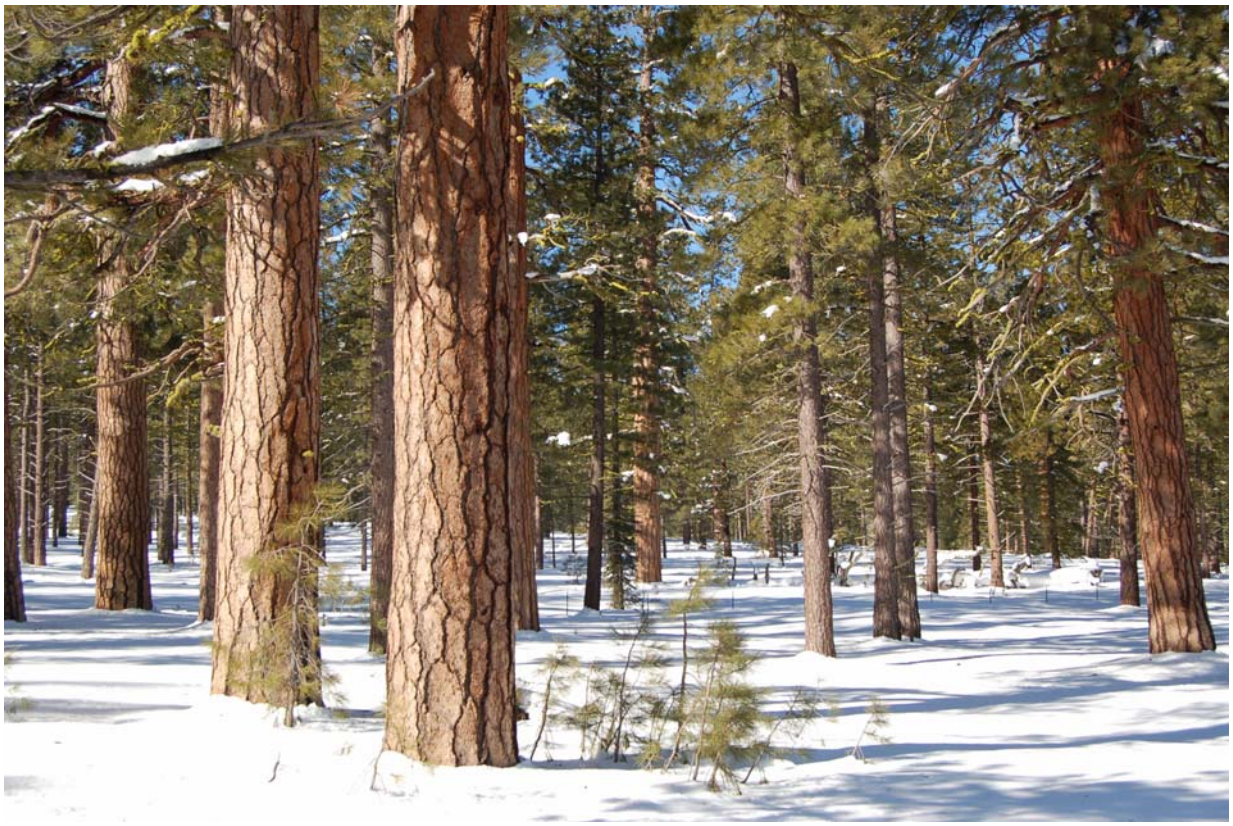
BARK BEETLES AND VEGETATION MANAGEMENT IN CALIFORNIA



This report was prepared by Forest Health Protection,
Region 5, Forest Service, U.S. Department of Agriculture.

BARK BEETLES AND VEGETATION MANAGEMENT

Talking Points

- Native bark beetles are a major cause of tree mortality in California. When, where, and the extent to which mortality occurs is influenced by forest stand conditions and weather patterns.

- During the past five years bark beetles have caused high levels of tree mortality on more than 6 million acres in California's forests. The most notable recent event was the catastrophic tree die-off during 2003-2004 in Southern California where thousands trees were killed over an area that exceeded a half million acres.

- Over $500 million dollars have been spent to abate the large number of hazardous dead trees, reduce fuel loads and restore forests in Southern California.

- Trees that appear healthy and green during periods of normal or above normal precipitation can become severely compromised and easy targets for bark beetles during periods of drought.

- In many areas of California, forest stand conditions are out of balance. At the same time, more and more people are living in or adjacent to forests. These factors point to the need for managing bark beetles and vegetation more actively than in the past.

- When tree density is not managed, high levels of tree mortality will occur, particularly during severe or protracted droughts.

- Most of California is experiencing a drought this year and increased tree mortality should be expected, particularly on the Modoc Plateau, throughout the Sierra Nevada range and across all of the forests in Southern California.

- An urgent, collaborative and financially supported effort is needed among forest land management agencies, private land owners, and the public, to implement large-scale thinning treatments.

- Extensive and timely thinning of California's forests will make them healthier and more resilient for many generations to come, while significantly reducing the threats to life and property during high fire danger years.

- Examples of ongoing collaborative efforts provide effective models for expanding thinning treatments across the state.

BARK BEETLES AND VEGETATION MANAGEMENT

Executive Summary

Tree health in many of California's forests is seriously declining. Health is compromised when there are too many trees competing for limited resources, especially water. Today's forests have many more trees than forests of the past. Tree densities have increased significantly since the late 1800's due to fire exclusion, past harvesting practices, grazing, and other factors. In addition, many of the lower elevation pine forests now have a higher component of drought-intolerant white fir.

Bark beetle outbreaks in California are typically triggered by drought. Areas with high tree density or trees not adapted to a site are very susceptible to high levels of mortality. Throughout the state, bark beetles have killed thousands of trees over the past five years. The most notable recent event was the catastrophic tree die-off during 2003-2004 in the southern part of the state where thousands of trees were killed over an area that exceeded a half million acres. Over $500 million dollars have been spent to abate the large number of hazardous dead trees, reduce fuel loads and restore forests following this event in Southern California.

Native bark beetles are a major cause of tree mortality in California. When, where, and the extent to which mortality occurs is influenced by forest stand conditions and weather patterns. A dramatic rise in the number of dead trees follows one to several years of inadequate moisture. Dense stands are particularly susceptible to bark beetle attacks due to stress caused by constant competition for limited resources. Stressed trees are suitable host material for bark beetles and their successful colonization results in more beetles and high levels of tree mortality. The more severe and prolonged the drought, the greater the number of dead trees.

Vegetation management (thinning) is the most effective tool we have for reducing bark beetle-caused tree mortality. Thinning improves tree vigor, reduces a tree's susceptibility to bark beetles and lowers the potential for catastrophic fire. The highest priority areas for thinning are in and around forested communities and at high value recreation sites. An urgent, collaborative, and financially supported effort is needed among forest land management agencies, private land owners and the public to implement large-scale thinning treatments. Extensive and timely thinning of California's forests will make them healthier and more resilient for many generations to come, while significantly reducing the threats to life and property during high fire danger years.

This report complements the 2007 Western Bark Beetle Report and the National Fire Plan. It provides more detail about forested lands in California and includes the east side of Lake Tahoe in Nevada. A brief overview of land ownership and coniferous types is followed by sections on the causes, effects and management options for native bark beetles.

BARK BEETLES AND VEGETATION MANAGEMENT

Who Owns and Manages our Forests?

California is comprised of 58 counties covering about 100 million acres, of which almost one third are forested. Slightly more than half of the total forest acres are under federal management with private individuals and private industrial companies owning the majority of the remaining acres (Figure 1 & