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

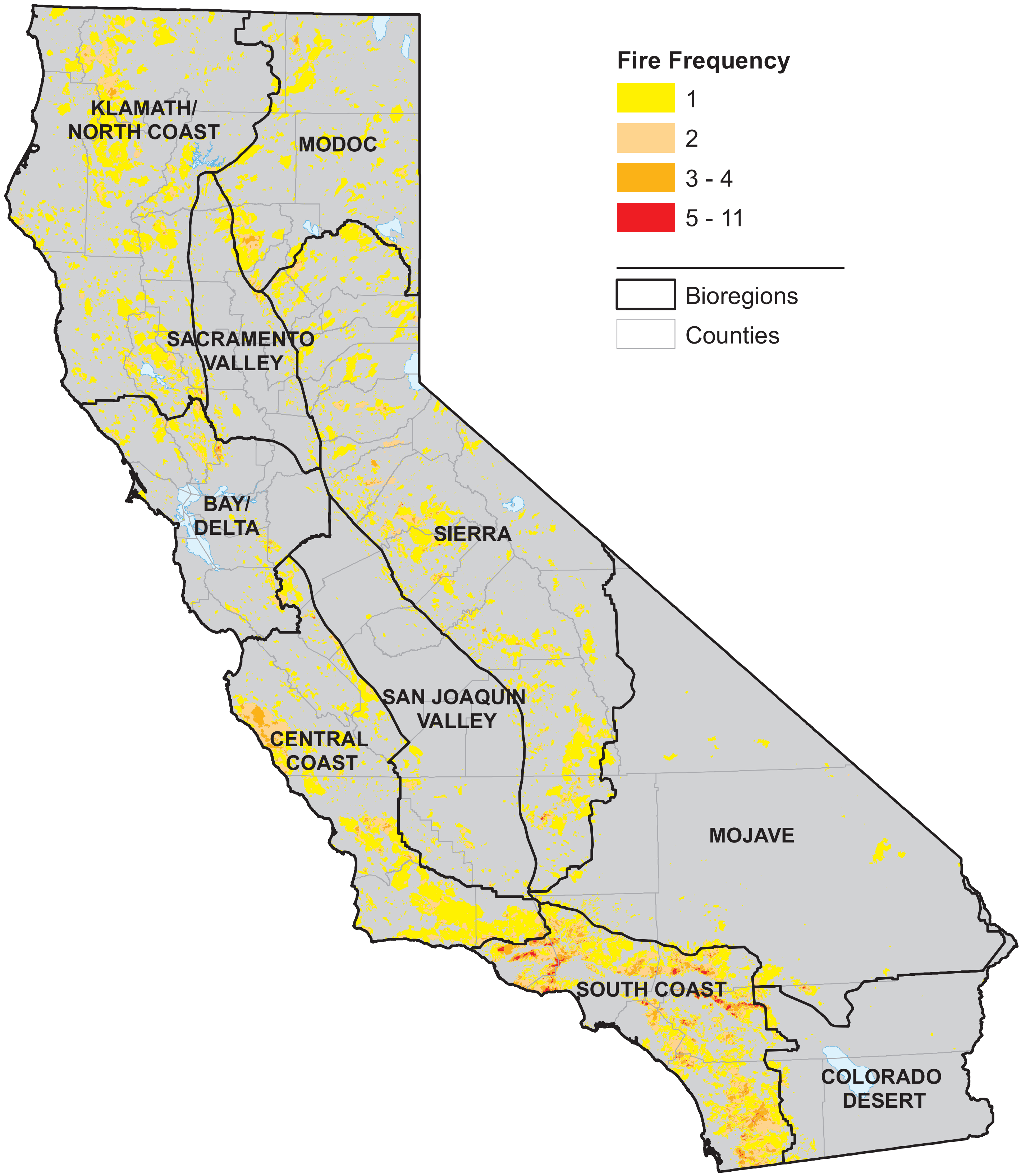


Figure 2.1.1.
Fire frequency (number of times burned) over the period 1950–2008.
Data Source: Fire Perimeters, FRAP (2009 v1)

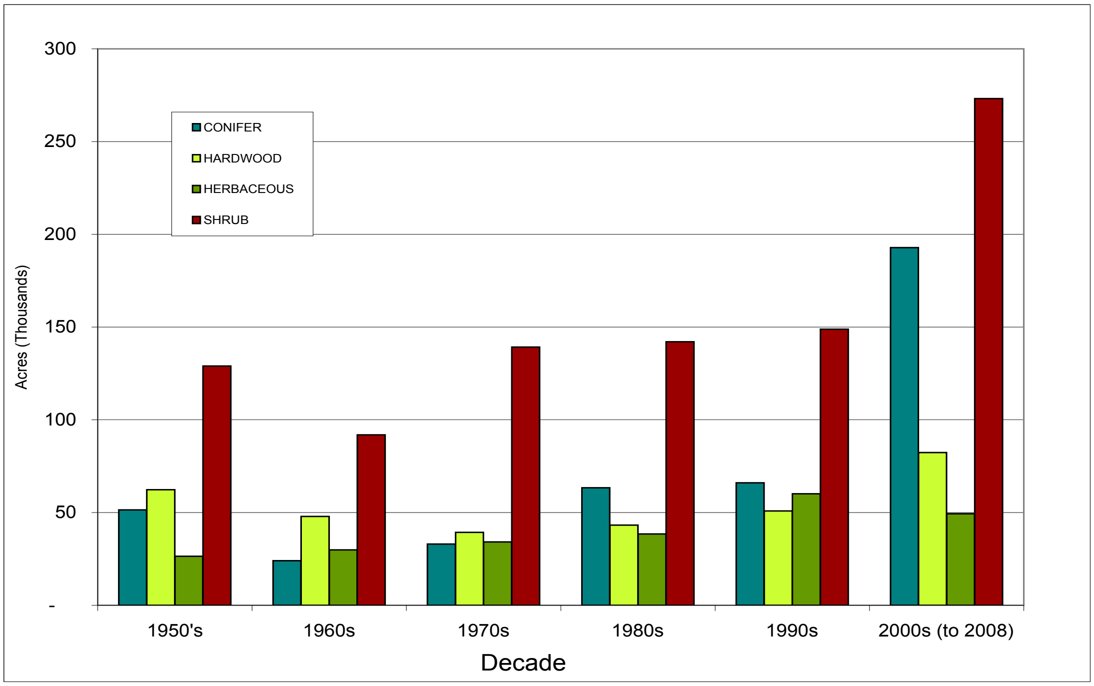


Figure 2.1.2.
Annual acres burned by decade and by life form, 1950s to 2000s.
Data Sources: Fire Perimeters, FRAP (2009 v1); Statewide Land Use / Land Cover Mosaic, FRAP (2006)

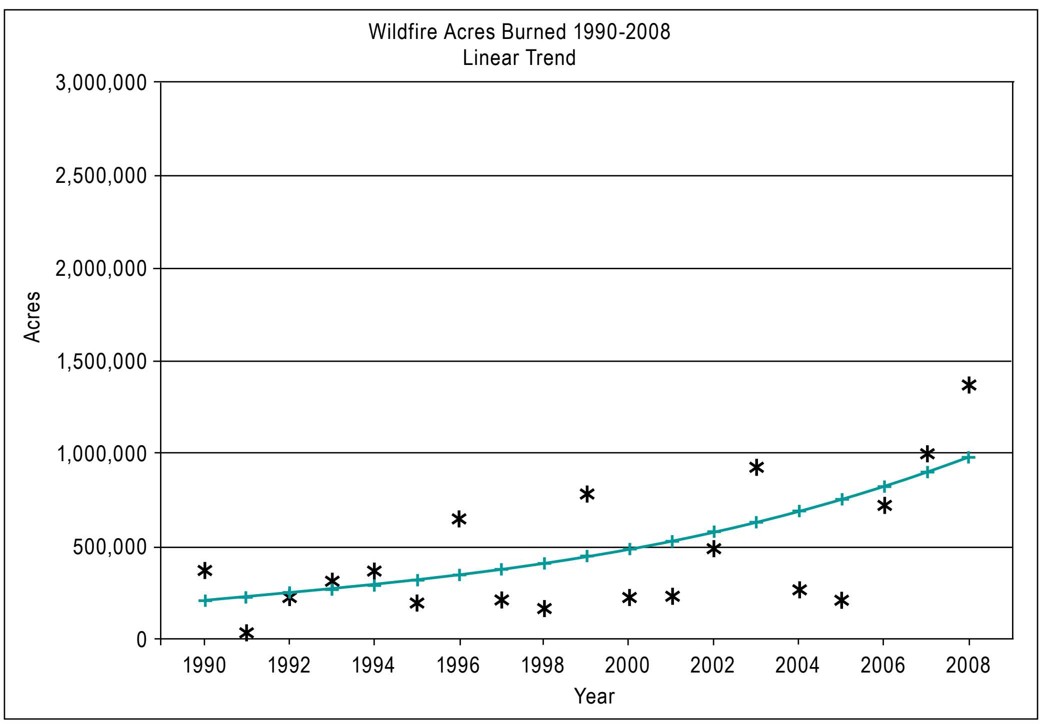


Figure 2.1.3.
Log-linear trend model for annual acres burned as a function of time, 1990–2008.
Data Sources: Fire Perimeters, FRAP (2009 v1); Statewide Land Use / Land Cover Mosaic, FRAP (2006)

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

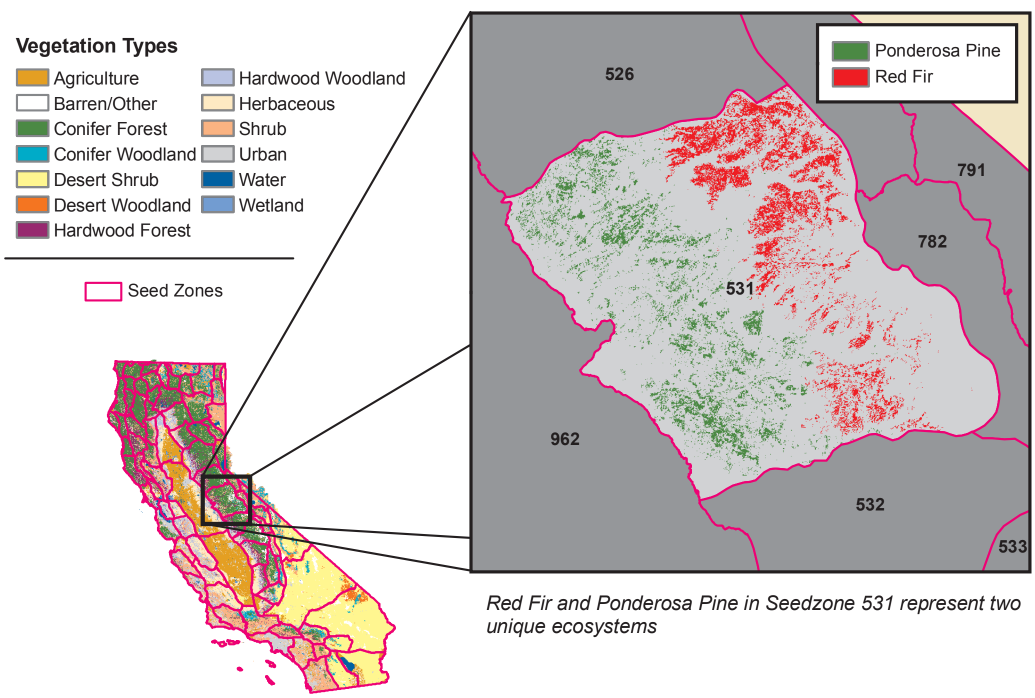
Ecosystems

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.

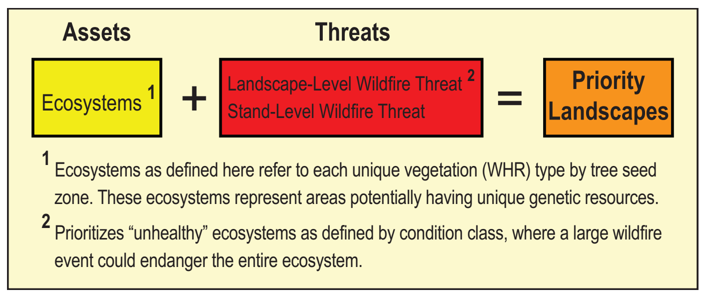
Many ecosystems in California that were previously adapted to frequent low to moderate severity fires have seen shifts in reduced fire frequency (missed fire cycles), associated fuel build-up, and subsequent increases in fire severity when wildfires eventually occur (Miller et al., 2008). At the landscape 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

