wildfire Protection Plan.

State Proposition 40 (2002)

The California Clean Water, Clean Air, Safe Neighborhood Parks, and Coastal Protection Act of 2002 (Proposition 40) provides funds for local assistance grants.

CAL FIRE implemented their Proposition 40 grants with the administrative assistance of the Sierra Coordinated Resource Management Council. These efforts supported vegetation projects on private land through the existing California Forest Improvement Program which provides cost-share assistance to private forest landowners, Resource Conservation Districts and non-profit watershed groups.

State Proposition 84 (2006)

Proposition 84, known as the Safe Drinking Water Bond Act, provides funding that can be used for fire planning and fuels reduction projects in the Sierra bioregion. The Sierra Nevada Conservancy, a state agency that focuses on the environmental, economic and social well-being of the region and its communities, administers the grants.

Non-profit Organizations

Fire Safe Councils (1993–present)

Fire Safe Councils organize and educate groups on available programs, projects and planning. The Councils work closely with the local fire agencies to develop and implement priorities. Much of the value in the Fire Safe Councils lies in their close ties to the communities. Members of the community educate their neighbors and plan Fire Safe projects that fit the needs of the local area. Local councils have made great strides in areas where agencies and governing bodies have struggled. Many communities have their own defensible space programs, with neighbors inspecting and educating neighbors.

The coverage of Fire Safe Councils is extensive. There are currently over 250 Councils or their equivalent (which includes homeowner associations, resource and fire protection districts, local government organizations, advisory groups, CAL FIRE units, Indian Tribes and others). Of these, forty-seven are county-wide in geographic scope. Others are community-centric or regional. Figure 3.3.3 indicates countywide Fire Safe Council coverage and also a sample of 170 community Fire Safe Councils. This is approximate, as new Fire Safe Councils are being formed continually.

County and state Fire Safe Councils also assist with the award and administration of grants through the State Clearinghouse which may come from federal agencies such as BLM or the U.S. Forest Service. FEMA provides assistance to communities that have identified wildfire hazard mitigation needs in the form of fuel reduction and planning grants.

Fire Safe Council inspections are conducted with the support of grant dollars, homeowner's association dues and county funds.

California Fire Alliance (2001–present)

The California Fire Alliance is a cooperative organization whose member agencies include CAL FIRE, U.S. Forest Service, California Fire Safe Council, U.S. Bureau of Indian Affairs, U. S. Bureau of Land Management, California Emergency Management Agency, Los Angeles County Fire Department, National Park Service and U.S. Fish and Wildlife Service. The focus is on community safety, cost and loss minimization, and environmental quality. The California Fire Alliance works with communities, providing information and education outreach to increase awareness of wildland fire protection program opportunities, and encourages the formation of local Fire Safe Councils. California Fire Alliance maintains the Fire Planning and Mapping Tools website

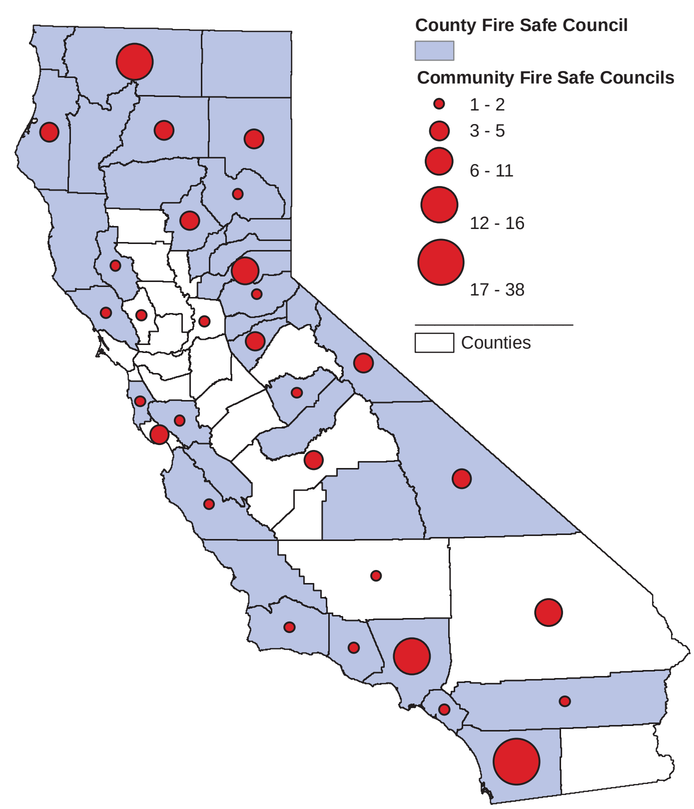


Figure 3.3.3.
Local and county Fire Safe Councils.
Data Source: California Fire Safe Council, Inc., 2009

(http://wildfire.cr.usgs.gov/fireplanning/), a useful tool for accessing wildfire planning data.

Property Insurance

The link between effective public fire mitigation capabilities and lower insured property loss is unquestioned, according to the Insurance Service Organization, a leading source of information about property and casualty insurance. It may be possible to lower insurance premium rates by taking preventative measures such as installing a non-combustible roof, clearing the brush around the home or landscaping with fire-retardant plants.

EVALUATING COMMUNITIES FOR WILDFIRE RISK

The analysis in Chapter 2.1 identified a priority landscape where wildfire threat coincides with human infrastructure such as houses, transmission lines and major roads. This chapter uses that priority landscape to identify priority communities meeting minimum area or population criteria as a starting point for identifying extent of risk and subsequent fine-scale assessments of fuel hazard reduction needs and treatment types. The analysis then examines which of these priority communities have CWPPs, are Firewise Communities, or meet other criteria suggesting the presence of community planning resources and experience.

Communities

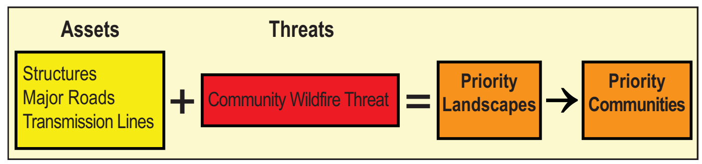
As detailed above, community wildfire planning occurs over land areas ranging from a housing subdivision or small rural community, to one or more larger communities or fire districts, to an entire county.

A GIS dataset of communities was developed based on incorporated city boundaries and Census Designated Places for unincorporated communities. Communities were tagged according to several criteria:

- Listed as a Community at Risk
- Served by a local Fire Safe Council
- Served by a county or regional Fire Safe Council
- Served by a County Fire Plan
- Firewise Community
- Covered by a CWPP

For the community analysis, county CWPPs listed on the California Fire Alliance website were assumed to apply to all communities within the respective counties, which may result in overestimation in some counties. Therefore this information was summarized at the bioregional scale.

Analysis



Assets

Community assets are defined as residential and commercial structures, major roads and transmission lines, and represent the human infrastructure assets potentially at risk from wildfire. The methods for ranking and combining these assets are discussed in detail in Chapter 2.1.

Threats

Wildfire threat to communities is derived using Fire Hazard Severity Zone data. This is identical to stand-level wildfire threat discussed in detail in Chapter 2.1.

Priority Communities

This analysis defines priority communities as communities with at least 500 people or 1,000 acres in either medium or high priority landscape. The purpose of the priority communities designation is to provide a way of identifying possible communities for outreach and further strategy development.

The very small communities on the Communities at Risk list which are not represented as areas in the Communities dataset are assumed to have at least a high level of wildfire risk, as was determined from the Communities at Risk methods developed in

2001. However, because the current analysis requires an accurate area representation of communities to quantify the area and population within priority landscape, they are not included in these results. The Communities at Risk methods, which only require an approximate community location point, will continue to be used in a general way to evaluate new submissions by communities wishing to be included on the Communities at Risk list.

Results

Figure 3.3.4 shows the location of priority communities and CWPP status, with bioregion and county boundaries. To be as inclusive as possible, the assumption is made that all priority communities within counties that have a countywide CWPP are covered by those CWPPs.

From this analysis 404 priority communities emerged, which include:

- 2.5 million people and 1.1 million acres
- 355 communities already classified as Communities at Risk
- 16 recognized Firewise Communities
- 234 communities covered by a CWPP

Bioregional Findings

Table 3.3.3 shows the number and percent of priority communities by bioregion and the population and acres.

- Priority communities are in all bioregions, but over 78 percent are in the South Coast, Sierra and Bay/Delta bioregions.
- The Sierra bioregion has substantial population growth in wildland areas and ecological concerns are emphasized in community planning efforts.

The Mojave, Colorado Desert, Sacramento Valley, San Joaquin Valley and the Modoc bioregions together account for only eight percent of priority communities.

Discussion

Planning Resources and Experience

Planning resources which may be available to communities are widespread and can include local, county and regional Fire Safe Councils, CAL FIRE units, USFS and other federal agencies and non-profit organizations. These can provide organizational support for addressing community concerns regarding wildfire protection and planning.

CWPPs

California's long history responding to wildfire has led to a multitude of planning efforts which are approximately equivalent to a CWPP, and for the purposes of analysis, it is assumed that the presence of planning resources and experience, including a CWPP, reduces risk from wildland fire.

The estimated percent of priority communities covered by a CWPP within a particular bioregion, as determined by this analysis and shown in Table 3.3.4, should be viewed with the knowledge that not all CWPPs were included in the analysis. In addition, given the wide range of laws, plans and programs in place, not all communities may need a CWPP.

- CWPPs are helping to protect a large number of the communities in the relatively rural, forested bioregions. In the Sierra, Klamath/North Coast, and Modoc bioregions, 72, 82, and 78 percent of medium or high priority communities, respectively, are covered by CWPPs. In terms of population, 69, 59, and 73 percent, respectively, are covered.
- The populous South Coast bioregion includes the largest share of priority communities (42 percent). Fifty-nine percent of these communities are covered by a CWPP. In terms of population, 42 percent are covered. Thus, an additional million people could benefit from new CWPP coverage, augmenting the already strong wildfire planning programs in Southern California counties. For example, an extensive CWPP is being developed for about 100,000 acres of the Santa Monica Mountains.

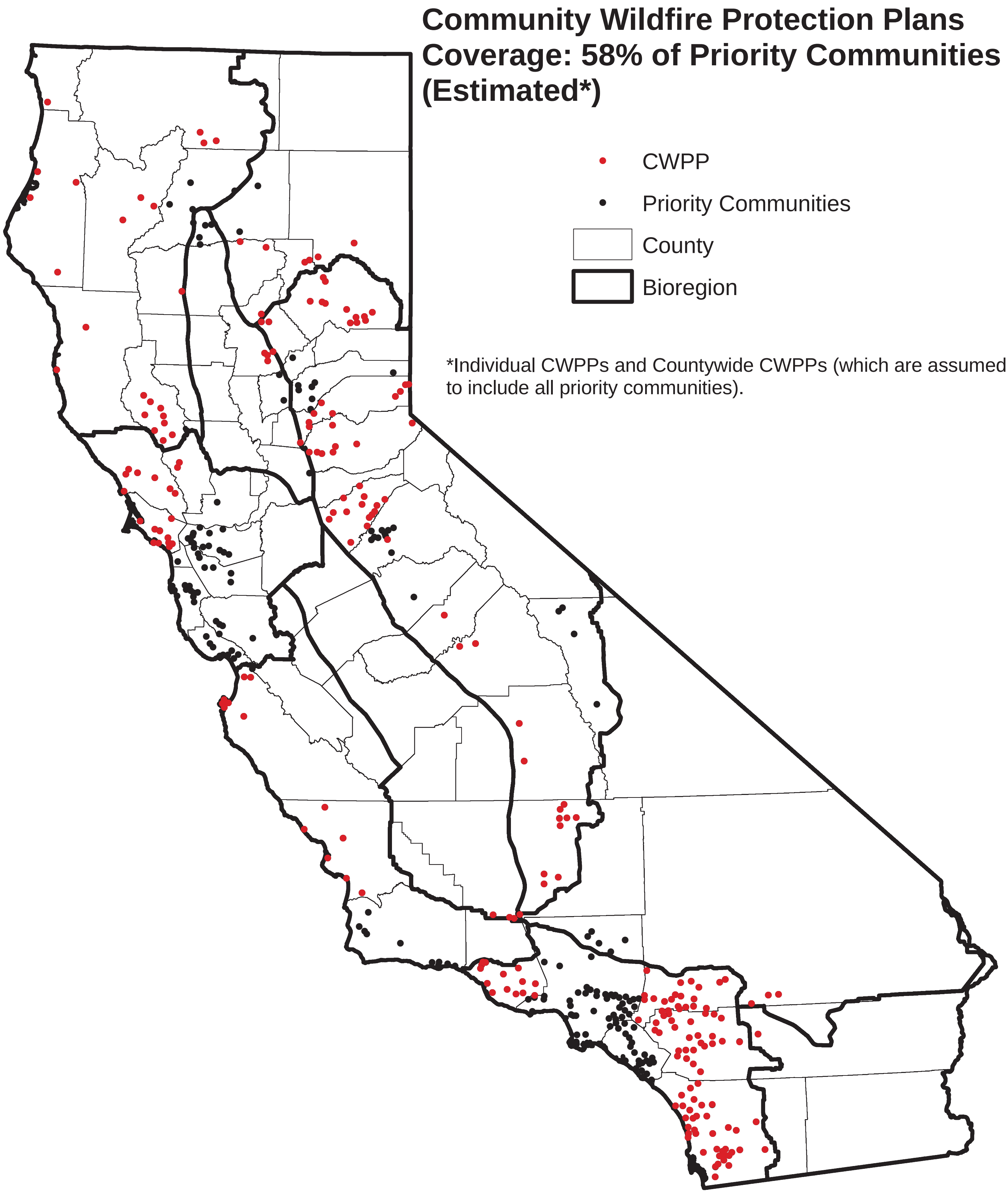


Figure 3.3.4.
Priority communities with CWPP coverage.

Data Sources: Transmission Lines, California Energy Commission (2007); Community Wildfire Protection Plans, California Fire Alliance, (2009); Communities, FRAP (2009 v1); Fire Hazard Severity Zones for SRA, FRAP (2006); Very High Fire Hazard Severity Zones for LRA, FRAP (2010); U.S. Census Bureau (2000); USGS National Land Cover Dataset (2001); Community Wildfire Protection, FRAP (2009, v1)

- BLM has a strong outreach program for desert communities that are CWPP candidates.

Tools

Tools to help build planning resources and experience, the capacity of a county, town or neighborhood to lead and participate in the planning process, should be a priority.

Information

Currently, a large amount of information is available to communities, but for a variety of reasons some communities that would benefit from a CWPP may not have developed one. A statewide strategy would explore ways to streamline information, data, analysis and communication resources to facilitate local efforts.

Funding

Depending on the size and complexity of a CWPP, start-up costs for a new organization to plan, implement and administer CWPP projects can be substantial. With resources for operations and administrative funding limited, new funding sources and strategies are needed to maintain and improve upon the gains already made.

Monitoring and Evaluation

The California Fire Alliance CWPP website has the capacity to provide links to completed CWPPs. However, reporting is voluntary and maintaining currency in this website will remain challenging. This website could provide additional resources by summarizing CWPPs in such a way as to facilitate analysis and monitor accomplishments.

Table 3.3.3 Priority communities for wildfire risk by bioregion (acres and population in thousands)

Bioregion	Priority Communities	Percent of Total	Acres	People
Bay/Delta	168	17	76	214
Central Coast	83	6	62	93
Colorado Desert	67	0	3	2
Klamath/North Coast	28	7	72	53
Modoc	24	2	31	19
Mojave	12	2	17	57
Sacramento Valley	9	3	18	16
San Joaquin Valley	9	1	5	5
Sierra	3	21	233	220
South Coast	1	42	594	1,900
Total	404	100	1,111	2,578

Table 3.3.4. Priority communities with CWPP coverage by bioregion (Acres and population in thousands)

Bioregion	Priority Communities with CWPP	Percent of Priority Communities	Acres of Priority Communities with CWPP	Percent of Priority Community Acres	People in Priority Communities with CWPP	Percent of Priority Community People
Bay/Delta	19	28	16	20	33	16
Central Coast	13	54	33	53	44	48
Colorado Desert	1	100	3	100	2	100
Klamath/North Coast	23	82	52	72	31	59
Modoc	7	78	17	57	14	73
Mojave	4	44	7	40	5	10
Sacramento Valley	5	42	7	40	10	62
San Joaquin Valley	3	100	5	100	5	100
Sierra	60	72	173	74	151	69
South Coast	99	59	348	59	807	42
Total	234	58	661	59	1,102	43

Chapter 3.4
Emerging Markets for Forest and Rangeland Products and Services

Assessments should identify forest landscape areas where there is a real, near term potential to access and supply traditional, non-timber, and/or emerging markets such as those for biomass or ecosystem services. These might be areas where necessary infrastructure currently exists, is planned or developing, where group certification of landowners has created market supply aggregation potential, or where retention and management of forest cover presents a money saving alternative to an engineered fix – such as a water filtration facility. Strengthening and developing new market opportunities for forest products and benefits provide incentives for forest stewardship and conservation (excerpted from the U.S. Forest Service State and Private Forestry Farm Bill Requirement and Redesign Strategies).

KEY FINDINGS

Emerging markets for renewable energy, ecosystem services and niche products are impacting how forest and rangelands are managed. Developing appropriate policies requires a better understanding of the benefits and environmental impacts of these emerging markets and how society values the various market and non-market products and services provided by forests and rangelands.

Renewable Energy Overview

- In the Mojave and Colorado Desert bioregions the number and size of proposed solar and wind power generation sites has engendered controversy over potential impacts to wildlife habitat. The science-driven Desert Renewable Energy Conservation Plan is intended to become the state road map for renewable energy project development that will advance state and federal conservation goals while facilitating the timely permitting of renewable energy projects in these desert regions.

Biomass Energy – Current Status and Trends

- Biomass energy from forestlands provides about one percent of California's electricity, while having the potential to provide nearly eight times this amount. Biomass also has unutilized potential for heating homes, businesses and schools and for conversion to liquid transportation fuels (as conversion technology evolves).
- Capturing energy from biomass that would otherwise decay, be disposed of by pile and burn or potentially consumed by wildfire, provides numerous economic and environmental benefits, which are not captured as an actual economic return for operators of facilities that utilize woody biomass material. Case studies confirm that fuels treatment activities involving biomass removal can mitigate wildfire behavior (Cone Fire, 2002).
- The various benefits and environmental impacts of forest biomass removal are complex and further research is required to guide appropriate policies and practices. Questions of long-term biomass supply (especially from public lands), as well as possible ecological and other impacts of biomass removal on forest sustainability, are key issues in California.
- The future of the biomass energy industry in California, at least as it relates to the forestry sector, is uncertain. California had 49 operating biomass plants in the mid-1990s; today there are 33.
- The California Energy Commission, working through the Bioenergy Interagency Working Group, has produced a comprehensive strategy for sustainable development of biomass in the state. The first Bioenergy Action Plan was released in 2006, and the goal is to adopt an updated plan by the end of 2010.

Biomass Energy – Ecosystem Health Analysis

Benefits of making six idle and six proposed biomass facilities operational are derived in terms of treating priority landscapes for ecosystem health from the wildfire and forest pests analyses articulated in previous chapters.

- Currently, 22 percent of high priority landscapes are within 25 miles of an operational biomass facility. Adding 12 facilities would increase this number to 39 percent, and would primarily benefit the Klamath/North Coast, Modoc and Sierra bioregions.
- Even with the additional facilities, 61 percent of high priority landscapes are farther than 25 miles from a facility. Since 57 percent of the high priority landscapes are on U.S. Forest Service lands, coordination across agency boundaries will be critical.

Biomass Energy – Community Safety Analysis

Building upon the wildfire and forest pests community safety analyses presented in previous chapters, this analysis determines the benefits of making six idle and six proposed biomass facilities operational in terms of treating priority communities.

- Currently, only 14 of the 66 priority communities are within 25 miles of an operational biomass facility. Adding the new facilities would reach eleven additional priority communities. Of the remaining 41 priority communities, 31 are in the South Coast bioregion.

- Developing a biomass industry in the South Coast bioregion that addresses the significant wildfire and forest pest threats will be challenging. In the bioregion, there are large acreages in shrub species that are difficult to recover and utilize as biomass, and much of the forestland is in public ownership.

Carbon

- Carbon sequestration is an ecosystem service for which markets are emerging; as part of these markets, the value of the service is quantified, prices determined and dollars generated for carbon credits.
- Markets are emerging for both voluntary exchange between parties (voluntary markets) and in response to the need to reduce carbon impacts as part of regulatory requirements (compliance markets).
- Demand for forest and range-related carbon is projected to be very significant in such markets and other venues.
- Carbon credit supply is constrained by economics, risk and other factors. It is estimated that one to two million metric tons a year will be available to the compliance market from California forests, which is only 10–25 percent of demand.
- Protocols already have been developed for forest and range-related carbon. The development of additional project type protocols for forests and rangelands could promote activities with ecological and economic co-benefits and increase the supply of carbon credits.
- California has large acreages of forest stands that with additional investment, could provide larger, future benefits in terms of forest products, jobs and carbon storage and sequestration. Opportunities also exist on rangeland, but the markets and necessary technologies to capture carbon are not sufficiently developed to quantify these opportunities.

Niche Markets

- There is potential for niche markets to stimulate rural economies through certified products, micro-biomass or landowner collaboratives to produce and market timber using small scale or portable milling technologies.

Ecosystem Services

- In many cases, market mechanisms for exchange of values from ecosystem services in California are still limited. Despite this, substantial investments have been made in the state that support ecosystem services. Typically, these investments involve protecting areas that provide unique or high levels of desired services, or restoring areas impacted by past events.
- These investments come through a variety of programs, agencies and stakeholders. Involvement of landowners and the development of partnerships and cooperation have been key factors. To a large degree, the underlying funding comes from public sources, such as ballot initiatives or agency budgets. Augmenting this with emerging market-based solutions could enhance the ability to sustain these important services into the future.

RENEWABLE ENERGY OVERVIEW

Current Status and Trends

Through legislation and executive orders, California has focused on increasing use and development of renewable energy. For example, one of the goals of the Renewables Portfolio Standard (RPS) (SB 107, 2006 and SB 1078, 2002) is to help reduce greenhouse gas (GHG) emissions. Another example is AB 32 which, in large part, is devoted to GHG reduction.

Related executive orders include:

- Executive Order S-06-06 (2006): established a biomass target of 20 percent within the established RPS goals for 2010 and 2020.
- Executive Order S-14-08 (2008): established accelerated RPS targets (33 percent by 2020) as recommended in the Energy Action Plan II. The order also called for the formation of the Renewable Energy Action Team, comprised of the California Energy Commission (CEC), Department of Fish and Game, U.S. Bureau of Land Management and U.S. Fish and Wildlife Service. Through the team, the Energy Commission and the Department of Fish and Game are to prepare a plan for renewable development in sensitive desert habitat.
- Executive Order S-21-09 (2009): directs the Air Resources Board (ARB) to work with the California Public Utilities Commission, the California Independent System Operator, and the Energy Commission to adopt regulations increasing California's RPS to 33 percent by 2020. The ARB must adopt these regulations by July 31, 2010.

The Air Resources Board's Scoping Plan points to achieving the RPS and 33 percent renewable as a key strategy for reducing greenhouse gases. The California Public Utilities Commission, California Energy Commission and Governor Schwarzenegger have sanctioned the Energy Action Plan, requiring that renewable energy sources increase to 33 percent of the state supply by 2020.

As of 2007, California was deriving 11.9 percent of its electricity from renewable energy sources (geothermal, biomass, small hydro, wind and solar) (CEC, 2007). Figure 3.4.1 shows that in 2007, 2.1 percent of the state's energy sources for electricity were derived from biomass, or 18 percent of the total renewable resources. Not all of this can be attributed to forests and rangelands, as biomass energy sources include urban and agricultural waste along with forest biomass.

Potential for Meeting the Renewables Portfolio Standard

Table 3.4.1 shows current and potential future renewable energy infrastructure by bioregion, derived from various sources. The Mojave bioregion has the most existing, and by far the most potential, solar and wind sites. Current sites occupy about 50,000 acres; if potential projects were actually implemented this could grow to well over a million acres, with 1,155 miles of new or updated transmission lines. The Colorado Desert and Modoc bioregions are also candidates for extensive development of renewable energy infrastructure.

Applications for Renewable Energy Projects

As of December 2009, there were 57 U.S. Bureau of Land Management (BLM) applications for solar projects in the California desert district and 93 applications for wind projects in California, many in the desert (BLM, 2010). Two of the more active areas for applications are shown in Figure 3.4.2. A significant portion of public lands are prohibited from renewable energy development due to environmental concerns (ecological reserves, wildlife refuges, national parks, wilderness and roadless areas, etc). Nonetheless, over 1.45 million acres of public lands in California are under consideration for alternative energy production (California Desert Council (CADC), 2009). Renewable energy development raises a new set of concerns, particularly related to impacts on wildlife habitat, and this creates controversy (CADC, 2009; LA Times, 1/23/09). The science-driven Desert Renewable Energy Conservation

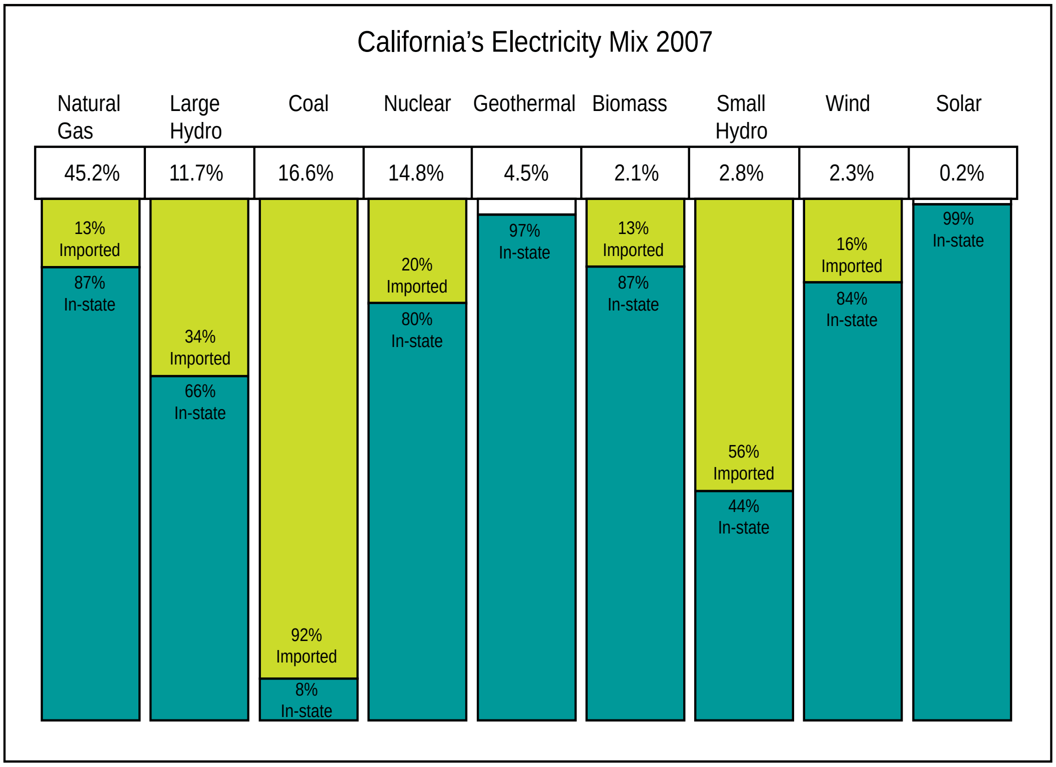


Figure 3.4.1.
California energy sources for electricity, 2007.
Source: California Energy Commission, Gross System Power Report, 2007

Plan is intended to become the state road map for renewable energy project development that will advance state and federal conservation goals while facilitating the timely permitting of renewable energy projects in these desert regions (Integrated Energy Policy Report, 2009).

While BLM has been the primary agency affected by emerging renewable energy markets in the state, the U.S. Forest Service has conducted a suitability study that identifies numerous areas within national forests in California that are potentially suitable for wind, solar or geothermal energy development (Karsteadt et al., 2005).

Revenue from Lease of Public Lands

Lease of public lands for renewable energy development provides a potential revenue source. For example, a recent competitive auction of lease parcels for geothermal energy resources on federal lands in California, Nevada and Utah generated $9,098,304 in revenue for 255,347 acres, an average of about $35 an acre (BLM, 2009). The California portion amounted to 11,392 acres for $131,126, about $12 an acre. Revenue is shared by the state (50 percent), county (25 percent), and BLM (25 percent).

Impact on Rural Economies

Developing renewable energy sources has the potential to create jobs for initial construction of infrastructure and for ongoing maintenance. Job creation for different types of renewable energy development is provided in Table 3.4.2.

Wind Energy

Wind power plants generate mechanical energy, which is converted to electrical energy. Ninety-five percent of California's wind generating capacity is located in three areas: Altamont Pass (Alameda County), Tehachapi (Kern County) and San Gorgonio (Riverside County) (CEC, 2009). The cost of wind power generation has decreased by nearly four-fold since 1980, primarily due to improved technology (American Wind Energy Association, 2009), and

Table 3.4.1. Current and potential future[1] renewable energy infrastructure by bioregion

	Wind				Solar				Geo-thermal	Biomass[2]		Transmis-sion Lines
	Existing		Potential		Existing		Potential		Existing	Existing	Potential	Potential New or Updated
Bioregion	**Sites**	**Acres**	**Sites**	**Acres**	**Sites**	**Acres**	**Sites**	**Acres**	**Sites**	**Sites**	**Sites[3]**	**Miles**
Bay/Delta	9	28,090										297
Central Coast	1	9,544	2	20,787			10	12,774				58
Colorado Desert	1	5,420	37	109,125	4	11,127	42	222,224	5	2		758
Klamath/North Coast			4	12,006						2	5	36
Modoc	1	8,761	54	307,521			2	723	1	5	2	96
Mojave	9	42,918	112	666,822	5	6,260	132	457,180	1			1,155
Sacramento Valley										5		303
San Joaquin Valley			1	38	1	1,277	15	19,809		5		601
Sierra	4	22,630	9	53,666			7	8,953		3	5	200
South Coast	2	4,053	13	27,787								809

[1] Potential future sites includes those from the Renewable Energy Transmission Initiative (RETI), plus current applications on BLM lands.

[2] Current and potential biomass facilities are based on data assembled from various sources by FRAP, and only includes facilities with the potential to reduce wildfire or forest pest threats on forests and rangelands.

[3] Includes six proposed facilities, five that are currently idle, and one operational facility in Carson City, Nevada that under current conditions gets minimal material from California.

Data Sources: RETI, California Energy Commission (2009); Biomass Facilities, FRAP (2010), Renewable Energy Applications, BLM (2009)

Table 3.4.2. Average employment for different energy technologies normalized to the amount of energy produced (or saved in the case of energy efficiency)

Technology	Total Job-Years per GWh
Biomass	0.22
Geothermal	0.25
Solar Photovoltaic	0.91
Solar Thermal	0.27
Wind	0.17
Carbon Capture and Storage	0.18
Nuclear	0.15
Coal	0.11
Natural Gas	0.11
Energy Efficiency	0.38

Data Source: Kammen and Engel, 2009

wind is becoming more competitive with energy sources such as coal and nuclear.

However, wind power requires large tracts of land, impacts visual quality, creates noise, typically operates at only 25 to 40 percent of capacity, and facility construction and maintenance can have extensive environmental impacts through vegetation clearing and soil disruption. There are significant concerns related to bird and bat mortality due to collisions with turbines and wires. A five year research effort at the Altamont Pass Wind Resource Area found that 1,766 to 4,721 birds are killed annually, including 40 different species, 881 to 1,300 of which are raptors (Smallwood et al., 2004). Newer, larger turbines installed in groups seem to cause fewer bird fatalities per megawatt (MW) than the smaller, older, lattice-style turbines (National Academy of Sciences, 2007; Smallwood et al., 2004).

The California Energy Commission and California Department of Fish and Game have developed guidelines for reducing impacts to birds and bats from wind energy. These include methods to assess bird and bat activity at proposed wind energy sites, design pre-permitting and operations monitoring plans, and develop impact avoidance, minimization and mitigation measures. The U.S. Fish and Wildlife Service

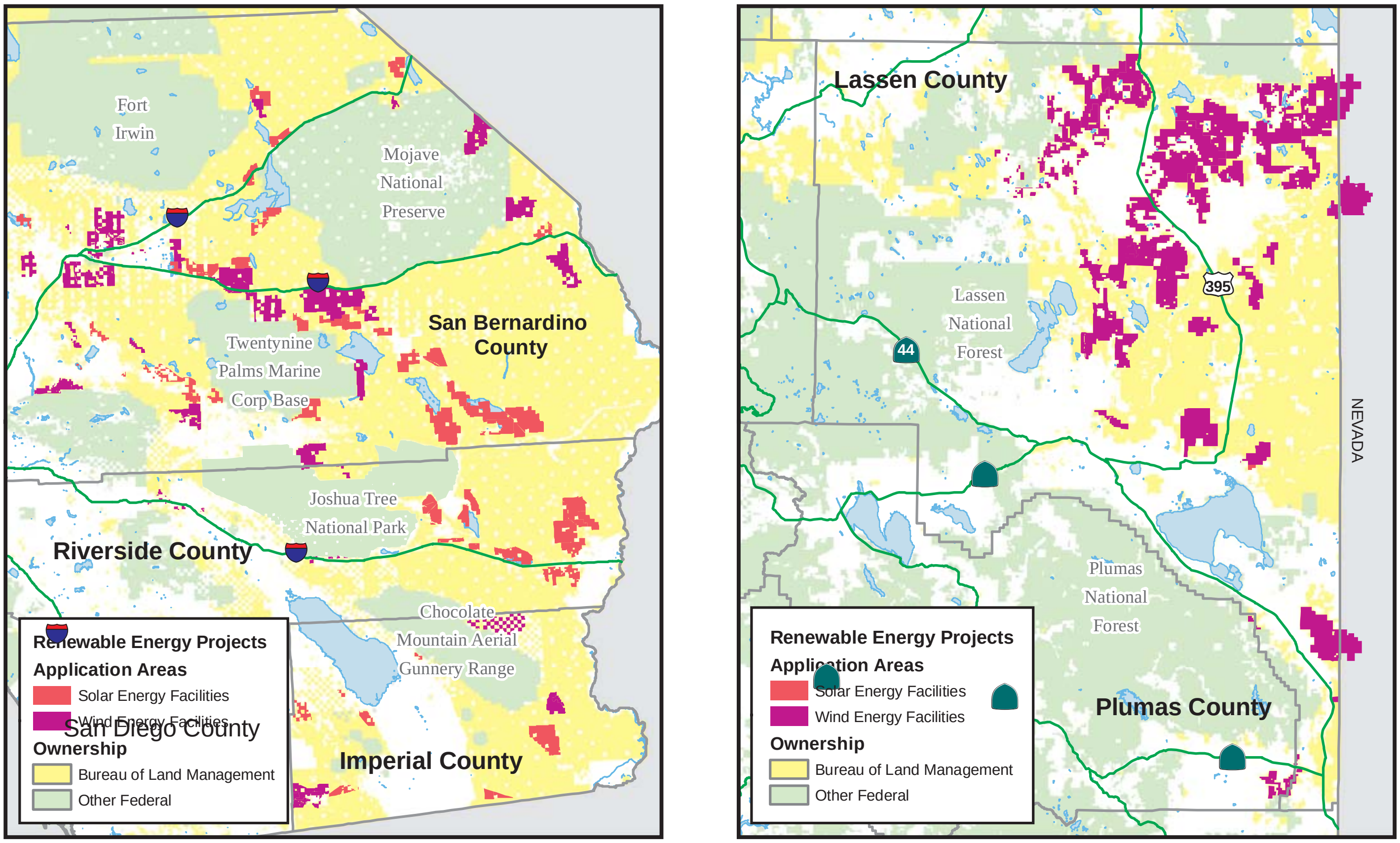


Figure 3.4.2.
Application areas for wind and solar energy development on BLM lands, for two of the more active regions of the state.
Data Sources: Renewable Energy Project Applications in California, BLM, (2008); California Protected Areas Database (CPAD), GreenInfo Network (2009)

also has released voluntary guidelines (National Academy of Sciences, 2007).

Solar Energy

Solar energy converts solar radiation to electricity. There are basically two types of systems that use solar to generate energy. Solar photovoltaic generates electricity directly from sunlight, while concentrated solar thermal panels use light to create heat and steam to drive turbines. A cursory review of BLM applications indicated a fairly equal mix of the two technologies.

Although California has an abundance of solar technical potential, in 2007 only 0.2 percent of total electricity generation was derived from solar, much less than other commercially available technologies such as wind, geothermal or biomass (CEC, 2007).

Some challenges for solar energy development are that the technology can be costly to install, is more appropriate for sunny locations, and its energy production varies seasonally and can drastically fluctuate within minutes due to cloud cover. Also, remote solar energy infrastructure development can require new transmission lines and may cover a large area (see photo on following page) which necessitates extensive permitting processes.

Geothermal Energy

Geothermal power requires thermal aquifers, primarily available where hot magma finds its way close to the surface and heats ground water to usable temperatures above 212°F. California contains the largest amount of geothermal generating capacity in the United States (CEC, 2009), because two tectonic plates meet under its surface, creating a large amount thermal activity.

The majority of California's geothermal plants have been operating since the 1960s in Napa and Sonoma Counties. In addition to operating virtually emission-free, geothermal plants have the smallest land requirements of any major power generation technology. However, suitable sites for geothermal are limited and expensive to establish.

Small Hydroelectric

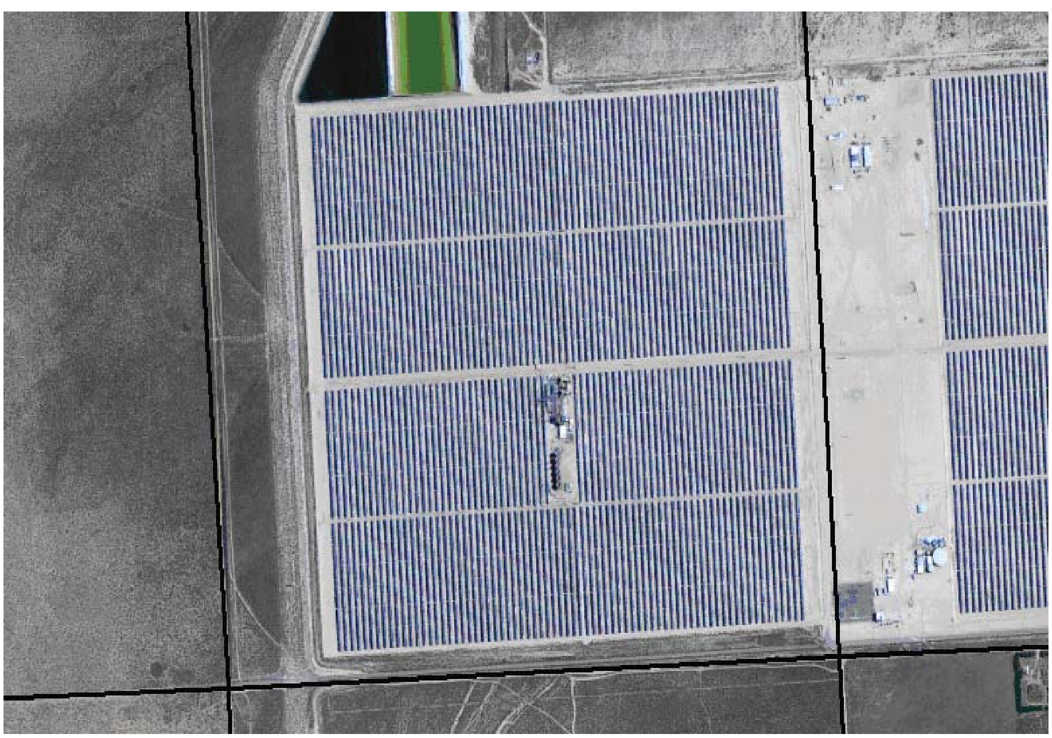
Small hydroelectric supplied 2.8 percent of California's electricity in 2007, or about 24 percent of the state's electricity from renewable energy sources (CEC, 2007), and the majority of these plants are located in forests and rangelands (Figure 3.4.3).

Small hydroelectric (under 30 megawatts) has limited potential for additional facilities, in part due to environmental concerns (Wall Street Journal, 2009). Regulations related to minimum water flows are likely to reduce production from some existing facilities, such that even maintaining current output levels is uncertain (Clay Brandow, personal communication). It is certain that some hydroelectric dams will be removed; for example, recent agreements were signed that will result in removal of four hydroelectric dams to restore flows in the Klamath River.

Tools

State Assembly Bill 1890 (Brulte, Chapter 854, Statutes of 1996) and Senate Bill 90 (Sher, Chapter 905, Statutes of 1997) created the Energy Commission's Renewable Energy Program. Under this legislation, portions of funds collected from customers through investor-owned utilities can be used as incentives for renewable energy development.

The California feed-in tariff allows eligible small renewable energy generators (as amended by SB 32 in 2009, up to three megawatts) to enter into 10 to 20 year standard contracts with their utilities to sell electricity at time-differentiated market-based prices (Database of State Incentives for Renewable Energy, 2010). The California Public Utilities Commission is currently developing a Renewable Auction Mechanism, in order to provide a more efficient pricing mechanism for renewable energy providers up to 10 megawatts (Local Clean Energy Alliance, 2010).



Solar energy facility occupying an entire square mile of land southeast of California City, San Bernardino County

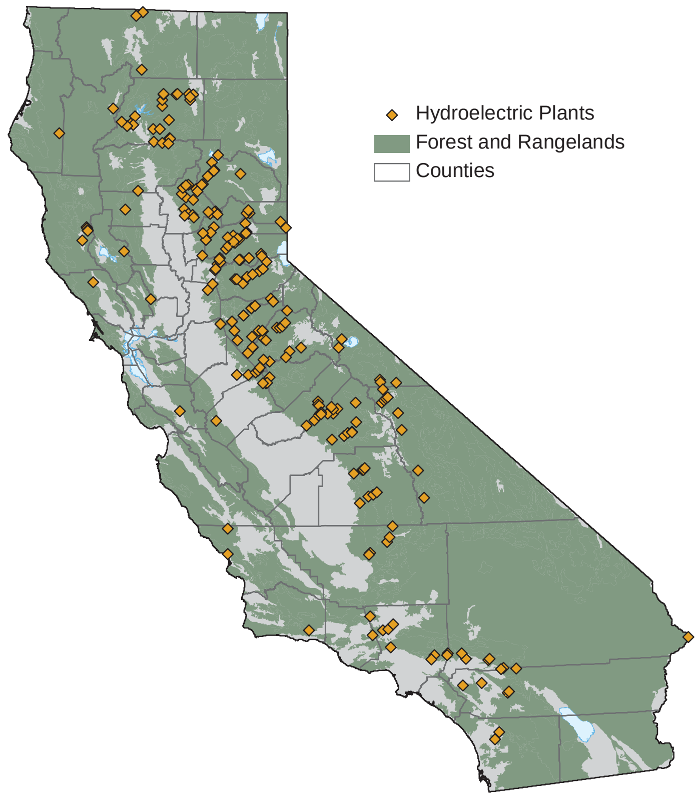


Figure 3.4.3.
Hydroelectric power plants in California.
Data Source: Hydroelectric Power Plants (derived from U.S. Army Corps of Engineers (1979), and Bulletin 160-93 Volume 2, DWR (1989)), FRAP (2002)

The California Energy Commission's Geothermal Program was created in 1981 (Assembly Bill 1905 (Bosco)) to promote geothermal energy development in California by offering financial and technical support for planning and mitigation projects and research and development to private entities.

The Renewable Energy Transmission Initiative (RETI) was created to facilitate meeting the Renewables Portfolio Standard goals. California currently does not have the transmission infrastructure to move the electricity generated by renewable resources to consumers, so extensive improvements and expansion are needed to reach the renewable energy goals. RETI is meant to be a transparent, inclusive stakeholder driven process. The goals are to identify needed transmission projects, support future energy policy, facilitate transmission corridor designation and transmission, and project siting and permitting. The Conceptual Transmission Planning Group is using RETI's conceptual planning as a starting point to develop a California statewide transmission plan to meet the 33 percent by 2020 Renewables Portfolio Standard (California Transmission Planning Group, 2010).

There are federal government incentives to produce wind electricity through tax credits of 1.5 cents per kilowatt-hour. The federal Energy Improvement and Extension Act of 2008 extends tax credits to clean, renewable energy, solar and energy improvement projects.

BIOMASS ENERGY

Current Status and Trends

The Governor's Bioenergy Action Plan states that biomass-fueled electricity generation constitute 20 percent of the Renewables Portfolio Standard by 2010 (BAP, 2006). As of 2007, biomass energy derived from forests, farms, landfills and other urban wastes provided 2.1 percent of electricity use, or almost 18 percent of all renewable energy (CEC, 2007). Biomass energy from forestlands provides about one percent of California's electricity use (USFS, 2009; California Biomass Collaborative, 2007), while having the potential to provide nearly eight times this amount (Morris, 2002). Biomass also has unutilized potential for heating homes, businesses, and schools, and for conversion to liquid transportation fuels (as conversion technology evolves). Biomass power has been a part of the state's power generation portfolio for over 25 years, and has facilitated the treatment and restoration of thousands of forested acres (Mason, 2010).

There are benefits from utilizing biomass energy beyond reduced reliance on fossil fuels. A recent intensive study looked at the long-term (40 year) impact of implementing biomass projects in a Northern California test area, and confirmed the following (USFS, 2009; California Biomass Collaborative, 2007):

- Reduction in greenhouse gas emissions

- Reduction in acres burned by wildfires, as well as severity of fires, with an associated reduction in damages to human infrastructure, economic values from working landscapes, and fire suppression costs
- Negligible impact on habitat suitability
- Minimal cumulative watershed impacts

Numerous studies indicate that the societal benefits derived from biomass removal and utilization are significant (USFS, 2009; California Biomass Collaborative, 2007). Biomass energy displaces the need to burn fossil fuels, and efficiently disposes of materials that would otherwise release methane emissions through decay, pile and burn disposal or wildfire (Reese, 2009). From an air quality perspective, five of six regulated emission categories are reduced by over 95 percent by burning material for biomass versus in open piles or by wildfire (Reese, 2009). Case studies (Cone Fire, 2002) confirm that fuels treatment activities that involve biomass removal can in fact mitigate wildfire behavior. Biomass energy can create jobs in rural economies that have been dependent on traditional resource-based industries. A 50 megawatt (MW) biomass plant can employ about 50 people, and also generate 125 indirect jobs (Reese, 2009). A 1999 study (Morris, 1999) found that 4.9 full time jobs are created for each MW of biomass power generation capacity.

However, there are public concerns about the environmental impacts of biomass removal. The various benefits and environmental impacts of forest biomass removal are complex and further research is required to guide appropriate policies and practices. Questions of long term biomass supply (especially from public lands), as well as possible ecological and other impacts of biomass removal on forest sustainability, are key issues in California (Heinz and Pinchot, 2010).

Other states also are challenged with balancing the need to reduce fire and forest pest risk, stimulate rural economies and expand renewable energy use while minimizing environmental impacts. Oregon passed legislation in 2005 (Oregon SB 1072) to promote the health of forests and rural economies through active forest management. The State Forester is directed to prepare a report every three years summarizing the effect of biomass removal on plants, wildlife, air and water, and identify changes that are necessary to encourage biomass energy use and avoid negative effects on the environment. The first report emphasized changes to insure that adequate downed wood and snags are left on site. The need for scientific input to help establish appropriate removal/residual policies for forest slash in thinnings and fuel reduction treatments by forest cover type, and continuing to encourage logger certification programs to include woody biomass harvesting techniques training (Oregon Department of Forestry, 2008).

In order to use biomass projects as a tool, first there must be a biomass energy facility within reasonable proximity, making the biomass material economically available. Biomass facilities operational in California that have the potential to address wildfire or forest pest issues are shown in Figure 3.4.4. A 25 mile buffer zone around facilities illustrates a gross estimate of the area where biomass material is economically available, given current costs and returns to landowners and energy producers. A more realistic zone would require an analysis of travel costs, road networks, and energy prices.

Secondly, biomass material must be technically available. Areas that are inaccessible, for example steep slopes, are excluded as are areas where regulations or management direction preclude biomass harvesting, wilderness areas or stream and lake protection zones. This second consideration can be complex, in that some areas may be accessible only under certain conditions, for example when a Zone of Infestation for forest pests is formally declared, or after a wildfire. Finally, this definition excludes materials that are likely to be used for higher-value products, for example wood that is suitable for lumber.

Currently, extensive areas of technically available biomass are not served by operational biomass

Figure 3.4.4.
Operational biomass facilities in California. This does not include numerous facilities that have limited potential to address wildfire or forest pest issues, for example those that primarily utilize biomass from landfills, urban waste, or agriculture. Exception – the two Southern California facilities shown on the map currently utilize primarily urban or agricultural wastes.
Data Source: Biomass Facilities, FRAP (2009 v1)

plants. Factors that constrain investment in new facilities include:

- Uncertainty in future energy prices, affecting biomass value and travel costs (Reese, 2009)
- Uncertainty over access to biomass on public lands
- Local opposition to the existence or proposed location of biomass facilities (SDN, 2009)
- Barriers related to permitting (CBC, 2006)

There are currently six idle biomass facilities that potentially could address wildfire and forest pest issues in California (including one in Nevada). The primary reason for closure is a reduction in timber harvesting associated with the current economic downturn (Sierra Pacific Industries, 2009). The Northern Nevada Correctional Facility biomass plant near Carson City, Nevada currently has minimal impact for biomass removals in California, and is included as an idle plant since under certain future conditions it could service areas in need of treatment in the Lake Tahoe area.

In addition, at least six new biomass facilities have been proposed across the state, which could address wildfire and forest pest issues. It remains to be seen which, if any of these will actually become operational. The optimal scale of new standalone grid energy biomass facilities in the Pacific Coast region, including California, appears to be small to medium (5 to 15 MW). The size of projects involves variables such as fossil energy prices, emerging technologies for liquid fuels, heat and power needs, carbon credit values, energy policy, and local forest conditions (Heinz and Pinchot, 2010).

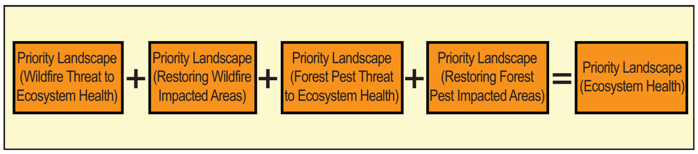
Given current trends, government action may be required if woody biomass utilization is to make a greater contribution towards meeting Renewables Portfolio Standard targets, or facilitate treatment of more areas at risk or damaged by wildfire and forest pests. Government action may also be warranted given that use of biomass for energy generation competes with other renewable energy sources or uses of biomass that are subsidized or otherwise encouraged through various government policies. Example policies include the diversion credit for use of green biomass as daily cover in landfills (BPA, 2009).

Analyses

The potential for biomass projects to play an increasing role in threat reduction and restoration efforts related to ecosystem health and community safety was analyzed, drawing on the analytical results presented in previous chapters. This involved simulating the effects of adding six proposed biomass facilities and making six idle facilities operational. However, a specific strategy to implement this scenario could require actions on multiple issues and a variety of options for addressing them, including changes to policies, programs or practices and funding sources.

Ecosystem Health

The potential for biomass projects to reduce threats and facilitate restoration efforts related to ecosystem health was examined. Each of the four priority landscapes in the following diagram represents priority areas where biomass projects could be applied. For example, biomass projects that thin overstocked stands and remove ladder fuels can reduce wildfire and forest pest threat. Restoring impacted areas often requires removal of dead, dying or infected trees.

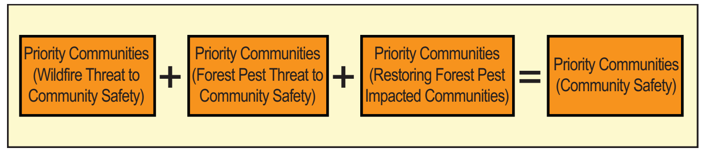


These four priority landscapes were combined to create a single priority landscape for ecosystem health, by assigning the maximum of the four component ranks. An area that is ranked high for any of the four inputs is also ranked high in the output. The resulting ecosystem health priority landscape represents areas most in need of treatments, such as biomass projects to reduce threats or restore impacted areas. The analysis involved determining which ecosystem health priority landscapes potentially become economically available as a result of adding the 12 facilities, and summarizing the results by county and bioregion.

Community Safety

A second analysis examined reducing wildfire and forest pest threats to community safety, or restoring impacted communities. Wildfire poses a direct threat to human infrastructure, while forest pests cause tree mortality that leads to indirect impacts from falling trees on roads, power lines and houses.

The analysis determined which priority communities that are currently not economically available due to distance from operational facilities, are within 25 miles of the added facilities.



Results

Ecosystem Health

Figure 3.4.5 shows the ecosystem health priority landscapes that might become economically available as a result of the 12 new biomass facilities.

Table 3.4.3 shows the additional acreage by county of high plus medium priority landscapes that potentially become economically available for biomass projects as a result of adding 12 facilities. A significant portion of these lands are federally owned.

Community Safety

Table 3.4.4 shows communities identified as priorities for protection or restoration in terms of which are potentially served by operational biomass plants, or idle/proposed plants. Southern California is currently not served by facilities that utilize a significant amount of biomass from forests and rangelands and these individual communities are not listed.

Discussion

Ecosystem Health

Proposed and idle biomass facilities potentially can make large areas of priority landscapes economically available for treatment in counties such as Siskiyou, Trinity, Modoc, Lassen, El Dorado, Amador and Placer. This would facilitate treatments to reduce threats from wildfire and forest pests and to restore impacted areas.

However, extensive areas of priority landscapes are not served by either existing, proposed or idle facilities. The first map in Figure 3.4.6 shows priority landscapes for ecosystem health that are not within 25 miles of operational, idle or proposed facilities. This map does not show the extensive areas of high priority landscapes in Southern California, since

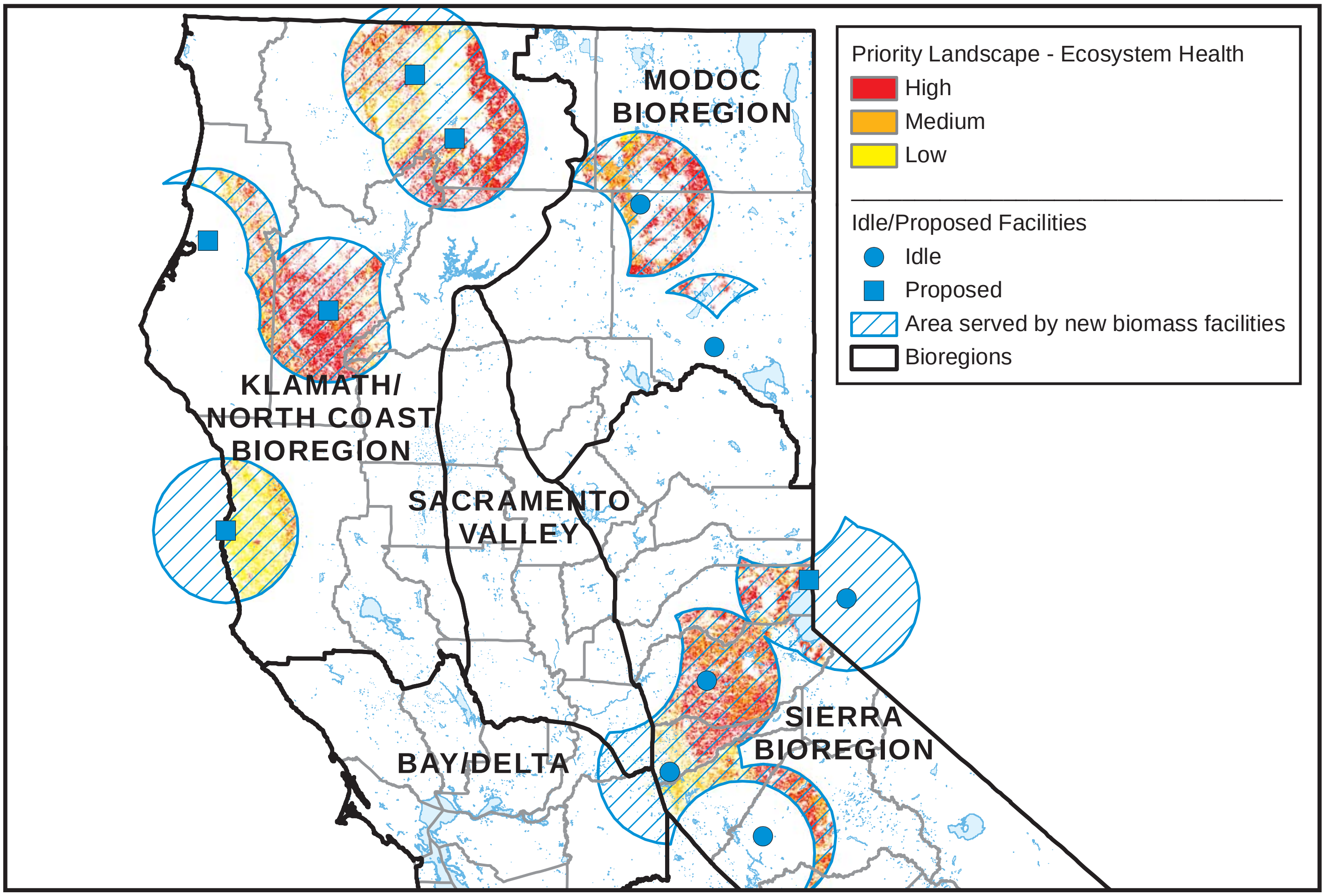


Figure 3.4.5.
Priority landscapes for ecosystem health with potential for new biomass facilities. Priority landscapes that are technically unavailable (e.g., steep slopes, stream buffers, wilderness areas), or have too little biomass to be economically available (less than 50,000 lbs/ha) are excluded in the map. Map shows only the portion of the state that is affected by making the 12 idle or proposed biomass facilities operational.

Data Sources: Biomass Facilities, FRAP (2009 v1); Burn Severity, USFS (2009); California Fire Regime Condition Class, FRAP (2003); California Tree Seed Zones, Buck, et al. (1970); Fire Threat, FRAP (2005); Statewide Land Use / Land Cover Mosaic, FRAP (2006); Aerial Detection Surveys, USFS FHP (2008 v1); Forest Pest Risk, USFS FHP (2009 v1); Fire Perimeters, FRAP (2009 v1); Fuel Rank, FRAP (2002)

in this region of the state there are currently no facilities that utilize significant biomass from forest or rangeland. The second map shows that since so much of these priority landscapes are on federal lands, access to a stable flow of material, especially from national forests, will be a critical factor in terms of whether these areas will ever be served by facilities.

Community Safety

Currently, only 14 of the 66 priority communities are within 25 miles of an operational biomass facility. Adding the 12 new facilities would reach 11 more priority communities. Of the remaining 41 communities, 31 are in Southern California.

Bioregional Findings

Ecosystem Health

Adding the idle and proposed facilities potentially would facilitate treatment of extensive priority landscape areas for ecosystem health in the Klamath/North Coast, Modoc and Sierra bioregions.

However, even if all idle and proposed facilities are made operational, there will still be extensive areas of priority landscapes that are not served by bio-

Table 3.4.3. High plus medium priority landscape (HMPL) acres (rounded to the nearest hundred) for ecosystem health by county that are potentially economically available as a result of making 12 proposed or idle biomass facilities operational

County	HMPL Acres*	Percent Federal
Amador	89,900	9
Calaveras	64,600	14
El Dorado	377,000	53
Humboldt	104,400	49
Lassen	163,900	60
Mariposa	4,000	97
Mendocino	53,600	2
Modoc	166,300	47
Nevada	4,300	16
Placer	141,300	68
Shasta	48,300	54
Siskiyou	485,300	47
Tehama	8,500	87
Trinity	415,700	78
Tuolumne	108,200	78
State Total	2,235,600	54
*counties with less than 1,000 HMPL acres excluded.		

mass facilities in these same bioregions, though the majority of this is federal lands.

Community Safety

As a result of adding idle and proposed facilities, 11 additional priority communities could potentially be treated using biomass projects, six of these are in the Lake Tahoe area. Numerous additional communities could be served, primarily in the Klamath/North Coast and Sierra bioregions.

About half of the priority communities identified occur in the South Coast bioregion where biomass projects currently are not a viable treatment tool due to lack of biomass facilities.

Tools

California had 49 operating biomass plants in the mid 1990s, today there are 33 (Reese, 2009). The current environment does not seem conducive to bringing new plants that rely on forest biomass online, or in some cases even keeping existing plants operational. The challenge is to develop strategies that capture the array of benefits provided by biomass energy in terms of incentives for sustainable

Table 3.4.4. Priority communities for protection or restoration for forest pests and wildfire, that are potentially serviced by an operational biomass facility, or idle/proposed facility

County	Priority Community (F = Wildfire; P = Forest Pests)	Biomass Facility (O = Operational; I = Idle/ Proposed)
Alameda	Oakland (F)	-
Alpine	Kirkwood (P)	-
Butte	Magalia (P)	O
	Paradise (P)	O
Calaveras	Arnold (FP) [1]	I
	Mountain Ranch (P)	I
El Dorado	South Lake Tahoe (P)	I
Humboldt	Willow Creek (P) [1]	I
Marin	Inverness (P)	-
Mono	Mammoth Lakes (P)	-
Monterey	Aromas (P)	-
Nevada	Grass Valley (P)	-
	Truckee (P) [1]	I
Placer	Dollar Point (P)	I
	Foresthill (P)	I
	Kings Beach (P)	I
	Sunnyside–Tahoe City (P)	I
Plumas	Bucks Lake (P)	O
	East Quincy (P)	O
	Graeagle (P)	O
	Iron Horse (P)	O
	Johnsville (P)	O
	La Porte (P)	O
	Meadow Valley (P)	O
	Mohawk Vista (P)	O
Shasta	Lakehead–Lakeshore (P)	O
	Redding (F)	O
Siskiyou	Mount Shasta (P)	I
	Weed (P)	I
Sonoma	Guerneville (P)	-
	Healdsburg (P)	-
	Occidental (P)	-
	Monte Rio (P)	-
Tehama	Mineral (P)	O
Tuolumne	Groveland–Big Oak Flat (P)	O
Southern California [2]	23 Communities (F) 7 Communities (P) 1 Community (F;P)	-

[1] Community is just inside the 25 mile buffer of an operational facility, but would be better served by a closer proposed/idle facility.

[2] San Diego, Orange, Los Angeles, San Bernardino, and Ventura counties.

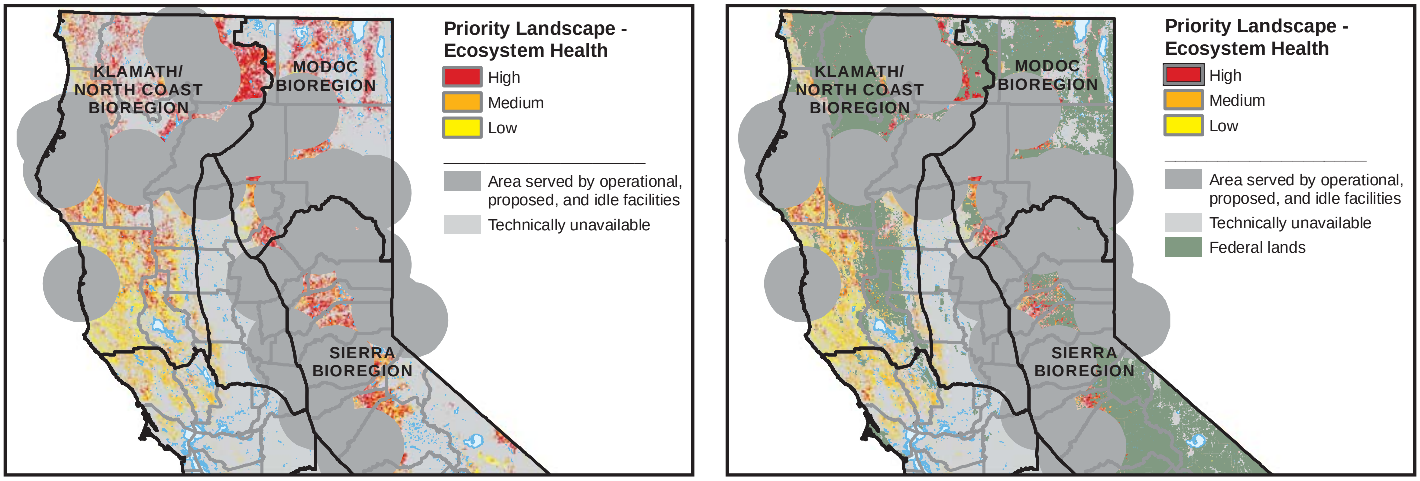


Figure 3.4.6.
Priority landscapes for ecosystem health that are not within 25 miles of operational, proposed, or idle biomass facilities.
Data Sources: Biomass Facilities, FRAP (2009 v1); Burn Severity, USFS (2009); California Fire Regime Condition Class, FRAP (2003); California Tree Seed Zones, Buck, et al. (1970); Fire Threat, FRAP (2005); Statewide Land Use / Land Cover Mosaic, FRAP (2006); Aerial Detection Surveys, USFS FHP (2008 v1); Forest Pest Risk, USFS FHP (2009 v1); Fire Perimeters, FRAP (2009 v1); Fuel Rank, FRAP (2002)

development of this technology (California Biomass Energy Alliance, 2006), while monitoring potential environmental impacts and adapting policies and regulations as needed. Transparent and inclusive stakeholder involvement is important in decisions about biomass. Collaborative processes, planning and long-term stewardship contracts are critical for determining and realizing supply from federal lands (Heinz and Pinchot, 2010).

Road Map to the Future

The California Energy Commission, working through the Bioenergy Interagency Working Group, has produced a comprehensive strategy for sustainable development of biomass in the state. The first Bioenergy Action Plan (CEC, 2006) was released in 2006, and the goal is to adopt an updated plan by the end of 2010. There are recommended actions in five areas:

- Resource access and feedstock markets and supply
- Market expansion, access, and technology deployment
- Research, development, and demonstration
- Education, training and outreach
- Policy, regulations, and statutes

Coordinated Resource Offering Protocol (CROP)

In response to the uncertainty for access to biomass from public lands, the U.S. Forest Service and BLM have launched a series of Coordinated Resource Offering Protocols (CROP) pilot projects, including one in the Lake Tahoe region in California (USFS, 2009). For the Lake Tahoe pilot project, a key concern is that 50 percent of CROP resource offering (acreage for biomass removal) has not started in the National Environmental Policy Act (NEPA) process.

The key tenets of CROP projects are to (USFS, 2009):

- facilitate coordination of biomass removal between public agencies;
- facilitate the use of long-term multi-agency stewardship contracts to achieve biomass removal;
- increase the certainty of levelized biomass supply offerings from public agencies;
- invite investment back into a sustainable forest management landscape and
- heighten public trust and support for biomass removal from public lands operating within a transparent process.

CROP projects are of limited application however due to the fact that they are focused only on biomass material sourced from federal lands. Financial institutions that provide funding for biomass utilization projects are interested in reliable sources of woody biomass material across all land ownership categories.

Integrated Resource Stewardship Contract

A promising contracting tool that the U.S. Forest Service and BLM have been utilizing in recent years is the Integrated Resource Stewardship Contract, which is focused on treatments conducted over three to ten years. Stewardship contracts have proven to facilitate forest fuels reduction and restoration activities at the landscape level. There are numerous examples of these contracts in place or proposed in California for fuels reduction projects to protect communities, endangered species habitat, key watersheds for anadromous fish and for ecosystem restoration (http://www.forestsandrangelands.gov/stewardship/ca.shtml).

Biomass Crop Assistance Program

Biomass Crop Assistance Program (BCAP) provides financial assistance to producers or entities that deliver eligible biomass material to designated biomass conversion facilities for use as heat, power, bio-based products or biofuels (USDA Farm Service Agency, 2009). For example, in Butte County BCAP funds made it economically feasible to convert 15,500 dry tons of charred timber into clean energy, and enabled Bamford Company to keep 37 people employed (timberbuysell.com).

CARBON

Carbon sequestration is an emerging market that quantifies and helps pay for an ecosystem service. Terrestrial carbon sequestration is considered in policy and at the project level. The role of carbon in compliance markets along with the economics of carbon and the opportunities in California for forest and rangeland carbon are explored here while the sequestration of carbon by trees and other plants is described in Chapter 3.7.

Carbon accounting may use "on-site" to describe carbon stored in the forest or soil while "off-site" refers to the pool of carbon in wood products, either in-use or in a landfill.

There are two kinds of carbon markets: voluntary and compliance. Voluntary carbon markets are generally unregulated by government, with transactions usually occurring directly between the buyer and seller. Specific systems, protocols and registries exist for the voluntary market. Compliance markets occur under regulatory schemes, usually cap-and-trade, where offsets are sold to emitters. These usually involve contracts between buyer and seller, but are regulated by the trading system so that offsets meet the system criteria, are properly credited, and are not used more than once. Entities may operate in both voluntary and compliance markets to assemble multiple landowners into projects for economies of scale.

Standards and guidelines are necessary to quantify greenhouse gas benefits from forestry and range-related activities. For example, protocols are the rules for carbon accounting that a project developer must follow to quantify reductions, while registries function like carbon credit banks where ownership may be tracked.

Two general approaches to protocol development are project specific (i.e., Clean Development Mechanism) and programmatic (i.e., Climate Action Reserve (CAR)). Project types that relate to forestry include reforestation, avoided conversion, urban forestry and forest management. Range-related project types include manure management systems and soil sequestration. Currently, the most likely forestry protocols to receive near-term adoption under AB32 or Western Climate Initiative (WCI) cap-and-trade systems would be CAR forestry protocols, the CAR manure management protocol and the Alberta Offset System soil sequestration protocol (WCI, 2010).

The State of California has supported the CAR forestry protocols for use in the voluntary market. It is expected that these protocols, or modifications of them, will be used for forestry offsets under a cap-and-trade compliance market under the Global Warming Solutions Act of 2006, WCI, or a national cap-and-trade program. Other protocols will also likely participate.

Reductions are the metric tons of carbon dioxide equivalent (CO2e) attributed to a project and may be referred to as credits in general or a more specific name associated with a specific protocol or registry. The quality of credits varies according to many factors, such as the nature of the carbon reduction, the extent to which the carbon removed will stay out of the atmosphere, and the ability to accurately measure and verify the amount of carbon saved.

An "offset" is the term generally used in conjunction with a cap-and-trade program where credits are generated outside of the capped sectors. Offsets are used in lieu of emission allowances. The use of offsets has been controversial, with critics questioning the effectiveness and proponents emphasizing the near-term necessity of offsets.

Within California, the amount of offsets to be allowed under cap-and-trade systems is still unknown. By one estimate, which proposed that four percent of annual GHG emissions in California could be met by each entity with offsets, total annual use of offsets could be about 7.7 million metric tons in 2012–2014, over 16 million metric tons in 2015–17, and over 15 million metric tons each year from 2018–2020 (ARB, 2009). Proposed federal legislation would allow upwards of one billion metric tons of domestic offsets a year with another billion metric tons of international offsets.

The apparent demand for offsets far exceeds the supply, at least in the near term (Sikorski, 2010). Estimates and potential value in markets that are emerging can be made for forest-related supply in California. Live tree carbon stored in California forests is estimated to be 5.1 billion metric tons (teragram, Tg) (see Chapter 1.2); the sequestration rate was 30 million metric tons (gigagram, Gg) per year. The estimate for private timberlands was 1.4 Tg; the sequestration rate was five Gg per year. A widely held 2020 auction allowance price range for AB 32, WCI and national programs is $15–$25 per metric ton (Economic and Allocation Advisory Committee, 2010; Point Carbon, 2010; PEW, 2010). For illustration, applying a $15 and $20 per metric ton value to offsets under a compliance market, the theoretical values if all carbon were monetized are:

- Total California forest carbon storage (live trees): $77–102 billion
- Total California forest carbon sequestration: $450–600 million/year
- California private timberland forest carbon storage (live trees): $21–28 billion
- California private timberland carbon sequestration: $75–100 million/year

Potential market revenue based on the $15–20 per metric ton assumption for offsets in a compliance market under AB32 is as follows:

- First Compliance Period (2012–2014): $116–155 million/year
- Second Compliance Period (2015–2017): $246–328 million/year
- Third Compliance Period (2018–2020): $226–301 million/year

These estimates are for all offset project types. Sikorski (2010) estimates that about two-thirds of nationwide domestic offsets will be supplied by forestry project types to 2020. This would reduce the potential revenues to the forestry sector accordingly.

In the case of range-related carbon, no estimates have been made on the supply from manure management; there is lack of information on the impacts of technology and other obstacles. Soil sequestration from forests and rangelands was not estimated; the associated protocols are unclear at this point.

The type of forest project is a critical factor when considering possible offset supply to 2020. For example, urban forestry and reforestation project types rely on carbon accruing in young trees, which will be minimal before 2020 although important for later years. In contrast, the avoided conversion and improved forest management project types could generate substantial credits in the next ten years.

The following assumptions were used in the estimates of credits generated from the avoided conversion and improved forest management project types. The stocking and sequestration estimates are from Chapter 1.2.

- One-half of the 139 metric tons per acre average stocking on forestlands are credited on average on avoided conversion projects
- Avoided conversion projects are 10,000 acres a year
- Sequestration rate is 0.746 metric tons per acre on forestland
- Sequestration rate is 1.244 metric tons per acre on timberland
- Non-industrial forestland owners will participate in the improved forest management projects at 10 to 20 thousand acres a year while industrial timberland owners will participate at 20 to 40 thousand acres a year.
- Improved forest management projects that have initial inventories above common practice are 11 to 23 thousand acres a year and result in immediate credits of 35 metric tons per acre.

Avoided conversion projects would produce 0.7 million metric tons per year. Improved forest management projects, by the CAR protocol, may produce credits in two ways: to incrementally as forests grow and as an avoided emissions type credit for exceeding common practice. Based on analysis of avoided conversion and improved forest management, estimates of annual forest carbon offsets available to a California compliance market for the three compliance periods results in the following:

- Compliance Period 1 (2012–2014): 1.17 to 1.67 million metric tons per year
- Compliance Period 2 (2015–2017): 1.25 to 1.83 million metric tons per year
- Compliance Period 3 (2018–2020): 1.33 to 2.00 million metric tons per year

If these estimates are approximately correct then the forestry sector in California will meet 10–25 percent of the potential offset demand through 2020. Fulfilling the demand for offsets to 2020 will require more landowner participation, other sector offsets, the development of other project types such as soil or avoided emissions from fire, or the use of forestry offsets from outside of California.

Carbon credits will be in demand for both the voluntary and compliance markets. Protocols are in place for many project types. The price of carbon, however, is generally low relative to the value for high quality timber products. A thousand board feet of Douglas-fir that is worth $400 is approximately four metric tons of CO2e, which is $80 at $20 a metric ton. This value discrepancy combined with the risk associated with a 100-year commitment to maintain the sequestered carbon, which is required for CAR projects, will likely keep supply low. If credits become widely used for mitigating climate impacts identified in the California Environmental Quality Act (CEQA) analyses of development projects, then prices in the voluntary market could possibly exceed prices in the compliance market, further constraining cap-and-trade supply.

Investments in working landscapes could bolster terrestrial carbon inventories and reduce risk of loss. Priority landscapes for carbon are identified in Chapter 3.7. Significant acreages on private and public lands could benefit from management. Carbon management must, however, be considered in the context of the multiple benefits that forests and rangelands provide. Quantities of carbon should be considered in combination with the risk of emission and long-term ecosystem health. Investments in restoring stands converted from either conifer or hardwood cover should be made soon to address ecological restoration and carbon contributions in future decades.

NICHE MARKETS

Definition

Natural Resources Canada defines niche products as "specialty, higher-value, non-commodity wood products that are directed at specific markets that value the unique appearance/quality of a product that has a limited production supply. Niche products are usually produced by smaller manufacturing plants that focus on producing a unique, high quality product in limited volumes. These are usually products that an end-user believes has an added-value component due to unique appearance/quality, end-use, etc. Many niche products have the same number of competitors as established commodity products but niche products have the advantage of being able to create brand or product loyalty to separate themselves from competitors, are more regional in market focus, are more attuned to market/demand changes and trends, and are quick to adapt to changes in market demand." (Natural Resources Canada, Canada Wood, 2003)

Niche Markets for Certified Products

Niche products are differentiated based on the nature of the process used to create them, in terms of being a more environmentally and socially responsible option for consumers. This typically involves a certification process by third-party entities such as the Forest Stewardship Council (FSC) or Sustainable Forest Initiative (SFI) for wood products, or the USDA National Organic Program for agricultural products. There are also various programs for certification of "natural" beef and grass-fed beef, which are generally less restrictive standards than organic.

"An on-product label that says a product is certified to a program such as SFI or FSC delivers assurance you are making a choice that represents conservation of biological diversity, protection of special sites, sustainable harvests, respect for local communities, and much more" (Larry Selzer, President and CEO, The Conservation Fund).

The demand for certified wood products can be driven by higher level certification programs, for example the trend towards "green building" and certification programs such as Leadership in Energy and Environmental Design (LEED®) (http://www.usgbc.org/DisplayPage.aspx?CategoryID=19).

In some cases, major retailers have endorsed certified products to the point of excluding or limiting selection of non-certified products. For example, Home Depot began endorsing certified wood products in 1999, and now sells more FSC certified wood than any retailer in America (http://corporate.homedepot.com/wps/portal/Wood_Purchasing).

Advantages of Niche Products

The mass marketing business model involves intense competition based on standardized product lines and fierce price competition (Hacker, 2006). Niche markets involve a unique business model that can often command higher prices by competing to meet a unique need for custom products.

Niche products sometimes utilize materials that would otherwise be discarded, or even incur a disposal cost. Eric Oldar of the California Department of Forestry and Fire Protection pioneered a project to utilize urban trees that would otherwise end up in landfills, by investing in portable sawmills and kilns which are loaned to municipalities (Hacker, 2006). The City of Lompoc, which was faced with a tree disposal problem and landfill regulations, was able to meet a need for higher quality park benches, flooring, and other wood products (Gamstetter, 2009). The number of municipalities now using portable sawmilling is widespread throughout the country in response to landfill regulations (Hacker, 2006).

Examples of Niche Products

Niche products are vast and diverse, a list of some of the more interesting or promising in California includes:

- West Coast Arborists, Anaheim: Utilizing the latest technology for urban forestry inventory, planning, and management (http://www.wca-inc.com/Introduction.aspx).

- California Hardwood Producers, Auburn: Utilizing tree removals from urban forests and orchards for high quality flooring, cabinets, beams, countertops, etc. (http://californiahardwood.com/).
- Humboldt Woodworkers Guild, Humboldt County: Collective marketing of unique high quality, environmentally and socially responsible wood products (http://woodguild.com/).
- Calaveras Healthy Impact Product Solutions, San Andreas: In response to local sawmill closures and fire hazard from small trees, this community organizing effort, funded by a $96,500 USDA grant, implemented a chipping station for landscaping and heating. One customer uses wood chips to heat a four acre greenhouse that supplies fresh organic local produce.
- Sierra Nevada Geotourism: The Sierra Business Council has partnered with the National Geographic Society and the Sierra Nevada Conservancy to develop a website to capture the history, heritage and attractions distinctive to the Sierra Nevada Region, to promote tourism that can conserve the region's historic towns and heritage sites, restore and protect the landscape, and sustain local businesses and communities (http://www.sbcouncil.org/Projects/Sierra-Nevada-Geotourism).
- There are many examples of California ranches that produce organic, natural or grass-fed animals and meat products.
- Numerous California livestock operators fill niche markets for various specialty products and services, ranging from beef jerky to ranch tours.

Opportunities for Niche Markets in California

There is a strong potential for niche markets to increase economic activity and employment in the state.

California hardwoods have historically received a lot of attention, since they are an underutilized resource. California is a major consumer of hardwood lumber (20 percent of nation's production) but the hardwood lumber production industry in the state is almost non-existent; this is in spite of a sizable hardwood tree resource (12 billion cubic feet of timber growing stock) (http://ucanr.org/delivers/impactview.cfm?impactnum=196). Although California producers have been unable to compete in traditional high-volume markets, the potential exists for utilizing this resource to fill additional niche markets.

As California loses more sawmills, many landowners will be unable to sell their timber. Portable sawmills provide an opportunity for these landowners to process their own logs, and sell their timber as finished products, commanding a higher price. This will require innovation in terms of forming landowner cooperatives for processing and marketing their products.

While this chapter deals extensively with opportunities for additional large biomass facilities, there is also potential for utilizing small or micro-biomass power generation, particularly for heating homes, businesses and schools. Examples include the U.S. Forest Service State and Private Forestry's Fuels for Schools program being initiated in six western states.

The various certification programs for rangeland products provide an opportunity for some ranchers to increase profitability. This could become especially important if food safety concerns become an emerging issue. For example, grass-fed beef avoids potential food safety concerns that could arise from sending animals to feedlots.

ECOSYSTEM SERVICES

Forests and rangelands provide a number of values which historically have not been captured easily in traditional markets. Examples are: carbon sequestration (until recently), watershed services, wildlife habitat and biodiversity, scenic and related values. Often these are viewed as "public goods" which are provided as benefits to the public at little or no cost. Since landowners are generally not compensated for providing these services, they may not receive adequate consideration in decisions related to keeping lands in production, or in how they are managed.

Markets have been slow to emerge for a number of reasons, such as the difficulty of defining market units and price, few buyers, and limited support in the investment community. However, a growing recognition of the importance of these services is leading to efforts to quantify their value, which could lead to market-based solutions. At the national level, for example, the Food, Conservation, and Energy Act of 2008 directs states to identify high-value areas for providing various ecosystem services and to delineate threats to those areas. The Act also seeks to facilitate landowner participation in emerging markets for ecosystem services. The Secretary of Agriculture must develop technical guidelines that measure the environmental services benefits from conservation and land management activities. These guidelines will facilitate measurement and reporting protocols and registries. A verification process and guidelines for reporting conservation and land management activities must also be developed (http://www.fs.fed.us/ecosystemservices/).

Across the country, some market-based frameworks can be found in the area of ecosystem services. These can include private payments, public payments or incentives and trading schemes. For example, in the case of preserving wildlife and plant diversity, payments for specific areas or programs can come from non-governmental organizations, pharmaceutical, agricultural or other companies, and even the ecotourism industry. In some cases regulatory frameworks have fostered a way to do market transactions, such as the emergence of conservation and mitigation banking in California and the U.S. Other investments are made in an effort to comply with or lessen cost of regulatory compliance, such as flood control structures or better road design to improve water quality.

Local or regional districts can also serve a quasi-market function. Examples include the East Bay Regional Park District, the Mid Peninsula Open Space District and the Marin Open Space District. These districts have programs that support ecosystem services directly or indirectly. They utilize property taxes, assessments, fees/rents/other charges, grants, interest and other funding sources. Programs relate to what the voters want and for which they will pay.

Some programs can influence market opportunities for ecosystem services. An example of this is the Private Lands Wildlife Habitat Enhancement and Management Area (PLM) Program administered by the Department of Fish and Game. The program was first authorized in 1983 and has undergone several revisions. The goals of the PLM are to encourage private landowners to manage for the benefit of fish and wildlife. In exchange for developing a management plan and adopting specific wildlife habitat improvements, landowners receive incentives that allow them to better realize the recreational value of wildlife. Incentives can include more flexible seasons and quality hunting experiences. Landowners gain by charging fees for hunting, fishing and other uses, such as photography and observing wildlife. (DFG, 2008). There are now 90 PLM properties that encompass almost 900,000 acres of wildlife habitat (http://www.dfg.ca.gov/wildlife/hunting/plm.html).

Conservation easements are another mechanism widely used in California. Many examples exist such as efforts by organizations including the Trust for Public Land, the Nature Conservancy and the California Rangeland Trust. Under a conservation easement, a landowner voluntarily donates or sells certain rights related to their property, such as the opportunity to develop to a private organization or public agency. This entity is willing to hold the right to enforce limitations agreed to by the landowners. Often landowners retain rights to manage the property for ongoing agricultural, rangeland or forestry uses, together with associated habitat, watershed and open space values. These easements are legally recorded agreements and conditions continue with the land when the land is sold. Compensation to the landowner can take several forms, such as direct payments or tax credits. Credits come from various sources. One example of a tax credit is the Natural Heritage Preservation Tax Credit (2000).

Administered by the Wildlife Conservation Board, the Tax Credit Act allows state tax credits for donations of qualified land (fee title or conservation easement) and water rights.

Still another example is the Oak Woodlands Conservation Act (2001). Under the Conservation Act, the Wildlife Conservation Board established a grant program designed to protect and restore oak woodlands utilizing conservation easements, cost-share and long-term agreements, technical assistance, public education and outreach.

In addition, state law provides for tax and zoning approaches that encourage landowners to maintain land in agriculture, ranching and timber production. The two key frameworks are the California Land Conservation Act, better known as the Williamson Act, and the Timberland Production Zone under the Forest Taxation Reform Act. Under both these laws, properties are taxed in a manner that supports continued use of the land for resource production with its related ecosystem service benefits (such as wildlife habitat and watershed health).

The provision of ecosystem services in California has benefited greatly from development of partnerships and cooperation among landowners, governmental agencies, non-profit organizations and other stakeholders. Forms of the partnerships vary, but can be seen in the abundance of watershed groups, Fire Safe Councils and community or neighborhood based organizations. Agencies, landowners, and non-governmental organizations all play key roles. These efforts have facilitated watershed and habitat planning, restoration, management and acquisition, and efforts to improve forest health.

Support for such activities comes from different sources. The main contributors are property owners, non-profit organizations, public agencies and the public. By far, the largest funding sources for projects and for ongoing program support for environmental services comes in the budgets of federal, state and local agencies. Funding comes from general taxes, special taxes and dedicated funds, user fees, and other sources.

Especially important to support and enhancement of ecosystem services in California has been voter support of four ballot initiatives in the last decade. These are Proposition 40 (2002), Proposition 50 (2002), Proposition 84 (2006), and Proposition 1E (2006). Funds from these initiatives are being used for many aspects of ecosystem services. These includie such things as assessment and planning for watersheds, fish and wildlife, infrastructure and habitat restoration and enhancement, habitat acquisition, improving forest health and conservation and technical assistance.

Federal initiatives have also been important. Examples include funding and programs related to: improved water quality; restoration and enhancement of ecosystems, wildlife and fish habitat; and fuel reduction and improved forest health. Some federal programs focus on specific areas and issues such as Lake Tahoe or the forests of Southern California.

Planning for and determination of projects, as well as management and ongoing support that relate to ecosystem services, take many forms. Much depends on enabling legislation and direction in agency budgets of governmental agencies. In addition, program focus and even type or location of projects can be written as part of state or local ballot measures. Goals of landowners, contributors and non-governmental organizations also play a role.

One example is that the importance of forested and rangeland watersheds to water quality and supply has been recognized in various ballot initiatives, related legislation, the CALFED Program and, most recently, in the draft California Water Plan. Public funding has been the primary source of investment in these watersheds. For example, under CALFED, millions of dollars have been invested for watershed assessment, watershed management and technical and staff assistance. A number of agencies, but especially the State and Regional Water Quality Control

Boards and the Department of Fish and Game, have worked with stakeholders to carry out such efforts.

The same is true for investment in forests and rangelands critical to providing biodiversity, habitat and open space. Funding has come from a variety of sources, again largely public in origin. Conservancies, such as the Coastal Conservancy and the Sierra Nevada Conservancy, have been established to provide facilitation, coordination, project focus and management. Several state departments have worked with stakeholders to guide these investments. Key among them is the California Department of Fish and Game, especially the Wildlife Conservation Board (WCB).

Many policies, programs, agencies and stakeholders are involved with making decisions over where to make investments that affect ecosystem services. This typically involves protecting areas that provide unique or high levels of desired services, or restoring areas impacted by past events. Augmenting this with emerging market-based solutions could enhance our ability to sustain these important services into the future.

Chapter 3.5
Plant, Wildlife and Fish Habitat Protection, Conservation and Enhancement

Protection, conservation, and restoration of forest and rangeland wildlife habitat are critical to maintaining and enhancing the rich biodiversity of our nation. Major threats to fish and wildlife habitat result from the patchwork of public-private ownership associated with urbanization and uncharacteristic wildfire (excerpted from the U.S. Forest Service State and Private Forestry Farm Bill Requirement and Redesign Strategies).

KEY FINDINGS

Current Status and Trends

- California is a biological hotspot of plant, wildlife and fish diversity. Climate, geology and ecological processes (fire, water, nutrient cycles, etc) combine to create and maintain the many habitats and high biodiversity found in the state.
- Since the California (1984) and federal (1973) Endangered Species Acts were passed, the general trend has been an increase in the number of both animals and plants listed as threatened or endangered.
- Other non-game wildlife and plant population trends are difficult to discern as data are lacking.
- California's native fish are well adapted to natural disturbance regimes, but they are having great difficulty adapting to human induced changes, such as introduction of exotic species and habitat degradation.
- At least 45 percent of California's 62 native fish species are considered by the California Department of Fish and Game (DFG) as those of greatest conservation need.
- There are 28 fish taxa listed as state or federally threatened or endangered.

- Black bear, pronghorn antelope, bighorn sheep, deer and elk populations are generally stable, but are now at much lower numbers than in the pre-European settlement era.

Habitat Threats and Protection

- The California Wildlife Action Plan (DFG, 2007a) presents at least 20 different threats to plant, wildlife and fish populations and their habitats. Four occur statewide: growth and development, water management conflicts, exotic invasive species and climate change. Five others occur in multiple regions: pollution and urban and agricultural runoff, excessive livestock grazing, altered fire regimes (due to fire suppression and wildland urban interface expansion), recreational pressure/ human disturbance, and other land management conflicts.
- In this section wildfire threat to natural blocks and essential connectivity areas identified in the California Essential Habitat Connectivity Project (CEHCP), and habitat in protected areas are analyzed. Over 14 percent of the state was determined to be in high priority landscapes and over 12 percent is medium priority landscape, suggesting that nearly a third of the state is considered protected habitat but is at risk from uncharacteristic wildfire. The medium and high priority landscapes are concentrated in the Sierra, Klamath/North Coast, Modoc and Central Coast bioregions. Lands managed by federal agencies dominate the priority landscapes.
- Other assessment chapters contain analyses related to wildlife, plant and fish species and their habitats:
  - Chapter 1.1 analyzes the threat from projected development on ecosystem health. Annual Grass, Coastal Scrub, Montane Hardwood and Blue Oak Woodland are at most risk of loss due to development. Bioregions with the largest proportion of ecosystem acres at risk include the South Coast, Bay/Delta, and portions of the Sierra.
  - Chapter 2.1 analyzes the threat to ecosystem health from uncharacteristic fire. The most at risk ecosystems are Klamath and Sierran Mixed Confer and Douglas-fir in the Klamath/North Coast, Modoc and Sierra bioregions. Shrub types most at risk are Sagebrush, Coastal Scrub and Mixed Chaparral.
  - Chapter 2.2 analyzes the threat from forest pests to ecosystem health. Ecosystems currently suffering the most extensive damage are Sierran Mixed Conifer, Eastside Pine, Red Fir and White Fir. Those at greatest risk from future damage include White Fir, Red Fir and Lodgepole Pine.
  - Chapter 3.1 uses a water quality model to highlight areas where important water quality assets coincide with elevated threats to water quality. High priority areas are concentrated in the Klamath/ North Coast bioregion watersheds and in certain basins located in the Sierra as well as portions of the South Coast bioregion.
  - Chapter 3.7 uses predictive models to analyze how vegetation species ranges might change as a result of climate change. Temperature increases coupled with declines in precipitation rates will result in shifts for certain key tree species ranges, typically to higher elevations and northern latitudes.
- A large amount of work has been completed or is underway in California to identify, preserve and protect important wildlife, plant and fish habitat. For example, nearly $200 million in grant monies has been awarded by DFG alone for fish habitat restoration in 26 counties since 1981.

INTRODUCTION

This chapter reports briefly on the status and trends of threatened and endangered species in the state, patterns of their distributions, and population trends for select species of large mammals. It also lists the plans, programs and other efforts underway to conserve wildlife habitat. Finally, the relative risk to important wildlife habitat from uncharacteristic wildfire is analyzed and mapped across the state.

CURRENT STATUS AND TRENDS

California abounds with rich plant, animal and ecosystem diversity, claiming the highest number of species in the United States and the greatest number of our nation's endemics – species that occur nowhere else in the world (Mittermeier, 1999). Climate, geology and natural processes (e.g., fire, water, nutrient cycles) combine to create and shape the many different habitats and high biodiversity found in the state.

It is beyond the scope of this report to paint a complete picture of species of concern and the complex environmental changes that may be affecting them. More complete information can be found in other publications (see the California Wildlife Action Plan (2007) and Life on the Edge (Thelander, 1994)). A brief overview of threatened and endangered species, broad patterns of their distributions and trends in the state and highlights of some flagship species and their status is provided in the section that follows. Tracking population trends can be a valuable tool for identifying species ranges, evaluating management practices, resource planning and assessing whether populations are increasing, remaining stable or in decline and are at risk.

Threatened and Endangered Species and Other Species of Concern

Special-status species, with limited populations or ranges, are of particular interest for conservation and protection. Species determined to be in danger of extinction are listed as threatened or endangered under either the California Endangered Species Act of 1984 (CESA), the federal Endangered Species Act of 1973 (ESA), or both. A number of factors are considered in evaluating whether a species should be listed. These include the condition of the species habitat range, pressures from commercial, recreation, scientific or educational use, disease or predation, poor management practices, or any other natural or man-made factors affecting the species' existence.

Species that have been listed under either act are then protected from activities that may result in "takings" or activities that may jeopardize their continued existence. "Take" is defined by DFG as "to hunt, pursue, catch, capture or kill, or attempt to hunt, pursue, catch, capture or kill a species." Activities resulting in take without a permit issued under the California Endangered Species Act can result in significant fines and penalties. The state and federal ESA prohibits the harvesting, import, export and ownership of any threatened or endangered species, and it also grants federal authorization to preserve and protect the listed species through the designation of critical habitat. The greater the rarity, the more extensive the regulations required to ensure its protection. Surveying and monitoring the status of these animals takes significant time, money and effort.

Since the California (1984) and federal (1973) Endangered Species Act were passed, the general trend has been an increase in the number of taxa listed. Figure 3.5.1 shows recent trends in listing for animal Classes (mammals, birds, amphibians, fish, reptiles), three additional Classes (insects, crustaceans and gastropods) and plants. Information on the insects, crustaceans and gastropods tends to be very limited, thus relatively few species are shown to be threatened or endangered. The trends for listed bird, mammal and fish species tend to be broadly similar, with fish species listings increasing most sharply over the last two decades.

Birds

The first list of California Birds of Special Concern (those which had experienced severe population declines or were vulnerable to future extinction)

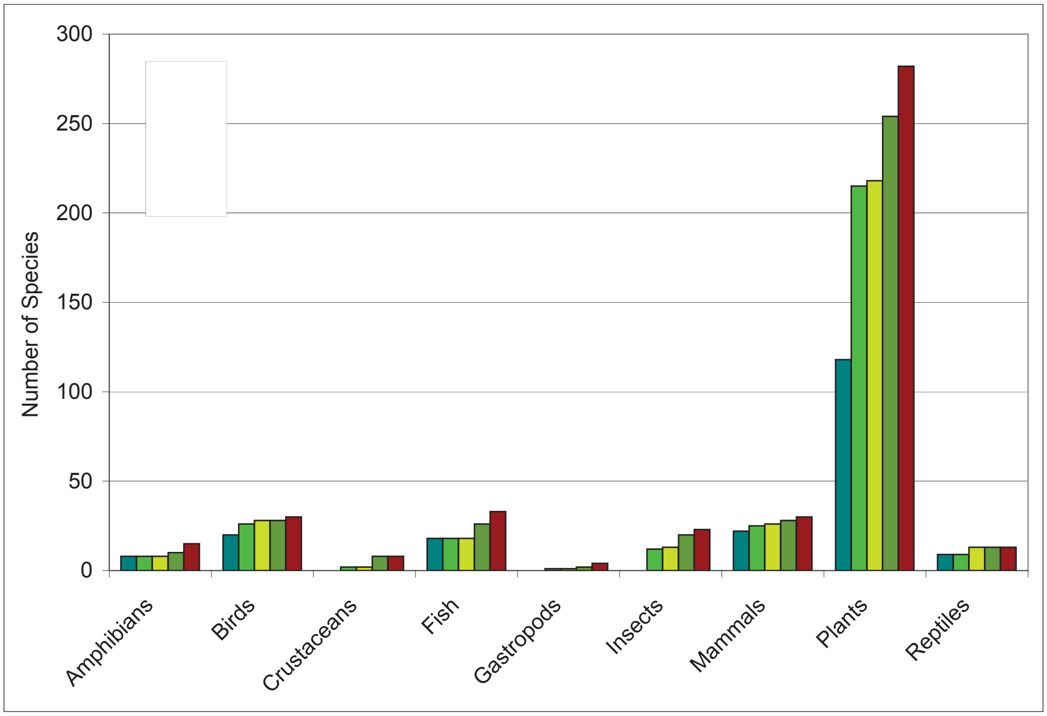


Figure 3.5.1.
Recent trends of listed species by taxa.
Data Source: California Natural Diversity Database, Department of Fish and Game, 2009; CAL FIRE, 2003

published in 1978, included 61 taxa. By 1992 the number increased to 73, with one species added in the last 18 years, bringing the current total to 74 (Shuford and Gardali, 2008). There are 24 state listed threatened or endangered birds and 18 appearing on the federal threatened and endangered species lists. Species listed under DFG's Fully Protected classification may not be taken or possessed at any time, with exceptions made for research and recovery efforts. This designation has the most strict "take" regulations. There are 10 bird species considered Fully Protected (DFG, 2009c). These birds' foremost threat is habitat loss and degradation, including fragmentation. Disease outbreaks have also played a role in large-scale mortality of some bird species.

Much of the state experiences high bird richness throughout phases of the year. While the Bay/Delta bioregion maintains the predicted high richness throughout the year, the Modoc and Klamath/North Coast bioregions contain the highest predicted number of bird species during the summer months (Figure 3.5.2), and the South Coast, the Central Coast, the Sacramento Valley and San Joaquin Valley bioregions see the most bird species during the winter months (Figure 3.5.3). The California Wildlife Action Plan (CWAP) has listed growth and development, climate change, invasive plants and animals, water management conflicts, degradation of aquatic ecosystems, loss of riparian habitat and intensive agriculture as serious pressures to all of these bioregions identified as having the highest bird species richness in the state.

Amphibians

Frogs, toads and salamanders comprise the Class Amphibia (cold-blooded, aquatic vertebrates with gills in early life stages, developing lungs during metamorphosis, characterized by smooth skin). They are sensitive to changes in their environment (e.g., decreased humidity, increased pollution). For more than a decade, many amphibian populations have been declining in California and worldwide. There are 13 species of amphibians listed as state, or federally threatened or endangered, including the California red-legged frog (*Rana draytonii*) and

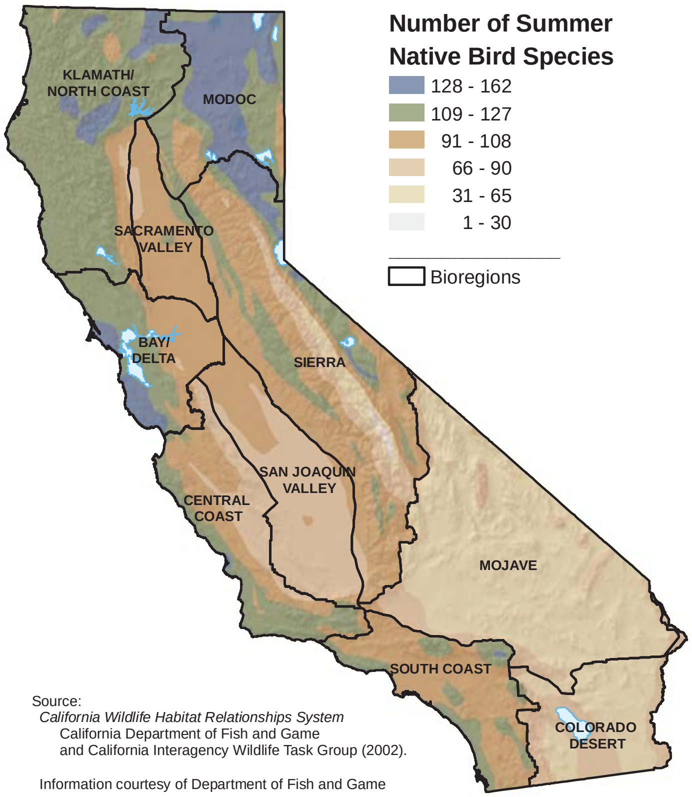


Figure 3.5.2.
Summer bird species richness.

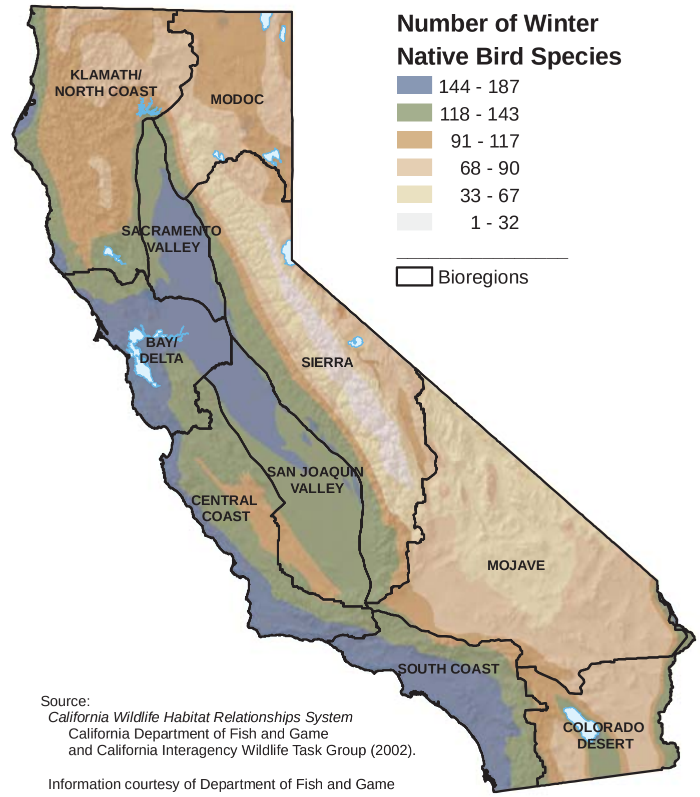


Figure 3.5.3.
Winter bird species richness.

the Sierra Nevada yellow-legged frog (*Rana sierrae*). Twenty-six species of amphibians are listed as California Species of Special Concern (DFG, 2009b). Species that are placed on these lists are recognized as having declining populations, limited ranges, or are vulnerable to extinction and merit monitoring. DFG is working with University of California Davis to update the list of California Amphibian and Reptile Species of Special Concern. At this time, 80 species are under consideration for the updated list. A report is expected to be available from DFG by July 2010.

Areas of the highest predicted amphibian richness (Figure 3.5.4) were identified to be in the Klamath/North Coast, the Central Coast, the South Coast and parts of the Sierra bioregion. Some of the primary threats to these four bioregions that were identified by the CWAP were growth and development, climate change, water management conflicts, degradation of aquatic ecosystems and loss of riparian habitat. These types of threats are expected to have a direct impact on amphibian species.

Mammals

There are currently 30 terrestrial mammal species and subspecies listed as either state or federally threatened or endangered. Included are species of mouse, squirrel, kangaroo rat, fox and bighorn sheep, as well as a shrew, bat, rabbit, beaver, vole and wolverine. Sixty-seven terrestrial mammals are listed as California Species of Special Concern. There are five mammal taxa listed as Fully Protected (DFG, 2009c).

The Sierra, Klamath/North Coast and Modoc bioregions have the highest predicted mammal species richness (Figure 3.5.5). Small, forest dwelling mammal taxa, such as the squirrel and chipmunk families, have the highest species richness, which explains the high concentration of species in those heavily wooded bioregions (DFG, 2003). The CWAP has

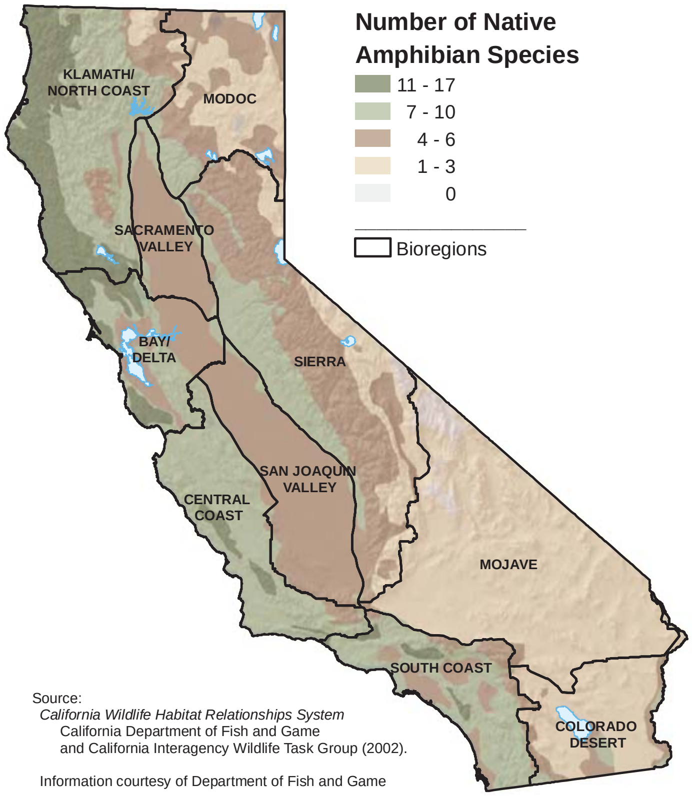


Figure 3.5.4.
Amphibian species richness.

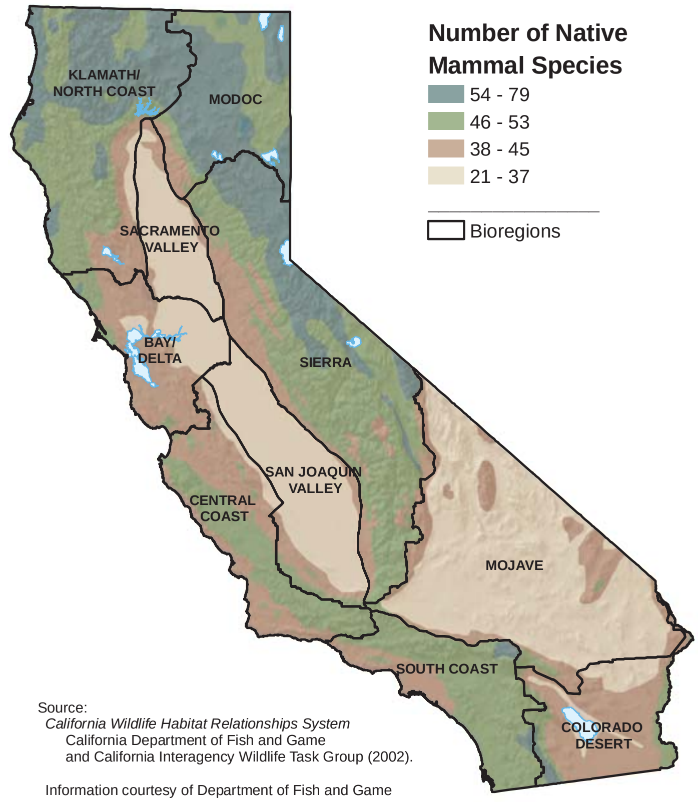


Figure 3.5.5.
Mammal species richness.

listed climate change, water management conflicts, degradation of aquatic ecosystems, loss of riparian habitat and forest management conflicts as stressors affecting wildlife habitat in all of the bioregions that were identified as having the highest mammal species richness in the state.

Reptiles

Snakes, lizards and turtles make up the Class Reptilia (cold-blooded, terrestrial vertebrates born fully developed with lungs and scaly skin). There are ten species of reptiles listed as state or federally threatened or endangered. Two examples include the giant garter snake (*Thamnophis gigas*) and the blunt-nosed leopard lizard (*Gambelia sila*). Twenty-five species of reptiles are listed as California Species of Special Concern (DFG, 2009b).

Reptiles have adapted well to dry areas and extreme environments, naturally making the Mojave, Colorado Desert and South Coast the bioregions with the highest predicted reptile species richness (Figure 3.5.6). The CWAP has identified growth and development, off-highway vehicle use, invasive plants, water management conflicts and climate change as major stressors that are degrading and disrupting wildlife habitat in all of these desert dominated bioregions. Low year round temperatures in the Sierra Nevada mountains and the Central Valley's historical wet expanses contribute to the fact that these bioregions have the lowest reptile species richness (DFG, 2003).

Fish

At least 45 percent of California's 62 native fish species are considered by DFG to be of greatest conservation need (Moyle et al., 2009). There are 32 fish taxa listed as threatened or endangered by either the state or the federal government, and nine species classified as Fully Protected (DFG, 2009c). A considerable amount of work has been completed or is underway to identify important habitat for preservation and restoration. However, the nexus between

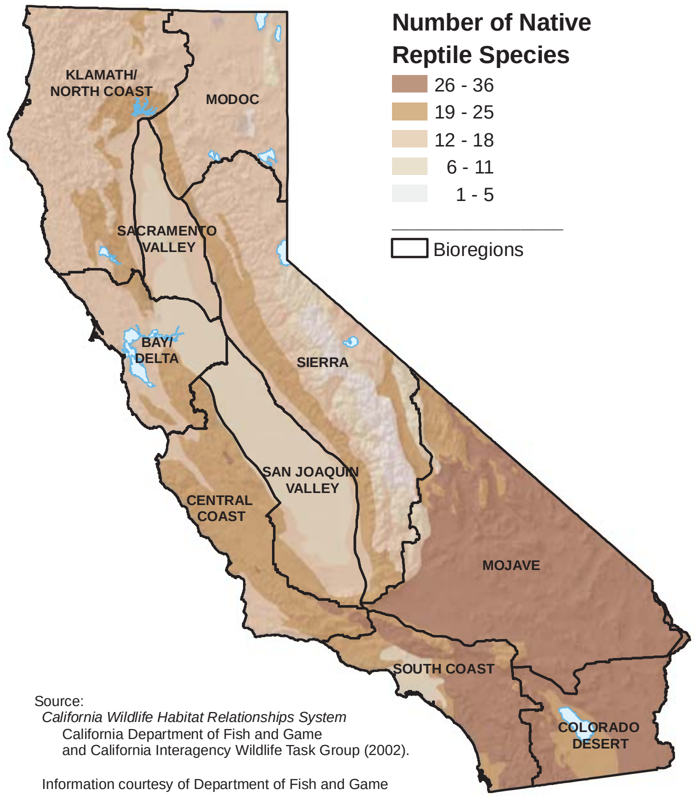


Figure 3.5.6.
Reptile species richness.

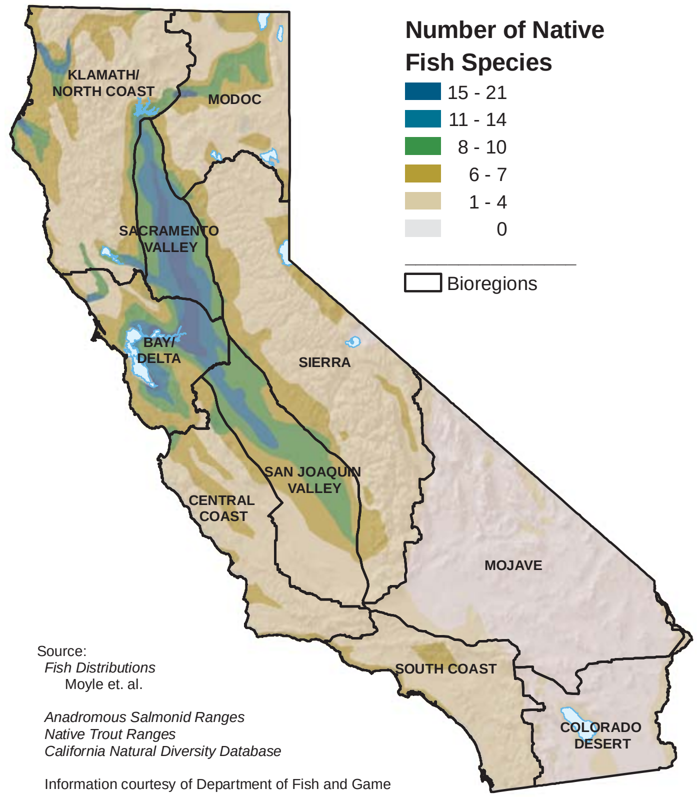


Figure 3.5.7.
Freshwater fish species richness.

threats, restoration and fish survival is not completely understood. A collaborative effort will be needed between federal entities, the state, private land owners and other stakeholders for watershed protection and species recovery.

The Sacramento Valley, San Joaquin Valley and Bay/Delta bioregions have the highest predicted freshwater fish richness (Figure 3.5.7). This is mostly based on highly productive habitats in the large rivers and estuary and bay system (DFG, 2003).

Invertebrates

Invertebrates are animals without backbones. Currently, there are 34 threatened or endangered species of mollusks, crustaceans, insects and arachnids as listed by the State.

Plants

The list of special-status plants far outnumber animals and fish, in part because the diversity of plant species reflects the multitude of unique habitats and microclimates found throughout the state. Many species have very limited geographical ranges making them more vulnerable to extinction (Dobrovolny, 2009).

The California Native Plant Society (CNPS) maintains, in cooperation with DFG, a listing system for plant species at risk. Plants given a 1B status describe plant species considered rare, threatened or endangered both in California and elsewhere. List 2 plants are described as species that are rare, threatened or endangered in California, but are more common elsewhere. The Department of Fish and Game classifies CNPS Lists 1B and 2 plant species as rare and regulates them accordingly. In 2001 there were 1,021 species on this list. By the end of 2009 the number increased to 1,089 species (DFG, 2009a).

The Klamath/North Coast and Sierra bioregions have the highest predicted plant species richness in the state (Figure 3.5.8). The high plant diversity in these areas is largely due to dramatic topography, large elevation gradients and a wide range of climate conditions (DFG, 2003). The CWAP has identified growth and development as a particularly critical stressor in the Sierra bioregion, while climate change, water management conflicts, degradation of aquatic ecosystems, loss of riparian habitat, invasive plants and animals, livestock grazing, forest management conflicts and altered fire regimes have been identified as some of the leading stressors in both bioregions.

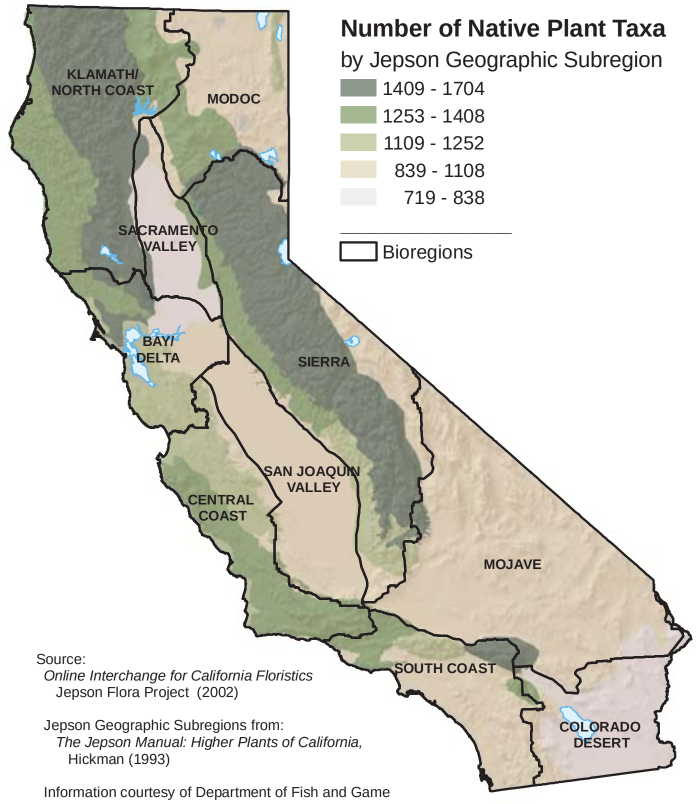


Figure 3.5.8.
Plant species richness.

Selected Mammal Population Trends

The Department of Fish and Game has a program that focuses on managing and monitoring large mammals that are classified as big game species, which includes black bear, pronghorn antelope, bighorn sheep, deer, elk and wild pig. They also manage mountain lion populations as large mammals that are considered specially protected species, not game species. Game animal populations are the most extensively tracked, as populations are generally abundant and managed through recreational hunting. Population trends are subject to environmental conditions such as climate extremes, loss of cover and food source availability, at times resulting in large population shifts on a year-to-year basis. Significant changes in their populations can indicate problems related to a populations' overall health and reproduction, impacts to important habitat, or other issues which may need to be examined more closely.

Game species and charismatic megafauna (e.g., mountain lions, bald eagles and deer) tend to garner the most attention by California's citizenry, and as a result, much more data is available to evaluate population trends than other, lesser known species (Dobrovolny, 2009).

Black Bear (Ursus americana)

Records of black bear populations over the last 18 years show a slow but steady increase in population. Statewide estimates in 1983 were around 7,000 (DFG, 2006, DFG, 2001a), and are now thought to be about 35,000 animals (Updike, 2009).

Pronghorn (Antilocapra americana)

The pronghorn was possibly once the most common land mammal in California (Pyshora, 1997), but their population was estimated to have dropped to a mere 1,100 in the 1920s, peaked near 8,000 in the mid-1990s and has subsequently fallen to an estimated 4,773 in 2009 (DFG, 2001b; Hobbs, 2009).

Black-Tailed Deer (Odocoileus hemionus)

Estimated to be between 500,000 to 600,000 before the gold rush, black-tailed deer may have increased to as much as 900,000 by the 1950s (DFG, 2001c). They are estimated to be close to 484,400 currently (based on population models), and stable in most areas. In other areas, they are showing a slow decline (Stowers, 2009). According to DFG, this decline is due to habitat loss resulting from fire suppression, the reduction and decadence of shrub-dominated habitats, herbicide treatments to reduce vegetative competition with young conifer plantings, and winter recreational use in deer wintering grounds (Stowers, 2009).

Elk (Cervus elaphus nanodes, C. e. roosevelti, C. e. nelsoni)

Beginning in the mid-1800s, the population of elk decreased precipitously, and by 1971 the number of endemic Tule elk (*C. e. nonodes*) had declined to a total of 500 wild animals. As a result of an active elk management program, the population increased to 2,680 by 1989 (DFG, 2007b). The number of animals was estimated to be 3,580 in 2009 (Hobbs, 2009). Roosevelt elk (*C. e. roosevelti*) are estimated to have increased from 4,000 to 6,000 between 2000 and 2009. Rocky mountain elk (*C. e. nelsoni*) have held steady at an estimated 1,500 since 2000 (DFG, 2007b; Hobbs, 2009).

Bighorn Sheep (Ovis canadensis sierrae and O.c. nelsoni)

The Sierra Nevada bighorn sheep (*O.c. sierrae*) is both state and federally listed as endangered. Their population was estimated at 250 in 1979, 150 in 1996 (Graber, 1996) and is 60 percent recovered at 400 animals as of 2007 (Wehausen et al., 2007). A distinct population segment of the Nelson bighorn (*O. c. nelsoni*), called the peninsular bighorn sheep, is state listed as threatened and federally listed as endangered. Nelson bighorn sheep management is directed by Fish and Game Code. Based on its distribution and abundance, limited sport hunting of mature rams as managed and directed by DFG is allowed. In 1989, the listed Peninsular bighorn sheep population was 334 and in 2006 it was estimated at 791 (DFG, 2001e; Rubin, 2000; Wakeling, 2007).

Mountain Lion (Puma concolor)

Mountain lion populations have generally been increasing. The population was estimated to be around 2,400 in 1973, and is currently estimated to be between 4,000 to 6,000 individuals (Updike, 2009; Sitton and Wallen, 1976; CAL FIRE, 2003).

Threats to Wildlife Habitat and Conservation Programs and Plans

The key to long-term preservation of wildlife is the conservation, improvement, reestablishment and management of their natural habitats. A myriad of pressures are impacting wildlands. An array of programs is now in place to help preserve and maintain the remaining wild places and the species to which they are home.

California Department of Fish and Game is the lead agency responsible for managing the state's wildlife, plant and fish resources. Other state agencies that influence wildlife habitat are Department of Parks and Recreation, the State Lands Commission, State and Regional Water Quality Control Boards, the Department of Pesticide Regulation, Department of Water Resources, CAL FIRE and various conservancies. Several federal agencies such as the Environmental Protection Agency, National Marine Fisheries Service and the U.S. Fish and Wildlife Service have considerable information and significant programs regarding species populations or habitat. Other federal agencies such as the U.S. Forest Service, National Park Service, Bureau of Land Management and Department of Defense (DOD), also have data and management programs that deal with species and habitat.

Recent or ongoing efforts by DFG related to habitat threats and protection include: the California Wildlife Action Plan (CWAP), the Natural Community Conservation Planning Program (NCCP), the newly released California Essential Habitat Connectivity Project and the Areas of Conservation Emphasis (ACE) program. These DFG endeavors are briefly summarized below.

California's Wildlife Action Plan (CWAP)

The California Wildlife Action Plan (DFG, 2007a) summarizes threats affecting all wildlife, including mammals, fish, birds, reptiles, amphibians and plants, and suggests actions needed to maintain habitats and diversity in the future. CWAP does not present a detailed spatial analysis. The report lists and describes approximately 20 different threats to wildlife and plant populations and their habitats. Four threats occur statewide: growth and development, water management conflicts, invasive species and climate change. Five others occur in multiple regions: pollution and urban and agricultural runoff, excessive livestock grazing, altered fire regimes (due to fire suppression and wildland urban interface expansion), recreational pressure, human disturbance and other land management conflicts. For purposes of this assessment, Table 3.5.1 summarizes the most important threats by bioregion.

Natural Community Conservation Planning Program (NCCP)

The primary objective of the NCCP is to conserve natural communities at the ecosystem scale while accommodating compatible land use. The program seeks to anticipate and prevent the controversies and gridlock caused by species' listings by focusing on the long-term stability of wildlife and plant communities and including key interests in the process.

California Essential Habitat Connectivity Project (CEHCP)

The CEHCP is a Department of Fish and Game and California Department of Transportation (Caltrans) sponsored, public/private project to meet legal obligations to map wildlife corridors and habitat linkages (Spencer et al., 2010). The goal is to produce a matrix summarizing the biological values of the linkages, a strategic plan that frames a methodology for finer-scale analysis and local and regional connectivity

Table 3.5.1. Threats to wildlife and habitat by region, identified by DFG's CWAP

Threat	Klamath/ North Coast	Modoc Plateau	Sierra Nevada/ Cascade	Mojave Desert	Colorado Desert	South Coast	Central Coast	Bay/ Delta	Sacramento Valley	San Joaquin Valley
Growth and Development			x	x	x	x	x	x	x	x
Off-Highway Vehicle Use			x	x	x					
Livestock Grazing	x	x	x	x			x			
Wild Burro or Horse Grazing		x		x						
Invasive Animals	x		x		x	x	x	x	x	x
Invasive Plants	x	x	x	x	x	x	x	x	x	x
Military Land Management Conflicts				x						
Mining				x						
Water Management Conflicts	x	x	x	x	x	x	x	x	x	x
Altered Fire Regime	x	x	x			x				
Recreational Pressure		x	x			x	x			
W. Juniper Expansion		x								
Forest Management Conflicts	x	x	x	x						
Climate Change	x	x	x	x	x	x	x	x	x	x
Water Pollution								x	x	x
Degradation of Aquatic Ecosystem/Loss of Riparian Habitat	x	x	x		x	x	x	x	x	x
Loss/Degradation of Dune Habitats					x					
Intensive Agriculture	x	x					x	x	x	x
Substantial In-Stream Gravel Mining	x									
Watershed Fragmentation			x							

Data Source: California Department of Fish and Game, 2007 plans and a habitat connectivity map (Parisi, 2009). The plan will assist planners in maintaining and restoring habitat connectivity while making infrastructure projects more cost-effective (Spencer et al., 2010).

Areas of Conservation Emphasis (ACE)

The Department of Fish and Game will soon complete a report called Areas of Conservation Emphasis (ACE). The purpose of ACE is to identify high priority areas for conservation based on threats to biodiversity and endemism, as well as key critical areas of habitat and habitat types. The study should provide a comprehensive analysis of wildlife habitat assets and threats, with a focus on lands that are not currently managed for wildlife conservation.

THREATS TO WILDLIFE HABITAT: RESULTS FROM OTHER CHAPTERS

Efforts to analyze wildlife habitat were constrained by a number of factors, including data limitations and the complexity of the interaction of various threats on habitat. However, material in other assessment chapters is relevant to habitat threats.

Development Threat to Ecosystem Health
Chapter 1.1 analyzed the threat from projected development on ecosystem health. The analysis identified priority areas most threatened by immediate development, as well as entire ecosystems where the cumulative landscape-level threat has the potential to impact unique genetic resources, biodiversity and associated ecosystem services. Key findings include:

- Annual Grassland, Coastal Scrub, Montane Hardwood and Blue Oak Woodland habitat types are at the most risk of loss due to development.
- Bioregions with the largest proportion of ecosystem acres at risk include the South Coast, Bay/Delta and portions of the Sierra.
- Other habitat types of much smaller extent show up as threatened in local areas of other bioregions, for example Blue Oak-Foothill Pine in the northern Sacramento Valley.

Forest Management Threat to Ecosystem Health
Sustainable Working Forests and Rangelands reported harvesting trends. In connection with forest management activities, CWAP listed a range of impacts, including the cultivation of even-aged stands, clear cutting and forest structure simplification, fire suppression, clearing of dead and downed wood, road building and maintenance and post-harvest herbicide use. It pointed to the cumulative effects of even-aged timber harvesting, and the elimination of older trees and snags and the biodiversity they foster.

Such activities can impact forest and stream habitats for wildlife. Timber harvesting practices can alter forest structure and the larger landscape scale patterns of habitat. Often impacts are species or habitat specific, and effects can be beneficial, neutral or negative depending on the species of interest. Impacts of harvesting and related management can affect such things as:

- Species behavior such as feeding, migration, reproduction
- Forest habitat structure such as increasing or decreasing specific seral stages (i.e., early or late seral stage)
- Configuration and extent of habitat, such as impacts along the edge of areas harvested
- Increased edge effects and the quantity and quality of habitat connection or integration
- Presence, absence or recruitment of specific habitat elements like nest trees, snags and large woody debris
- Overall richness, complexness, diversity and productivity of habitat
- Status of in-stream and adjacent riparian habitat, such as shade, sediment movement and available nutrients
- Establishment and spread of undesired habitat elements, such as invasive species

CWAP identified forest practices as potentially impacting the streams of San Mateo and Santa Cruz county areas of the Bay/Delta bioregion, as well as those of the Klamath/North Coast bioregion. The plan also indicated that forest management conflicts and their past and current effects are major stressors on forest habitats in the Sierra, Klamath/North Coast and Modoc bioregions. The Plan emphasizes the maintenance of old growth forests, now mostly on federal lands, in addition to efforts to reduce the risk of catastrophic fires through thinning of densely packed understory trees.

Rangeland Management Threat to Ecosystem Health

Large rangeland areas provide continuous open space critical for wildlife movement and ecological function (DFG, 2007a). The recent CEHCP report finds that extensive rangelands (e.g., along the edges of the Central Valley) provide essential connectivity habitat for wildlife (Spencer et al., 2010).

Proper management of livestock grazing, the main use impacting rangelands, is important to retaining high quality habitat for both terrestrial wildlife and aquatic species. Excessive grazing can lead to problems with invasive species, soil erosion and loss, habitat loss for ground nesting birds and overall habitat degradation. In some areas, endangered species such as the kit fox can be severely impacted by the effects of livestock grazing. Seasonal timing, number of livestock and degree of grazing are important to rangeland management. In more wooded rangelands, grazing can reduce understory plants and eliminate habitat for wildlife species dependent on it for protection and cover.

Riparian areas in grazed rangelands have historically suffered impacts from livestock trampling, browsing and direct urination and defecation into streams. Many streams flowing through rangelands are listed under 303 (of the Clean Water Act) as having impairment from the effects of rangeland and riparian livestock grazing. In addition, cattle trails can be an important mode of sediment transport into rangeland streams, further degrading water quality (George, et al., 2004).

CWAP listed the Mojave, Central Coast, Klamath / North Coast, Modoc and Sierra bioregions all as having excessive livestock grazing as a major wildlife stressor. Riparian habitat degradation was highlighted in the Sierra bioregion, with livestock grazing as a listed cause. Invasive plants, a problem often exacerbated by excessive grazing, is also listed as a stressor for the Mojave, Modoc and Sierra bioregions.

Wildfire Threat to Ecosystem Health

Wildfire Threat to Ecosystem Health and Community Safety analyzed the threat to ecosystem health from uncharacteristic wildfire. This chapter identified important trends related to increased acres burned, fire severity, and departure from historic fire regimes which is impacting vegetation communities that are adapted to, or even dependent on natural wildfire. Key findings include:

- The most at risk ecosystems are Klamath and Sierran Mixed Conifer and Douglas-fir in the Klamath/North Coast, Modoc and Sierra bioregions. Shrub types most at risk are Sagebrush, Coastal Scrub and Mixed Chaparral.

Forest Pest Threat to Ecosystem Health

Forest Pests and Other Threats to Ecosystem Health and Community Safety analyzed the threat from forest pests to ecosystem health. This chapter highlighted the widespread commercial, aesthetic, economic and environmental impacts throughout California's ecosystems being caused by various native and exotic forest pests. Key findings include:

- Ecosystems currently suffering the most extensive damage are Sierran Mixed Conifer, Eastside Pine, Red Fir and White Fir.
- Those at greatest risk from future damage include White Fir, Red Fir and Lodgepole Pine.

Threats to Water Quality and Quantity

Water Quality and Quantity Protection and Enhancement analyzed threats to water quantity and quality, both of which play a key role in wildlife and fish related habitat in California. The water quality analysis compares water quality assets such as anadromous fish-bearing streams, riparian vegetation canopy cover, wild and scenic rivers, forest meadows and natural lakes to water quality stressors such as impaired waterbodies, post-fire erosion, development and impervious surfaces. Key findings include:

- High priority areas for water quality are concentrated in North Coast watersheds and in certain basins located in the Sierra as well as portions of the South Coast.

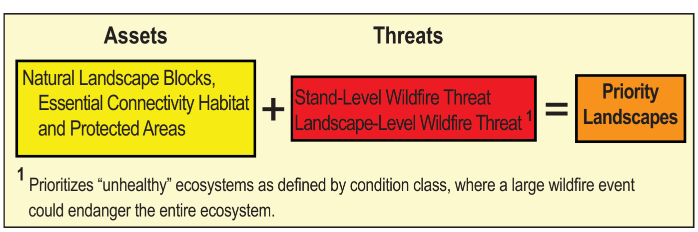
Climate Change Threat

Chapter 3.7 discusses the potential effects of climate change on California's ecosystems, such as changes in species distribution ranges, tree growth and disturbance regimes. Predictive models were used to analyze how vegetation species ranges might change as a result of climate change. Key findings include:

- Projected temperature increases coupled with steady or declining precipitation rates may result in longer dry seasons and shifts for tree species ranges, typically to higher elevations and more northern latitudes. Most affected would likely be habitats situated at the highest elevations of mountain ridges, with types in some areas being eliminated. Most wildlife can follow the movement of suitable habitat, but there may be a net loss of habitat overall for species inhabiting higher elevations in the state.

WILDFIRE THREAT TO AREAS PROTECTED FOR HABITAT

Analysis



In this section wildfire threat to natural blocks, essential connectivity and protected areas are analyzed. These lands are a key foundation for existing wildlife diversity and may be even more critical as wildlife and other species attempt to adapt to climate change. This approach is being used as an interim analysis until ACE data becomes available for a more extensive habitat analysis.

As outlined in California's Wildlife Action Plan, many threats exist to wildlife habitat in the state. One of the most common threats is high severity or frequent wildland fire. Wildfire can have varied impacts on habitat, depending upon many factors (fire behavior, frequency, duration, seasonality and landscape alterations). Generally speaking, as the intensity of fire increases, the severity of impacts also increases. An exception occurs when habitat is adapted to high intensity fire (e.g., chaparral, lodgepole pine). The vast majority of habitats in California are not resistant to high severity wildfire.

Fire suppression practices have reduced fire frequency in most areas of the state over the past 50 years, resulting in a buildup of wildland fuels. This has greatly increased the threat of high intensity or uncharacteristic wildfire. High intensity wildfires often cause more severe ecological damage in less resilient ecosystems. Intensely burned landscapes are often unusable to even specially-adapted plants and animals generally expected to be found in post-fire habitats.

The priority landscape (Figure 3.5.10) identifies natural blocks, essential connectivity and protected areas which are most at risk from uncharacteristic wildfire. Identification of protected habitat threatened by high intensity wildfire is a step in conserving, protecting and restoring habitats crucial to sustaining and enhancing the rich biodiversity of California.

Asset

Protected Areas, Natural Landscape Blocks and Essential Connectivity Habitat Areas

Areas of three designations were combined to produce the GIS coverage of the habitat asset layer: natural habitat blocks, essential corridor habitat (both defined by the California Essential Habitat

Connectivity Project (CEHCP)) and protected areas. The CEHCP delineated natural landscape blocks and essential connectivity areas deemed important to facilitate the movement and long-term viability of wildlife populations throughout the state (Spencer et al., 2010). While not geared to any particular species or guild, the GIS data and maps are offered as spatial guides to regional conservation planning rather than delineating specific areas recommended for some form of protected status.

For the purposes of this analysis, protected areas are defined as land that is legally established in public ownership, private land trusts, or in similar status that provides wildlife habitat values and is likely to remain as habitat into perpetuity. The protected areas asset layer used for this analysis was derived from the California Protected Areas Database (GreenInfo Network, 2009). This dataset includes all protected areas within California from small, local and regional parks to large federal lands, preserves, reserves, conservancies, land trusts, foundations and easements. Department of Defense lands, given their in-depth resource management plans, were added to the protected areas asset layer.

This analysis gave all habitat asset areas the same rank, regardless of their ecological health and level of management, assuming that all of these lands currently offer high quality habitat, or have the potential to offer good habitat once improved or restored. Such areas may be key to landscape-scale wildlife habitat improvement and other adaptive management strategies for climate change. The asset layer is shown in Figure 3.5.9.

Threat

Wildfire Threat

Wildfire threat represents a combination of the level of impact and severity that a wildfire causes, and the frequency with which an area is expected to burn; the higher the rank the higher the likelihood of a damaging fire event. The fire threat layer used considers both landscape and stand level wildfire risk. See Chapter 2.1 for additional information on threats from wildfire.

Results

The wildlife habitat asset layer was combined with the threat layer to create a statewide priority landscape depicting high value areas that are at highest risk for uncharacteristic wildfire. The priority landscape is shown in Figure 3.5.10. About 62 percent of the state was determined to be in asset areas. The analysis shows that over 14 percent of the state is considered high priority (both protected and high wildfire threat), while over 12 percent is medium priority and 35 percent is low priority. The high and medium priority landscapes (HMPL) are at most risk, and these are concentrated in the Sierra, Klamath/North Coast and Modoc bioregions (Table 3.5.2).