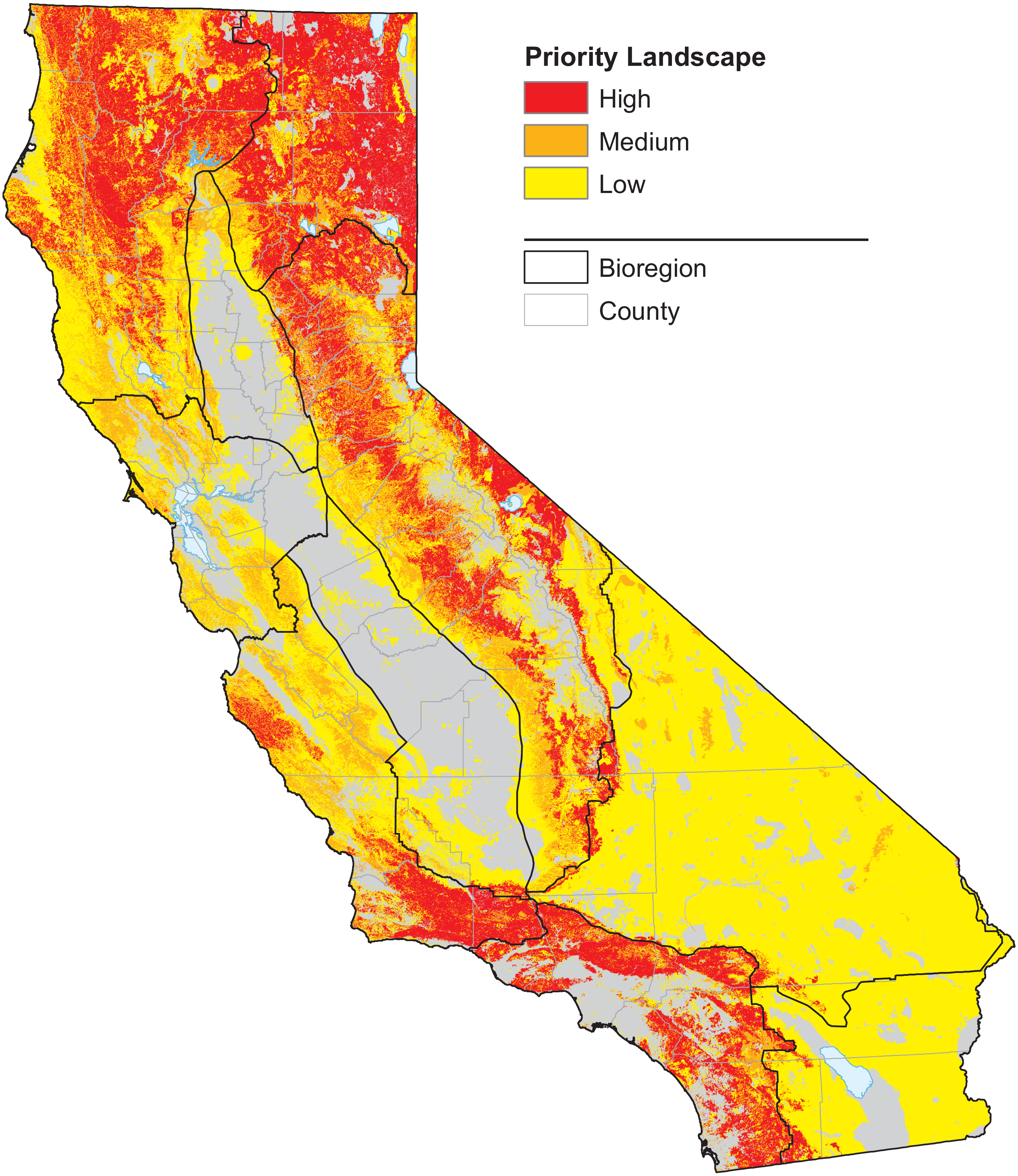


Figure 2.1.5.
Priority landscape for preventing wildfire threats to maintain ecosystem health.
Data Sources: California Fire Regime Condition Class, FRAP (2003); California Tree Seed Zones, Buck, et al. (1970); Fire Threat, FRAP (2005); Statewide Land Use / Land Cover Mosaic, FRAP (2006)