The priority landscape is largely characterized by public land managed by federal agencies. The

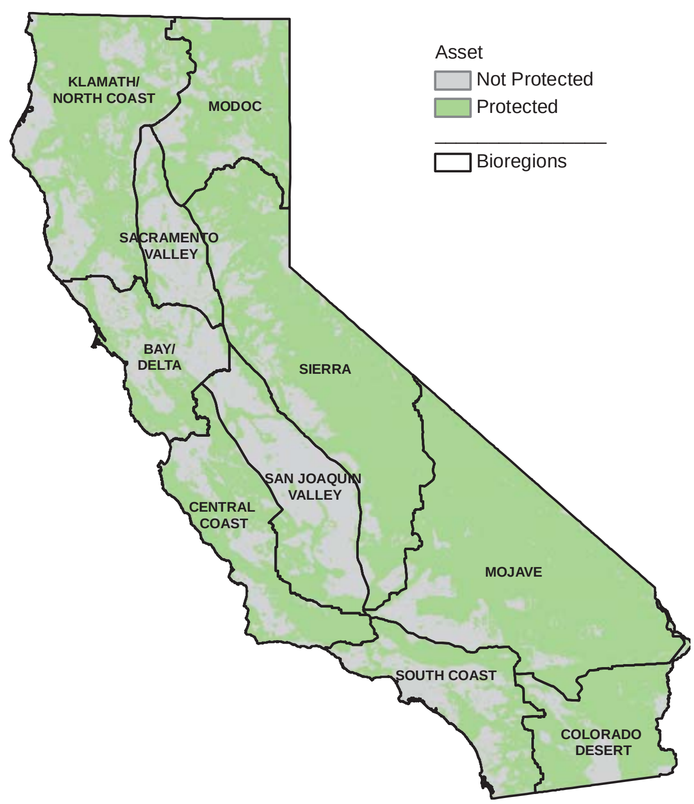


Figure 3.5.9.
Protected and wildlife corridor areas asset.
Data Sources: California Protected Areas Database (CPAD), GreenInfo Network (2009); California Essential Habitat Connectivity Project, DFG (2010)

bioregions with the most medium and high priority landscape (Sierra, Klamath/North Coast and Modoc) are all dominated by federal lands. Lands administered by the U.S. Forest Service (USFS) comprise the majority of this designation overall. The Modoc bioregion has more high and medium priority landscape held by the Bureau of Land Management (BLM) than any other bioregion (Table 3.5.3). About 89 percent of the high and medium priority landscape is managed by federal agencies, three percent falls on state lands, and less than one percent is owned by non-profit agencies. The Sacramento Valley bioregion contains the most non-profit and state owned high and medium priority landscape.

Discussion

The results suggest that over one-quarter of the wildlife habitat asset acres in California are at high or medium risk from uncharacteristic wildfire. Lands managed by federal agencies dominate the priority landscapes. To the extent that these lands are considered key to effective wildlife conservation, and catastrophic wildfire would severely alter or destroy this habitat, efforts should be directed to reduce this threat and restore a more characteristic fire regime to these key ecosystems.

This analysis was limited by factors including:

- Some areas important to wildlife may have been inadvertently omitted. The areas used as wildlife habitat assets were derived from protected status, natural block and essential corridor work, but may be incomplete in some areas. Areas not included in the analysis may also potentially be of high value for wildlife habitat.
- Despite numerous programs, regulations and efforts put in place to protect wildlife species and their habitat, there is still a general trend of species decline across all California taxa. The CWAP has identified the leading stressors responsible for these continuing declines. Updating of the CWAP, completion of ACE by DFG and other studies by governmental agencies with jurisdiction over wildlife, fish and water quality could significantly add to and refine lands considered as key for habitat protection, and mechanisms for other protection measures.

Tools

A large amount of work has been completed or is underway in California to identify, preserve, protect and restore important wildlife, plant and fish populations and their habitat. The Department of Fish and Game, other agencies, universities and other stakeholders are also active in examining the potential impacts of climate change on species and habitat and are designing mitigation and adaptation strategies. Many broad-scale and local efforts recognize the value of collaboration and include multi-agency agendas in their planning efforts.

Below is a partial list of efforts underway related to wildlife habitat planning and conservation. These are covered further in the strategies document.

- Chapter 6 of the CWAP addresses the important elements and needs of effective wildlife habitat conservation efforts in California. It also summarizes the numerous plans, programs and initiatives now underway to meet this challenge.
- The results of the CEHCP have just been released, and data from that project was used in the analysis in this chapter. As part of its analysis, it mapped statewide natural habitat blocks and essential habitat connectivity routes for wildlife moving between these blocks.
- Various efforts by watershed groups, Fire Safe Councils, local communities and other stakeholders often implement important projects related to watershed restoration, fuel reduction and habitat improvement. Local efforts frequently involve non-profit agencies to set up land trusts, easements, preserves and reserves.
- Policies and regulations can be a driving force in enhancing and protecting habitat, such as through the National Marine Sanctuaries Act and the California Forest Practice Rules.

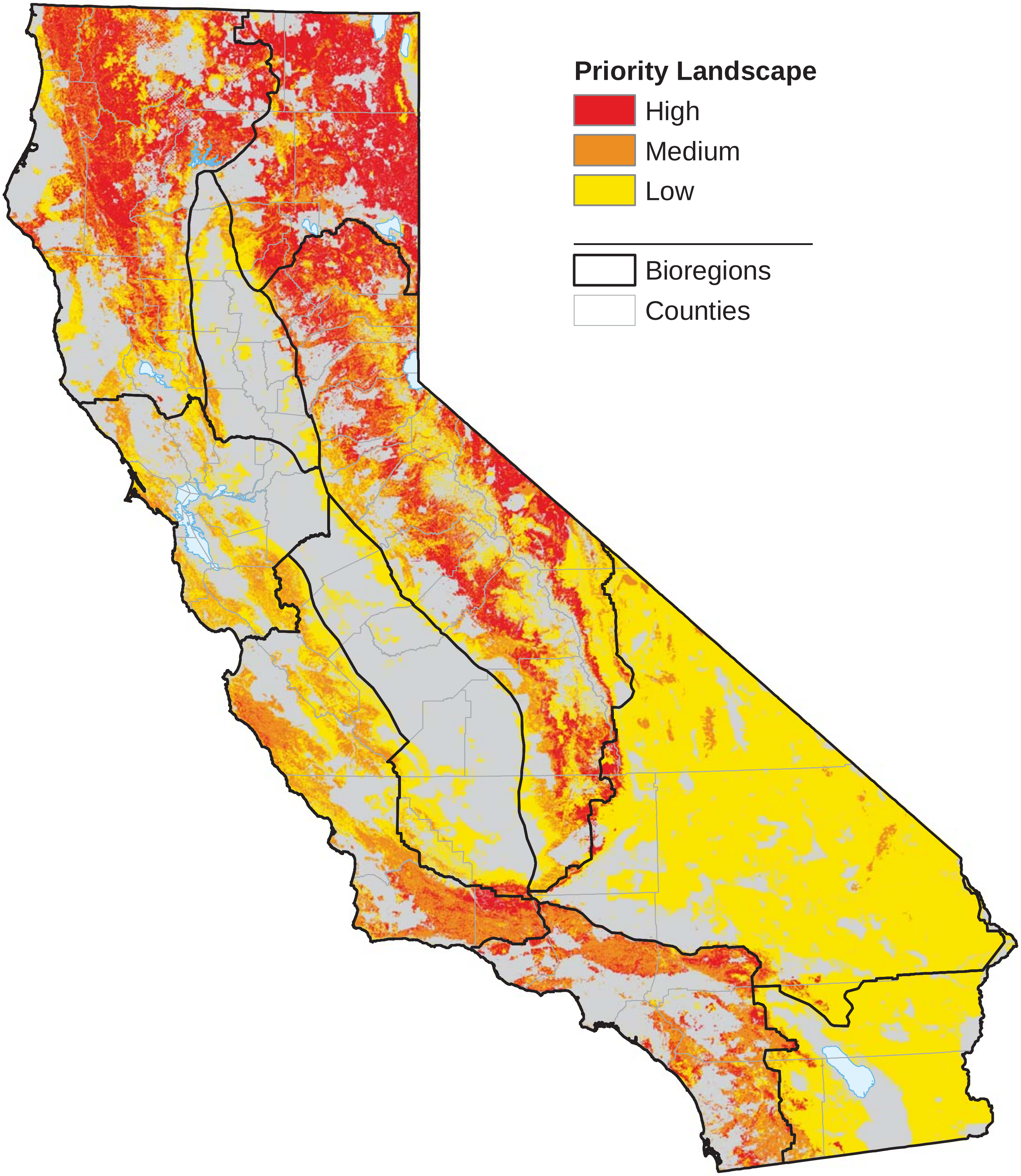


Figure 3.5.10.
Priority landscape of wildfire threat to areas important for wildlife habitat.
Data Sources: California Essential Habitat Connectivity Project, DFG (2010); Protected Areas from California Protected Areas Database (CPAD),GreenInfo Network (2009); Bureau of Indian Affairs lands from California Protected Areas Database (CPAD), GreenInfo Network (2010); Department of Defense lands from Public Conservation Trust Lands, Legacy Project, California Resources Agency (2005); California Fire Regime Condition Class, FRAP (2003); Fire Threat, FRAP (2005)

Table 3.5.2. Priority landscape for wildfire threat to areas protected for habitat by bioregion (acres in thousands)

Bioregion	Total Acres	Low	Medium	High	Percent HMPL of State
Bay/Delta	6,292	1,542	843	4	0.84
Central Coast	7,986	2,107	2,611	577	3.15
Colorado Desert	6,757	4,592	168	64	0.23
Klamath/North Coast	14,383	2,808	2,264	4,367	6.55
Modoc	8,332	772	842	4,094	4.88
Mojave	19,937	15,687	447	252	0.69
Sacramento Valley	3,953	702	192	34	0.22
San Joaquin Valley	8,224	1,619	148	60	0.21
Sierra	18,303	4,912	3,235	4,390	7.53
South Coast	7,059	538	1,980	1,082	3.02
Total	101,226	35,280	12,730	14,923	27.32

Table 3.5.3. High plus medium priority landscapes for wildfire threat to areas protected for habitat by ownership and bioregion (acres in thousands)

Bioregion	USFS	NPS	DOD	BLM	Other Federal	BIA	Other Public	Private	NGO
Bay/Delta	0	46	<1	7	12	<1	245	511	26
Central Coast	1,502	10	149	122	6	<1	114	1,276	10
Colorado Desert	6	<1	0	56	4	29	94	41	1
Klamath/North Coast	1,195	45	0	291	1	129	66	1,481	4
Modoc	2,456	116	14	1,166	16	13	110	1,038	7
Mojave	39	260	29	249	3	<1	13	90	16
Sacramento Valley	0	0	<1	9	1	<1	12	191	13
San Joaquin Valley	66	0	0	40	3	0	7	77	15
Sierra	4,703	499	0	658	16	46	177	1,518	9
South Coast	1,559	19	88	95	48	138	365	723	26
Total	11,526	994	281	2,693	110	355	1,202	6,946	128

- University and academic research and instruction can improve understanding and management and help focus efforts.
- Funding is a key component of the habitat protection, conservation and enhancement process. Nearly $200 million in grant monies have been awarded by DFG alone for fish habitat restoration in 26 counties since 1981. Voter approved initiatives and bond measures have provided critical funding, especially for land acquisition and water quality improvements.
- The U.S. Fish and Wildlife Service and the U.S. Geological Survey are working together on a “strategic habitat conservation” initiative, which requires the agencies and their partners to set biological goals for priority species populations, inform and make strategic resource management decisions, and constantly reassess and improve conservation actions.
- California Partners in Flight, a partnership of agencies and private groups, have published bird-centered conservation plans for most habitat types in California.

Chapter 3.6
Green Infrastructure for Connecting People to the Natural Environment

Our nation's federal, state, urban and private forests are the natural backyards for many communities and serve as society's connection to nature. Assessments and resource strategies can attempt to conserve and enhance a green infrastructure that effectively connects people with their natural environment. Resource strategies can include programs that provide opportunities for children, teens and adults to recreate while gaining an appreciation for the importance of forests and open space with respect to the health, security and well-being of society (excerpted from the U.S. Forest Service State and Private Forestry Farm Bill Requirement and Redesign Strategies).

KEY FINDINGS

Current Status and Trends

- For the purposes of this assessment, green infrastructure refers to all public and private forest and rangeland landscapes which provide economic, social, cultural, and environmental services such as recreation, open space, watersheds, wildlife habitat, viewsheds and working landscapes for commodity production. This definition ignores the vital importance of smaller urban parks, bikeways and greenbelts, areas that are not mapped statewide. In addition, although agricultural lands provide open space and other values, they are also not included in this discussion.
- Given decreasing budgets, agencies are struggling with how to meet public demand for diverse, safe, high-quality recreation opportunities. Ongoing fiscal challenges have already resulted in instances of reduced hours of park operation, and deferred maintenance.
- Activities such as off-highway vehicle (OHV) recreation, mountain biking, boating and adventure recreation, have increased dramatically in recent years; while at the same time population growth, urbanization and alternative energy production compete for suitable

lands. To meet these demands and minimize associated impacts, it is critical that opportunities are provided to the public in a responsibly managed environment, where it is possible to efficiently apply Best Management Practices, law enforcement and education efforts, monitoring of impacts, and restoration efforts.

- California's statewide outdoor recreation strategy is formulated through a combination of:
  - — the California Outdoor Recreation Plan (CORP), published every five years by the California Department of Parks and Recreation (State Parks), which identifies various issues and needs of statewide importance;
  - — the Recreation Policy, developed by the State Park and Recreation Commission, which outlines the state's strategies, priorities, and actions based on issues and needs identified in the CORP; and
  - — the California Department of Parks and Recreation's Off-Highway Motor Vehicle Recreation Division legislatively mandated Strategic Plan. This provides guidance for motorized recreation in the eight State Vehicular Recreation Areas (SVRAs), and direction for a statewide financial assistance program that supports motorized recreation by providing for law enforcement, operations and management, education, natural and cultural protection, and restoration on local, state, and federal lands.
- Effective regional and local efforts to protect and manage green infrastructure are found throughout California. These efforts are typically cross-jurisdictional, involve stakeholders, and address multiple issues such as recreation, water, wildlife habitat and economic development.
- Public involvement in supporting green infrastructure is critical in terms of advocacy, participation in the decision-making process, and involvement in local stewardship and program activities.

Conserving Green Infrastructure (Development Threat)

This analysis identified priority landscapes which emphasize green infrastructure that serves larger communities and faces significant development threat, to characterize the overall magnitude of the threat by county and bioregion.

- The South Coast bioregion has by far the most high priority landscape acres since green infrastructure there serves large populations and faces high development pressures.
- In the Sacramento Valley and San Joaquin Valley bioregions, high development pressure is eliminating options for protecting remaining green infrastructure that serves local communities.
- In the Sierra bioregion, development is an emerging issue, focused mostly in the foothills.
- Counties in the Bay/Delta bioregion have achieved a significant level of green infrastructure protection despite the absence of large federal landholdings, by adopting a wide range of complementary public-private strategies and programs.

Managing Green Infrastructure (Wildfire/Forest Pest Threat)

Priority landscapes were identified that emphasize green infrastructure that serves larger communities or has recreation value, and faces significant threat from wildfire or forest pests (insects and disease).

- The densely populated and high wildfire threat South Coast bioregion has by far the most high priority landscapes.
- Bioregions such as the Bay/Delta, Sierra and Central Coast have large acreages of medium priority landscapes, which are typically high value areas at a medium threat, or medium value areas at a high threat.
- Although the threat from exotic invasive species has not been adequately mapped and ranked, they do pose a real threat in all bioregions. Similarly, the future impact from climate change cannot be analyzed given current knowledge and data, but will likely pose major challenges.

CURRENT STATUS AND TRENDS

Demographic Changes and Recreation Demand

California's population has increased by more than five million since 2003, to over 38 million (California Department of Finance, 2009). Hispanics, the fastest growing segment, are likely to prefer developed parks near their homes for family outings, and are frequent visitors to parks, going two or more times a week (State Parks, 2009).

The state's overall population is also aging, with those over 50 expected to double by 2020 from their 1990 numbers. This demographic group is now generally wealthier and in better physical condition than in past generations, and enjoys recreating in non-traditional ways, showing a growing interest in adventure activities (State Parks, 2009).

The needs of the disabled have become a focus of recreation planning. Currently, 29 percent of the population consider themselves in some way disabled (U.S. Census Bureau, 2009). People with disabilities participate in most outdoor recreation activities at a rate equal to or even greater than the non-disabled.

Another emerging social group is the immigrant population, which now comprises 26 percent of California's population. Immigrants tend to have unique traditions and values which shape their recreational needs (State Parks, 2009).

Concern has grown over the trend showing a lack of children's outdoor recreation since the publication in 2005 of The Last Child in the Woods (Louv, 2005), and The California Children's Outdoor Bill of Rights (California Roundtable on Recreation, Parks and Tourism, 2007). As of 2007, 18 percent of California's youth lived in poverty (Public Policy Institute of California, 2009). Providing low cost or free recreation opportunities and transportation may be necessary to connect these youth to the great outdoors.

Recreation Visitation

Traditional non-urban park use has changed over time. California State Parks attendance has been stable, with total visits down about one-tenth of a percent since 2003 (State Parks, 2005 and 2009). However, the national parks in California have seen declining attendance. The Channel Islands National Park, Lassen Volcanic National Park, Death Valley National Park, Redwood National Park, Santa Monica Mountains National Recreation Area, Sequoia National Park and Whiskeytown National Recreation Area have all experienced smaller visitor numbers since 2003 (National Park Service Database, 2003-2009 (http://www.nature.nps.gov/stats/park.cfm)).

Flat or declining attendance numbers may seem counter-intuitive given the increase in population. Initial research indicates a variety of causes may contribute to changes in use. Some studies point to a reduction in leisure time, particularly for two-income families. With reduced leisure time, families that may have visited a park for a week are now staying only three to four days. Other studies point to an increase in structured leisure time supplanting traditional use. For example, there has been a substantial increase in organized youth sports which typically occur in urban parks.

Less understood causes include cultural relevance, perceived safety and comfort in natural settings, and economics. Based on survey results (State Parks, 2008), gang activity in parks was the number one factor affecting respondents' physical activities in parks (almost 50 percent), followed closely by drug and alcohol use (39 percent). An additional factor can be poorly maintained parks (26.5 percent). A survey by the Forest Service (National Survey on Recreation and the Environment, 2005) reinforced the notion that safety and maintenance of parks rank high in terms of public perception. Cultural relevance relates to whether the spectrum of recreation facilities and opportunities continues to meet the needs of a rapidly changing customer base. Finally, other correlating factors include economic conditions, travel costs and entrance fees.

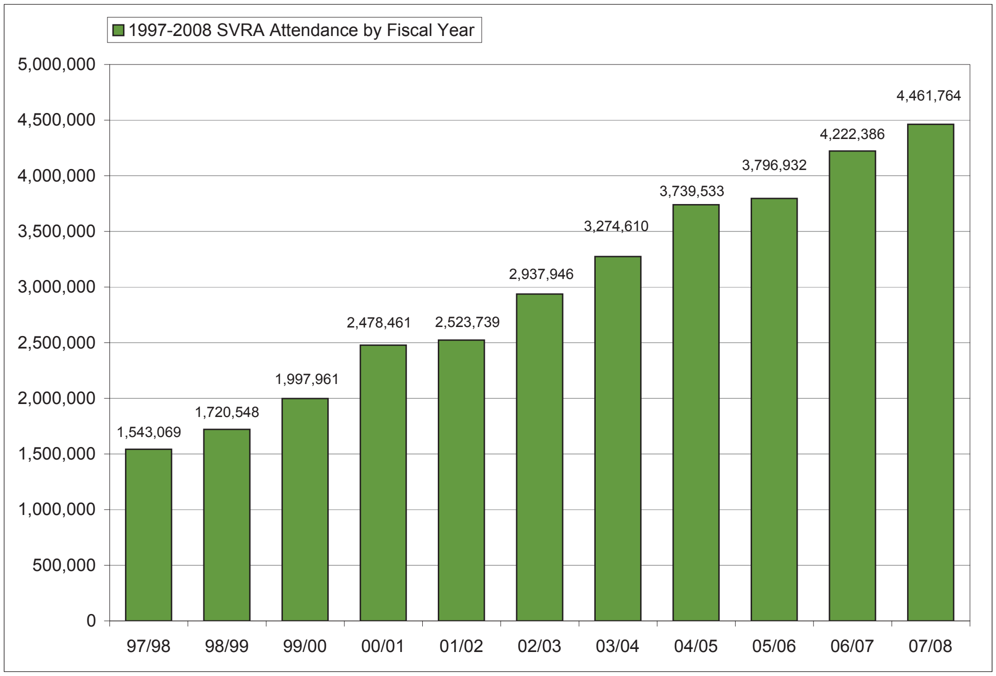


Figure 3.6.1.
Visitation at state vehicular recreation areas (SVRA), 1997–2008.
Data Source: OHMVR Division Strategic Plan, 2010

At the same time, certain activities such as OHV recreation, mountain biking, boating and adventure recreation have increased dramatically in recent years (Figure 3.6.1). This increase in demand occurs at the same time land uses such as urbanization and alternative energy production compete for suitable lands. As a result, the demand and impact on the already limited amount of OHV recreation areas in close proximity to urban areas becomes an even more significant issue, especially in and around heavily populated and rapidly growing counties such as Los Angeles, Orange, San Diego, Riverside, and San Bernardino, and along the western slope of the Sierra Nevada and in the Central Valley (OHMVR Division, 2010).

Funding for Managing Recreational Areas

Federal Agencies

Funding for The National Park Service has been slowly declining since 2003, and the agency had a deferred maintenance backlog of between $4.1 billion and $6.8 billion in 2004 (N.Y. Times, 2004). Similarly, the U.S. Forest Service estimated in 2005 that deferred maintenance for recreation facilities (not including trails, bridges, roads and other high cost items), was $342 million (USFS, 2008). The American Recovery and Reinvestment Act of 2009 provides some funding to address this problem, but the condition of recreation facilities and infrastructure will continue to be a concern that could affect the quality of recreation experiences, and ultimately visitation.

State Agencies

The California Department of Parks and Recreation experienced an 11 percent reduction in General Fund revenue for the 2009–2010 fiscal year (Harris, 2009). Factoring in other revenue sources, the total budget reduction was over 16 percent of the department's core operating budget. As a result, parks have revised their operating hours, with many closed weekdays and open shorter hours on weekends.

Special fund programs which do not rely on general fund dollars have more resources available to support recreation. In 2008, the off-highway vehicle community doubled their registration fees, increasing program funding by 51 percent for trail maintenance and operations, law enforcement, restoration and education.

Local

It has been shown that during difficult economic times, parks and recreation funding suffers a disproportionate share of budget cuts (Walls, 2009). During the recession of 2002–2003, local government spending declined two percent, while parks and recreation budgets declined up to 13 percent. The full impact of the current economic decline is yet to be determined, but evidence of budget cuts can already be seen in terms of reduced hours of operation, and deferred maintenance.

Public Involvement

Public involvement is critical in terms of advocacy and support, participation in the decision-making process, and involvement in local stewardship and program activities. For example, since 1988 California voters have approved 54 state and local funding measures that provide some $13 billion to support the creation and development of parks and open space (Trust for Public Land, 2010). The proliferation of watershed groups and Fire Safe Councils are evidence of the public interest in being involved in the decision-making process for managing green infrastructure. Finally, there are a multitude of state and local stewardship programs using volunteers to actively manage or participate in programs to connect people to green infrastructure. Public interest is fostered in part through a variety of successful education programs such as Project Learning Tree, Project WILD, and the 4-H Youth Development Program.

Green Infrastructure Protection

Several levels of protection exist for preventing green infrastructure from being developed for residential or commercial uses. Official designation as reserve status can convey protection into perpetuity (e.g., wilderness areas or national parks). Publicly owned lands are generally considered protected, although land sales from public to private ownership do occur. On private lands, conservation easements are a commonly used tool for preventing development, and often result in maintaining lands as working landscapes, most in perpetuity. A largely unexplored strategy for protecting green infrastructure near urban areas includes acquisition of lands for active, compatible recreation use.

Figure 3.6.2 shows the distribution of green infrastructure by bioregion and its protection status. Many of the largest protected green infrastructure areas are located far from most communities.

Figure 3.6.3 provides a way to characterize counties in terms of the prevalence of green infrastructure within the county, and its level of protection. At one extreme, counties such as Alpine and Mono are dominated by green infrastructure and have very high levels of protection. Conversely, some Central Valley counties such as Kings and San Joaquin have a relatively small acreage of green infrastructure, and most of this is unprotected.

Figure 3.6.4 shows entities providing protection in each county. Federal lands are critical for green infrastructure protection in most counties. Local government protects a significant portion of green infrastructure in many counties in the Bay/Delta bioregion, through entities such as the East Bay Regional Park District. Non-profit organizations such as land trusts, provide a significant portion of green infrastructure protection in certain counties, often where federal and state lands are limited.

Role of Non-profit Organizations

Various conservancies and land trusts have become very active in protecting green infrastructure, through acquisitions and easements (Table 3.6.1). In addition, various non-profit groups provide assistance to agencies to maintain and protect green infrastructure and recreation facilities through active, on the ground support for maintenance and protection. These groups contribute thousands of days of service each year, and are essential to agencies working with reduced resources.

Figure 3.6.2.
California green infrastructure and protection status.
The primary data source for protected areas excluded Department of Defense lands, and these are considered unprotected throughout this chapter.
Data Sources: California Protected Areas Database (CPAD), GreenInfo Network (2009); Statewide Land Use / Land Cover Mosaic, FRAP (2006); Communities, FRAP (2009 v1)

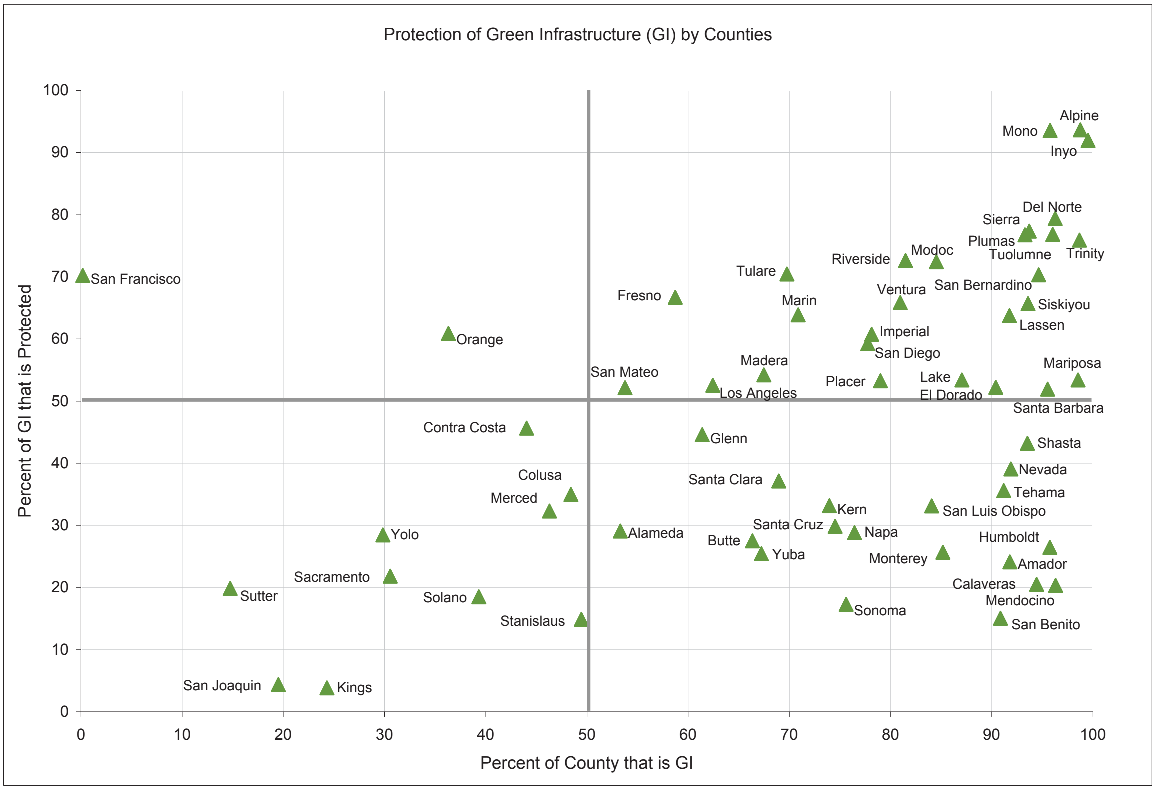


Figure 3.6.3.
County green infrastructure prevalence and protection
Data Sources: California Protected Areas Database (CPAD), GreenInfo Network (2009); Statewide Land Use / Land Cover Mosaic, FRAP (2006); County Boundaries, FRAP (2009 v1)

Statewide Outdoor Recreation Strategy

California's statewide outdoor recreation strategy is formulated through a combination of three documents. First, the California Outdoor Recreation Plan (CORP), published every five years by the California Department of Parks and Recreation, identifies various issues and needs of statewide importance. The CORP "provides guidance for the planning, acquisition, and development of needed recreation lands and facilities by detailing these concerns and identifying actions to address them" (State Parks, 2009). In addition, it serves to prioritize expenditures of the Land and Water Conservation Fund.

Secondly, the Recreation Policy, developed by the State Park and Recreation Commission, and adopted by the Director of the California Department of Parks and Recreation, outlines the state's strategies, priorities, and actions based on issues and needs identified in the CORP. California's 2005 Recreation Policy addressed five general policy areas;

- Adequacy of recreation opportunities
- Leadership in recreation management
- Outdoor recreation's role in a healthier California
- Preservation of natural and cultural resources
- Accessible recreational experiences

Thirdly, the California Department of Parks and Recreation Off-Highway Motor Vehicle Recreation Division Strategic Plan, explores four core themes:

- *Emphasizing the Basics*, particularly ensuring on-going maintenance and protection of existing infrastructure;
- *The Greening of OHV Recreation*, which addresses strategies to reduce the carbon footprint and other impacts of not just OHV recreational use but the park facilities that provide

Figure 3.6.4.
Entities protecting green infrastructure by county.
Data Sources: Statewide Land Use / Land Cover Mosaic, FRAP (2006); California Protected Areas Database (CPAD), GreenInfo Network (2009).

Table 3.6.1. Acreage[1] held by non-profit organizations by bioregion (includes fee title and easements)

Bioregion	Acres[2] held by non-profits
Bay/Delta	153,300
Central Coast	225,700
Colorado Desert	21,300
Klamath/North Coast	68,000
Modoc	50,400
Mojave	28,900
Sacramento Valley	126,900
San Joaquin Valley	143,800
Sierra	81,000
South Coast	41,600
California	940,900

[1]Much of this is green infrastructure, but agricultural lands are included as well
[2]Acres rounded to the nearest hundred
Data Source: California Protected Areas Database, GreenInfo Network (2009)

them, particularly reducing system-wide transit time to reach recreation destinations;

- *Improving Technology*, which has a particular emphasis on facilitating technological advancements to reduce environmental impacts of OHVs and the
- *New Gateway*, which directly addresses issues of cultural relevance and supports returning people to a connection with nature.

Coordinated Regional Strategies to Protect Green Infrastructure

Effective green infrastructure protection and management requires a wide range of strategies, including land use regulation, acquisition, cooperative management, voluntary private action and a variety of stakeholder-based collaborative approaches. In some cases, landscape-level protection is defined through strong planning and zoning policies, often supplemented with selective acquisition. In others, land protection is established through long-standing large ownerships of federal or state agencies, supplemented with conservation or recreation policies.

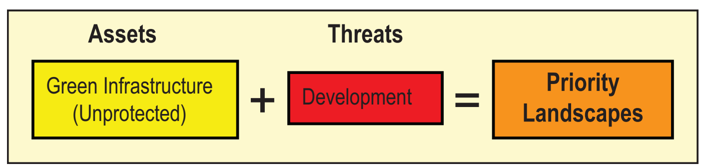
In addition to land protected, efforts like the proposed 500 mile Bay Area Ridge Trail and the similarly-sized Bay Trail can highlight regional connections and improve recreational access through multi-agency and stakeholder based planning and implementation. Regional projects like these can help inspire other, broader regional planning for green infrastructure, such as the "Focusing Our Vision" initiative (Association of Bay Area Governments, 2009), which seeks broad adoption of a range of sustainable development and livable community policies in the Bay Area region.

CONSERVING GREEN INFRASTRUCTURE

This section analyzes the impact of residential and commercial development on green infrastructure to characterize the overall magnitude of threat by county and bioregion. Development tends to consume lands close to existing communities, so is an especially significant threat.

Analysis

The analysis involved determining which unprotected green infrastructure areas are most at risk from future development.



Assets

Green Infrastructure (unprotected)
In order to rank green infrastructure areas an indicator was calculated called per capita community green infrastructure. This provides a measure of how many people are potentially served by a green infrastructure area, ranking areas closer to large communities highest.

Figure 3.6.5 shows the asset ranks for an example area, Orange County. The first map shows how the initial green infrastructure asset ranks are assigned. Green infrastructure closest to (or inside) large communities, such as Anaheim, receive a high rank, areas more distant are ranked medium and the farthest

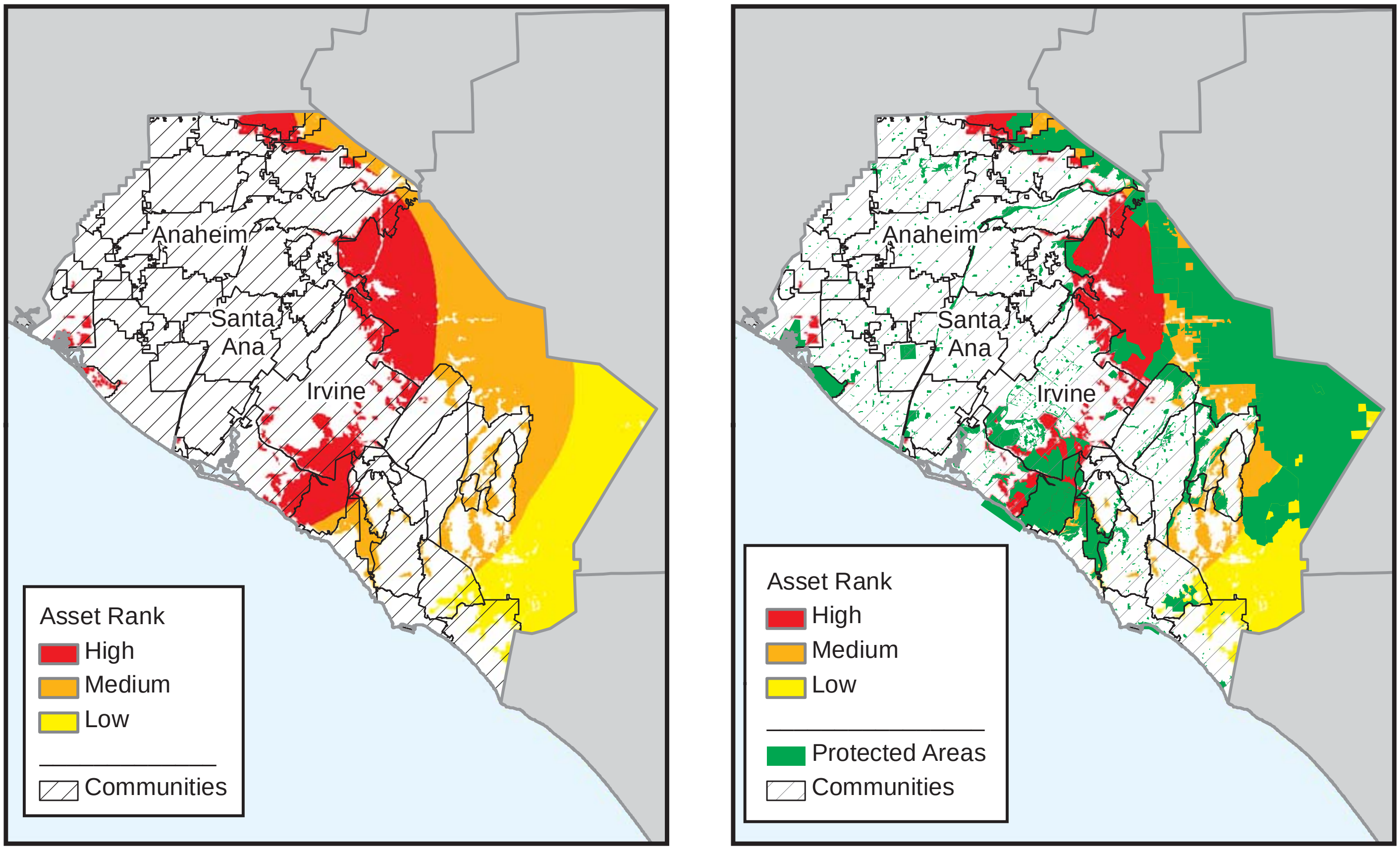


Figure 3.6.5.
Asset ranks for green infrastructure, and green infrastructure (unprotected), Orange County.
Data Source: California Protected Areas Database (CPAD), GreenInfo Network (2009); U.S. Census Bureau (2000); Statewide Land Use / Land Cover Mosaic, FRAP (2006); Communities, FRAP (2009 v1)

are low. The second map shows how areas already protected from development are removed since they are not at risk. The remaining ranked areas represent the unprotected green infrastructure asset.

Threats

Development Threat
High threat rank is associated with areas that are expected to be converted (five housing units per acre) by 2020. Medium ranking is assigned to areas with potential to be converted by 2030, or "parcelized" (one housing unit per 20 acres) by 2020. The development threat is discussed in detail in Chapter 1.1.

Results

The green infrastructure (unprotected) asset and the development threat are combined to create a statewide priority landscape, shown for one example area, Orange County, in Figure 3.6.6. The resulting high priority landscapes (in red) are unprotected green infrastructure that potentially serves larger communities and is threatened by development in the near term.

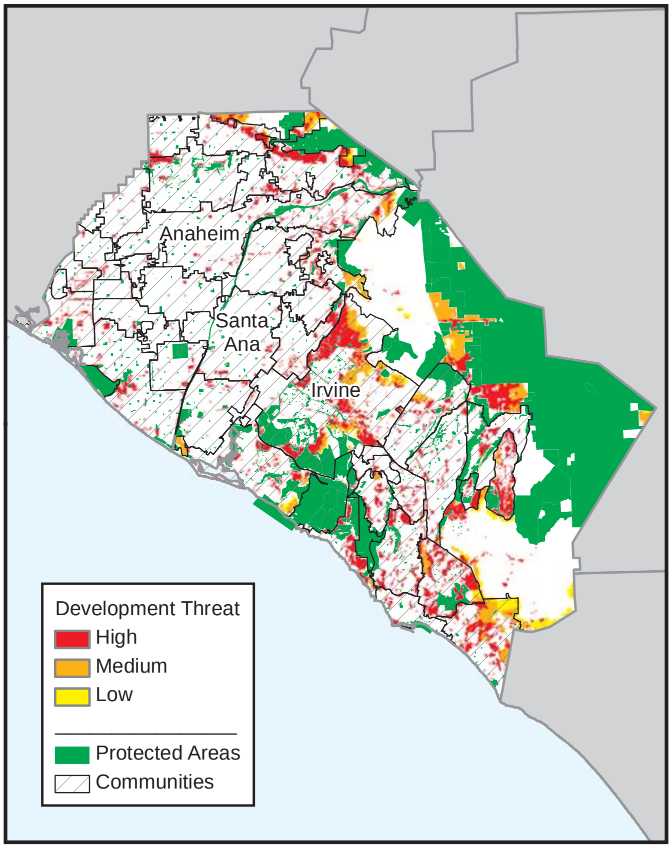
Discussion

Figure 3.6.7 shows which counties (and bioregions) have the most high and high plus medium priority landscapes. For a complete accounting of priority landscape acres by county, see http://frap.fire.ca.gov/assessment2010/3.6_green_infrastructure.html.

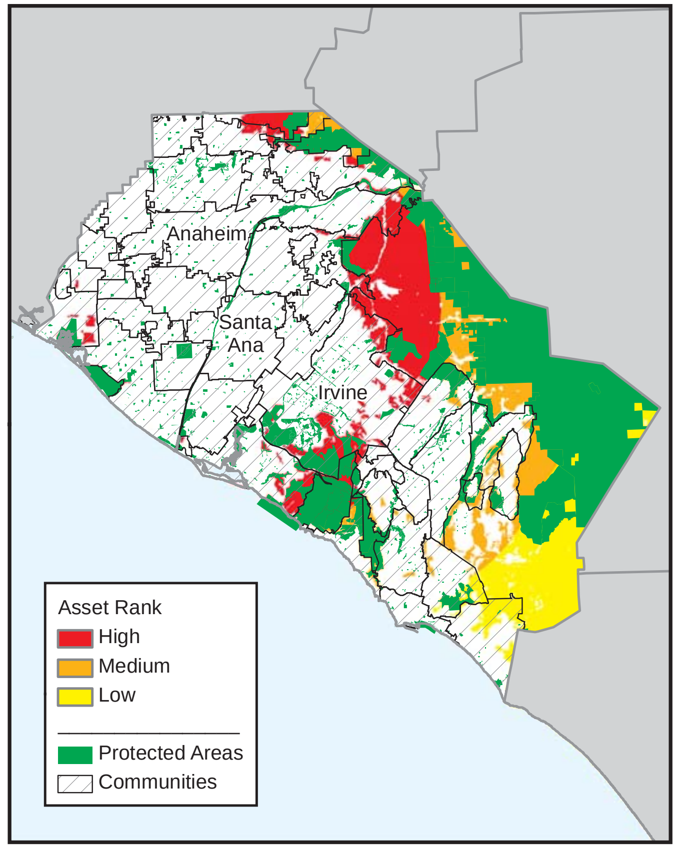
Bioregional Findings

- *Klamath/North Coast, Modoc and Colorado Desert*: Green infrastructure is abundant, development is not a major threat, and large areas are in federal protection. Local entities may still

DEVELOPEMENT THREAT



GREEN INFRASTRUCTURE ASSET



PRIORITY LANDSCAPE

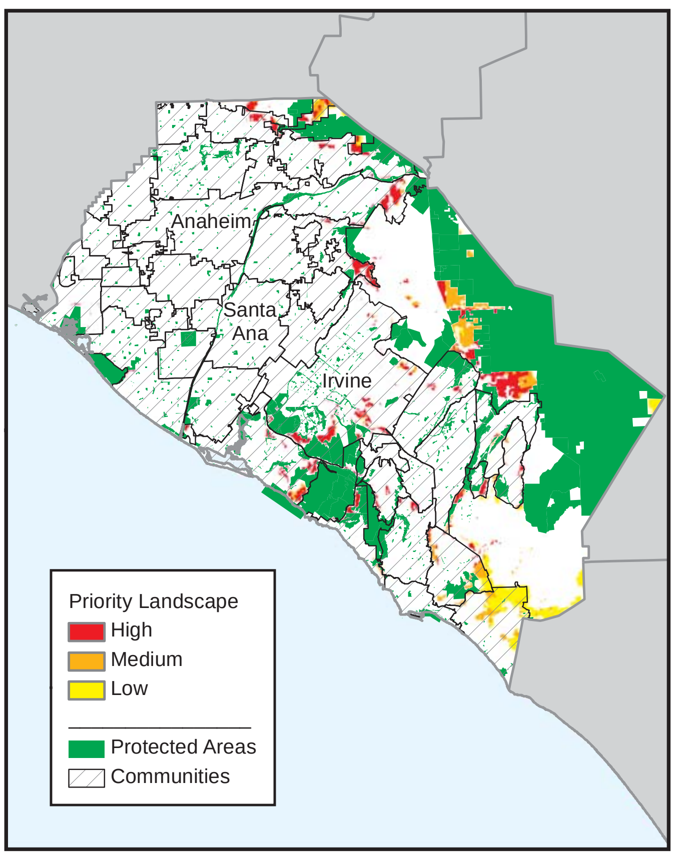


Figure 3.6.6.
Example of priority landscape for conserving green infrastructure, Orange County.
Data Sources: California Protected Areas Database (CPAD), GreenInfo Network (2009); Statewide Land Use / Land Cover Mosaic, FRAP (2006); U.S. Census Bureau (2000); ICLUS, U.S. Environmental Protection Agency (2009); Commission on Local Governance for the 21st Century (2000); Communities, FRAP (2009 v1)

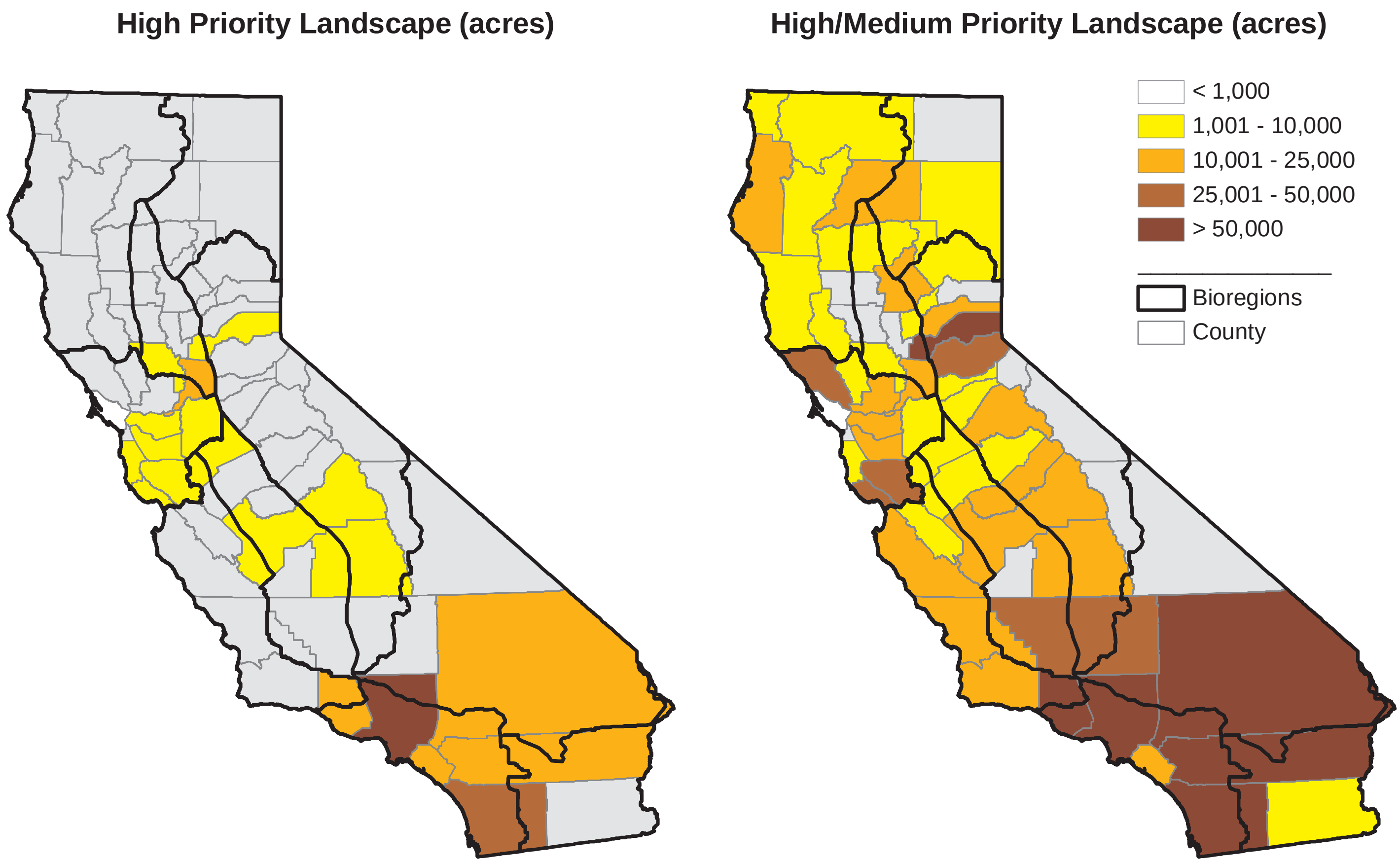


Figure 3.6.7.
Counties ranked based on acres of high priority landscapes and high plus medium priority landscapes.
Data Sources: California Protected Areas Database (CPAD) (GreenInfo Network 2009); Statewide Land Use / Land Cover Mosaic, FRAP (2006); U.S. Census Bureau (2000); ICLUS, U.S. Environmental Protection Agency (2009)

identify areas that provide unique amenities or opportunities that are protection priorities.