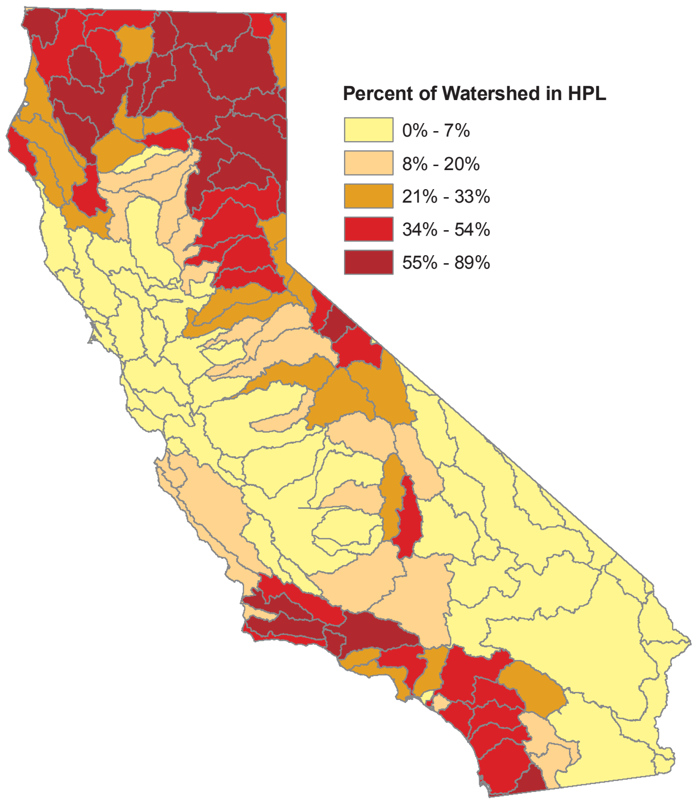


Figure 2.1.6.
Percent of watershed Hydrologic Unit Class 8 (sub-basins) in high priority for preventing wildfire threats to maintain ecosystem health.
Data Sources: California Fire Regime Condition Class, FRAP (2003); California Tree Seed Zones, Buck, et al. (1970); Fire Threat, FRAP (2005); Statewide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

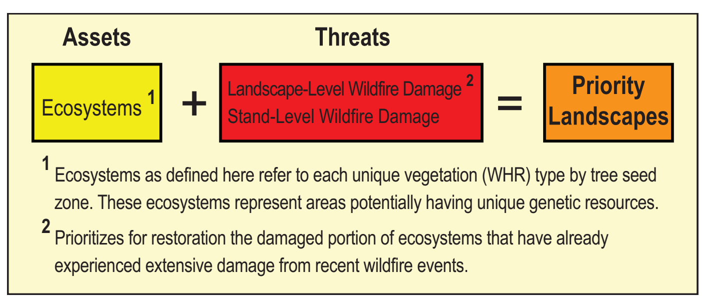
Finally, tactical operations and strategies employed in fire suppression can be used effectively to either alter or significantly redirect fire occurrence in high value/high sensitivity areas.