- *Sacramento Valley and San Joaquin Valley*: Green infrastructure is limited and fragmented, and development threat is generally high. Public ownership is limited, thus green infrastructure overall has a relatively low level of protection. Non-profits are active, but are also concerned with protecting diminishing farmlands. Some counties have very low acres in high and medium priority landscapes because there is relatively little remaining unprotected green infrastructure. It could be argued that these should be the highest priority landscapes due to their rarity.
- *Bay/Delta*: Counties have typically achieved a significant level of protection despite having very little federal land. Diverse public and private entities are extremely active in protecting lands and have worked with stakeholders to develop a coordinated strategy to address multiple values across multiple jurisdictions (Bay Area Open Space Council, 2009). These counties have significant acreages in high and medium priority landscapes, due to high development pressures. Since these tend to be smaller counties, their total priority landscape acreages tend to be smaller than the larger counties in the South Coast bioregion.
- *Sierra*: Green infrastructure is relatively abundant, and large federal landholdings provide a significant level of overall protection. However, the larger communities, where there is demand for green infrastructure, as well as strong development pressure, tend to be in the foothills, while the protected areas are in high elevations. The northern Sierra bioregion has large acreage of medium priority landscapes, due to high

development pressures potentially impacting green infrastructure that serves medium-sized communities.

- *Central Coast*: Green infrastructure is relatively abundant, with large federal landholdings providing a significant level of overall protection, and development pressures being limited. Conversion of green infrastructure to agriculture, not addressed in this chapter, is an additional concern.
- *South Coast*: There are large federally protected green infrastructure areas, and unprotected fragmented areas that face high development pressure. This bioregion has by far the most high priority landscape acres. A variety of public agencies and non-profit organizations are active in various planning and protection activities.
- *Mojave*: There are vast federal landholdings and development pressures are concentrated around several fast-growing communities.

Tools

Tools for conserving green infrastructure include land acquisition, easements, establishing reserves to strengthen protection on public lands and zoning mechanisms, which are discussed in detail in Chapter 1.1. In addition, tools related to education can be critical for gaining public support and acceptance for green infrastructure initiatives and conservation strategies, and involving the public through volunteerism and stewardship.

MANAGING GREEN INFRASTRUCTURE

Green infrastructure faces a variety of threats such as wildfire, forest pests (insects and disease), exotic invasive species, land conversion and climate change. Management of green infrastructure is critical in order to protect lands from threats that can damage recreation infrastructure, impact important amenity values, or result in extended closures. Management may also be needed to restore areas impacted by these threats.

Wildfire

As an example, in 2002 the Biscuit Fire burned almost half a million acres and damaged recreation facilities in the Siskiyou and Six Rivers National Forests of Oregon and Northern California, with restoration expected to cost $2.4 million (Morton et al., 2003). This does not include additional costs such as extended closure of facilities and losses by recreation-based businesses.

Forest Pests

Various diseases and insects such as bark beetles can cause tree mortality in recreation areas, leading to extended closures for safety reasons due to the potential for falling trees.

Exotic Invasive Species

Exotic invasive species are an additional threat to recreation values. Many large recreation areas develop plans and carry out programs specifically for control of these species. For example, Yosemite National Park has been dealing with this problem since the 1930s and has an Invasive Plant Management Plan (Yosemite National Park, 2009).

Land Conversion

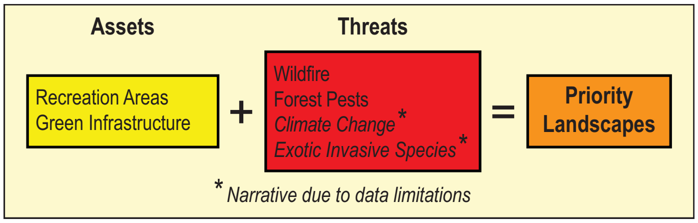
Lands previously open for recreation use are being converted and are no longer available to the public. Access to privately held lands is declining due to increased concerns regarding liability and litigation.

Climate Change

Climate change has the potential for direct impacts, as changes in the geographic extent of vegetation communities can affect amenity values. Perhaps more significantly, indirect impacts on fire regimes, forest pest outbreaks and incidence of exotic invasive species could create significant management challenges in the future.

Analysis

This analysis determined which green infrastructure, particularly important recreation areas, are most at risk from wildfire and forest pests (i.e., insects and disease).



Assets

Two unique assets were included in the analysis and combined to generate the composite asset. The first asset ranks green infrastructure based on per capita community green infrastructure to prioritize areas closer to large communities. This asset includes all green infrastructure, since public lands protected from development are still potentially susceptible to damage by wildfire and forest pests. The second asset ranks important outdoor recreation areas such as local and regional parks, U.S. Forest Service developed recreation areas and California state parks.

The green infrastructure and recreation areas assets were combined to generate a composite asset. In the composite asset, important recreation areas such as state, regional and local parks are ranked high; other green infrastructure that serves large communities receives a medium rank, while green infrastructure serving smaller communities tends to be a low rank.

Threats

Threats included wildfire and forest pests; data do not currently exist to map and rank the exotic invasive species and climate change threats. These threats are identical to the stand-level wildfire threat and stand-level forest pest threat described in previous chapters. Since wildfire can cause severe damage to recreation infrastructure, it was assigned a weight of three relative to forest pests when the two threats were combined to create the composite threat.

Results

Combining the composite asset and the composite threat results in the priority landscape, which is shown for one example area (Santa Monica Mountains) in Figure 3.6.8.

The priority landscape ranks were assigned such that only areas with both a high composite asset and high composite threat rank receive a high priority landscape rank. For example, in Figure 3.6.8 the only high priority landscapes are areas of high wildfire threat within high value asset areas such as state parks.

This very restrictive ranking scheme highlights where the most valuable assets are at the highest risk. As a result, only five counties have significant high priority landscape areas (Table 3.6.2), and all are at least partially in the bioregion with the highest wildfire threat, the South Coast.

Since a restrictive scheme was used to identify high priority landscapes, medium priority landscapes still represent important areas of concern. These are either high ranked asset areas at medium threat, or medium ranked asset areas at high threat (Table 3.6.3).

Discussion

Bioregional Findings

The densely populated and high fire threat South Coast bioregion has by far the most high priority landscapes. However, other bioregions such as the Bay/Delta, Sierra and Central Coast have significant acreages of medium priority landscapes.

Tools

Tools related to threat from wildfire and forest pests are discussed in Chapter 2.1 and Chapter 2.2. In addition, tools related to fostering public involvement through education, collaboration, and stewardship can be critical for planning, implementing and gaining acceptance for various management activities.

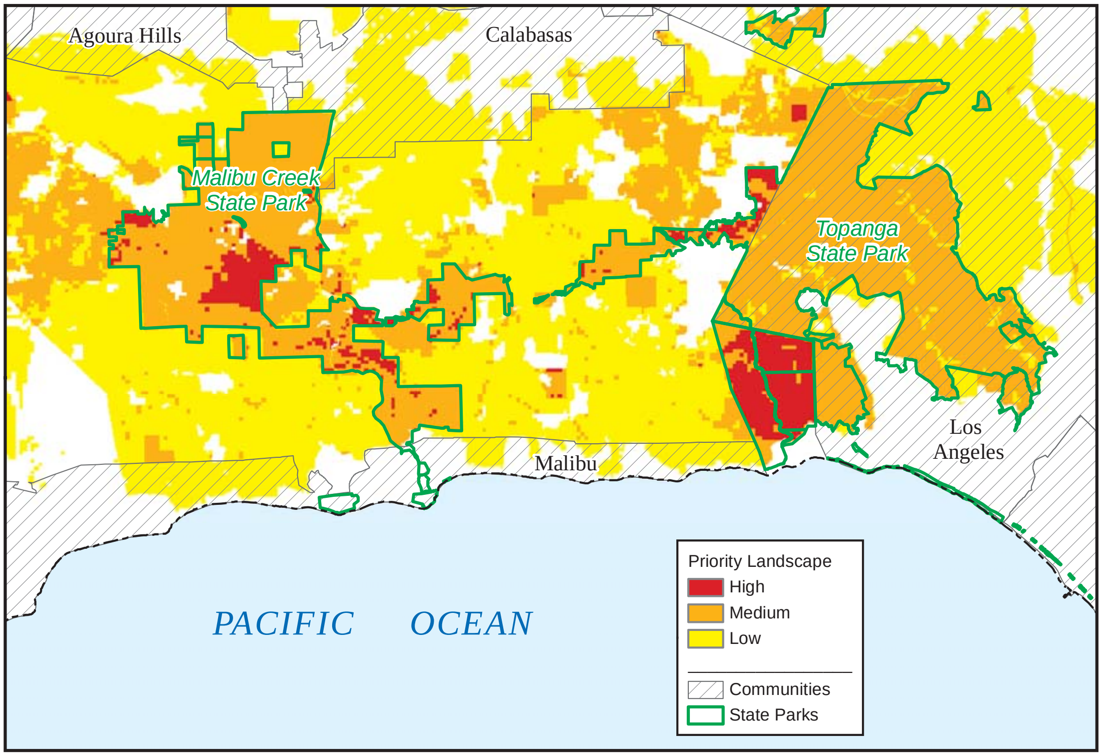


Figure 3.6.8.
Example of priority landscape ranks for managing green infrastructure, Santa Monica Mountains.
Data Sources: California Protected Areas Database (CPAD) (GreenInfo Network 2009); Fire Threat, FRAP (2005); Statewide Land Use / Land Cover Mosaic, FRAP (2006); Developed Recreation Areas, USFS (2006)

Table 3.6.2. Acres of high priority landscapes by county, for managing green infrastructure

County[1]	High Priority Landscape (acres)[2]
Los Angeles	5,800
Riverside	2,400
Orange	2,000
Ventura	1,400
San Diego	1,000

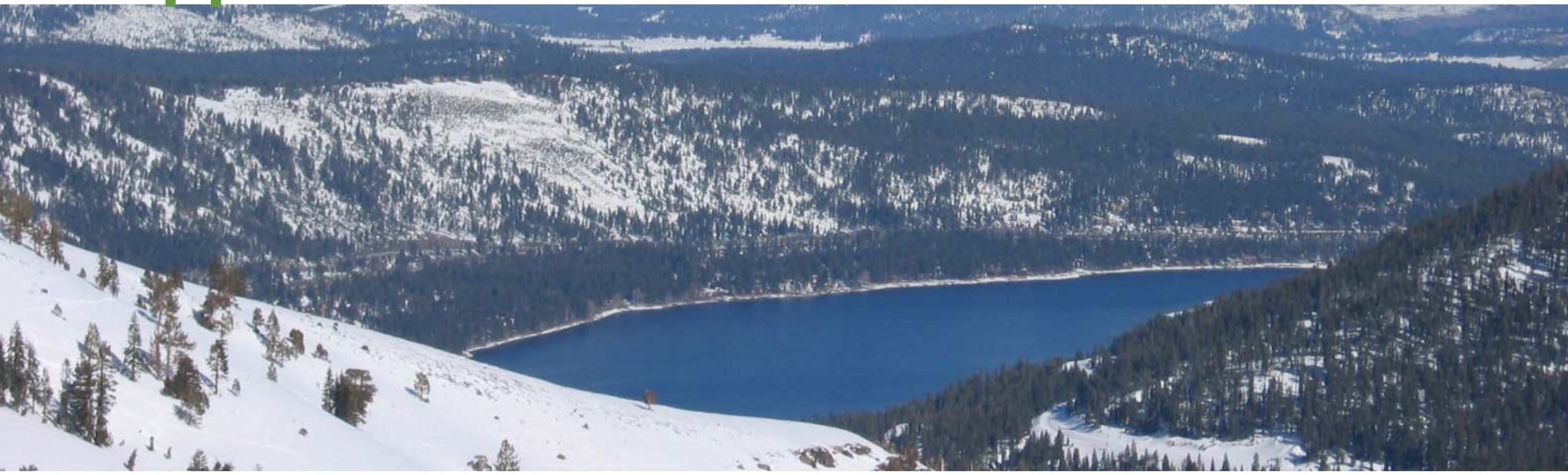
[1]counties with less than 500 acres of high priority landscape are excluded
[2]acres are rounded to the nearest hundred

Table 3.6.3. Acres of high and medium priority landscapes by county, for managing green infrastructure

County[1]	High and Medium Priority Landscape (acres)[2]
Alameda	29,200
Contra Costa	13,700
El Dorado	500
Los Angeles	185,700
Marin	14,800
Orange	43,900
Plumas	600
Riverside	30,700
Sacramento	1,400
San Benito	4,400
San Bernardino	22,100
San Diego	39,700
San Mateo	18,000
Santa Barbara	4,100
Santa Clara	43,900
Santa Cruz	13,400
Ventura	33,000

[1]counties with less than 500 acres of high plus medium priority landscape are excluded
[2]acres are rounded to the nearest hundred

Chapter 3.7
Climate Change: Threats and Opportunities



America's forests offset a significant portion of the nation's annual carbon emissions. Additional climate change mitigation benefits could be achieved through partnerships and management measures. These measures include supporting the development of markets for carbon offsets, utilizing woody biomass for energy, wood product substitution, and promoting tree growth in urban areas. Assessments should identify opportunities for promoting carbon emissions offsets through forestry.

The important benefits that forests provide such as, biodiversity, wildlife habitat, and water storage and flows are affected by climate change. Forest range, type and composition are projected to change significantly– with corresponding changes in wildlife habitat, biodiversity, water flows, and fire regimes. Assessments should consider how climate change will affect important public benefits from forests. Resource strategies should attempt to maintain and enhance resilient and connected forest ecosystems that will continue to provide public benefits in a changing climate (excerpted from the U.S. Forest Service State and Private Forestry Farm Bill Requirement and Redesign Strategies).

KEY FINDINGS

This chapter consists of an analysis of environmental trends in primary climate variables, followed by an assessment of threats to forest carbon under future climate scenarios, and concludes with an evaluation of the adaptive response of forest vegetation under future climate scenarios. Results from each analysis are summarized below.

Evaluation of Environmental Trends

A climate threat index was developed using data from downscaled global climate models (GCMs), which allowed for a comparison of changes in climate variables by Baily's U.S. Department of Agriculture ecological unit.

- The results show an expected increase in temperature among all ecological units, but the magnitude of the increase varies with ecological units. For all ecological units, average annual temperatures are expected to increase within the range of 0.8 degrees Celsius (1.4 °F) in 2039 to 2.7 degrees Celsius (4.9 °F) in 2099.
- Maximum daily temperatures during summer months showed the greatest increase in interior ecological sections including: Northwestern Basin and Range, Modoc Plateau, Mojave/Sonoran/Colorado deserts, Sierra and the Sierra foothill ecological sections. Temperature changes alone are expected to result in declining snowpack, affecting water resources and related environmental services.
- A variable pattern of annual precipitation is expected; increasing through 2069, then followed by a large decrease by 2099.

Forest Carbon – Threats from Wildfire, Insects and Disease and Development

Aboveground forest carbon was estimated using data from the MC1 vegetation dynamics model to evaluate expected changes in forest carbon in 2020, 2050 and by 2100. The analysis identified locations where high value forest carbon assets coincide with high risks, such as wildfire, insects, disease and development that threaten the sustainability of carbon sequestration.

- Carbon stocks were found to be mostly stable through 2050 and then declining substantially through 2100.
- Below-ground carbon pools showed less variation than aboveground carbon pools.
- The expected loss of carbon sequestration from wildfire, insects and disease was much more extensive than from development.
- Threats to the loss of terrestrial carbon (forest and range) from development were greatest in the San Francisco Bay Area, and the South Coast and Sacramento Valley bioregions. The current amount of medium and high priority landscapes are two to three percent in 2010 expanding to 10 to 14 percent by 2100.

Vegetation Response – BioMove

The response of forest species to climate change was also evaluated. Through collaboration with researchers at UC Santa Barbara, a climate change model (BioMove) was used to predict future shifts in range of tree species. A species distribution model was generated for a set of indicator species found in Table 3.7.6.

- The results show a mixed response among tree species, with some species showing an expansion in range and some species contracting in range by 2080.
- The two climate models used to estimate future conditions were reasonably consistent in predicting the shift in a species range. For several of the indicator species both GCMs predicted gains or losses in range that were within 10 percent of each other. Although for one species, giant sequoia (*Sequoiadendron giganteum*), the estimated extent of gain in species range varied by 58 percent between the two climate models.
- Many tree species showed a shift toward higher elevations and towards northern latitudes.

FORESTS AND CLIMATE CHANGE

Environmental Changes: Observed and Expected Trends

While climate model results differ, there are likely to be significant changes in the composition of forests throughout the state under all scenarios and models. In some cases, environmental effects from climate change have already been observed in California forests and rangelands (Cayan et al., 2006). This includes shifts in species ranges, changes in frequency of disturbance from wildfires and pests, and effects on forest productivity. Following is an overview of many of the observed and expected changes in climate.

Climate Change and Environmental Effects on Forests and Rangeland

Climate can greatly influence the dynamics of forest and rangeland ecosystems. Climate influences the type, mix and productivity of species. Future climate change scenarios predict increases in temperature, increases in atmospheric CO2 concentrations and changes in the amount and distribution of precipitation (Cayan et al., 2006). Altering these fundamental drivers of climate can result in changes in tree growth, changes in the range and distribution of species, and alteration to disturbance regimes (e.g., wildfires, outbreaks of pests, invasive species).

Given the long lifespan of trees in a forest stand, from decades to hundreds of years, the effects of climate change on disturbance regimes may become apparent prior to noticeable changes in forests and rangelands. These include changes in the timing, frequency and magnitude of wildfires, pest infestations and other agents of disturbance (Dale et al., 2001). While disturbances occur regularly in nature, large changes in the patterns of disturbance could make forests less resilient. Vegetation types with restricted ranges may be more vulnerable than others, as well as areas that are already under stress from land use (e.g., expansion of wildland urban interface) and management (Foster, 2003).

The influence that climate has on disturbance regimes may already be affecting forests and rangelands. In California, extended drought and earlier snowmelt are leading to longer and drier summers with more pronounced fire activity. Relatively small changes in temperature and precipitation can affect reforestation success, growth and forest productivity. Table 3.7.1 summarizes climate change effects that have already been detected and those that are expected under future climate scenarios.

Temperature

Temperature in California and the western states has been increasing (Cayan et al., 2006). The 1990s was one of the warmest decades on record since 1861. Over the last 100 years, the nine warmest years have occurred in the last 14 years (DWR, 2008). Climate models forecast increased temperatures that range from 1.7 degrees Celsius to 5.8 degrees Celsius between 2000 and 2100 depending on the model and the assumed emissions scenario (Cayan et al., 2006). This single factor can have broad reaching implications for the forest sector. In areas where water availability is not limiting, forests may expand under warming temperatures, while drier areas may

Table 3.7.1. Climate change impacts in the forest sector

Factor	Description
Hydrologic	Changes in temperature, precipitation, and hydrologic processes (e.g., decreased snowpack, earlier spring runoff, lower summer baseflow).
Fire	Changes in the extent and frequency of disturbances from wildfires, pests, and disease outbreaks.
Biologic	Conditions may favor the spread of invasive species.
Biologic	Tree species expected to move northward or to higher altitudes.
Biologic	Changes in reforestation and regeneration success.
Biologic	Changes in forest productivity affecting growth and carbon storage. The effect of additional CO2 on forest productivity is uncertain.
Economic	Economic impacts from increased fire damage and fire suppression costs.

Data Source: PEW Center on Global Climate Change, 2008 see regeneration failures of some species and a loss of productivity. Temperature increases are expected to be more pronounced during summer months, but also show a trend towards warmer winters. Some studies have suggested that temperature increases will vary across California, with higher increases in the Sierra Nevada Mountains (Snyder et al., 2002).

Precipitation

Precipitation variability has been a natural part of California's historic climate. Studies of tree ring data suggest that the last 200 years have been relatively wet and that the longer historic record has been composed of periods of prolonged drought (Meko et al., 2001).

Although GCMs are fairly consistent in their predictions of increasing temperature, there is less agreement among models forecasting precipitation patterns. While models show variation in wetter or drier trends, the seasonal distribution of rainfall is still typical of Mediterranean climate, with most precipitation occurring during the winter months. In general, the climate models show little or no change in annual precipitation, but they do show substantial inter-annual and decadal fluctuations in precipitation (Cayan et al., 2006).

Hydrology

Recent winters have been warmer and snow melt has begun sooner. Studies have documented declines in snow water equivalent from 1925 to 2000 that correlate with increases in temperature (Mote, 2005). The timing of snowmelt and spring runoff can lead to longer dry periods in the summer months and reduced moisture availability for forest plants. With less snow, the peak in spring runoff occurs sooner (Peterson et al., 2008). The decline in snowpack is expected to reduce current snowpack by up to 90 percent by 2100 (Anderson, 2008; Mote, 2005).

Climate models forecast this trend to continue. Coupled with warmer temperatures, climate models predict decreases in snow accumulation and a greater percentage of precipitation from rainfall (Knowles et al., 2006). This also leads towards an expectation of earlier snowmelt. Climate model simulations suggest that snowpack losses are likely to occur more quickly in milder climates and lower elevations. Slower losses are expected at higher elevations and particularly in the mountainous regions in the southern Sierra (Mote, 2005; Hayhoe et al., 2004). This has been shown through predictive models to affect the timing of river flows in the Sierra that are supported by snowmelt (Dettinger et al., 2004). Research has speculated that a change resulting in earlier and shorter spring runoff from snowmelt will likely affect water supply (Roos, 2003). Chapter 2.1 contains additional information on climate change impacts to water resources.

Wildfire

The size, severity, duration and frequency of fires are greatly influenced by climate. Although fires are a natural part of the California landscape, the fire season in California and elsewhere seems to be starting sooner and lasting longer, with climate change being suspected as a key mechanism in this trend (Flannigan et al., 2000; Westerling et al., 2006). The rolling five year average for acres burned by wildfires on all jurisdictions increased in the past two decades from 250,000 to 350,000 acres (1987–1996) to 400,000 to 600,000 acres (1997–2006) (2006, California Wildfire Activity Statistics). In addition, the three largest fire years since 1950 have occurred this decade, with both 2007 and 2008 exceeding the previous five-year average.

An increase in wildfires has been attributed in part to warmer spring and summer temperatures, reduced snowpack and earlier spring snowmelt, as well as increased frequency of Santa Ana conditions (Mote, 2005; Westerling and Bryant, 2006; Bryant and Westerling, 2009). Warmer and drier conditions may also lead to increased moisture stress that can result in an earlier and thus longer fire season. An increase in wildfire frequency may mean an increase in greenhouse gas (GHG) emissions and a corresponding increase in the number of bad air days. Alternatively, a wetter climate scenario may reduce rate of spread

(Fried et al., 2006), but may increase fuels and thus increase wildfire hazard.

Wildfire risk will continue to be highly variable across the state. Research suggests that large fires and burned acreage will increase throughout the century (Westerling and Bryant, 2006; Lenihan et al., 2008), with some declines after mid-century due to vegetation type conversions. Recent research estimates that the wildfire area burned is expected to increase by at least 100 percent in the forests of Northern California (Westerling et al., 2009). This estimate was consistent for the three GCMs that were used in the analysis.

Impacts on Tree Species and Ecosystem Shifts

With warmer temperatures, tree species in California are likely to respond by migrating both northward and to higher altitudes (Shugart et al., 2003). As the rate of climate change increases some tree species may not be able to adapt to changed conditions. It is expected that species with currently restricted ranges will be most vulnerable, while species with broader climate tolerances may be able to adapt more easily. Alpine forests and related plant species are particularly vulnerable. With projected temperature increases, their habitat range is likely to be compressed with little room to expand. Forest adaptations from paleoclimate studies have documented the advancing and retreating tree line for sub-alpine conifers, as well as other species in the Sierra (Stine, 1996).

The simulated effect of climate on the distribution of vegetation types has been analyzed for several different climate change scenarios (Lenihan et al., 2006). Under all three scenarios, Alpine/Sub-alpine forest cover declined with increased growing season and warming temperatures. Conifer forests were displaced by mixed evergreen forest, and declines in the extent of woodlands and shrubland were due to encroachment by forest types and grassland.

Productivity Changes

Climate change effects on tree growth are uncertain, due largely to uncertainties about precipitation and water availability, and also by a limited understanding of the effects that increased CO2 could have on plant growth (Stugart, 2003). For example, Lenihan et al., (2006) showed increased woody biomass over the next century using a wetter climate scenario model, but showed biomass decreases when using the drier climate scenario model. In a related study, Battles et al., (2006) predicted reduced conifer tree growth of up to 18 percent in mature stands and up to 31 percent for pine plantations that would result under a warmer climate scenario. However, preliminary results in more recent studies have shown an increase in pine yield with corresponding increases in temperature (Battles et al., 2009). Recent studies in other areas of North America suggest a general trend of increased productivity in response to climate change, where ranges are stable and water is not limiting (McMahon et al., 2010).

Global Climate Models: Projected Trends

The future climatic conditions in California are uncertain and dependent on a complex set of social and biophysical systems. To account for this variability the Intergovernmental Panel on Climate Change (IPCC) developed a set of possible future emissions scenarios based on different assumptions about pathways for economic, demographic and technological change, which resulted in a broad range of emissions scenarios. The analysis presented in this chapter is based largely on a higher emissions scenario (A2) and in some cases contrasted with results from a lower emissions scenario (B1). See Cayan et al., (2006) for a review of GCMs and emissions.

Role of Forests in Adaptation and Mitigation

Forests that are managed sustainably can help mitigate or offset the emissions of CO2 and other GHGs. Mitigation generally refers to any activities that are aimed at reducing GHG emissions. In forestry this can include both actions that lead to additional carbon sequestration, as well as actions that reduce emissions associated with wildfires, land use conversions and other forms of disturbance. The California Department of Forestry and Fire Protection (CAL FIRE) has identified five strategies to mitigate against GHG emissions: reforestation, forestland conservation, fuels reduction, urban forestry, and forest management to improve carbon sequestration.

As described in the previous section, climate change itself can have detrimental effects on forests. With the increasing certainty found in recent climate change reports (IPCC, 2007; Cayan et al., 2006) it appears that even with reductions in GHG emissions, some level of climate change is likely and adaptation strategies will be needed to maintain productive forests and rangelands.

Adaptation

Adaptation to climate change is any activity that reduces the negative impacts of climate change or takes advantage of new opportunities that may be presented. Within the forest sector, adaptation is defined as actions that are undertaken to increase the capacity of forests, ecosystems and society to function productively and cope with impacts from climate change (Millar et al., 2007). This can include actions that are taken before impacts are observed (proactive) and after impacts have been felt (reactive) (Easterling et al., 2004). The goal of adaptation planning is to reduce the vulnerability of forests and rangelands to climate changes and to increase the resiliency of lands to climate change. Resiliency is defined as the ability of a system, managed or natural, to withstand negative impacts without losing its basic functions. This does not imply that adaptation prevents impacts from occurring, but rather promotes more resilient ecosystems.

Adaptation to climate change impacts will require making decisions with limited information and with uncertain outcomes. This underscores the need to make long-term investments in monitoring and research and to develop a robust set of management options. The 2009 California Climate Adaptation Strategy (CAS) report includes a number of approaches, including both near- and long-term actions, which will help California forests adapt to climate change. Forest sector strategies in the CAS report are focused on (http://www.climatechange.ca.gov):

- Incorporating climate information into policy and program planning
- Improving the institutional capacity to assess climate effects and forest vulnerabilities
- Management actions to address and minimize forest vulnerabilities
- Implementing a priority research agenda
- Continued emphasis on forest health monitoring

Analysis – Climate Threat Index (Projected Trends)

To better understand expected trends in key climate variables, an analysis of downscaled climate data from GCMs was conducted. Daily climate data was collected to assess expected changes in future conditions from 2010 to 2100. The data was provided by the California Energy Commission and was originally collected as part of the Climate Scenario's Project which was directed by the California Climate Change Center (Cayan et al., 2006; Cayan et al., 2008). The following climate variables were included in the analysis.

- Annual Temperature
- Summer Temperature Max (June, July, August, September)
- Winter Temperature Min (December, January, February)
- Annual Precipitation
- Snow Water Equivalent

A Climate Threat Index was developed using downscaled climate change data from the Geophysical Fluid Dynamics Laboratory (GFDL) global climate model for the B1 climate scenario (Hidalgo et al., 2008). This index was used to identify the deviation of future climate conditions from historic conditions for each climate variable. Data for each variable was summarized to estimate average conditions for the following time periods:

- Historic T1 (June–Sept.) 1970–1999
- Future T2 (June–Sept.) 2010–2039
- Future T3 (June–Sept.) 2040–2069
- Future T4 (June–Sept.) 2070–2099

The index was calculated for a regularly spaced grid of points across California. These points were then overlayed with a GIS layer representing ecological units for California (Figure 3.7.1). This stratification allowed for a comparison of climate trends among ecological units.

Results

Using the climate threat index, expected trends in temperature and precipitation was evaluated for future time periods when compared to historic conditions (1970–1999). For all ecological units average annual temperatures are expected to increase within the range of 0.8 degrees Celsius in 2039 to 2.41 degrees Celsius in 2099. Estimated increases are consistent with predictions for increased warming from other studies, but are lower in the magnitude of expected change (Cayan et al., 2008; Bonfils et al., 2008). The differences may be attributed to the averaging that was used to develop the climate threat index in this study. The temperature increases represent the difference from a baseline temperature (i.e., historic average 1970–1999) and an estimated average annual temperature for a future time step (i.e., average annual temperature 2070–2099). Seasonal differences were also evaluated in a similar manner. The climate threat index was calculated for a grid of points, with 12 kilometer spacing, covering California. A table of the results by ecological units is presented in Table 3.7.2. In addition to evaluating statewide trends, the data was further stratified by ecological unit boundaries to evaluate regional differences in projected trends in climate variables. The results in Table 3.7.2 shows the expected increase in temperature and precipitation for ecological units across California.

Zone	Ecological Section
261A	Central California Coast
261B	Southern California Coast
262A	Great Valley
263A	Northern California Coast
322A	Mojave Desert
322B	Sonora Desert
322C	Colorado Desert
341D	Mono
341F	Southeastern Great Basin
342B	Northwestern Basin and Range
M261A	Klamath Mountains
M261B	Northern California Coast Ranges
M261C	Northern California Interior Coast Ranges
M261D	Southern Cascades
M261E	Sierra Nevada
M261F	Sierra Nevada Foothills
M261G	Modoc Plateau
M262A	Central Valley Coast Ranges
M262B	Southern California Mountains and Valleys

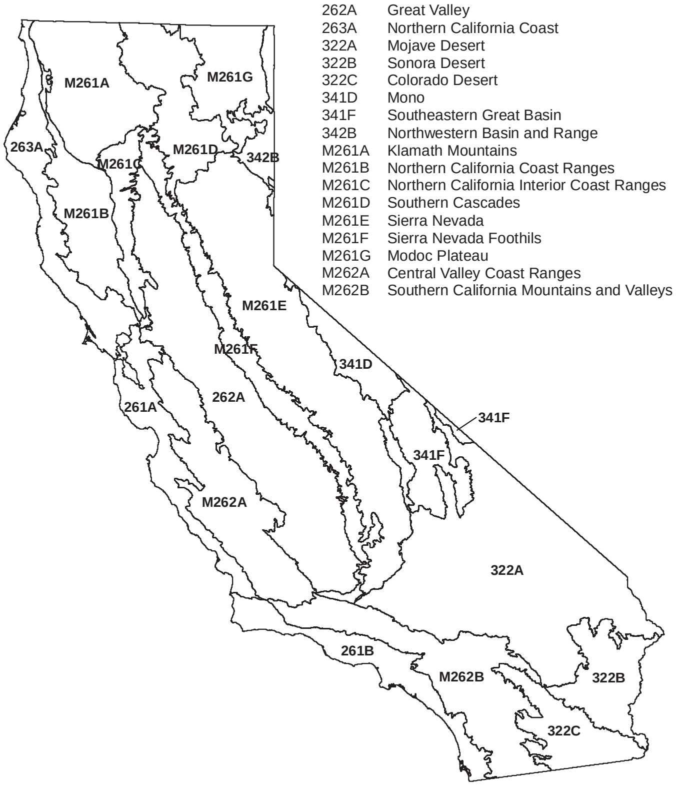


Figure 3.7.1.
Ecological sections.
Source: Miles and Goudy, 1997

Discussion

Bioregional Findings

The results from the climate threat index were made for each of the ecological sections. From this data some general patterns emerged at the larger bioregional level. The following section provides a brief summary of the key findings for the major bioregions in California based on model results from the GFDL global climate model using the B1 emissions scenario.

Overall, the maximum daily temperatures during summer months showed the greatest increase in interior ecosections including: Northwestern Basin and Range, Modoc Plateau, Mojave/Sonora/Colorado deserts, Sierra and the Sierra foothill ecosections. Depending on moisture availability, temperature increases combined with strong decreases in precipitation could lead to dramatic shifts in forest composition in later decades. In addition, the expected increases in temperature alone are likely to result in

Table 3.7.2. Climate threat index – expected changes in temperature (Celsius) and precipitation (mm) by ecological units. The analysis is based on the GFDL climate model under the B1 emissions scenario.

Zone	Eco-Section	Temp 2039	Temp 2069	Temp 2099	Precip 2039	Precip 2069	Precip 2099
261A	Central California Coast	0.82	1.3	1.69	24.58	-11.97	-117.9
261B	Southern California Coast	0.84	1.32	1.76	2.64	-40.86	-56.35
262A	Great Valley	0.98	1.55	1.98	21.65	5.64	-49.81
263A	Northern California Coast	0.8	1.3	1.62	66.44	60.46	-73.16
322ABC	Mojave/Sonoran/Colorado Deserts	1.18	1.87	2.3	-1.16	-22.86	-9.62
341DF	Mono, Southeastern Great Basin	1.16	1.9	2.33	8.95	-14.16	-37.84
342B	Northwestern Basin and Range	1.2	1.95	2.41	5.77	-5.26	-29.17
M261ABC	Klamath Mountains, Northern California Coast and Interior Coast Ranges	0.91	1.48	1.85	56.42	43.65	-66.48
M261D	Southern Cascades	1.07	1.74	2.17	37	18.6	-64.22
M261E	Sierra Nevada	1.09	1.76	2.18	70.05	17.57	-110.57
M261F	Sierra Nevada Foothills	1.04	1.65	2.08	49.24	11.07	-96.55
M261G	Modoc Plateau	1.17	1.89	2.34	15.22	-2.53	-32.06
M262A	Central California Coast Ranges	0.94	1.51	1.96	20.27	-5.27	-75.91
M262B	Southern California Mountains and Valleys	1.12	1.77	2.22	-6.3	-54.81	-44.74
Data Source: Climate Change Scenarios; California Energy Commission, 2009							

declining snowpack over time, which will affect water resources and related environmental services.

Klamath/North Coast (ecosections: 263A, M261A, M261B, M261C)
Expected increases in temperature that range from 0.8 degrees C (1.6 °F) in 2039 to 1.9 degrees C (3.2 °F) in 2099; the seasonal difference between maximum temperatures in winter and summer months is present, but slight. The pattern for average annual precipitation is variable; showing substantial (more than 60 millimeters) increases through 2069, but then showing large decreases by 2099.

Sierra (ecosections: M261E, M261F)
Expected increases in temperature that range from 1.1 degrees C (1.8 °F) in 2039 to 2.2 degrees C (3.8 °F) in 2099; the seasonal difference between maximum temperatures in winter and summer months is more pronounced than in coastal ecosections. The pattern for average annual precipitation is variable; showing increases through 2069, but then showing a substantial decrease by 2099.

Central Coast and South Coast (ecosections: 261A, 261B, M262A, M262B)
Both bioregions show a nearly identical trend with average annual temperatures increases that range from 0.8 degrees C (1.4 °F) in 2039 to 2.2 degrees C (3.0 °F) in 2099. There are also seasonal differences in the rate of temperature increase. For these bioregions, the maximum temperature during summer months is expected to increase by approximately 0.5 degrees C (0.9 °F) compared to winter maximum temperatures. The interior ecological sections show a more pronounced increase in temperature (approximately 0.5 degrees C (0.9 F)) compared to the direct coastal units. The pattern for average annual precipitation is variable; showing increases through 2039, but then showing a substantial decrease by 2099.

Sacramento and San Joaquin Valleys (ecosections: 262A)
Expected increases in temperature that range from 1.0 degrees C (1.8 °F) in 2039 to 2.0 degrees C (3.6 °F) in 2099; the seasonal difference between maximum temperatures in winter and summer months is more pronounced than in coastal bioregions. The pattern for average annual precipitation is variable;

showing increases through 2069, but then showing a decrease by 2099.

Mojave and Colorado Desert (ecosections: 322A, 322B, 322C)
Expected increases in temperature that range from 1.2 degrees C (2.1 °F) in 2039 to 2.3 degrees C (4.1 °F) in 2099; temperature increase during summer months are expected to increase nearly 3.0 degrees C (5.4 °F) by 2099. Changes in precipitation are slight through 2039, but expected to decline through 2099.

FOREST CARBON

Forest Carbon Accounting

A broad range of methods are being explored to count carbon sequestered and released from forests in California. Initial estimates were developed by the California Energy Commission and later refined by Air Resources Board as part of climate change legislation in California (AB 32) that requires emissions to be reduced to 1990 levels by 2020. These initial estimates show California forests operating as a net sink of approximately five million metric tons of carbon dioxide, taking both removals and emissions into account. Recently, an inter-agency forest working group was formed to address a number of forestry-related issues associated with AB 32, including appropriate methods and agreed upon standards for carbon accounting in the forest sector. In addition, the U.S. Forest Service in Region 5 has conducted an initial inventory of carbon stocks in California. These results show that under a "business as usual" scenario forest carbon will see an overall increase over the next four to six decades before declining to 1990 levels by 2100 (Goines and Nechodom, 2009). The capacity to maintain a carbon sink over time was determined to be dependent on how well national forests can manage risk of losses from wildfire and the effectiveness of implementing strategies to maintain forest health.

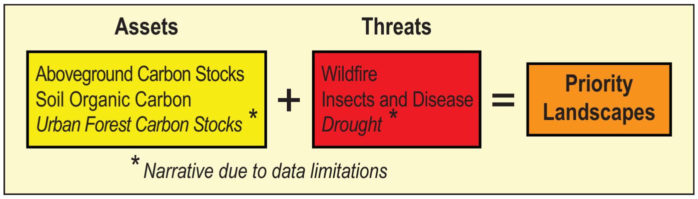
Estimates of forest carbon presented in this chapter are based on a single model (MC1) and are not intended to provide a detailed accounting of forest carbon. Rather, the analysis is intended to highlight areas where forest carbon assets are highest and identify areas that are at greatest risk to losses of forest carbon in the future.

Analysis: Forest Carbon – Threats from Wildfire, Insects and Disease

A broad range of environmental services (e.g., clean water, clean air, soil, wildlife habitat, carbon sequestration, nutrient cycling, recreation) are produced by California forests and are potentially altered or threatened by climate change. Potential impacts on many of these forest assets are discussed earlier in this chapter. In addition, a recent study found expected declines due to climate change for a number of key environmental services; carbon sequestration, forage production, water flows for salmonids, snow recreation, and biodiversity (Shaw et al., 2008). While the analysis presented here is focused on forest carbon, the priority areas identified through this analysis also support many other important environmental services that are not explicitly modeled.

The following section describes the development of data layers that were used to evaluate above and below ground carbon stocks over future time steps. This represents the capacity of forests and rangelands to sequester carbon. In the first analysis, estimates of above and belowground carbon stocks were evaluated against the risks of losing carbon stocks from ecosystem threats (e.g., wildfire, insects and disease).

The use of a vegetation dynamics model allowed stocks to be evaluated for four different time periods that include: 2010, 2020, 2050 and 2100. The ranking of forest carbon considers both the existing carbon sequestration and the expected increases and decreases over time. The analysis was based on a GIS model that combined threats and assets to produce a priority landscape (see diagram below). Above and below ground forest carbon grids were developed at four different time intervals: 2010, 2020, 2050 and 2100. A unique priority landscape was developed at each time step by overlaying threats from wildfire, insects and disease against a composite assets layer that represents forest carbon. The following section describes forest carbon assets, threats to the assets, and the development of the priority landscape.



Assets

Aboveground Carbon Stocks

Forests act as both a sink and a source of carbon dioxide (CO_2). Forests operate as a sink when they remove carbon dioxide from the atmosphere and through photosynthesis convert carbon into plant tissue where it is stored as biomass both above and belowground. When the forest is harvested, burned, destroyed by insects or converted to other land uses, some of the carbon is returned to the atmosphere as carbon dioxide and the forest becomes a source. This is part of a natural cycle where forests periodically store and release carbon back into the atmosphere. A forest can operate as a sink, over a fixed period of time, when carbon sequestration exceeds the release of carbon. It is the net effect of forest management activities and natural disturbances that will determine whether the forest is a sink or a source over time.

Estimates of aboveground carbon stocks were derived from the MC1 dynamic global vegetation model (Table 3.7.3) developed by the U.S. Forest Service and the Forest Sciences Laboratory at Oregon State University. The MC1 model can be used to estimate distribution of broad forest vegetation types, fluxes in forest carbon, nutrients and water. Coupled with climate data from general circulation models (GCMs), the model can simulate expected changes in vegetation under a broad range of climate scenarios. MC1 consists of several sub-modules that simulate interactions between climate and vegetation over time (Bachelet et al., 2003). This model was previously developed and run for California using a range of GCMs under differing emissions scenarios (Shaw et al., 2008). For this analysis forest carbon stocks were estimated using the GFDL GCM for both lower (B1) and higher (A2) emissions scenarios. When compared with other GCM models, the GFDL model tended to predict hotter and drier conditions for California (Cayan, 2006). The MC1 model has been previously used to evaluate the possible effects of future climate scenarios on vegetation in California (Lenihan et al., 2003; Shaw et al., 2009).