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

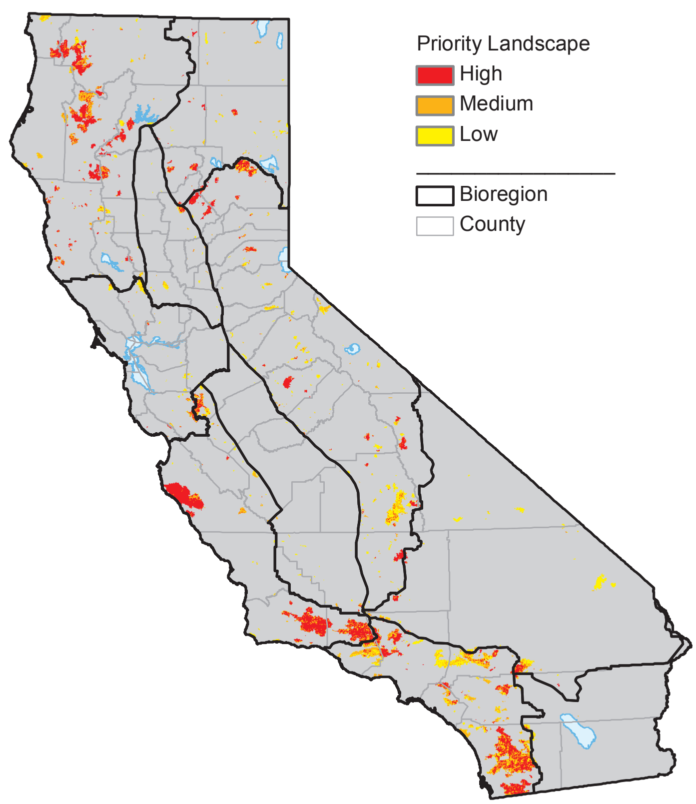


Figure 2.1.7.
Priority landscape for restoring wildfire impacted areas to maintain ecosystem health.
Data Sources: Burn Severity, USFS (2009); California Tree Seed Zones, Buck, et al. (1970); Fire Perimeters, FRAP (2009 v1); Fuel Rank, FRAP (2002); Statewide Land Use / Land Cover Mosaic, FRAP (2006)

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

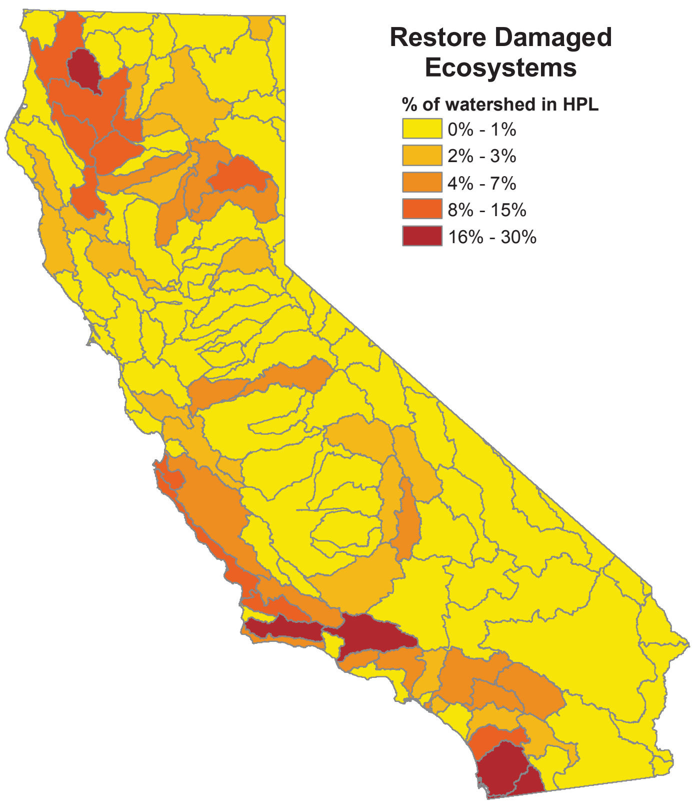


Figure 2.1.8.
Percent of Hydrologic Unit Class 8 (sub-basins) in high priority for restoration from wildfire damage.
Data Sources: Burn Severity, USFS (2009); California Tree Seed Zones, Buck, et al. (1970); Fire Perimeters, FRAP (2009); Fuel Rank, FRAP (2002); Statewide Land Use / Land Cover Mosaic,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

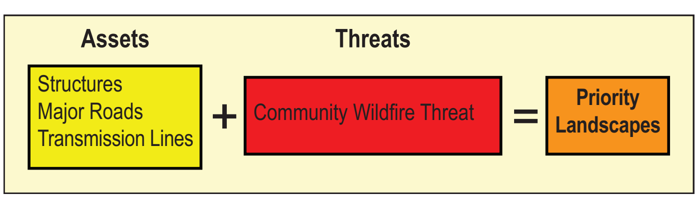
PREVENTING WILDFIRE THREATS FOR COMMUNITY SAFETY

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.