Aboveground carbon was estimated for the following time periods: 2010, 2020, 2050 and 2100. The aboveground carbon storage for California was based on the MC1 "climate neutral" dataset. Climate neutral data is defined as not including any extra anthropogenic emissions, and is based on historical mean climate data. The aboveground carbon includes aboveground dead carbon, live tree carbon and live herbaceous carbon based on the MC1 neutral climate outputs in metric tons per hectare. The aboveground carbon data layer was ranked into three groups (high, medium and low) to identify locations where forest carbon is considered a high asset. If the GCM models predicted a loss of carbon then the rank was lowered by a point, and if the model predicted a gain then the rank was raised by a point. If there was no change in total carbon by the model then the carbon rank was not changed. This method of incorporating the amount of change from the climate neutral data is a way to compare the different GCM model results, and it also places additional emphasis on areas that have a substantial carbon stock to begin with.

Soil Organic Carbon

Soil is also an important carbon sink and can be influenced by the same pressures as forest carbon. Like forest carbon, there are a number of natural and anthropomorphic factors that can shift the role of soil from a sink to a source, such as plant growth, rate of decomposition, nutrient cycles, wind, fire, drought, land use and forest management (Lal, 2005).

Soil organic carbon is represented as belowground carbon storage for the following time periods: 2010, 2020, 2050 and 2100. The belowground carbon

Table 3.7.3. Bioregional estimate of aboveground forest carbon in teragrams (Tg) and the percent change from base year. Note: The estimates are based on results from the MC1 vegetation dynamics model using the GFDL GCM for emission scenarios A1 and B2.

Bioregion	Base Year 2010	GFDL A2 2010	GFDL A2 2020	GFDL A2 2050	GFDL A2 2100	GFDL B1 2010	GFDL B1 2020	GFDL B1 2050	GFDL B1 2100
		116.7	115.7	112.3	94.8	115.7	116.5	112.2	100.8
Bay/Delta	117.8	-1%	-2%	-5%	-20%	-2%	-1%	-5%	-14%
	57	55.2	55.9	54.4	43.8	55.1	57.5	56.8	47.2
Central Coast		-3%	-2%	-5%	-23%	-3%	<1%	<-1%	-17%
	9.3	9.3	9.2	8.8	7.7	9.1	9.1	8.4	8.1
Colorado Desert		0%	-1%	-5%	-13%	-2%	-2%	-10%	-13%
Klamath/North	578.1	581.1	580.1	568.7	474.9	572.7	573.7	556.2	525.4
Coast		<1%	<1%	-2%	-18%	-1%	-1%	-4%	-9%
	208.5	209.1	207.5	199.3	142.1	206.3	206.5	206.6	192.9
Modoc		<1%	<-1%	-4%	-32%	-1%	-1%	-1%	-7%
	31	30.9	31	30.2	26	31.1	30.5	29.3	27.6
Mojave		<-1%	0%	-3%	-16%	<1%	-2%	-5%	-11%
	46.5	45.5	45.6	44.1	29.2	44.6	46.8	43.8	35.4
Sacramento Valley		-2%	-2%	-5%	-37%	-4%	1%	-6%	-24%
	14.8	14	13.6	13.8	12.4	14.1	14.2	13.4	12.1
San Joaquin Valley		-5%	-8%	-7%	-16%	-5%	-4%	-9%	-18%
	343.9	343	346	336.7	260.1	339.3	342.2	338.4	326.5
Sierra		<-1%	1%	-2%	-24%	-1%	<-1%	-2%	-5%
	23.5	23.5	23.8	23.7	20.2	23.4	23.6	22.8	22.1
South Coast		0%	1%	1%	-14%	<-1%	<1%	-3%	-6%
	1430	1,428.3	1,428.4	1,392.1	1,111.3	1,411.3	1,420.6	1,387.9	1,298.0
Total		<-1%	<-1%	-3%	-22%	-1%	-1%	-3%	-9%

storage for California was based on the MC1 "climate neutral;" dataset. The belowground carbon includes both dead and live carbon from grass and tree roots. The data is in metric tons per hectare units. Similar to the aboveground carbon data, the belowground storage values were ranked, and then the ranks were adjusted based on whether the GCM model showed an increase or decrease in carbon storage.

Urban Forest Carbon Stocks

The planting of new trees and the maintenance of existing trees in urban areas contributes to carbon sequestration and the reduction of carbon dioxide. In addition, urban trees provide shade that can reduce energy demands during the warm summer months. However, the coarse nature of the grid cells used by MC1 vegetation dynamics model (12km) combined with limitations in the processes represented by the model are not compatible with the finer scale conditions that characterize urban forests. As such, the contribution of urban forests to carbon sequestration was not included in the GIS based model.

Composite Assets

The composite asset dataset is a combination of the aboveground and belowground carbon data combined into a single dataset that represents the total carbon across the state. To support the GIS based model the data is reclassified into four ranks. These ranks were assigned first by applying quantile breaks to the MC1 climate neutral carbon estimates, and then adjusting the ranks by applying an index of the percentage of change between the carbon neutral and GFDL A2 carbon values to account for areas that are expected to experience carbon fluctuations over time. Rank three represents high carbon sequestration, rank two represents medium carbon sequestration, rank one and rank zero represents low carbon sequestration (Figure 3.7.2). The composite asset for carbon sequestration is at four time periods: 2010, 2020, 2050 and 2100. This estimate is derived from

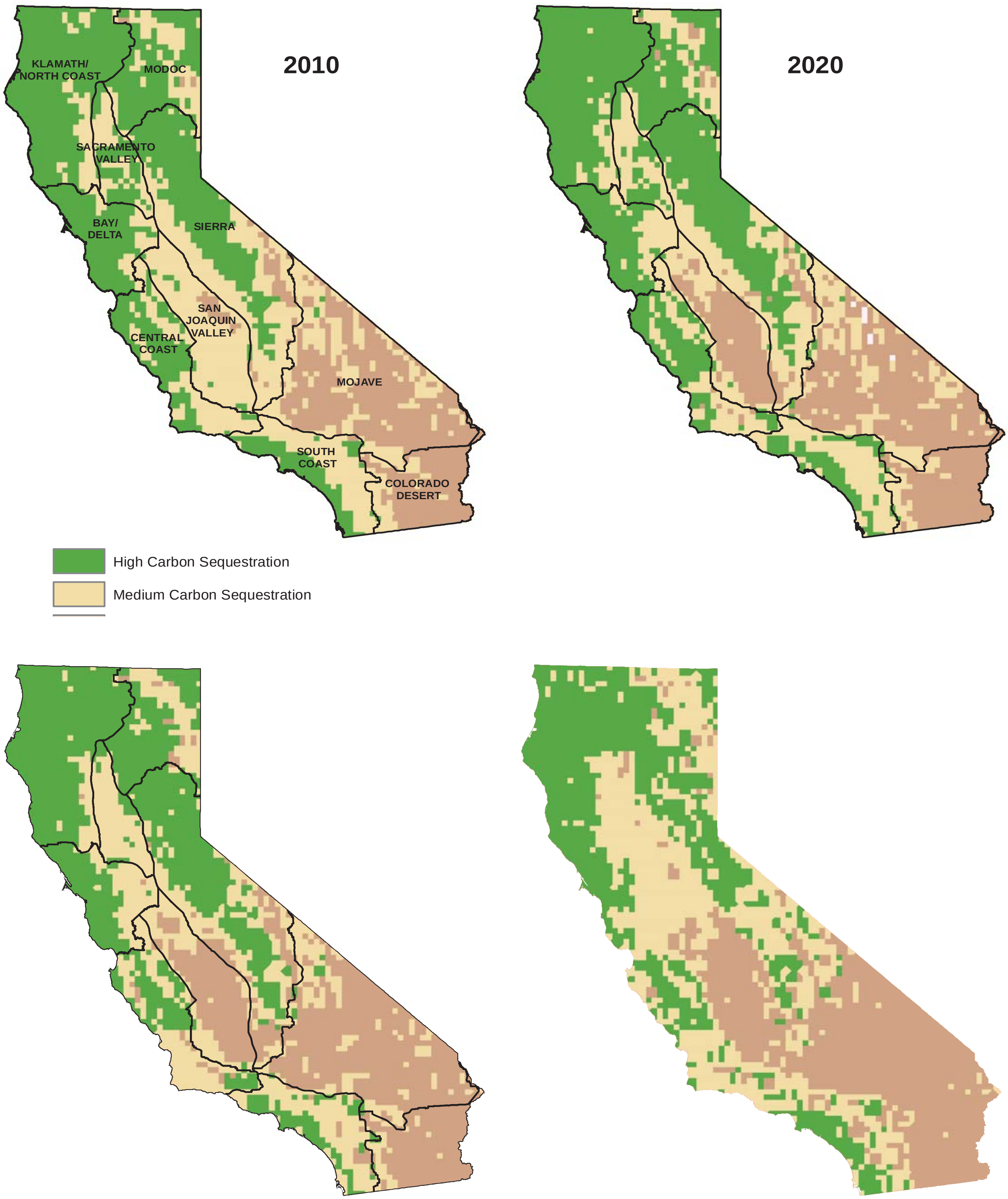


Figure 3.7.2.
Composite forest carbon assets (A2 scenario).
The resulting output is from the MC1 dynamic global vegetation model and is based on climate data from the GFDL GCM under the A2 emissions scenario. Under this scenario forest carbon is relatively stable through 2050.
Data Source: MC1 Dynamic Global Vegetation Model, USFS / Oregon State University / The Nature Conservancy (2009)

the MC1 vegetation dynamics model and is based on climate data from the GFDL GCM under the A2 emissions scenario. Under this scenario forest carbon is relatively stable through 2050. Additional GCM models and emissions scenarios will be evaluated to support future assessments.

Threats

Disturbance resulting in the loss of forest carbon can come from both natural (wildfires, insects, disease) and human related causes (development, deforestation).

Wildfire

Recent research suggests that regardless of the climate model or emissions scenario an increase in wildfire is expected (Westerling et al., 2006). By mid-century the frequency of large wildfires is expected to increase by 30 to 50 percent, and could reach as high as 94 percent by 2085 under the A2 emissions scenario (Westerling, 2009).

Wildfire threat is measured and ranked based on FRAP fire threat data. Fire threat is a combination of two factors: 1) fire frequency, or the likelihood of a given area burning, and 2) potential fire behavior (hazard). These two factors are combined to create four threat classes ranging from moderate to extreme. (See Chapter 2.1 for additional information on threats from wildfire.) This data layer represents a future hazard that is evaluated against the forest carbon assets estimated through the MC1 model at future time period. The MC1 model also incorporates fire, but in a different manner. The MC1 model simulates the occurrence of fire as a disturbance when thresholds for fuel and moisture content are meet. The direct effect of fire simulated in MC1 is on the consumption and mortality of dead and live vegetation carbon, which is removed from the carbon pool at each time step in the model. Lenihan et al. (2006, 2008), provide a more comprehensive discussion of the MC1 fire module. The remaining aboveground carbon pool is then evaluated against the hazard of future fires, represented by the FRAP fire threat layer to determine areas where the remaining aboveground carbon pool is at risk.

Insects and Disease

The loss of carbon stocks from forest health issues, such as outbreaks of insects and disease, can be substantial. These outbreaks can result in direct mortality and increase the risk of high severity wildfires. For this analysis threats from insect and disease outbreaks is used to represent threats to forest health. The threat of damage to ecosystems was evaluated at the stand level and takes a number of factors into account such as severity of damage, the damage causing agent, and how recent the event was with more recent events emphasized over older ones. (See Chapter 2.2 for additional information on threats from forest pests.)

The threat to a particular small area is called the stand-level insect and disease threat, and is based on expected tree mortality over the next 15 years, as developed by the U.S. Forest Service's Forest Health Protection Program (FHP).

Loss of Carbon Stocks from Prolonged Drought

Forests in California and across the western U.S. are periodically under the influence of drought conditions. Many forest species have adaptations that allow them to survive under drought conditions. To the extent that climate change may alter the frequency and severity of drought, forests will likely be adversely affected. Increases in temperature alone may result in decreases in water availability during the dry summer months. Moisture stress from drought can affect plant physiology, productivity, seed production, recruitment and mortality rates (Hansen and Weltzin, 2000).

Results

An overlay of forest carbon assets with the combined threats from wildfire, insects, and disease was done to produce a priority landscape (Figure 3.7.3). The overlay of threats and assets was used to identify where high value carbon stocks coincide with ecosystem threats from wildfire, insects and disease. The resulting priority landscape represents areas where

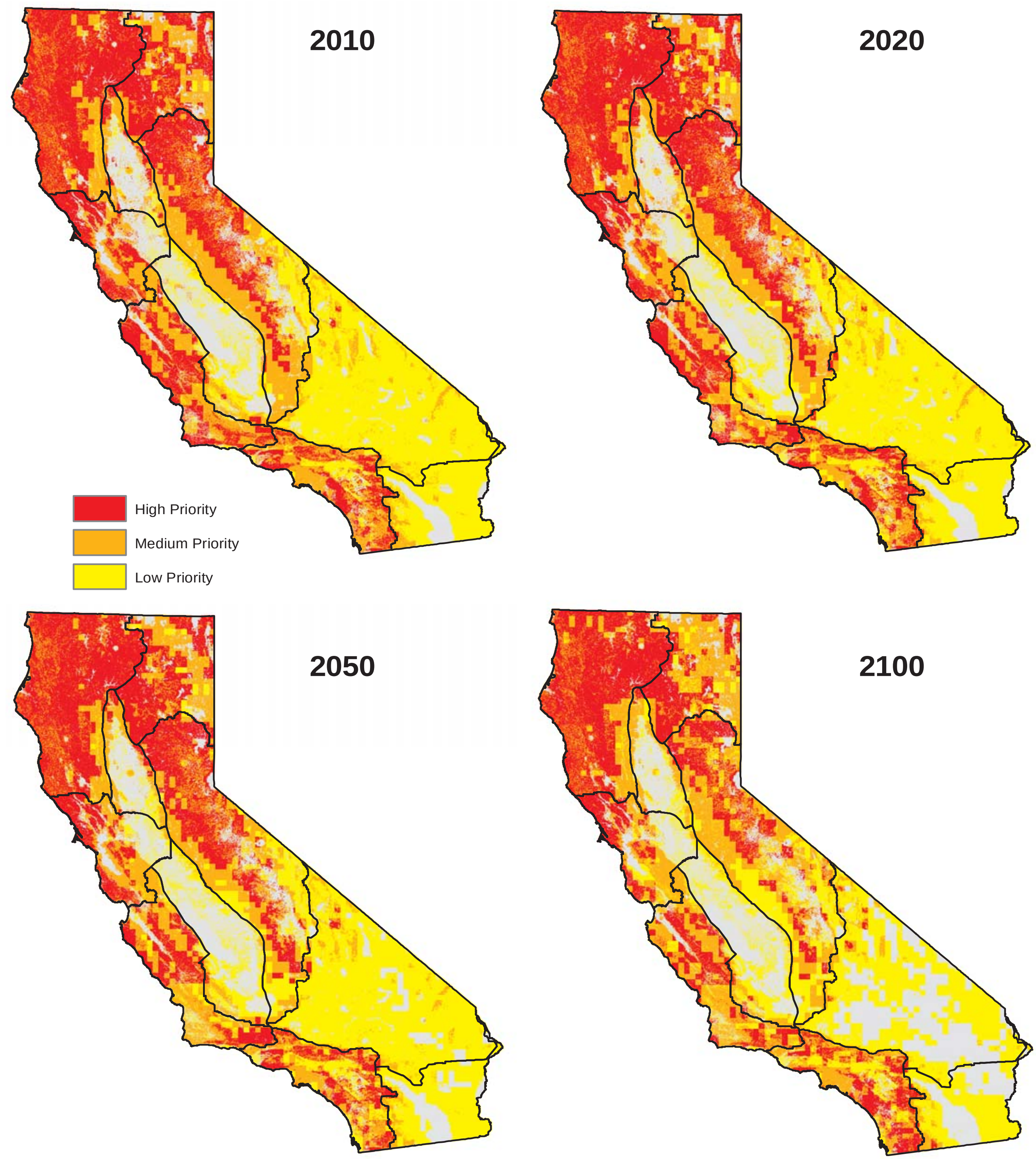


Figure 3.7.3.
Priority landscape forest carbon and ecosystem threat (A2).
The data inputs to the priority landscape were derived from the MC1 vegetation dynamics model and are based on climate data from the GFDL GCM under the A2 emissions scenario. Under this projected climate scenario the priority landscape areas remain relatively stable through 2050.
Data Source: MC1 Dynamic Global Vegetation Model, USFS / Oregon State University / The Nature Conservancy (2009); Forest Pest Risk, USFS FHP (2006 v1); Statewide Land Use / Land Cover Mosaic, FRAP (2006); California Fire Regime Condition Class, FRAP (2003)

high value carbon stocks are at risk. A priority landscape was generated for four different time steps: 2010, 2020, 2050 and 2100. The results for the priority landscape are influenced by both the GCM (GFDL) and the A2 emissions scenario that was used. The composite threat data (insects and wildfire) was not intended to predict as far out as the year 2100, so the results for that year should be considered less reliable than the previous year model outputs.

Results 2010

The evaluation of carbon stocks from the baseline conditions for 2010 showed limited gains or losses in forest carbon stocks. The priority areas are focused predominately on forestlands in the Klamath/North Coast and Sierra bioregions and to a lesser extent for some regional areas in the Central Coast and South Coast bioregions.

Results 2020

The evaluation of carbon stocks from the baseline conditions for 2020 showed limited gains or losses in priority areas compared to 2010. The priority areas remain relatively stable across all bioregions.

Results 2050

An evaluation of carbon stocks from the baseline conditions for 2050 begins to show greater variation in gains or losses in forest carbon stocks when compared to baseline conditions. The warmer and drier conditions forecast through the A2 scenario result in declines in forest carbon in many parts of the state. However, the overall pattern for the priority landscape is similar to previous time periods.

Results 2100

An evaluation of carbon stocks from the baseline conditions for 2100 shows a considerable amount of decline in forest carbon stocks when compared to baseline conditions. The warmer and drier conditions forecast through the A2 scenario result in declines in forest carbon throughout the most of the state.

Discussion

The results from the MC1 vegetation dynamics model, using the GFDL GCM and the A2 emissions scenario, show estimated carbon sequestration across California forests to be relatively stable through 2050. Following 2050, the model shows a dramatic increase in temperature coupled with less precipitation that may result in a substantial decline in forest carbon by 2100. In addition, there are substantial threats to forest carbon from both wildfire and from insects and disease. The implications of the analysis suggest that forests will continue to grow and operate as a carbon sink for several decades, but that in the absence of any changes in management forest carbon will decline in the later decades through 2100. While forests are expected to continue to operate as a carbon sink over the next several decades, if the projected declines in carbon storage in later decades are realized, forests will eventually have a diminished

Table 3.7.4. Summary of acres of medium and high priority landscape (ecosystem threats) by bioregion (acres in thousands). Note: These estimates are based on results from the MC1 vegetation dynamics model.

	2010		2020		2050		2100	
Priority Rank	Medium	High	Medium	High	Medium	High	Medium	High
Bay/Delta	2,017	2,263	1,979	2,104	2,027	1,934	1,996	1,624
Central Coast	3,344	3,477	3,344	3,477	3,566	2,651	3,893	2,411
Colorado Desert	605	17	605	17	418	51	428	80
Klamath/North Coast	3,688	9,864	3,688	9,864	3,343	10,261	3,766	9,740
Modoc	3,042	3,978	3,042	3,978	2,859	3,975	3,669	2,768
Mojave	1,875	53	1,875	53	1,317	190	980	150
Sacramento Valley	1,171	508	1,171	508	1,108	312	1,061	129
San Joaquin Valley	897	142	897	142	644	89	602	94
Sierra	7,868	5,962	7,868	5,962	6,337	6,352	7,220	3,949
South Coast	3,192	2,454	3,192	2,454	2,817	2,202	2,804	2,404

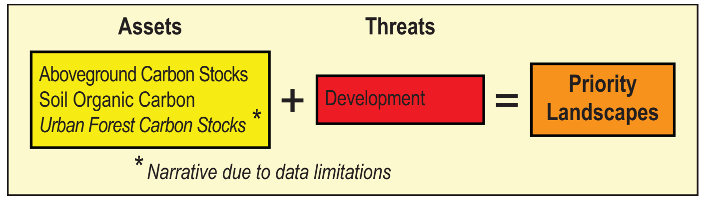
capacity to regulate climate. Maintaining forests as carbon sinks will require policies that address issues related to forest health and strive to lessen the amplitude with which carbon cycles between forests and the atmosphere.

The priority landscape represents the intersection of extensive areas of threats from wildfire and forest pests that coincide with areas that have high carbon sequestration. Priority areas are broadly distributed across forests in the Sierra, Cascades and North Coast ecological sections. There are a range of opportunities to maintain and enhance forest carbon through reforestation, forest management and reduction of losses from wildfire. A further discussion of these and other approaches are found in the strategies report. Overall, the results suggest that managing the risks or threats to loss of forest carbon are equally as important as policies aimed at sequestering additional forest carbon. Management actions and forest policies are needed in high priority areas to reduce risk to loss in forest carbon.

There is considerable uncertainty in the predictions from GCMs and the Dynamic Global Vegetation Model (DGVM), which affect the reliability of predictions from these models. Different assumptions on climate emission scenarios can lead to different trajectories for vegetation dynamics and related ecosystem processes. Ideally, multiple GCMs would be evaluated to bracket the range of possible outcomes. Future assessment work will attempt to incorporate results from other GCMs. Other limitations in DGVMs are that the models use coarse grid cells that do not represent complex topographic changes. In addition, these models typically do not incorporate vegetation changes due to management practices or impacts from insects and disease.

Analysis: Forest Carbon – Threats from Development

The expansion of urban areas, as a result of population growth, can result in conversion of forestlands to other land uses and poses a threat to forest carbon. Estimates of above and belowground carbon stocks were evaluated against patterns of expected development at 2010, 2020, 2050 and 2100. The analysis was based on a GIS model that combines threats and assets to produce a priority landscape.



Asset

Aboveground Carbon Stocks
See above analysis for a description of methods for estimating forest carbon stocks.

Threat

Development
The threat from development is discussed in Chapter 1.1. For this analysis a threat layer was used to represent expected development at future time steps. The GIS data layer depicting future development was created by the EPA as part of the Integrating Climate and Land Use (ICLUS) project (EPA, 2009) and is the result of a demographic model that spatially allocates housing density at decadal time steps.

This data was used to create a statewide development layer for four time steps: 2010, 2020, 2050 and 2100. The area for projected development expanded with each time step. The density of development was assumed to increase over time, which had the effect of increasing the development threat rating for developed areas. For example, an area projected as low density development in 2010 would begin with a low threat rating that would increase at each future time step. The analysis was conducted for the entire state, but the results are difficult to discern on a statewide map. As an example, the progression of development is shown for the Sierra foothill region east of Sacramento (Figure 3.7.4).

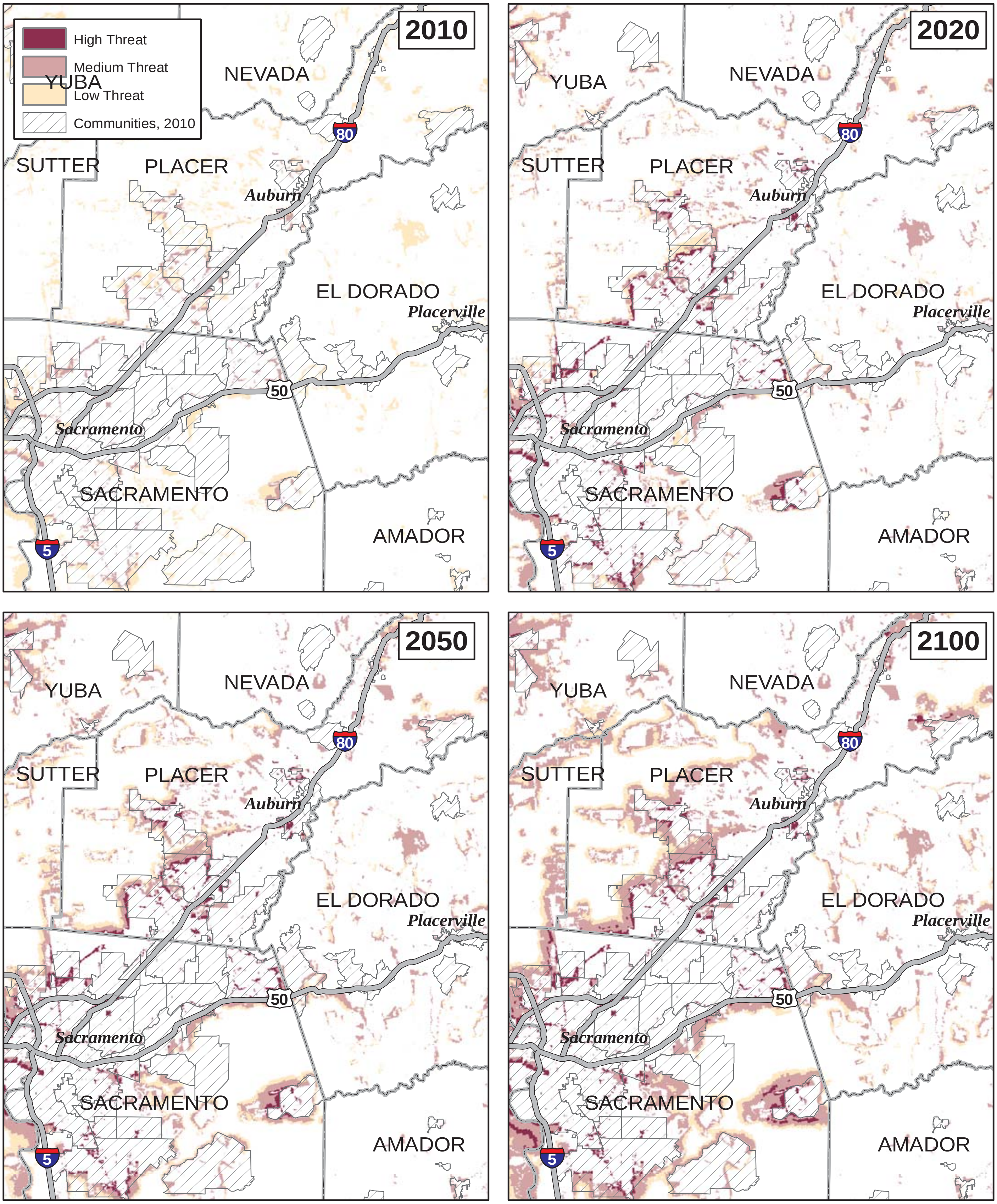


Figure 3.7.4.
Threat to aboveground carbon from projected development.
As development densifies over time, the threat to carbon is expected to increase.
Data Sources: U.S. Census Bureau (2000); ICLUS, U.S. Environmental Protection Agency (2009); Communities, FRAP (2009 v1); Commission on Local Governance for the 21st Century (2000)

Results

Overlaying development threat and forest carbon stocks identified where high value carbon stocks coincide with threats from development that result in the conversion of forests to other land uses. The resulting priority landscape represents areas where high value carbon stocks are at risk. A priority landscape was generated for different time steps: 2010, 2020, 2050 and 2100. The results, shown by bioregion in Table 3.7.5, were influenced by the GFDL GCM used and the B1 and A2 emissions scenarios that were used. An example of the expected changes to the priority landscape over time is given for the Sierra Foothills (Figure 3.7.5). In this region oak woodlands and forests are likely to be at risk to conversion from the progression of development. For additional information on risks to oak woodland and forests see Gaman and Firman (2006).

Results 2010

The priority landscape for 2010 shows priority areas that are largely associated with expanded development around the fringe of existing cities and towns. These newly developed areas are generally associated with a lower level of housing development. As a result most priority areas are listed as low or medium.

Results 2020

The priority landscape for 2020 shows an expansion of priority areas that result from a projected expansion of development. Priority areas that were present in both time periods (2010 and 2020) are likely to have increased in rank. As newly developed areas in 2010 continued to be developed at a higher density there is a greater likelihood of a resulting loss in carbon sequestration. As a result these areas may become a higher priority.

Results 2050

The priority landscape for 2050 shows an expansion in the amount of priority areas that were represented during the 2020 time period. In addition to a greater extent of priority area, those priority areas present in previous time periods (2010 and 2020) are likely to have increased from a lower to higher priority.

Results 2100

The priority areas for 2100 are more speculative. The direction and pattern of development is less certain. However, the 2100 time period shows a continued expansion in priority areas surrounding existing developments.

Discussion

The priority landscape that resulted from the overlay of projected development with aboveground carbon results in a substantial amount of high priority acreage that is expected to increase between 2010 and 2100. The Bay/Delta and South Coast bioregions contain the greatest amount of high priority landscape. In both bioregions high priority areas occupy two to three percent of the bioregion in 2010; by

Table 3.7.5. Summary of high priority landscape (forest carbon and development) by bioregion (acres in thousands). Note: The estimates are based on results from the MC1 vegetation dynamics model. The table summarizes the results for the forest carbon and development analysis.

	2010		2020		2050		2100		Bioregion
Priority Rank	**Medium**	**High**	**Medium**	**High**	**Medium**	**High**	**Medium**	**High**	**Total Acres**
Bay/Delta	192	14	182	173	300	270	533	327	6,292
Central Coast	65	1	86	58	183	76	254	189	7,986
Colorado Desert	6	0	37	6	53	7	106	19	6,757
Klamath/North Coast	36	0	22	37	15	52	19	53	14,383
Modoc	7	0	13	7	15	20	17	30	8,332
Mojave	25	0	76	26	137	26	165	21	19,937
Sacramento Valley	83	13	103	83	194	82	327	66	3,953
San Joaquin Valley	34	1	130	19	183	14	332	28	8,224
Sierra	55	1	93	68	136	94	175	85	18,303
South Coast	137	37	185	167	320	213	409	354	7,059

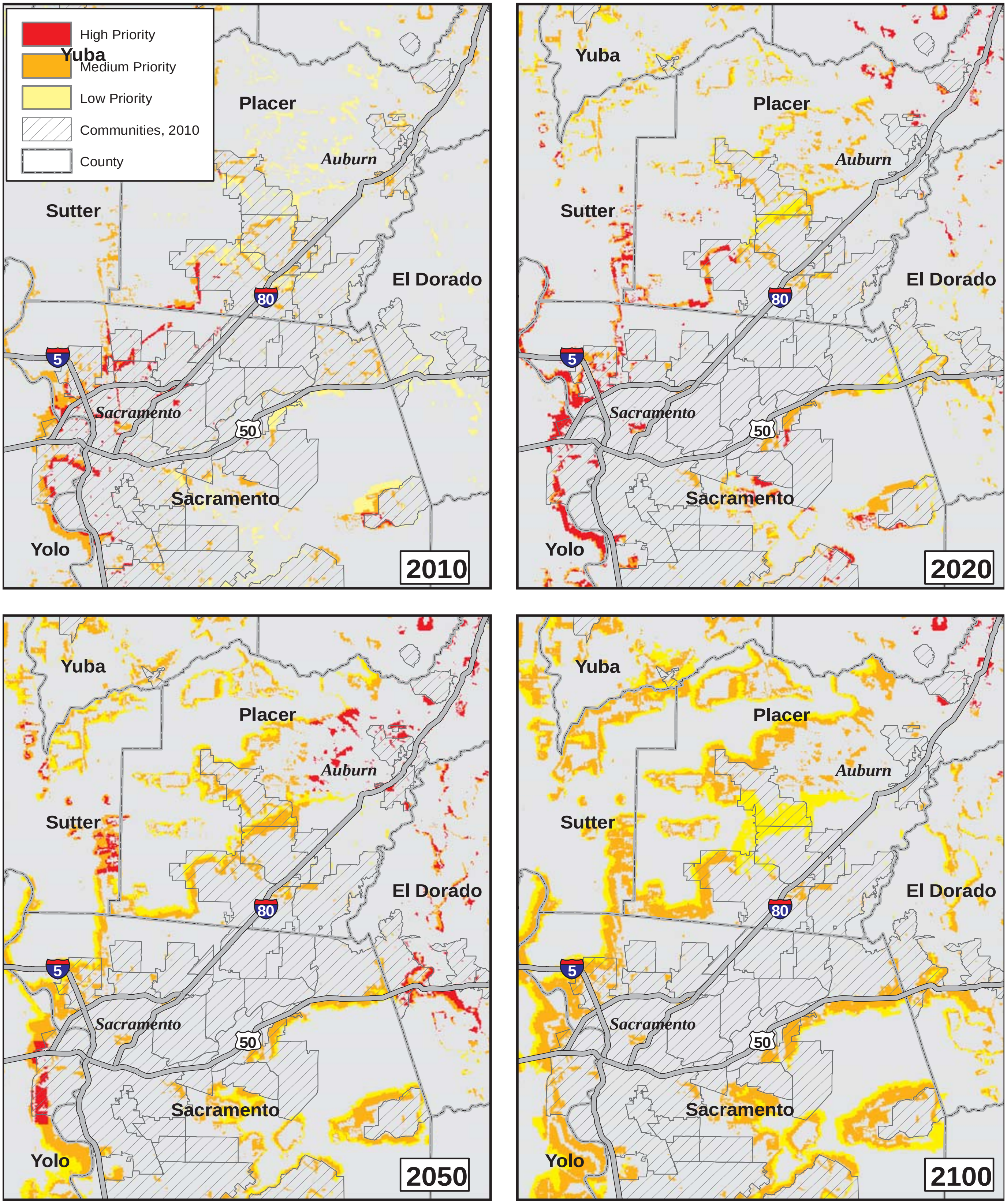


Figure 3.7.5.
Priority landscape for forest carbon (A2) and development.
The data inputs (i.e., forest carbon) to the priority landscape were derived from the MC1 vegetation dynamics model and are based on climate data from the GFDL GCM under the A2 emissions scenario. Areas projected for development in time 2010 can increase in rank as the density of development increases in future decades.
Data Sources: MC1 Dynamic Global Vegetation Model, USFS / Oregon State University / The Nature Conservancy (2009); U.S. Census Bureau (2000); ICLUS, U.S. Environmental Protection Agency (2009); Communities, FRAP (2009 v1); Commission on Local Governance for the 21st Century (2000)

2100 the area is projected to occupy 11 to 14 percent of the bioregion. The Sacramento Valley bioregion showed a similar trend with the amount of high priority landscape starting at two percent in 2010 and projected to increase to 10 percent by 2100. For all other bioregions the amount of high priority landscape was expected to occupy less than five percent of the bioregion.

Policy Options

To preserve and enhance forest carbon management policymakers need to consider both actions that increase carbon sequestration where possible, and actions that reduce losses from wildfire, forest health, land use conversion and other forms of disturbance. Financial incentives to forest landowners (government subsidies and market-based) and regulation are the primary policy tools available to promote sustainable forest management that can contribute to mitigation and adaptation. Regulation must be considered in the context of other interacting factors to be effective; these include leakage (the shifting of emissions elsewhere) where regulatory actions may result in an increase in carbon sequestered by California forests with an unintended increase in emissions elsewhere due to wood imports.

VEGETATION RESPONSE TO CLIMATE CHANGE

The distribution of trees and plants found in forest ecosystems are heavily influenced by temperature and precipitation patterns. The response of forests to changes in climate depends greatly on the availability of water and nutrients. Temperature changes alone can affect plant growing seasons and cause phenological changes in the seasonal timing of flowering and budding (Penuelas and Filella, 2001). As discussed earlier in this chapter, expected changes in future climatic conditions coupled with altered disturbance regimes are likely to result in shifts in species ranges and possible changes in forest productivity. Tree species with the greatest risk of extinction are the ones that are rare and isolated or have fragmented habitats that limit room for migration.

Analysis – Vegetation Response (BioMove)

Through collaboration with researchers from UC Santa Barbara, analysis of potential range shifts using both species distribution models and a vegetation dynamics model called BioMove was conducted for a set of indicator species to evaluate the possible effects of future climate scenarios on the extent and distribution of forest and rangeland vegetation. BioMove is a species-based model for assessing vegetation dynamics that are likely to result under future climate change scenarios.

Species distribution models were constructed using multiple GCMs to capture a broad range of climatic variability based on IPCC climate scenarios. Using climate suitability data from the species distribution models, the BioMove model identified the environmental conditions that could support an individual species under a future climate scenario and evaluated the likelihood of a species occupying the site, given constraints from disturbance and competition. Each model run produced a GIS database that showed the future distribution of individual species. This analysis evaluated the adaptive response of key forest and rangeland species to climate change.

Species Distribution Model

For the species on the indicator list (Table 3.7.6), a species distribution model (SDM) was developed that predicts the range or niche that a species might occupy under future climatic conditions. The SDM assumes that a species range or niche is primarily determined by environmental conditions and that by incorporating predictions from global climate models the shifts in future species range can be predicted (Aitken et al., 2007). As such, the representation of species distribution does not include the constraints from disturbance, competition or dispersal.

The premise behind these models is that environmental conditions are the primary determinant of realized species niches, and that the future preferred range distribution of species can be predicted by transferring the environmental parameters as-

Table 3.7.6. Summary of percent change in species range

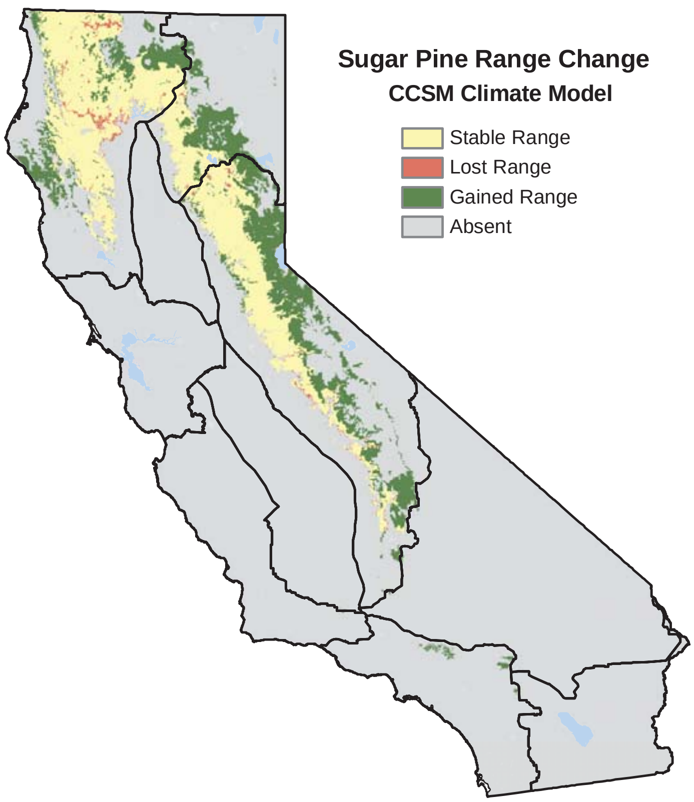
Species	Description	Community Climate System Model		Hadley Centre Model	
		Acres	Percent Change	Acres	Percent Change
Red Fir (*Abies Magnifica*)	Gained	53,127	1	494	0
	Lost	4,911,854	77	6,340,092	100
	Stable	1,432,933	23	4,695	0
	Past	6,344,787		6,344,787	
Sugar Pine (*Pinus Lambertiana*)	Gained	6,753,243	61	2,189,059	20
	Lost	383,993	3	3,727,256	34
	Stable	10,709,067	97	7,365,804	66
	Past	11,093,060		11,093,060	
Coulter Pine (*Pinus Coulteri*)	Gained	1,089,958	15	241,664	3
	Lost	5,346,009	75	6,008,978	84
	Stable	1,804,324	25	1,141,355	16
	Past	7,150,333		7,150,333	
Bigcone Douglas-fir (*Pseudotsuga Macrocarpa*)	Gained	3,715,396	63	1,961,233	33
	Lost	1,812,479	31	2,016,089	34
	Stable	4,060,100	69	3,856,490	66
	Past	5,872,579		5,872,579	
Blue Oak (*Quercus Douglasii*)	Gained	975,057	4	4,336,852	16
	Lost	10,008,538	37	7,053,222	26
	Stable	16,965,886	63	19,921,202	74
	Past	26,974,424		26,974,424	
Pasadena Oak (*Quercus Engelmannii*)	Gained	1,220,180	38	2,607,399	82
	Lost	633,317	20	1,160,876	36
	Stable	2,551,802	80	2,024,243	64
	Past	3,185,119		3,185,119	

sociated with the present distribution onto maps representing future climate scenarios.

The results summarize the expected increases and decreases in indicator species range when comparing current range extent to the predicted range in 2080. The species range was developed for two global climate models: the Community Climate System Model (CCSM) developed by National Center for Atmospheric Research and the Hadley Centre Model (HAD) under the higher emissions A2 scenario (Figure 3.7.6). For many species there was strong agreement in the predicted species shift from both models. However, in other cases the model results are quite different. As shown for sugar pine, the CCSM model predicts an expanding range that is influenced by the warmer and wetter conditions. In contrast, hotter and drier conditions forecasted by the Hadley global climate model results in a contraction of the species range.

Discussion

The species distribution models provide an approximation of the degree to which future climatic conditions are likely to alter a species range. This interpretation is based on predictions of climate change derived from two global climate models. These projected shifts in species range are an approximation based solely on expected changes in environmental conditions. The BioMove model will further refine the expected locations that species are likely to occupy by introducing constraints from disturbance, dispersal and competition (Hannah et al., 2008). The shifting of species ranges due to a changing climate has implications for forest management. Environmental conditions may no longer support some species. In other cases management actions may be taken to enhance survival, or protect key refugia based on the expected shift in species range.



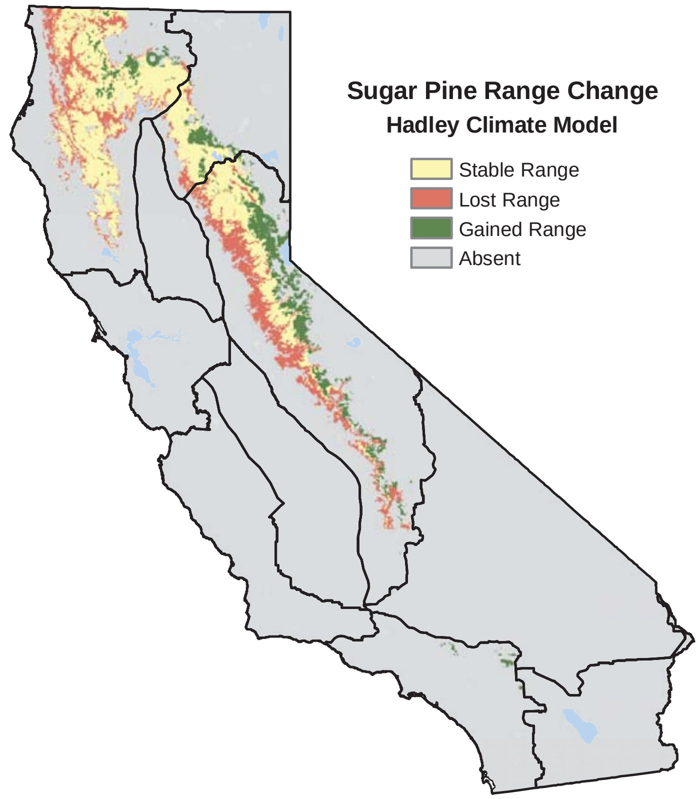


Figure 3.7.6.
Predicted shift in species range for sugar pine.
The map on the left shows an expanding range that is influenced by the warmer and wetter conditions predicted under the CCSM climate model. The map on the right predicts a contraction in species range that is influenced by the hotter and drier conditions forecasted by the Hadley climate model.
Data Sources: BioMove, UC Santa Barbara (2009); California Protected Areas Database (CPAD), GreenInfo Network (2009)

Beyond California: Bordering States

California is bordered by the Pacific Ocean to the west, Oregon to the north, to the east by Nevada and Arizona, and Mexico to the south. State borders can often complicate issues and means for their resolution. Issues vary by region, but several concerns are common to all of these cross-state areas including wildfire, water, insect and disease, energy and wildlife habitat. This chapter addresses some of these issues and challenges.

California is home to millions of acres of public lands including parks, forests, wilderness areas, wildlife refuges, grasslands and others. These public lands are managed by several different agencies including the Bureau of Land Management which manages over 15.2 million acres of land, the U.S. Fish and Wildlife Service, the National Park Service managing approximately 7.5 million acres of parks and recreation areas, California State Parks managing 1.5 million acres of parks, and the U.S. Forest Service that manages 20 million acres of forests and other lands. Many of these managed lands cross multiple state borders. Cooperative working relationships across borders aids in the efficient allocation of resources and sustainability of public lands.

KEY FINDINGS

- Drought conditions and water shortages are impacting many of the western states. These shortages are compounded by warming temperatures.
- Renewable energy policies are beneficial to the emerging industry of renewable energy generation. Many cross-state projects are being developed or awaiting approval.
- Wildfire concerns increase with drought conditions and warming temperature trends. Areas of concern include densely populated areas in the wildland urban interface (WUI), such as the Lake Tahoe area.
- Wildlife habitat decreases with urban development and deteriorating forest health. The indirect consequences of habitat loss can be devastating to ecosystems and conservation efforts.

- Movement of damaging insects and diseases across state or national borders is a critical concern for the health of our forests (wildland and urban) and rangelands.
- Non-native pests have a long history of causing severe damage to California forests. The potential for new damaging pests to arrive is great.