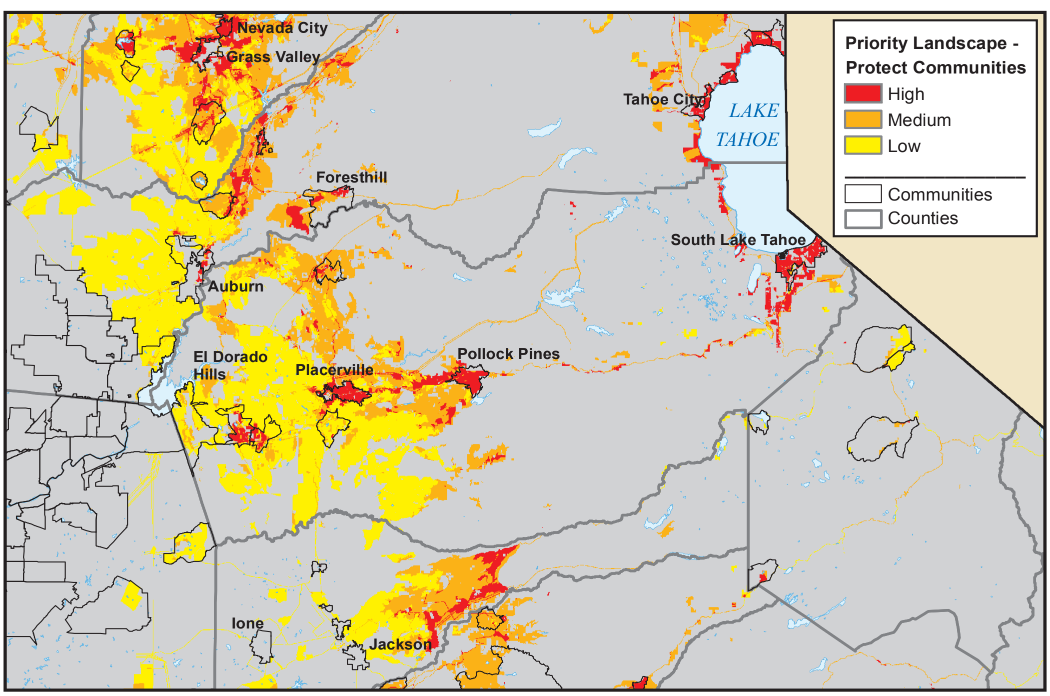


Figure 2.1.9.
Sample priority landscape for preventing wildfire threats for community safety, Lake Tahoe region.
Data Sources: Transmission Lines, California Energy Commission (2007); Communities (FRAP 2009 v1); Fire Hazard Severity Zones for SRA, FRAP (2006); Very High Fire Hazard Severity Zones for 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).

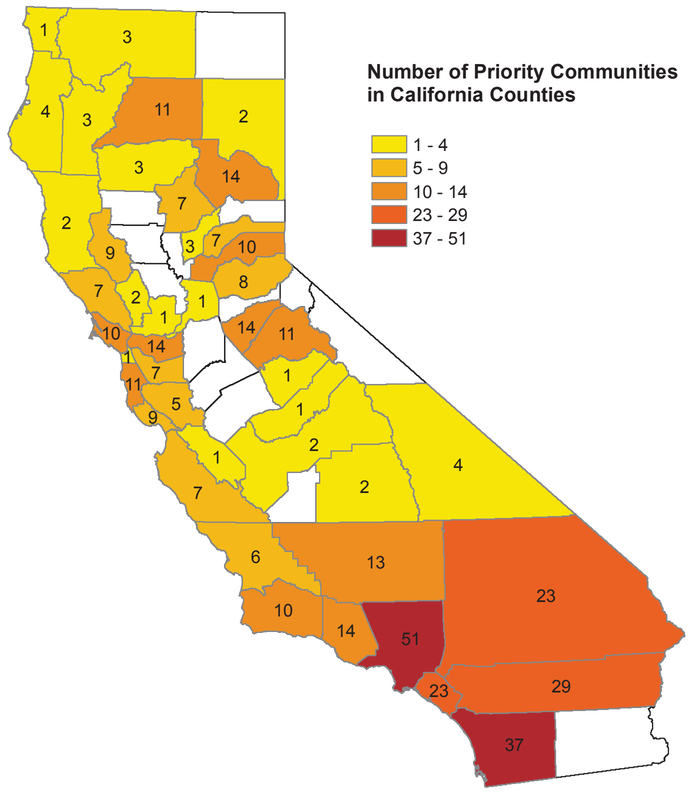


Figure 2.1.10.
Number of communities meeting HMPL thresholds for preventing wildfire threats for community safety.
Data Sources: Transmission Lines, California Energy Commission (2007); Communities, FRAP (2009 v1); Fire Hazard Severity Zones for SRA, FRAP (2006); Very High Fire Hazard Severity Zones 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.