NORTHERN CALIFORNIA–OREGON BORDER

California counties bordering Oregon include Del Norte, Siskiyou and Modoc. Several national forests can be found in this area including the Six Rivers, Shasta-Trinity, Modoc, Klamath and Rogue River-Siskiyou. The ecological functions in each of these forests vary considerably, as do the conditions.

Fish (Salmonids) and Water

The Klamath River in Oregon and California was once the third most productive salmon fishery on the west coast, behind the Columbia and Sacramento Rivers. Today, the salmon runs are about 10 percent of their previous size, forcing closure of almost all ocean fishing of chinook salmon in Oregon and California for the past several years. The coho salmon is in such low numbers in the Klamath that it has been listed as threatened under the federal Endangered Species Act (ESA). The economic loss to California resulting from the closure of salmon fishing in 2008 was estimated at $255 million and more than 2,000 jobs. In 2009, the loss was even greater at $279 million and almost 3,000 jobs (Morse and Manji, 2009).

These are just a few of the unexpected results of dams having been built in the salmon migratory pathways without constructing salmon ladders or bypass channels. Instead, hatcheries were built to replace the loss of natural salmon runs. Federal biologists have indicated that there are several threats to salmon, including ocean conditions that produce very little food, an over reliance on hatchery fish that do not adapt to changes in conditions, and agricultural pesticides that contaminate the water.

Much of the water is controlled by the Klamath Project, one of the earliest federal reclamation projects dating back to the early 1900s. The Klamath Project provides irrigation water to agricultural and wildlife refuge lands, as well as flood control in the Klamath basin areas in south central Oregon and north central California (Bureau of Reclamation, 2000). The project diverts water from the Upper Klamath basin in Oregon for agricultural irrigation.

Conditions and demands have changed since the early 1900s and water quality in the Klamath has continued to decline over the years, resulting in the suspension of diversions in recent years. For the past several years, toxic algae caused by water heating and stagnation has spread downriver killing thousands of fish and resulting in public health warnings (Klamath Riverkeeper, 2009).

Pressure to restore the 300-mile migratory route for the salmon has been building for years, but agreement on how to approach the restoration has been elusive. In September 2009, a tentative agreement to remove four dams, (the Klamath Hydroelectric Settlement), was made between 28 parties including American Indian tribes, farmers, fishermen and PacificCorp, the hydroelectric company that operates the dams. If impacted parties agree to the plan in December 2009, the dams will be dismantled starting in 2020 (San Francisco Chronicle, 2009).

Estimates for dam removal and river restoration costs range from 75 to 175 million dollars. Under the agreement, the cost to remove the dams is capped at 450 million dollars. Oregon Pacific Gas and Electric customers would contribute up to $200 million, and if costs exceed this amount, California Pacific Gas and Electric would contribute another $250 million (U.S. Department of the Interior, 2009). The agreement proposal to retire 100 thousand acres above and around Klamath Lake and 30,000 acre-feet of water to be diverted to the lake has caused concern among the cattle industry (Beaver, 2009).

Late Seral Stage and Associated Habitat

Seral stages refer to the ecological development of plant communities from bare ground to a climax plant community. A late seral stage ecosystem generally is one that is distinguished by older trees and related structural attributes. Old growth encompasses the later stages of stand development that typically differ from earlier stages in a variety of characteristics which may include tree size, accumulations of large dead woody material, number of canopy layers, species composition and ecosystem function (U.S. Forest Service and U.S. Bureau of Land Management, 2001).

Late seral stage forests support a specific group of wildlife. Wildlife of special concern to Northern California and Southern Oregon include the northern spotted owl (*Strix occidentalis caurina*) and marbled murrelet (*Brachyramphus marmoratus*).

Northern Spotted Owl

The northern spotted owl is federally listed as a threatened species in California, Oregon and Washington. They generally inhabit older forests because of the abundance of structural characteristics required for nesting, roosting and foraging. They require a multi-layered, multi-species canopy with a high percentage of canopy closure. Suitable habitat areas have declined as a result of timber harvesting and wildfires. Subsequently, the northern spotted owl health and populations have also decreased (U.S. Fish and Wildlife Service, 2009).

More recently, barred owls (*Strix varia*) have invaded northern spotted owl territories, with negative impacts (strongly correlative) on northern spotted owl populations. In May 2008, the Northern Spotted Owl Recovery Plan was released to provide suitable habitat in a forest reserve-based system. This plan includes 133 owl conservation areas totaling nearly 6.4 million acres of federal land. In addition to the reserves, each state can make rules to govern timber harvests on non-federal lands. The California Forest Practice Rules provide for protection of habitat around nesting areas.

Marbled Murrelet

The marbled murrelet is federally listed under the Endangered Species Act as a threatened species in California, Oregon, and Washington. Marbled murrelets spend most of their lifes on the ocean, but nest in late seral stage forests. Breeding range extends from Bristol Bay, Alaska to Monterey Bay, California. They winter in the same range, but may go as far south as Southern California. In California, nests are generally found in coastal redwood (*Sequoia sempervirens*) and Douglas-fir (*Pseudotsuga menziesii*) forests. Suitable habitat areas have declined as a result of commercial timber harvesting and development. Consequently, marbled murrelet populations have also decreased (U.S. Fish and Wildlife Service, 2009).

The 1997 Marbled Murrelet Recovery Plan protected known nesting and habitat sites and sought to halt population decline. In June 2009, the U.S. Fish and Wildlife Service completed a five year status review indicating that despite the recovery efforts, the status was still critical, and the marbled murrelet remains listed as threatened.

Forest Insects and Disease

Spread of native and exotic insects and disease in California and from outside the state is a management concern. Opportunities for spread are found in unregulated transportation of goods such as firewood, Christmas trees, agricultural and nursery products. Movement of soil on vehicles and hiking boots can transport agents such as Port-Orford-cedar root disease and sudden oak death.

Port-Orford-Cedar Root Disease

Port-Orford-cedar grows in the coastal region of Oregon and Northern California. It can grow in a variety of sites including stream banks, bogs, sand dunes and deep productive soils. The disease is considered a “water mold” and is more prolific in sites of slow moving water and those with poor drainage. Infected trees show rapid decline with crowns dying and root collars displaying a cinnamon-brown stain.

The disease was found in several river locations in Siskiyou and Shasta Counties in 2001. Removal treatments made to contain the spread appear to be successful with no upstream spread observed in 2008 (California Forest Pest Council (CFPC), 2008).

Sudden Oak Death

Over three million tanoaks, black oaks and coast live oaks have died in the past decade as a result of *Phytophthora ramorum* infection, or sudden oak death. Ornamental plants such as camellias and rhododendrons are also susceptible to this fungal infection. Infestation has impacted the central coast area of California and the southwest corner of Oregon, causing increased fire hazard and impact to wildlife habitat. Other tree species can be stressed by the infestation leaving them vulnerable to other pest attacks and further deteriorating forestlands.

Bark Beetles and Wood Borers

Bark beetles are one of the most destructive insects to the coniferous forests in California, impacting 4.2 million forested acres since 1994. There are many beetle genera, but the types of major concern in California include mountain pine bark beetle, Jeffery pine bark beetle, western pine bark beetle, fir engraver beetle and the flatheaded fir borers. Beetles cause destruction in forests by engraving and boring, girdling and spreading fungi in trees. Climate change influences the frequency, intensity and distribution of bark beetle outbreaks by affecting both the beetles, and the trees. Warming temperatures in the West allows bark beetles to have a greater effect on forests in higher latitudes and at higher elevations (Lawrence, 2009).

In Northern California, mountain pine beetle has killed many trees in previous years. Increased beetle activity was noted in the Modoc National Forest in 2008. Scattered outbreaks continued to occur in the Klamath National Forest and private land in Siskiyou County, causing extensive mortality in lodgepole pine (CFPC, 2008).

Douglas-Fir Tussock Moth

The Douglas-fir tussock moth (DFTM) is a defoliator of true firs and Douglas-fir in western North America. Severe outbreaks have occurred in British Columbia, Idaho, Washington, Oregon, Nevada, Arizona, New Mexico and California (Wickman et al., 1981). Severe outbreaks have occurred in California and Oregon regions over the years. Outbreaks usually occur at several year intervals. The DFTM is considered one of the most serious defoliators in North American forests. Between 1947 and 1974 more than 1.2 million acres of U.S. forests were treated for DFTM. Intensive monitoring programs are in place to detect and control outbreaks early (European Plant Protection Organization, 2009).

The Bear Mountain area in Shasta County experienced a Douglas-fir tussock moth outbreak that lasted from 2005 to 2007 with approximately 30 acres of elevated tree mortality. In 2008, traps were installed and the data collected indicate the lowest count of DFTM in 13 years. There was no detection of DFTM defoliation or outbreaks in 2008 (CFPC, 2008).

Wildfire

The suite of wildfire-related issues in the region mirrors those found on both sides of the border and are well documented in other chapters. They include increasingly more frequent large and high-intensity fires requiring significant restoration efforts and fire threats to communities. Of particular note for this region was the 2002 Biscuit Fire, which burned almost 500,000 acres in southern Oregon and Northern California, and resulted in significant controversy over the role and efficacy of salvage logging activities on fire hazard and ecosystem recovery (Donato et al., 2006). The other notable fire-related issue endemic to the region is damage to native anadromous fish populations, particularly in the Smith River and the Klamath River watersheds. This damage may arise from either direct impacts from high severity wildfire or indirect or cumulative impacts from forest management actions (e.g., logging, road building) designed to reduce fire hazards.

EASTERN CALIFORNIA–NORTHERN NEVADA BORDER

California counties bordering northern Nevada include Modoc, Lassen, Sierra, Nevada, Placer and El Dorado. National forest land found in this area includes the Tahoe and El Dorado National Forests and the Lake Tahoe Basin Management Unit. The area around Lake Tahoe is of special concern to California and Nevada because of its uniqueness and its sensitivity.

Northeastern California, southeastern Oregon and northern Nevada are dominated by the shrub-steppe and conifer forest habitat type (Barbour et al., 2009). Like other places in California, the interruption of the fire cycle, overgrazing and invasive plants, have combined to drastically change those habitats. For these reasons, even the previously most abundantly occurring animals have been in decline for several decades (Bunn et al., 2005). Interestingly, the shrub-steppe suffers from fire occurring either too often or not often enough, depending on the elevation (Sugihara et al., 2006). Overgrazing by sheep, cattle and wild horses has lead to an increase in invasive grasses (i.e., cheat grass (*Bromus tectorum*)). This, in turn, has increased the frequency of fires that are deadly to shrubs, thus decreasing the amount of shrub-steppe habitat available (Young and Evans, 1978). Simultaneously, the lack of fires at higher elevations in combination with the relatively wetter time period of the last 50 years has lead to an increase in juniper woodland, which shades out shrubs. Grazing pressure has also negatively affected those areas with high biodiversity; springs, riparian zones, montane meadows and aspen groves, which are a small fraction of the area. If managed well, grazing can be beneficial to sensitive plants and animals (Marty, 2005). With grazing being a major economic driver in the region, it will continue to affect habitat.

Water

Lake Tahoe is a deep fresh water lake spanning 194 square miles across the California and Nevada border. The annual average deep water transparency for Lake Tahoe between 1967 and 1971 was 97.4 feet; in 2007 it was 70 feet. The decline in water quality is due to pollution of fine sediment and nutrients, largely from stormwater runoff in urban upland areas (Lahonton Regional Water Quality Control

Lake Tahoe is a deep fresh water lake spanning 194 square miles across the California and Nevada border.

Board, 2009). The Lake Tahoe basin is vulnerable to invasive species because of the many streams and rivers feeding into the lake. Non-native mollusks can have detrimental impacts on native wildlife, fisheries and ecosystems. The Asian clam (*Corbicula fluminea*) is a fast growing invasive species that has been in the lake for about 10 years and is replacing the native pea clam. Researchers are concerned that the Asian clam population may be able to aid an invasion of quagga and zebra mussels (University of California, Davis. 2009). Many non-native species are transported to new locations by recreational boaters. Boat inspections have been implemented to prevent the introduction of quagga and zebra mussels into Lake Tahoe and other lakes in the Tahoe basin.

Recreation

Lake Tahoe and its forested watershed provide drinking water and various recreational opportunities including fishing, boating, swimming, camping and picnicking. Water quality conditions in the lake have been impacted by historical logging in the basin combined with urban and residential development around the lake (Murphy et al, 2000). These management activities have diminished water clarity and quality and currently the lake is listed under the Clean Water Act as impaired for both sediment and nutrients (nitrogen and phosphorus).

Fuel Load Management

Threat of wildfire in the Lake Tahoe area is a top concern, especially during drought years. In June 2007, the Angora Fire destroyed 254 homes and 3,100 acres. This devastation resulted in a bi-state review of fire prevention and fuels management practices in the basin area. The review recommended several strategies such as increased defensible space, new development standards, education and implementation of a 10-year plan to reduce fuel loads (California-Nevada Tahoe Basin Fire Commission, 2008).

Current forest stand conditions in the basin contain dense, over-stocked stands with high fuel loads. Bark beetle caused tree mortality is increasing as drought conditions persist. Unhealthy forests cannot maintain healthy wildlife habitat, causing wildlife to expand their search for food frequently to urbanized areas. Improving forest conditions by reducing fuel loads increases public safety and reduces the risk of habitat loss from catastrophic wildland fire. Non-hazardous logs and snags are purposely retained during fuel reduction efforts to provide perches, nesting and cover for wildlife habitat (USFS, 2004).

Biomass

Plans to build a biomass facility in the Tahoe basin to utilize wood scraps produced in urban areas and during fuel reduction operations are being discussed. In the past, material has been burned or trucked 30 miles to the nearest biomass facility (Fletcher, 2009). Creating a biomass initiative could encourage new technologies to produce electricity and reduce the amount of forested lands cleared with prescribed burns (Holl, 2007).

Wildfire

The possible influences of large wildfire on sedimentation and nutrient pollution into the lake as well as the high potential for loss of life and property have been a great concern in the Tahoe basin. The basin has historically exhibited relatively low rates of wildfire in the modern era, compared to other similar areas of the Sierra bioregion (CAL FIRE, 2009). However, the recent 2007 Angora Fire, which destroyed 254 structures in the basin's wildland urban interface, triggered significant debate over forest restoration activities and effectiveness on U.S. Forest Service lands (Safford et al., 2009; Moyle et al., 2006). There was relatively little fallout regarding impacts on lake water quality, likely owing to the massive investment in rehabilitation and restoration implemented in the months following the early-summer fire. However, fire-related impacts on watershed health and threats to life and property persist as a key issue in the basin and elsewhere.

EASTERN CALIFORNIA–SOUTHERN NEVADA–ARIZONA BORDER

California counties bordering southern Nevada and Arizona include Alpine, Mono, Inyo, San Bernardino, Riverside and Imperial. The El Dorado, Inyo and Humboldt-Toiyabe National Forests and Death Valley National Park are located in this area. Cross state concerns in this area include the Colorado River, renewable energy sources, recreation opportunities and forest health in the southeast Sierra bioregion.

Recreation and Forest Health
California's diverse topography is exemplified in the California and Nevada border region where the mountains meet the desert. Mount Whitney, the highest point in the 48 contiguous United States, and Death Valley, the lowest point in the United States, lie only 76 miles from each other in this region. The Inyo National Forest contains over two million acres and offers multiple recreational opportunities including mountain climbing, wilderness hiking, camping and fishing. Many of the recreational facilities were built more than 30 years ago and do not support today's recreational preferences. A Recreation Site Facility Master Plan process has been implemented to guide the restoration.

Forest health is threatened by bark beetle activity causing over 140,000 acres of mortality in the Inyo National Forest during the past five years (USFS FHP, 2008). Jeffery pine mortality was seen in much of the Jeffery pine stands in Inyo National Forest during 2008. Mortality was observed in groups and single trees (CFPC, 2008).

Water

The Colorado River basin is the largest watershed in the American Southwest, draining approximately 246,000 square miles through portions of seven western states from the Rocky Mountains in Colorado to the Gulf of California. The threats to this ecosystem are numerous. Dams created to hold water for irrigation and residential use have altered the water flow blocking migratory paths for fish, and changing water temperatures and sediment regimes. Very little of the Colorado River actually flows to the Gulf of California because much of it is siphoned off in Arizona and Southern California for residential and irrigation water supply needs. Drought conditions and increased population have amplified the water shortage issue and water disputes have developed as demands exceed the supply available. Modification of the natural flow of the river has also created loss of wetlands and habitat for native species and altered the Colorado River aquatic ecosystem (Grahame and Sisk, 2002). In the Colorado River delta area, wetlands have been reduced by 80 percent due to water management practices, and wetland restoration has become critical for many bird and fish species (Hinojosa et al., 2005).

Renewable Energy

California has implemented policies that support increased generation of electricity from renewable resources. Several projects and initiatives have been adopted to generate renewable power. Projects may be cooperative efforts with neighboring states as renewable infrastructure is built and technologies developed. Current efforts include:

- *Renewable Energy Transmission Initiative (RETI)*: A statewide initiative to help identify the transmission projects needed to accommodate renewable energy goals, support energy policy, and facilitate transmission corridor designation and generation citing and permitting. RETI will assess competitive energy zones in California and possibly neighboring states (CEC).
- *Renewable Energy Coordination Office*: Initiative by U.S. Department of Interior to expedite the leasing and production of renewable energy resources on public lands in the West, with offices in California, Nevada, Arizona and Wyoming. Proposed wind and solar projects that could be ready for construction by the end of 2010 include more than 5,300 megawatts of new capacity, enough to power 1.8 million homes, and would create more than 48,000

project construction jobs (U.S. Department of the Interior, 2009).

- *California Renewable Energy Initiative*: Signed in October of 2009, this initiative will create a "Renewable Energy Policy Group to guide the cooperative work; develop a strategy to identify areas suitable and acceptable for renewable energy development; identify renewable energy zones based on renewable energy development potential and environmental, wildlife, and conservation criteria; prioritize application processing for solar development in renewable energy zones; and coordinate with federal and state agencies to identify energy and transmission needs, as well as to designate transmission needs and corridors" (U.S. Department of Energy, 2009).
- *California Renewables Portfolio Standards (RPS)*: Established by SB 1078 (2002) and accelerated under SB 107 (2006), this requires electric corporations to increase acquisition from eligible renewable energy resources by at least one percent of retail sales per year, until they reach 20 percent by 2010 (California Public Utilities Commission, 2009). Executive Order S-14-08 (2008) established a target of 33 percent renewables by 2020, as recommended in the Energy Action Plan II.
- *Energy Corridors*: In response to the Energy Policy Act of 2005, 38 National Forest Plans were amended in 2009 to identify locations of corridors suitable for future energy transmission infrastructure across forestlands. The corridors offer a way to meet public energy needs and minimize impact to land and surface resources. Participating states include Arizona, California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington and Wyoming (USFS, 2009). Energy corridors may disrupt wildlife habitat and populations (Western Governors' Association, 2008)
- *Private Projects*: Several private projects await approval and permitting, while many others are currently generating renewable energy from wind and solar. Many of these projects cross state lines and are cooperative ventures. Projects include Western Wind Energy Corporation (WND), a company owning 500 wind turbines with 34.5 megawatt (MW) capacity and an additional 131 MW expansion power agreements in Arizona and California. WND owns additional development assets for both wind and solar energy in California, Arizona, and Ontario, Canada (WND, 2009). The Agua Caliente project includes construction of a 290-megawatt photovoltaic farm on private land in Arizona with power to be supplied to California Pacific Gas and Electric (PG&E); if the project is approved, construction will begin in 2010 (Woody, 2009). BrightSourceEnergy headquartered in Oakland, California is a producer of large-scale solar power plants. The California Public Utilities Commission recently approved contracts between BrightSourceEnergy and PG&E to supply 1,310 megawatts to serve California customers (California Public Utilities Commission, 2009).

SOUTHERN CALIFORNIA–MEXICO BORDER

Southern California counties bordering Mexico are San Diego and Imperial. The Cleveland National Forest in San Diego County extends within five miles of the Mexico border. Management of border issues is a significant concern for the U.S. Forest Service. Concerns in this area include pollution, fire activity from illegal immigration, movement of wildlife and disease or insect transportation into the United States.

Pollution

Pollution concerns include air, water and trash. In testimony to the U.S. House of Representative, a former Forest Supervisor discussed the impacts of illegal border activity on national forest lands (USFS, 2006). There are 1.5 million acres of national forest lands within 50 miles of the Mexican border, managing these lands is of significant concern. Issues in the Cleveland National Forest caused by cross-border violators include the creation of new trails, abandoned campfires and large amounts of trash. In 2005, over 370 acres of national forest burned due to illegal campfires and over four tons of trash was removed (USFS, 2006).

Water pollution in the New and Tijuana Rivers is a concern. The New River has been referred to as the most severely polluted river of its size in the United States, flowing 15 miles through Baja California and then to the Salton Sea. New River contaminants include agricultural and chemical runoff from the United States (18.4 percent) and Mexico (51.2 percent), sewage from Mexicali (29 percent), and manufacturing plants in Mexico (1.4 percent). Where the river crosses at the border near Calexico, California about 100 contaminants can be detected. In 2005, Senate Bill 387 provided funding for the New River Improvement Project.

The Tijuana River flows through Mexico for most of its 120 mile length crossing into California for the lower five miles, ending at the 2,500 acre Tijuana estuary in Imperial Beach, south San Diego County. Up until the early 1990s, uncontrolled discharges of raw wastewater from Mexico flowed untreated into San Diego beach areas. In 1997, an International Wastewater Treatment plant opened to treat the water and catch trash in basins before the polluted water could flow to the coast. Population growth in Tijuana has led to more pollution and demands on the treatment plant. During the winter of 2004 and 2005, silt and sand burst through the catch basins and buried 18 acres of salt marsh (Chang, 2008). Several conservation projects are being conducted to restore the marshlands and decrease the amount of pollution coming from Mexico.

Tijuana forms part of the San Diego-Tijuana Metropolitan Area, the total population of which has been estimated to be just over 5 million in 2009, making it the 22nd largest metropolitan area in the Americas (World Gazeteer, 2010). The manufacturing and trade base in Tijuana has also increased resulting in more cross-border activity, and more pollution resulting from factories and increased transit trips. The San Diego-Tijuana Air Quality Task Force was created under the U.S.-Mexico Border 2012 Environmental Program. One of the goals of this program is to identify major sources of air pollution and define strategies to reduce emissions (EPA, 2007).

Wildlife

Barrier fences and walls being constructed along the Mexico border to reduce illegal activities are causing considerable environmental concern. Human activity (vehicular traffic, amplified noise, artificial lighting) associated with the barrier can affect how animals behave, which may lower survival rates (Oregon State University, 2009). Biologists have reported that the fence could threaten wildlife and significantly alter movement patterns and connectivity of wildlife populations. Species with small populations will be broken into smaller isolated groups which may endanger some species by making them more susceptible to disease, extreme weather events and predators. Potential impact on the pygmy owl and bighorn sheep was evaluated; the pygmy owl flew lower than the height of the fence 75 percent of the time, and an impermeable barrier would isolate the bighorn sheep and reduce their genetic diversity. Modification to the barrier fence such as gaps in steep terrain for the sheep and perches and vegetation for the owls may help the movement of wildlife which may mitigate the effect of the fence to act as a barrier.

Insects and Disease

The spread of forest insect infestations and disease increase with unregulated cross-border activity and movement. The goldspotted oak borer, thought to have been brought to California on firewood illegally transported from Mexico, has been identified as the primary cause of oak mortality in Southern California. This oak borer attacks along the main stem and largest branches, weakening the tree by boring holes and leaving feeding larvae. Tree mortality occurs after continuous infestations. During 2008, approximately 1,400 dead oaks were surveyed in the Cleveland National Forest. The range of this non-native pest was 30 square miles in October 2008, investigation of impacts continues in 2009. An oak management task force has been formed to aid in the investigation and management action to mitigate the effects of the infestation (CFPC, 2009).

Pitch canker continues to be a concern in coastal counties, and there have been isolated infestations in Southern California. Although activity has slowed in 2008 due to drought conditions, the disease has killed thousands of Monterey pines, shore pine, grey pine, ponderosa pine and Douglas-fir. All native stands of Monterey pines in California have been infested by this fungus disease that girdles branches, roots, and trunks of pine trees.

Wildfire

Fire-related issues along the Mexican border, largely limited to San Diego County, involve international level cooperation, and have generally been highly successful examples of collaboration between the United States and Mexico as exemplified by the creation of the Border Area Fire Council comprising 32 separate fire management agencies from both countries. The Council's objectives are to "Establish and maintain relationships with Mexican government agencies, strengthen awareness and cooperation on biodiversity, and continue effective fire prevention, emergency response and suppression efforts." In addition to assisting in tactical collaboration on suppressing ongoing wildfires, the council has worked on developing and maintaining an international fuel break along the border, and in addressing the most problematic fire-related issue for the area, namely wildfires resulting from illegal immigration activities (Border Agency Fire Council, 2003).

MULTI-STATE RESEARCH PROGRAMS

Cooperative research and monitoring programs in forest management, fisheries, wildlife and watershed studies often follow ecoregional and habitat range boundaries. Examples of efforts include the young stand computer model CONIFERS (Ritchie, 2009), and the National Council for Air and Stream Improvement (NCASI) spotted owl study (NCASI, 2006).

California is a leader in climate change mitigation and adaptation planning and program implementation. The California Climate Action Registry was started by legislative action in 2001 to begin a registry and protocol development in anticipation of a cap and trade program in greenhouse gases (California Climate Action Registry). Since then, the Climate Registry was formed to continue the voluntary inventory reporting of greenhouse gas emissions beyond California borders and throughout North America. California emission reporting is being transitioned to the Climate Registry in 2009 to be counted in the national offsets program of the Climate Action Reserve which manages the U.S. carbon market.

California is also a member of the Western Climate Initiative (WCI), a group of independent jurisdictions working together on climate change at a regional level. All states and bordering countries that are interested in collaboration to combat climate change regionally are encouraged to participate in WCI.

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Appendix

Data and Analytical Needs

State forest resource assessments will identify, describe, and spatially define forest landscape areas where forestry program outreach and activity will be emphasized and coordinated...This component of a state's assessment should be geospatially based...States should identify information gaps as part of their assessment process. These geospatial information gaps will help focus future data development work at regional and national levels (excerpted from the U.S. Forest Service State and Private Forestry Farm Bill Requirement and Redesign Strategies).

KEY FINDINGS

Data Priorities – Framework Data

Framework data served critical functions in multiple Assessment chapters; in some cases data were insufficient or not current. Suggested action for each dataset is provided.

- *Vegetation*: Create and maintain statewide, consistent vegetation data that can be used for multiple purposes.
- *Development*: Explore options for statewide standardized parcel data to track residential and commercial development.
- *Land ownership*: Support and enhance efforts to capture and maintain parcel-based land ownership and protection status data.
- *Fire perimeters*: Continue and enhance collaborative efforts to update fire perimeters annually; improve completeness and quality of associated burn severity data.
- *Communities*: Develop an alternative method for mapping clusters of human settlement in unincorporated areas.
- *Tree mortality*: Continue USFS efforts to capture tree mortality by cause of death; develop a process for estimating data accuracy.
- *Forest survey data*: Enhance and adapt Forest Service inventory survey frequency and methods to meet near-term challenges related to climate change, fire and other threats, and better address urban forestry issues.

Data Priorities – Other Data

Suggested actions are provided for datasets that were critical for analyzing a single or small number of issues.

- *Fire Hazard Severity Zones*: Amend Government Code to include a reporting mechanism to track local government ordinances adopted in response to CAL FIRE's FHSZ recommendations.
- *Condition class*: Augment efforts to maintain and improve condition class data; capture management activities that can alter condition class; develop better techniques for applying the condition class metric to aggregated areas reflecting natural fire regimes.
- *Groundwater basins*: Create a more detailed statewide representation of groundwater basins with well locations, groundwater withdraws, recharge rates, and pollution levels.
- *Mountain meadows*: Systematically map mountain meadows statewide.

Data Gaps

There were several instances where critical data were not available to analyze important issues.

- *Exotic invasive species data*: Develop and maintain data for analyzing the threat from exotic invasive species.
- *Rangeland monitoring data*: Implement a comprehensive and consistent system to monitor rangeland condition and trends across all ownerships.
- *Energy use data*: Develop a method to measure energy use at a finer scale than counties.
- *Restoration data*: Establish a statewide database of all restoration projects and accomplishments.
- *Waterbodies beneficial uses*: Assemble a comprehensive list of beneficial uses for waterbodies.
- *In-stream flow data*: Develop detailed GIS based stream flow data to support estimating water supply.
- *Fisheries data*: Create stronger access to current data.
- *Riparian condition data*: Assemble a comprehensive riparian condition spatial dataset.

Analytical and Research Priorities

In addition to the need for better data, improved and if possible standardized analytical techniques would benefit future analyses.

- *Development projection*: Standardize statewide parcel data as a tool to project development and for establishing improved methodologies.
- *Ecosystem health*: Develop a standard methodology for analyzing ecosystem health and its various threats.
- *Forest growth simulation*: In order to better simulate alternative policies, programs, and scenarios, we must prioritize enhancements to components of the initial simulation model used for this assessment, such as disturbance regimes, benefits from ecosystem services, etc.
- *Wildlife habitat*: Continue current efforts by California Department of Fish and Game to identify critical habitats for restoration and protection priorities.
- *Statewide water balance model*: Develop a statewide model on a regional scale and incorporating climate change variables to significantly improve analysis of water supply.
- *Cumulative watershed impacts*: Standardize approaches to evaluate cumulative impacts to water quality from land management activities; comprehensively track management activities at the project level.
- *Climate change*: Increase funding to compile and distribute downscaled climate data from global climate models (GCM), and to develop appropriate methods for interpreting trends.
- *Soil organic carbon*: Complete high resolution statewide soils maps (SSURGO) and develop a standard methodology to estimate soil organic carbon base data from soil maps as a collaborative effort between NRCS and USFS.
- *Fisheries limiting factors*: Support additional research to better understand the interaction of fish and habitat. Develop appropriate analytical methods to identify where and how policies, programs, and projects can improve the status of fish populations.

DATA PRIORITIES

Analyses in the assessment chapters relied on data from various sources. Based on the summaries of data quality for each chapter, two main types of priority datasets were identified;

- Datasets that address multiple issues, sometimes called "framework data."
- Datasets that were a critical component for analyzing specific issues.

Data Priorities – Framework Data

Datasets that contributed to analyses in multiple chapters, their uses, and any concerns about their quality are shown in Table A.1.

Table A.1. Framework datasets used for multiple purposes in this assessment

Data Theme (Number of Chapters)	Uses	Quality Issues
Vegetation (11)	Ecosystems, timber asset, rangeland asset, wildfire threat, forest meadows, riparian cover, tree canopy (urban forestry), green infrastructure, vegetation types (reporting unit)	Outdated, inconsistent, inadequate for urban forestry
Development (8)	Undeveloped lands, housing asset, energy use	10 year census cycle inadequate to track/project development, too coarse in rural areas
Land ownership (7)	Developable lands, protected lands, recreation areas, federal/private (reporting unit)	Problems identifying protection status, missing Dept. of Defense and BIA lands
Fire perimeters (7)	Fire threat input, burn severity, condition class input	Missing perimeters, quality of severity data
Communities (6)	Reporting unit	Census data inadequate for unincorporated places, misses areas, outdated
Tree mortality (5)	Forest pest current damage/future threat	Unknown accuracy
Forest survey data (3)	Timber growth/inventory, carbon storage and sequestration, biomass potential, understocked and overstocked stands	10 year update cycle, concentration on timberland

Particulars of data needs, current status of data capture and maintenance efforts, and suggestions for future actions are summarized by general theme below.

Vegetation

Need: Vegetation data contributed to analyses in every assessment chapter. It was used to map and rank critical assets such as ecosystems, timber, rangeland forage, biomass, carbon storage, forest meadows and riparian areas (for water analyses), urban tree cover, and green infrastructure. It also contributed to defining major threats such as wildfire, climate change, and urban heat potential. Various data sources were utilized in this assessment as the "best available" data. This often resulted in using data captured at different scales and standards, and at various time periods – some captured as long as twenty years ago. Invariably, this had a negative impact on the quality of analyses. Finally, mapping efforts within the state have typically focused on non-urban lands and were inadequate for addressing urban forestry issues.

Status: Various stakeholders have signed a Memorandum of Understanding recognizing the importance of vegetation data and the value of a collaborative approach. However, to date funding has not been allocated to ensure that quality data are captured and maintained on a statewide basis with an adequate update frequency.

Suggested action: Allocate funds to create and maintain consistent statewide vegetation data that can be used for multiple purposes.

Development

Need: Development pressures are an ongoing threat to ecosystems, productive forest and rangeland (and agricultural) land, green infrastructure, watersheds and wildlife habitat. Also, housing and businesses are assets that are threatened by fire, forest pests, urban heat and air pollution. Development data was required for analyses in eight assessment chapters. Currently, the primary source for housing is the U.S. Census, which is captured at ten year intervals, by census block. The resolution of this data is coarse for rural areas, where scattered development occurs within huge census blocks.

Status: Nearly all California counties invest significant resources in maintaining digital parcel data, and most make the data publicly available in some form. However, it can be difficult or impossible to identify which parcels actually contain residential or commercial development. If the state would work with counties to develop a data standard and sharing agreements, and provide incentives for compliance, it could result in rich datasets for tracking the progression of development. The state sponsored a comprehensive needs analysis for use of parcel data by state agencies (Gooch and Marose, 2004). The state Geographic Information Officer has convened a working group and is exploring options for compiling standardized parcel data.

Suggested action: Continue to explore options for compiling statewide standardized parcel data from counties, which could be used to track residential and commercial development

Land ownership

Need: Land ownership and protection status data contributed to analyses in seven chapters: for defining developable lands versus protected areas; defining the recreation asset; and as a reporting metric, for example for federal versus private lands. Land ownership was derived from the California Protected Areas Database (CPAD) (GreenInfo Network, 2009), which is based upon county parcel data. However, not all counties contributed data to this effort, there are accuracy issues in certain counties, and protection status needs additional work, including consideration of lands managed by the Department of Defense and Bureau of Indian Affairs.

Status: CPAD is part of the national effort (PAD-US, 2009), and is being improved and updated regularly, but it is unclear whether this effort has guaranteed ongoing funding.

Suggested action: Support and enhance current efforts to capture and maintain parcel-based land ownership and protection status data.

Fire perimeters

Need: Fire perimeters are a data input that contributes to the development of critical datasets such as current fire threat, condition class, fire rotation, and Fire Hazard Severity Zones. Burn severity data associated with perimeters is critical for identifying wildfire-damaged areas in need of restoration. Existing fire perimeter data provided a high quality data input that contributed to analyses in seven chapters. Data concerns relate mainly to missing perimeters, and quality and completeness of the burn severity data.

Status: Fire perimeter data is not a budgeted item for CAL FIRE and other fire service organizations. However, the data have been developed and maintained using various federal grants, CAL FIRE staffing, and annual contributions of perimeters from the various collaborators.

Suggested action: Continue and enhance collaborative efforts between the various fire protection agencies in California to annually update fire perimeters and improve the completeness and quality of associated burn severity data.

Communities

Need: Communities were used as an analytical reporting unit in six chapters. Priorities assigned to these communities could influence their potential to receive federal grants for various purposes. This is especially significant for unincorporated clusters of development that were not identified as “places” in the 2000 census, and thus were not recognized as communities in the analyses. Some small rural communities were mapped as huge census “places” (for example, the small community of Hayfork in Trinity County is almost 100,000 acres), which caused analytical difficulties and influenced quality of the results. Finally, the census did not include development that occurred in unincorporated areas since 2000.

Status: CAL FIRE maintains a dataset of incorporated city boundaries, and annexations are provided by Board of Equalization on a continuous basis. There is currently no alternative to using census data for identifying unincorporated communities. Statewide standardized parcel data would potentially provide the basis for more detailed community mapping.

Suggested action: Develop an alternative method for mapping clusters of human settlement in unincorporated areas throughout the state.

Tree mortality

Need: Tree mortality data was used to map and rank the forest pest threat, which contributed to analyses in five chapters. This data will become increasingly important in monitoring climate change over time. The accuracy of this data is critical if used to develop and monitor effectiveness of policies and programs that mitigate threats.

Status: Tree mortality data is captured by the U.S. Forest Service Forest Health Protection staff on an annual basis using aerial survey methods.

Suggested action: Continue current efforts by the U.S. Forest Service to capture tree mortality by cause of death, and develop a process for estimating data accuracy.

Forest survey data

Need: Forest inventory data provides for measuring and monitoring timber inventory and growth, carbon storage and sequestration, biomass energy potential, and understocked and overstocked stands. There are increasing threats, including climate change, to forest resources, and whether the current inventory frequency and methods provide the range of data to develop and monitor effective programs needs to be evaluated. The increasing importance of urban forests suggests a need to expand the extent of survey efforts to include urban areas.

Status: Current efforts by the U.S. Forest Service's Forest Inventory and Analysis (FIA) program annually updates plot data on ten percent of California, with a complete inventory every ten years. Sampling procedures were designed for estimating timber statistics such as inventory and growth to a specific confidence level over broad timber resource regions of the state.

Suggested action: Continue current forest inventory efforts by the U.S. Forest Service, and consider enhancing and adapting survey frequency and methods as needed to meet near-term challenges related to climate change, fire and other threats, and to better address urban forestry issues.

Data Priorities – Other Data

Fire Hazard Severity Zones (FHSZ) in Local Responsibility Areas (LRA)

Need: FHSZ data was used to represent fire threat to communities.

Status: FHSZ data for Local Responsibility Areas (LRA) was based on CAL FIRE recommendations provided to local government. There is no required reporting mechanism that allows CAL FIRE to efficiently track which specific local ordinances have been adopted by local government in response to these recommendations.

Suggested action: Amend the Government Code to ensure there is a reporting mechanism that allows CAL FIRE to track local ordinances that have been adopted in response to FHSZ recommendations.

Condition Class

Need: Condition class was used in assessment analyses to develop landscape-level wildfire threat, which provides a measure of ecosystem susceptibility to damage from large fire events. There has been an identified need to develop a more robust methodology for analyzing wildfire and ecosystem health. It is likely that condition class will play a larger role, for example as a contributing factor for which stands and ecosystems are priorities for restoration.

Status: Condition class is currently derived from the best available vegetation data combined with measures of expected fire frequency and fire behavior.

Suggested action: Augment current efforts to maintain and improve condition class data, in part through improved vegetation mapping, by capturing management activities that can alter condition class, and better techniques for applying the condition class metric to aggregated areas reflecting natural fire regimes.

Groundwater basins

Need: Groundwater basins are a critical resource facing threats such as drawdown and pollutants. Information is needed on condition and use of groundwater basins (e.g., rates of withdraws and recharge).

Status: Bulletin 118 from Department of Water Resources provides periodic information on the status of Groundwater in California:

http://www.water.ca.gov/groundwater/bulletin118/bulletin118update2003.cfm

Suggested action: Create a more detailed statewide representation of groundwater basins that depicts monitoring well locations, groundwater withdrawals, recharge rates, and pollution levels.

Mountain meadows

Need: Mountain meadows are an important component of watershed function. Since they typically occur as smaller inclusions within larger vegetation types, they are often poorly represented by bioregional vegetation mapping efforts.

Status: Currently, the USFS provides a detailed inventory of meadows on the lands that they manage, but there is limited information on private lands.

Suggested action: Support a systematic effort to map mountain meadows, ideally as part of a comprehensive vegetation mapping strategy.

DATA GAPS

There were numerous cases where the quality of an analysis was compromised or an analysis could not be conducted due to missing data; each is described below.

Exotic invasive species

Need: Exotic invasive species were identified in this assessment as a significant threat to ecosystem health, wildlife habitat, timber and rangeland production, and green infrastructure. In addition, they can influence threats such as wildfire by altering fuel conditions and natural fire regimes.

Status: The threat from exotic invasive species was not effectively analyzed due to lack of quality statewide data. Data needed for each pest would include current extent, current and potential future damage, extent and effectiveness of control efforts, etc.

Suggested Action: Develop and maintain statewide data for analyzing the threat from exotic invasive species.

Rangeland monitoring

Need: Assessing current condition and trends in rangelands would allow for development of more effective policies and programs targeted towards protecting and restoring priority rangeland areas. Rangelands are complex systems, and an effective monitoring system would address factors such as soil erosion, water quality, riparian condition, changes in extent of rangeland vegetation, and impacts of exotic invasive species.

Status: There are numerous efforts to capture certain factors related to rangeland condition, but there is no consistent comprehensive statewide system similar to Forest Survey and Forest Health Monitoring on forestlands.

Suggested Action: Implement a more comprehensive and consistent system to monitor rangeland condition and trends across all ownerships in California.

Energy use

Need: Energy use is a threat component that can help prioritize areas for tree planting or maintaining existing tree canopy in urban areas. However, energy use data more specific than at the county level was not identified; housing density and commercial development were used as a proxy for energy use. Spatially explicit energy use data could identify areas that are more or less energy efficient than others, for example, due to local ordinances that set energy efficient building standards, or where different technologies can be applied (e.g., swamp coolers versus air conditioners). Such data could also prove useful in measuring the effectiveness of tree planting efforts and other projects and policies to improve energy efficiency.

Status: Data related to energy use at a finer scale than the county level was not available for assessment analyses.

Suggested Action: Develop a method to measure energy use at a finer scale than the county.

Restoration data

Need: With projects funded by a variety of state, federal, and NGO sources, it is difficult to track current restoration efforts and determine the effectiveness of investments. An inter-jurisdictional repository for all restoration projects could also encompass monitoring of restoration projects which would facilitate tracking the effectiveness of restoration strategies.

Status: There is a considerable amount of monitoring and reporting of restoration efforts, but no collective inter-jurisdictional repository.

Suggested Action: Establish a statewide database of all restoration projects across ownerships to track forest and rangeland restoration efforts and the success of projects.

Waterbodies beneficial uses

Need: Better information is needed to evaluate water resource assets and determine the highest priorities for protecting water quality.

Status: This information is collected independently by each of the Regional Water Quality Boards.

Suggested action: Regional Water Quality Control Boards need to assemble a comprehensive list of beneficial uses for waterbodies.

In-stream flow data

Need: Additional information is needed on the surface runoff and stream flow in upper watersheds to assist in developing priorities for watershed protection.

Status: The California Data Exchange Center (CDEC), managed by the Department of Water Resources maintains and distributes information on stream flow.

Suggested action: Develop more detailed statewide GIS-based stream flow data to support estimating water supply.

Fisheries data

Need: Fish are a critical resource facing a variety of threats, with some populations declining to the point of an official listing as threatened or endangered. A more comprehensive system for accessing data related to fish is needed to prioritize restoration and conservation of landscapes and habitats important for fish survival.

Status: Lack of access to high quality data sources was a limiting factor for analyzing fish in this assessment.

Suggested Action: Create a more comprehensive system for accessing current data related to fish for prioritizing restoration and conservation of landscapes and habitats important for fish survival.

Riparian condition

Need: Riparian areas are a critical asset for water quality, fish habitat, and wildlife habitat. Riparian areas have undergone extensive modifications, and many areas are currently in need of restoration.

Status: The U.S. Forest Service and BLM have captured riparian condition on all lands under the Northwest Forest Plan. California Department of Fish and Game has intensive stream-reach riparian condition data on all streams that have been surveyed, but the data are not all spatially linked. Statewide GIS data of riparian condition would assist in the analysis of water quality as well as wildlife and fish habitat.

Suggested Action: Fund an effort to assemble a comprehensive riparian condition spatial dataset.

ANALYTICAL AND RESEARCH PRIORITIES

The assessment chapters include various analyses, and the specific methodologies are documented in detail online (http://frap.fire.ca.gov/assessment2010.html). In some cases, there was an identified need to improve current analytical methodologies, or to conduct additional research. For each identified need, a suggested action is provided below.

Development projection

Need: Development is a significant threat that impacts wildlife habitat, working landscapes, water quality, and green infrastructure.

Status: The assessment identified the EPA's ICLUS tool (http://cfpub.epa.gov/ncea/global/recordisplay.cfm?deid=216195) as a reasonable starting point for looking at future development patterns. However, projection methods typically rely on census data, which has significant limitations. Standardized statewide parcel data would provide a much richer dataset to improve methods for projecting development.

Suggested action: Standardize and create stronger accessibility to statewide parcel data.

Ecosystem health

Need: Due to the lack of a common framework for defining and analyzing ecosystem health, a measure of ecosystem health was developed for this assessment which analyzed the impacts of development, wildfire and forest pests.

Status: There was no prior methodology for analyzing impacts of various threats on ecosystem health and numerous questions remain that should be answered prior to our next assessment cycle, for example:

- How are ecosystems defined, mapped and ranked across the landscape?
- Which ecosystems are more sensitive or resilient as related to fire or forest pest damage?
- At what point do natural processes such as fire and forest pests go beyond being a normal part of natural cycles and require human intervention?
- Which fire or forest pest damaged areas are most in need of restoration? Which are most likely to have a favorable response to various restoration treatments?

Suggested action: Develop standard methodologies for analyzing ecosystem health and its various threats as a collaborative effort between ecologists, fire scientists, pathologists, entomologists, other professionals and stakeholders.

Forest growth simulation

Need: To meet increasing demands from forestlands, particularly for ecosystem services under more diverse and magnified threats, California will need to revise or adopt new policies and programs. Modeling forest growth and management, future economic and non-economic benefits, and disturbance regimes from fire and forest pests under various scenarios can strongly inform policy direction.

Status: An initial simulation model was developed for this assessment using FIA field plots, standard growth and yield models, and stylized disturbance regimes resulting in initial estimates related to carbon storage and sequestration. A more robust model is needed to more fully address forest management options, ecosystem services, and disturbance regimes.

Suggested Action: CAL FIRE will lead an effort to improve the initial simulation model by identifying and prioritizing improvements to its components. Model support and development will be done in cooperation with other stakeholder agencies. Model run requests from policy bodies such as the Board of Forestry and Fire Protection and interagency groups will be supported to the extent that resources allow.

Wildlife habitat

Need: California natural areas are rapidly diminishing making it challenging for the California Department of Fish and Game to meet its mission to preserve, conserve and manage wildlife resources to sustain all wildlife species, and to protect and preserve native species that are experiencing significant decline.

Status: The California Department of Fish and Game is working on the Areas of Conservation Emphasis (ACE) project, which is expected to be completed in 2010. Ideally ACE will provide spatial data related to conservation priorities, as well as a robust methodology to identify areas in the future as conditions change.

Suggested action: Continue current efforts by California Department of Fish and Game to identify critical habitats for protection priorities.

Statewide water balance model

Need: With increasing pressure on water resources, the state of California needs a statewide assessment of water inputs and outputs. A water balance model would contribute to understanding water supply and water quality parameters.

Status: No statewide water balance model currently exists.

Suggested action: Develop a statewide water balance model at a regional scale and incorporating climate change variables to significantly improve the analysis of water supply.

Cumulative watershed impacts

Need: Cumulative impacts from forest management and other land management activities can adversely affect water quality. Spatial data is needed on the extent and types of management activities that are occurring. Standardized methods for evaluating cumulative impacts from forest management are also needed.

Status: There is extensive information collected by CAL FIRE on timber harvesting and other types of vegetation management. The U.S. Forest Service and other federal agencies have also developed detailed databases on management activities. Additional work is needed to integrate databases across agencies.

Suggested action: Adopt standardized approaches to evaluate cumulative impacts to water quality from land management activities; this requires consistent and comprehensive tracking of management activities at the project level.

Climate change

Need: Higher resolution data is needed that predicts trends in climate parameters that have been derived from global climate models (GCM). Methods for interpreting data and displaying trends would promote its use and integration into land use planning.

Status: unknown

Suggested action: Increase funding to compile and distribute downscaled climate data from global climate models, and to develop appropriate methods for interpreting trends.

Soil organic carbon

Need: Current statewide estimates are based on coarse resolution soil databases. These estimates could be improved by further development of higher resolution soils databases derived from SSURGO.

Status: NRCS is currently developing a class based method to estimate soil organic carbon at a regional level using NASIS soil maps, but there is currently no statewide effort or technical review.

Suggested action: Complete high resolution statewide soils maps (SSURGO) through a collaborative effort between NRCS and USFS, and develop a standard methodology to estimate soil organic carbon base data from soil maps.

Fisheries limiting factors

Need: Analysis of fish was severely limited due to the need for a more comprehensive understanding of the current status of fish habitat and populations, limiting factors for fish survival, and the relative impact of the various threats on fish populations.

Status: The interaction of fish populations and their habitat and the diverse threats that impact them is complex. Several watersheds have limiting factors analyses, especially those with special status species and undergoing a TMDL process. The current lack of knowledge, quality data, and appropriate analytical methods limits effectively addressing the problem of declining fish populations.

Suggested Action: Conduct additional research to better understand the interaction of fish populations and habitat, limiting factors for fish survival, and the relative impact of the various threats on fish populations. Likewise, develop appropriate analytical methods to identify where and how policies, programs, and projects can improve the current status of fish populations.

Glossary

Aboveground Carbon Stocks: Carbon stocks refer to a distinct pool or reservoir capable of accumulating and releasing carbon. Aboveground carbon stocks refers to the amount of carbon stored in the living biomass of forest trees and plants, and dead wood and litter.

Acquisition: Parcels of land changing ownership through title transfer. It can refer to the purchase of land parcels by a public agency or non-profit organization for the purpose of providing a higher level of protection against threats.

Afforestation: The establishment of a forest in an area where preceding vegetation or land was not forest.

Age Class: An interval into which a tree is classified based on its age, often in ten year increments.

Agriculture: A Management Landscape class where the primary use is agriculture (crops, orchards, vineyards, irrigated pastures, and other farming activities). Human impact on natural ecological processes is significant, but presumed to retain some habitat value for some native species.

Air Pollution: The introduction of chemicals, particulate matter, or biological materials that cause harm or discomfort to humans or other living organisms, or damages the natural environment, into the atmosphere.

Anadromous Fish Watersheds: These are watersheds that coincide with the current range of anadromous salmonids. These watersheds provide important habitat for salmonids.

Assets: Items of commercial and non-commercial value, both natural and human-made. Examples are areas of buildings, commercial standing timber, and production of water.

Belowground Carbon Stocks: This includes living and dead roots, soil mesofauna, and the microbial community. In addition to this is the larger pool of soil organic carbon (see Soil Organic Carbon, SOC).

Biological Diversity: The variety of life over some spatial unit, used to describe all aspects of the broadly diverse forms into which organisms have evolved especially including species richness, ecosystem complexity and genetic variation.

Biological Legacy: A biologically derived structure or component inherent from a previous ecosystem including large trees, snags, or down logs.

Biomass: Plant material that can be converted into fuel. Harvested vegetation is taken to a biomass energy facility, a process which typically results in an improved vegetation condition in terms of potential fire threat, wildlife habitat capability, timber growth, or forage production.

Bioregion: An area that includes a rational ecological community with characteristic physical (climate, geology), biological (vegetation, animal), and environmental conditions.

Bioswales: Landscape elements designed to remove pollution from surface run-off water. Commonly placed in parking lots where substantial automotive pollution is collected by the paving and then flushed by rain.

California Wildlife Habitat Relationship System (CWHR): A state-of-the-art classification system for California's wildlife, containing life history, management, and habitat relationships information on 675 species of amphibians, reptiles, birds, and mammals known to occur in the state.

Carbon Dioxide: A colorless, odorless, non-combustible gas, present in low concentrations in the atmosphere (about three hundredths of one percent by volume). Carbon dioxide is produced when any substance containing carbon is burned. It is also a product of breathing and fermentation. Plants absorb carbon dioxide through photosynthesis.

Carbon Sequestration: The ability of forests or other natural systems to store carbon as biomass, thereby preventing it from collecting in the atmosphere as carbon dioxide. Forests absorb carbon dioxide from the atmosphere through photosynthesis. Carbon sequestration in forests is potentially reversible, however, because carbon contained in terrestrial ecosystems is vulnerable to disturbances such as wildfires or pest outbreaks, as well as land use conversions and other losses of carbon from management actions.

Carbon Sink: A carbon pool, such as a forest, that has more carbon flowing into it than flowing out. Forests are the good sinks because they are the most efficient means of taking carbon out of the atmosphere and storing it for long periods of time.

Carbon Storage: The process of storing carbon in leaves, woody tissue, roots, and soil nutrients.

Climate Change: Any long-term significant change in the "average weather" that a given region experiences. Average weather may include average temperature, precipitation and wind patterns.

Condition Class: A measurement of the degree to which a vegetation community has departed from its historical fire regime resulting in alterations of key ecosystem components such as species composition, structural stage, stand age, and canopy closure.

Conifer Forest: A land cover class with greater than 10 percent total tree canopy and of which 50 percent or more are conifers (30 percent or more for the CWHR type Montane-Hardwood Conifer). Conifer Forests are generally located in higher elevation mountainous areas and have commonly recognized evergreen tree species such as ponderosa pine (Pinus ponderosa) and redwood (Sequoia sempervirens).

Conifer Woodland: A land cover class where the overstory canopy occupied by trees is composed of 10 percent or more conifers and dominated by small, brushy tree species such as California juniper (Juniperus californica) and pinyon pine (Pinus edulis). Conifer Woodlands are generally located on the east side of the Sierra Nevada mountains and the southern regions of the state and characterized by an open canopy with intervening lower vegetation such as grasses and shrubs.

Conifer: Trees belonging to the order Gymnospermae, comprising a wide range of trees that are mostly evergreens. Conifers bear cones and have needle-shaped or scalelike leaves. In the wood products industry the term "softwoods" refers to conifers.

Conservation Easement: A restriction deeded to a qualified third party that permanently limits certain activities on real property in order to protect conservation values such as biodiversity, water quality, wildlife habitat, or carbon sequestration. The restriction stays with the property through successive owners. The restriction reduces the "highest and best" economic use of the property so that the property's value reflects only the allowed uses. If the landowner donates the easement as a gift, this reduction becomes a charitable tax deduction. An easement also can be sold to nonprofit or government agencies to provide revenue.

Corridors: Any space that improves the ability of a species to move among patches of their habitat.

CWPP (Community Wildfire Protection Plan): Authorized and defined in Title 1 of the Healthy Forests Restoration Act of 2003, the CWPP must be collaboratively developed (with agreement among local government, local fire departments and the state agency responsible for forest management), identify and prioritize areas for hazardous fuel reduction treatments, and recommend measures that homeowners and communities can take to reduce the ignitability of structures. In communities where a CWPP does not exist, first the capital must be developed to create a plan. This involves forming a local or county Firesafe Council, or going through the process to become a Firewise community. Once a CWPP is created, implementation requires specific actions and funding to conduct various projects and activities. Finally, a CWPP must be periodically evaluated and updated to reflect changing conditions.

Developed Land: A Natural Resource Inventory definition comprising large urban and small built-up areas, as well as roads and railroads not included in urban/built-up areas.

Development: A human settlement pattern measured by housing density. Includes “conversion”, where natural landscapes are assumed to lose virtually all of their ecological processes, and “parcelization”, where ecosystem processes are impacted but not completely lost. It is assumed that conversion occurs at an average housing density of five housing units per acre, and parcelization at 20 per acre.

Disturbance Regime: The characteristic pattern of natural or human caused events that disrupt the current physical and biological conditions of an area, such as floods, fires, storms and human activity that shape vegetative composition and seral stage.

Drought: A protracted deficiency of precipitation over an extended period of time, usually a season or more. This deficiency results in a water shortage for some activity, group, or environmental sector. Drought occurs is most all climatic zones, but its characteristics can vary from one region to another.

Easement: A right, such as a right of way, to make limited use of another’s real property. legal title to the underlying land is retained by the original owner for all other purposes. Easements are a tool for protecting lands against threats such as development, without the costs of actually acquiring and managing the land.

Ecological Integrity: The degree to which the components (types of species, soil etc.), structures (arrangement of components), and processes (flows of energy and nutrients) of an ecosystem, or natural community are present and functioning intact. Lands with high ecological integrity generally have not been subjected to significant human influences or disruption of natural processes, such as fire, floods, and nutrient and hydrological cycling.

Ecosystem Function: The operational role of ecosystem components, structure, and processes.

Ecosystem Health: The degree to which a biological community and its nonliving environmental surroundings function within a normal range of variability; the capacity to maintain ecosystems structures, functions and capabilities to provide for human need.

Ecosystem Processes: The flow or cycling of energy, materials, and nutrients through space and time.

Ecosystem Services: The beneficial outcomes, for the natural environment, or for people, that result from ecosystem functions. Some examples of ecosystem services are support of the food chain, harvesting of animals or plants, clean water, or scenic views. In order for an ecosystem to provide services to humans, some interaction with, or at least some appreciation by, humans is required.

Ecosystem Structure: Spatial distribution or pattern of ecosystem components.

Ecosystem: The interacting system of a biological community and its nonliving environmental surroundings.

Endangered Species: Any species, including subspecies or qualifying distinct population segment, which is in danger of extinction throughout all or a significant portion of its range.

Endemic Plant Richness: The total number of native plant species based on species range overlap as found in CalJep.

Endemic: Found only in a specified geographic region.

Energy Consumption: This threat represents the conditions that exist in some areas that lead to higher rates of electricity consumption. This includes climate, which is represented by average annual days over 90 degrees, and the presence of impervious surfaces such as parking lots which create "heat islands."

Exotic Invasive Species: Plants, animals, and microbes not native to a region which, when introduced either accidentally or intentionally, out-compete native species for available resources, reproduce prolifically, and dominate regions and ecosystems. Because they often arrive in new areas unaccompanied by their native predators, invasive species can be difficult to control. Left unchecked, many invasives have the potential to transform entire ecosystems, as native species and those that depend on them for food, shelter, and habitat, disappear (http://mdc.mo.gov/nathis/exotic/).

Fire Frequency: A broad measure of the rate of fire occurrence in a particular area. For historical analyses, fire frequency is often expressed using the fire return interval calculation. For modern-era analysis, where data on timing and size of fires are recorded, fire frequency is often best expressed using fire rotation.

Fire Prevention: This includes various precautions that are taken to prevent or reduce the likelihood of a fire (Wikipedia). Specific fire prevention tools include education, law enforcement, inspections, etc.

Fire Regime: A measure of the general pattern of fire frequency and severity typical to a particular area or type of landscape: The regime can include other metrics of the fire, including seasonality and typical fire size, as well as a measure of the pattern of variability in characteristics.

Fire Rotation: An area-based average estimate of fire frequency, calculated as the length of time necessary for an area equal to the total area of interest to burn. Fire rotation is often applied to regionally stratified land grouping where individual fire-return intervals across the variability of the strata (i.e., the fine scale pattern of variation in timing of fires) is unknown, but detailed information on fire size is known. Hence, fire rotation is a common estimate of fire frequency during periods of recorded fire sizes.

Fire Suppression: This is the act of extinguishing destructive fires (Wikipedia). In areas that burn too frequently, fire suppression infrastructure (engines, personnel, etc.) may be augmented in order to increase the effectiveness of extinguishing ignitions before they can spread.

Fire Threat: An index of expected fire frequency and physical ability to cause impacts. Components include surface fuels, topography, fire history, and weather conditions.

Forage: Browse and herbage that is available and acceptable to grazing animals.

Forb: A broad-leafed herb other than a grass, especially one growing in a field, prairie, or meadow.

Forest Health: The capacity of a forest for renewal, for recovery form a wide range of disturbances, and for retention of ecological function, while meeting the current and future needs of people for desired levels of values, uses, products, and services.

Forest Inventory and Analysis (FIA): A plot-based survey and statistical analysis with representative field based plots of all forest lands outside the National Forest System. Every decade, the Pacific Resource Inventory, Monitoring and Evaluation program (PRIME) of the Pacific Northwest Research Station (PNW) conducts the FIA, a national mandate authorized by the Forest and Rangeland Renewable Resource Research Act of 1978.

Forest Management: The processes of planning and implementing practices for the stewardship and use of forests and other wooded land aimed at achieving specific environmental, economic, social and /or cultural objectives.

Forest Management (Climate Change): In the context of climate change forest management refers to management actions that are taken to either reduce the potential loss of carbon from wildfire and associated emissions, or actions that are taken to increase carbon sequestration. This can cover a broad range of actions that includes: forest thinning, fuel reduction project, reforestation and afforestation projects.

Forest Management (Water Quality): Potential water resource impacts from forest management can be evaluated using the ERA (Equivalent Roaded Acres) calculation. The ERA calculation estimates potential sediment related impacts from forest management (timber harvesting, roads, and fuel treatments).

Forest Meadows: Wet and dry grassland vegetation in montane areas. Impacts to meadow systems from forest encroachment, grazing, and other land management practices can degrade montane meadows.

Forest Pests: Organisms (insects and diseases) capable of causing injury or damage to forests (particularly trees).

Forest Structure: The horizontal and vertical distribution of components of a forest stand including height, diameter, crown layers, and stems of trees, shrubs, herbaceous understory, and down woody debris (Helms,1998).

Forest/Forests: A biological community of plants and animals that is dominated by trees and other woody plants; by definition in the Assessment, all lands with greater than 10 percent tree canopy cover and including all CWHR types in the Conifer Forest, Conifer Woodland, Hardwood Forest and Hardwood Woodland land cover classes.

Forests and Rangelands: All CWHR types in the Conifer Forest, Conifer Woodland, Hardwood Forest, Hardwood Woodland, Shrub, Grassland, Desert Shrub, and Desert Woodland land cover classes plus the Wetland CWHR type Wet Meadow, excludes Urban, Agriculture, Barren, and Water.

Fragmentation: The process by which a contiguous land cover, vegetatative community, or habitat is broken into smaller patches within a mosaic of other forms of land use/land cover, e.g., islands of an older forest age class immersed within areas of younger aged forest (Helms, 1998), or patches of oak woodlands surrounded by housing development.

Fuels Reduction Projects: The harvest of vegetation in order to reduce potential fire threat, and often resulting in improved wildlife habitat capability, timber growth, or forage production. Some projects create revenue through the sale of wood products or biomass for energy.

Geographic Information System (GIS): A computer based system used to store and manipulate geographical (spatial) information.

Geothermal: Natural heat from within the earth, captured for production of electric power, space heating, or industrial steam.

Grassland: A land cover class with greater than two percent grass cover but less than ten percent tree or shrub cover. Grasslands are dominated by grasses, grasslike plants, and forbs. For the Assessment, the CWHR type Non-irrigated Pasture is included in the Annual Grassland type.

Green Infrastructure (Unprotected): The portion of green infrastructure that is available for development (e.g., conversion and parcelization). Typically this includes all privately owned lands that are not restricted by easements that preclude development.

Green Infrastructure: An interconnected network of waterways, wetlands, woodlands, wildlife habitats, and other natural areas; greenways, parks and other conservation lands; working farms, ranches and forests; and wilderness and other open spaces that support native species, maintain natural ecological processes, sustain air and water resources and contribute to the health and quality of life for America's communities and people.

Gross State Product: Gross economic output (sales, receipts and other operating income, commodity taxes, and inventory changes) minus intermediate inputs (consumption of goods and services purchased from other U.S. industries or other nations).

Groundwater Basins: A groundwater basin is defined as an area underlain by permeable materials capable of furnishing a significant supply of groundwater to wells or storing a significant amount of water. Groundwater basins in California have been delineated by the Department of Water Resources (Bulletin 118).

Habitat: The living place of an organism, natural or otherwise, characterized by its physical or biologcial properties; a specific classification of vegetation in the California Wildlife Habitat Relationship System.

Hardwood Forest: Land cover class with greater than 10 percent total tree canopy and of which 50 percent or more are hardwoods. Typical species include black oak (Quercus kelloggii), canyon live oak (Quercus chryoslepis), tanoak (Lithocarpus densiflorous) and madrone (Arbutus menziesii). Hardwood Forests are usually located in the mountainous elevations above the Hardwood Woodlands and are often associated with Conifer Forest tree species.

Hardwood Woodland: A land cover class with greater than 10 percent total tree cover and of which 50 percent or more are hardwoods (70 percent or more for mixed hardwood-conifer stands, except the CWHR type Blue Oak-Foothill Pine, which for the Assessment, is considered Hardwood Woodland); different from Hardwood Forest in species composition and in that trees are widely spaced, of shorter stature and often found in lower elevations in the transition between Grassland/Shrub and Conifer Forest. In the foothills of the Sierra Nevada and the eastside of the northern coast ranges, tree species typically include blue oak (Quercus douglasii) and interior live oak (Quercus wislizenii). In the mid to southern coast range, species include coast live oak (Quercus agrifolia) and California bay (Umbrellula californica) and further south, Englemann oak (Quercus englemannii). Typical understory is composed of extensive annual grass vegetation.

Hardwoods: Dicotyledonous trees; generally deciduous, broad-leafed species such as oak, alder, or maple.

Herbaceous: Having characteristics of an herb, i.e., a non-woody stem such as forbs, grasses and ferns, or the non-woody tissues of a branch or stem.

HUC 8 (Hydrologic Unit Code): A medium size watershed unit represented by an 8 digit code. California has 142 HUC 8 watersheds that are 825,000 acres average.

Hydroelectric: Of or relating to production of electricity from falling water that turns a turbine generator, referred to also as "hydro".

Impaired Water Bodies (303d): Section 303(d) of the federal Clean Water Act, requires States to identify waters that do not meet water quality standards (called "impaired water bodies") after the technology-based effluent limits or other required pollution control mechanisms are put into place. States are then required to prioritize waters/watersheds for total maximum daily loads (TMDL) development.

Impaired: Condition of the quality of an ecosystem or habitat that has been adversely affected for a specific use by contamination or pollution.

Invasive Species: A species of plant or animal that is able to proliferate and alter native biological communities and ecosystem function.

Land Cover: Predominant vegetation life forms, natural features, or land uses of an area.

Land Trust: A private, nonprofit organization formed to protect natural resources such as wildlife habitat, prime farmland, and recreational lands. It accomplishes this through a variety of means, including outright purchase, securing donations, and receiving conservation easements.

Landscape-Level Development Threat: The potential for development to have a significant impact on a habitat type over an entire bioregion. It is measured as the percentage of each vegetation type in each bioregion that has a Localized Development Threat rank of medium or high, meaning that these areas will experience conversion by 2030 or parcelization by 2020.

Landscape-Level Insect and Disease Threat: When a large proportion of a vegetation type is "unhealthy" in terms of having overstocked stands that are stressed by drought, there is the potential that an insect or disease outbreak could damage the entire broad ecosystem. To measure health of existing tree stands, we use current tree mortality. To project future health, we use expected tree mortality which estimates future tree mortality based on current stand conditions.

Landscape-Level Wildfire Threat: When a large proportion of a vegetation type is "unhealthy" in terms of having not experienced a normal fire regime, there is the potential that an extreme fire event could damage the entire broad ecosystem. To measure health, we apply the notion of "condition class." Areas where fire has been excluded beyond historical frequencies, or areas where fire has occurred much more often than historical frequencies, with associated significant changes in ecosystem and fuel components and structure, are unhealthy (e.g., have a large proportion of their acreage in the most extreme condition class).

Litter: The uppermost layer of the forest floor consisting chiefly of fallen leaves and other decaying organic matter.

Livestock: Domestic animals, such as cattle or horses, raised for home use or for profit, especially on a farm.

Localized Development Threat: The direct threat from development occurring on a specific site. This includes "conversion", where natural landscapes are assumed to lose virtually all of their ecological processes, and "parcelization", where ecosystem processes are impacted but not completely lost. It is assumed that conversion occurs at an average housing density of five housing units per acre, and parcelization at 20 per acre.

Major Roads: An important component of human infrastructure including interstate highways, U.S. highways, and state highways.

Management Landscape: A conceptual framework which classifies lands based on the primary land use objective, ownership status, and housing density.

Meadow Restoration: Montane meadows consist of wet and dry grassland vegetation. Impacts to meadow systems from forest encroachment, grazing, and other land management practices can degrade montane meadows. The restoration of these meadow systems can enhance water quality, water quantity, and improve wildlife habitat.

Megawatt: One thousand kilowatts; one megawatt is approximately the amount of power required to meet the peak demand of a large hotel.

Mitigation Banking: The restoration, creation, enhancement, or preservation of a habitat conservation area which offsets expected adverse impacts to similar nearby ecosystems. In the United States, the federal government as well as many state and local governments, require mitigation for the disturbance or destruction of wetland, stream, or endangered wildlife habitat. Once approved by regulatory agencies the mitigation bank may sell credits to developers whose projects will impact these various ecosystems.

National Forest: Federal lands that have been designated by Executive Order or statute as national forest or purchased units and other lands under the administration of the U.S. Forest Service (U.S. Department of Agriculture).

Native Species: A species of plant or animal present prior to European settlement.

Natural Community Conservation Plan (NCCP): A cooperative effort to protect habitats and species, between private landowners, the California Department of Fish and Game (DFG) and other interested parties. The primary objective of NCCPs is to conserve natural communities at the ecosystem scale while accommodating compatible land use. The DFG seeks to anticipate and prevent the controversies and gridlock caused by species' listings by focusing on the long-term stability of wildlife and plant communities and including key interests in the process.

Non-Point: Pollution whose source cannot be ascertained including runoff from storm water and agricultural, range, and forestry operations, as well as dust and air pollution that contaminate waterbodies.

Nutrient Cycling: The exchange or transformation of elements (nutrients) among the living and nonliving components of an ecosystem.

Old Growth Forest: A stand or stands of forest trees that exhibit large tree sizes, relatively old age, and decay characteristics common with over-mature trees; As defined by USDA FS ecologists, specific forest structure characteristics, by forest type and site class, such as size of trees, number of trees per acre, multiple canopies, degree of decay, and size and number of snags and down woody debris.

Open Space: Land free from intensive residential or commercial uses.

Ozone (O3): An unstable, poisonous allotrope of oxygen that is formed naturally from atmospheric oxygen by electric discharge or exposure to ultraviolet radiation. It is also produced in the lower atmosphere by the photochemical reaction of certain pollutants.

Parcelization: The process of land ownership being broken into increasingly smaller tracts; by definition in the Assessment, housing density of one or more units per 20 acres and less than one unit per acre.

Perennial: 1. A plant which lives or continues over two years, whether it retains its leaves in winter or not; 2. a stream or water body that persists year round in normal weather years.

Population: The number of individuals of a particular taxon in a defined area.

Post-Fire Erosion: This is the accelerated soil loss that can occur after a large fire event. The rate of loss is a function of factors such as slope, soil type, geology, burn severity, vegetation, and rainfall.

Prescribed Fire: A deliberate burn of wildland fuels in either their natural or modified setting and under specific environmental conditions which allow the fire to be confined to a predetermined area and intensity to attain a planned resource management objective (Helm, 1998).

Public Water Supply: Water supplied to a group through a public or private water system. This can include residential, commercial, and industrial uses.

Rangeland Productivity: This asset ranks areas based on their potential to grow forage for livestock grazing. Since it only measures potential, it does not capture whether the forage is actually utilized for livestock production.

Rangelands: Any expanse of land not fertilized, cultivated or irrigated that is suitable, and predominately used for grazing by domestic livestock and wildlife. These include the Conifer Woodland, Hardwood Woodland, Shrub, Grassland, Desert Woodland and Desert Shrub land cover classes along with and some habitats within the Wetland and Hardwood Forest land cover classes.

Recreation Areas: Lands that support human outdoor activities such as hiking, bird-watching, camping, hunting, off-road vehicle use, etc. This can also include lands used for educational purposes that also serve to connect people to the green infrastructure.

Reforestation: The establishment of forests on land that had recent (less than 10 years) tree cover.

Renewable Energy: A power source other than a conventional power source within the meaning of Section 2805 of the Public Utilities Code, provided that a power source utilizing more than 25 percent fossil fuel may not be included.

Reserve: A Management Landscape class where lands are permanently protected from conversion of natural land cover and have a mandated management plan in operation to maintain a primarily natural state, but which may receive management practices; lands managed consistent with statutory designation such as wilderness, wild and scenic, national park, and nation monument. Commodity production is prohibited or greatly restricted.

Riparian Area: Transition zone between a stream's edge and the dryer uplands.

Riparian Vegetation: Vegetation found on the interface between land and a stream or water body. Plant communities that develop along the banks of streams are referred to as riparian vegetation. Riparian vegetation is characterized, but not exclusively defined, by hydrophytic (water adapted) plants. This asset is represented using vegetation data to capture the Wildlife Habitat Relationships (WHR) types Montane Riparian, Valley Riparian, and Desert Riparian. In addition, other vegetation types within a 30 meter buffer zone from hydrologic features is represented with a lower ranking.

Riparian: Relating to or located on the banks of a river or stream.

Salmonids: Any of the family Salmonidae, some of which are freshwater species, such as golden trout (Salmo aquabonita) and Lahontan cuththroat trout (Salmo clarki henshawi), and some of which are anadromous (spending part of their life cycle at sea and returning to freshwater to reproduce), such as coho (Onocorhynchus kisutch) and chinook (Onocorhynchus tshawytscha Walbaum).

Seed Tree: A silvicultural method in which all trees are removed except for a small number of seed bearers left singly or in small groups, maybe 10 per acre. The seed trees are generally harvested after regeneration is established. An evenaged stand results.

Shelterwood: A silvicultural method to establish seedling regeneration via a series of partial harvests, followed by the almost complete removal of overstory trees in a removal harvest once adequate numbers of seedlings are in place to permit the seedlings to grow in full sunlight.

Shrub: A land cover class with greater than ten percent non-Desert shrub cover and less than ten percent tree cover. Typical species include sagebrush (Artemisia sp.), chamise (Adenostoma fasciculatum), and manzanita (Arctostaphylos sp.).

Silviculture: Generally, the science and art of cultivating (such as with growing and tending) forest crops, based on the knowledge of silvics. More explicitly, silviculture is the theory and practice of controlling the establishment, composition, constitution, and growth of forests.

Site Class: A species-specific classification of forest land in terms of inherent capacity to grow crops of industrial, commercial wood (Helms, 1998).

Size Class: An interval into which a tree is classified based on its trunk diameter at breast height (DBH), often in two-inch size classes.

Small Hydro/Hydroelectric: A facility employing one or more hydroelectric turbine generators, the sum capacity of which does not exceed 30 megawatts.

Snags: Standing dead trees with a minimum DBH of 10 inches and a height of 10 feet.

Soil Organic Carbon: Organic carbon in mineral soils to a specified depth and applied consistently through a time series. This is a generic term referring to all organic material in soil that is not part of a root system.

Soil Productivity: The capacity of a soil, in its normal environment, to support plant growth. This capacity can be diminished by large wildfire events, due to post-fire soil erosion.

Species of Special Concern: An administrative designation given to animals that were not listed under the federal Endangered Species Act or the California Endangered Species Act at the time of designation but are declining at a rate that could, and sometimes does, result in listing.

Species Recovery Plans: A program to develop protocols for protecting and enhancing federally rare and endangered species populations. A recovery plan is a non-regulatory document that may apply to one species or an ecosystem.

Species Richness: The total number of species, based on species range overlap and taken from "A GAP Analysis of California."

Stand: A group of trees sufficiently uniform in composition, age, and/or condition forming a management entity and distinguishable from adjoining tree groups.

Stand-Level Insect and Disease Threat: The insect and disease threat unique to a small area as a result of its current tree stocking and drought index. This is identical to the "Insect /Disease" threat referred to in subthemes where there is no associated landscape level threat.

Stand-Level Wildfire Damage: Areas that have recently burned in large wildfires, where stress is measured based on burn severity. These areas often require restoration in order to restore important public benefits and ecosystem services, and to prevent potential future impacts such as soil erosion, regeneration failures, etc.

Stand-Level Wildfire Threat: The fire threat unique to a small area as a result of its current fuel conditions, weather, and historic fire frequency. This is identical to the "Wildfire" threat referred to in subthemes where there is no associated landscape level threat.

Stocking Level: A measure of the quantity of wood fiber growing in a standing timber acre.

Stressor: Pressure that directly or indirectly influence the quality and quantity of habitat used by terrestrial and aquatic wildlife, mainly from human-induced changes in the landscape. Stressors include agricultural and urban land use, introduced invasive and exotic species, nutrient enrichment, direct human disturbance, water management conflicts, climate change and toxic chemicals.

Structures: Residential and commercial development, which is measured using housing density classes applied to census blocks from the 2000 U.S. Census, and commercial areas mapped in National Land Cover data.

Succession: The gradual, either in response to an environmental change or induced by the organisms themselves.

Sudden Oak Death (SOD): A brown algae species, Phytophthora ramorum, that infects a variety of host plant species, including several coastal oak species.

Sustainability: Meeting the needs of the present without compromising the ability of future generations to meet their own needs.

Take: To hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill.

Taxon: The name that is applied to a group in biological classification, for example, species, subspecies, variety, or evolutionarily significant unit (ESU). The plural is taxa.

Threatened and Endangered Species: Federal and State legally protected plants and animals. Data sources include U.S. Fish and Wildlife Service designated critical habitat and occurrence data from California Natural Diversity Database (by quad).

Threats: Agents that can trigger major negative impacts on assets. Examples include wildfire, future development, and forest insect outbreaks.

Timber: Standing trees which will be used for lumber and other wood products. The value depends on tree species present, tree size, and stocking.

Timberland: Forest land capable of growing 20 cubic feet or more of industrial wood/acre/year (mean increment at culmination in fully stocked, natural stands). Timberland does not include lands placed in a reserved status through removal of the area from timber utilization by statute, ordinance, or administrative order and is not in a withdrawn status pending consideration for reserved.

Timberland Production Zone (TPZ): A statutory designation for lands assessed for taxes based on growing and harvesting timber as the highest and best use of the land.

Total Maximum Daily Load (TMDL): A calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, as well as an estimation of the percentage originating from each pollution source. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The calculation must include a margin of safety to ensure that the waterbody can be used for State-designated purposes. The calculation must also account for seasonal variation in water quality.

Transfer Payments: Income payments to persons for which no current services have been performed. They consist of payments to individuals and to nonprofit institutions by businesses and federal, state, and local governments.

Transmission Lines: Electrical power lines that move electricity over long distances (69 kilovolts or higher).

Tree Canopy: This asset is ranked based on the density of tree cover as determined by satellite imagery. This recognizes that communities with more tree cover merit consideration for prioritization for urban forest management to maintain existing tree cover.

Turbidity: The relative clarity of water that may be affected by material in suspension in the water.

Understory: The trees and other woody species growing under a relatively continuous cover of branches and foliage formed by the overstory trees.

Unevenaged: A silvicultural system in which individual trees originate at different times and result in a forest with trees of many ages and sizes; stands where less than 70 percent of the tree stocking falls in three adjacent 10 year age classes.

Unsuitable: Lands that are not in a reserved status through removal of the area from timber utilization by statute, ordinance, or administrative order, but in practice or as prescribed in management plans or regulatory rules, are not primarily managed for timber production.

Urban Forest Carbon Stocks: Refers to the carbon stocks associated with trees planted within the urban area. It can include both the above and below ground carbon stocks. See aboveground carbon stocks.

Urban Forest Expansion: The planting of trees and associated vegetation in urban areas that is additional to a baseline measurement and will increase economic, environmental, and social benefits to urban residents. Often the tree planting is a cooperative venture with the community and is completed with citizen participation and labor.

Urban Forest Management: The care and management of urban forests (i.e., tree populations in urban settings) for the purpose of improving the urban environment. Urban forestry advocates the role of trees as a critical part of the urban infrastructure. Urban foresters plant and maintain trees, support appropriate tree and forest preservation, conduct research and promote the many benefits trees provide. Urban forestry is practiced by municipal and commercial arborists, municipal and utility foresters, environmental policymakers, city planners, consultants, educators, researchers and community activists (Urban forestry: Definition from Answers.com)

Urban Heat: A measure for ranking areas within urban landscapes based on relative presence of urban heat islands as calculated by percent tree canopy and impervious surfaces; and climatic conditions as measured by average annual days over 90 degrees. This measure will be a proxy for energy use. Urban Heat results in areas that are significantly warmer than the surrounding rural areas.

Urban Population (Public Health and Energy Conservation): Identified asset and proxy variable to measure public health and energy conservation in urban areas. Urban population is measured by the proxy variable housing density combined with commercial development. Generally, it can be assumed that more densely populated areas, and areas where people work or do business, have a higher rate of energy use and more people potentially at risk from pollutants.

Urban Tree Maintenance: The systematic technical care of trees in urban areas that conforms to currently accepted national standards. Such standards currently are the ANSI A-300 tree care standards in association with the International Society of Arboriculture Best Management Practices. Such activities include tree inventory (measurement), young tree care, root management, tree pruning, tree removal, stump removal, and pest and disease assessment and treatment utilizing Integrated Pest Management techniques.

Urban Tree Planting: This involves expanding or augmenting the urban forest through tree planting. Often the tree planting is a cooperative venture with the community, and is completed with citizen participation and labor.

Urban: A land cover class and Management Landscape class dedicated to high density residential (one or more housing units per acre) and commercial/industrial/transportation uses. Human impact on natural ecological processes is significant and areas are not assumed to have value for habitat.

Value-Added: Of or relating to the estimated value that is added to a product or material at each stage of its manufacture or distribution.

Variable Retention: A silvicultural approach to harvesting based on retention of structural elements or biological legacies from the harvested stand for integration into a new stand to achieve various ecological objectives (Helms, 1998).

Viewshed: The total area visible from a point or series of points along a linear transportation facility. Viewshed is typically evaluated both from the roadway and conversely of the roadway as viewed from the adjacent area.

Water Conservation: This refers to reducing the use of water and reducing the waste of water.

Water Demand: The desired quantity of water that would be used if the water is available and a number of other factors such as price do not change. Demand is not static. Water demand is assessed as part of the California Water Plan.

Water Supply Watersheds: Those areas that contribute to public water supply. These are watersheds that drain downstream to a reservoir or major water storage facility.

Watershed Groups: Community based groups that conduct planning and restoration projects to protect and enhance the broad range of natural resources found within California watersheds.

Watershed Management Plan: The goal of watershed management is to plan and work toward an environmentally healthy watershed that provides a broad range of ecosystem services and benefits to all who live in the watershed. Typically, watershed management plans bring together stakeholders to develop solutions to address environmental issues of concern.

Watershed Restoration: Restoration of a watershed returns the ecosystem to as close an approximation as possible of its state prior to impairment. This typically benefits water quality that has been degraded by non-point source pollution.

Watershed: The land area drained by a single stream, river, or drainage network (Helms, 1998).

Wetland: An aquatic (water dominated) land cover class having greater than two percent vegetation cover and having less than 10 percent of the over story canopy occupied by trees or shrubs.

Wild and Scenic Rivers: The National Wild and Scenic Rivers System was created by Congress in 1968 (Public Law 90-542; 16 U.S.C. 1271 et seq.) to preserve certain rivers with outstanding natural, cultural, and recreational values in a free-flowing condition for the enjoyment of present and future generations. The Act is notable for safeguarding the special character of these rivers, while also recognizing the potential for their appropriate use and development. It encourages river management that crosses political boundaries and promotes public participation in developing goals for river protection. Rivers are classified as wild, scenic, or recreational.

Wildfire Threat to Communities: The direct impact of wildfire on houses and other human infrastructure in the wildland-urban interface. This is a result of fire spread into developed areas, as well as fire starts caused by flying burning embers.

Wildfire: Any fire occurring on undeveloped land; the term specifies a fire occurring on a wildland area that does not meet management objectives and thus requires a suppresion response. Wildland fire protection agencies use this term generally to indicate a vegetation fire. Wildfire often replaces such terms as forest fire, brush fire, range fire, and grass fire.

Wildland Urban Interface (WUI): The geographical intersection of two disparate systems, wildland and structures. At this interface, structures and vegetation are close enough that a wildland fire could spread to structures or fire could spread from structures to ignite vegetation.

Wildland: A region with minimal development as evidenced by few structures; transportation networks may traverse region. Region typically contains natural vegetation and may be used for recreational or agricultural purposes.

Wildlife Habitat: This asset ranks areas based on their relative importance for sustaining wildlife populations. Rankings were derived by merging data related to vertebrate species richness, endemic plant richness, rare natural communities, old-growth forests, riparian vegetation, and threatened and endangered species.

Woody Debris: Fallen dead wood or large branches; Woody debris is an important source of nutrients and habitat as well as a source of fuel for fire.

Woody Plant: A plant having hard lignified tissues or woody parts, especially stems.

Working: A component of Management Landscape classes where land is held or managed for some degree of commodity output, usually range or forested lands. Human impact is measurable and definite yet there remains considerable habitat value for species.

Zoning: Assigning a legal status to land that defines permitted uses. Zoning can be a tool for keeping lands as working landscapes for a set period of time. Examples of state-level zoning mechanisms include Timberland Production Zones (TPZ) that designate lands for timber production, and Williamson Act lands that are designated for livestock grazing. Local governments also define zoning which can include timber zones, agriculture preserve zones, etc.

Acronyms

ACE	Areas of Conservation Emphasis
ARB	Air Resources Board
BAER	Burned Area Emergency Recovery
BAFC	Border Area Fire Council
BLM	Bureau of Land Management
BOF	Board of Forestry and Fire Protection
CADC	California Desert Council
CAL FIRE	California Department of Forestry and Fire Protection
CAL-IPC	California Invasive Plant Council
CAR	Climate Action Reserve
CAS	Climate Adaptation Strategy
CBC	California Biodiversity Council
CCSM	Community Climate System Model
CEC	California Energy Commission
CEHCP	California Essential Habitat Connectivity Project
CEQA	California Environmental Quality Act
ESA	U.S. Endangered Species Act
CESA	California Endangered Species Act
CFPC	California Forest Pest Control
CFR	Code of Federal Regulations
CNPS	California Native Plant Society
CO	Carbon Monoxide
CO2	Carbon Dioxide
CO2e	Carbon Dioxide Equivalent
CORP	California Outdoor Recreation Plan
CPAD	California Protected Areas Database
CROP	Coordinated Resource Offering Protocols
CWAP	California Wildlife Action Plan
CWPP	Community Wildfire Protection Plan
DFG	Department of Fish and Game
DFR	Douglas-Fir
DFTM	Douglas-Fir Tussock Moth
DGVM	Dynamic Global Vegetation Model
DOD	Department of Defense
DOE	U.S. Department of Energy
DPR	Department of Pesticide Regulation
DWR	Department of Water Resources
EIR	Environmental Impact Report
EPA	U.S. Environmental Protection Agency
EPN	Eastside Pine
ESU	Evolutionary Significant Units
FAST	Forest Area Safety Taskforce
FEMA	Federal Emergency Management Agency
FHP	Forest Health Protection
FHSZ	Fire Hazard Severity Zone
FIA	Forest Inventory and Analysis
FRAP	Fire and Resource Assessment Program
FSC	Forest Stewardship Council
GFDL	Geophysical Fluid Dynamics Laboratory
GHG	Greenhouse Gas
GIS	Geographic Information Systems
GCM	Global Climate Models
GSOB	Goldspotted Oak Borer
HAD	Hadley Centre Model
HFRA	Health Forests Restoration Act
HMPL	High Plus Medium Priority Landscape
HPL	High Priority Landscape
HUC	Hydrologic Unit Codes
ICLUS	Integrating Climate and Land Use
IP	Intrinsic Potential
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
IRWM	Integrated Regional Water Management
LEED	Leadership in Energy and Environmental Design
LPN	Lodgepole Pine
LRA	Local Responsibility Areas
MAST	Mountain Area Safety Taskforce
MHW	Montane Hardwood
MSG	Monitoring Study Group
MW	Megawatt
NCASI	National Council for Air and Stream Improvement
NCCP	Natural Community Conservation Planning Program
NCCPA	Natural Communities Conservation

	Planning Act
NEPA	National Environmental Policy Act
NGO	Non Government Organization
NMFS	National Marine Fisheries Service
NO2	Nitrogen Dioxide
NOx	Nitrogen Oxides
NPS	National Park Service
O/E	Observed/Expected
OPR	Office of Planning and Research
PG&E	Pacific Gas and Electric
PL	Priority Landscapes
PM	Particulate Matter
PPN	Ponderosa Pine
PRC	Public Resources Code
RCD	Resource Conservation District
RETI	Renewable Energy Transmission Initiative
RFR	Red Fir
ROGs	Reactive Organic Gases
RPS	Renewable Portfolio Standard
RWQCB	Regional Water Quality Control Board
S&PF	State and Private Forestry Program
SCAG	Southern California Association of Governments
SDM	Species Distribution Model
SFI	Sustainable Forest Initiative
SGC	Strategic Growth Council
SMC	Sierran Mixed Conifer
SOD	Sudden Oak Death
SOs	Sulfate
SRA	State Responsibility Areas
SVRA	State Vehicular Recreation Area
SWRCB	State Water Resources Control Board
TMDL	Total Maximum Daily Load
TPZ	Timberland Production Zones
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
VOCs	Volatile Organic Compounds
WBD	Watershed Boundaries Database
WCI	Western Climate Initiative
WFR	White Fir
WHR	Wildlife Habitat Relationships
WND	Western Wind Energy Corporation
WUI	Wildland Urban Interface
ZOI	Zone of Infestations

List of Figures

List of Tables

Photo Credits

Page	Photo	Source
1	Sierra Buttes, Sierra County, California	Lauren McNees
31	Mixed hardwood conifer	CAL FIRE
45	Verdugo Mountains and Glendale, California	Wikimedia Commons
50	Verdugo Mountains and Glendale, California	Wikimedia Commons
59	Ponderosa pine forest	CAL FIRE
89	Cattle grazing	CAL FIRE
95	Wildfire	CAL FIRE
113	Mixed conifer forest	CAL FIRE
137	Western Grebe	National Biological Information Infrastructure Library of Images from the Environment
157	Snow survey	Department of Water Resources
161	Urban forest in Sacramento, California	Sacramento Tree Foundation
163	Urban forest in Sacramento, California	Sacramento Tree Foundation
179	Wildfire damage to communities, Lake Arrowhead, California	Lauren McNees
193	Sawmill in Lake Arrowhead, California	Lauren McNees
200	Solar energy facility, San Bernardino County, California	National Agriculture Imagery Program
217	Red Fox	Wikimedia Commons
235	Mt. Tamalpais State Park, Marin County, California	California State Parks
251	Lake Tahoe, El Dorado County, California	Wikimedia Commons
273	Eastern Tijuana (view from Otay Mountain, San Diego County, California)	Lauren McNees
277	Lake Tahoe, El Dorado County, California	Wikimedia Commons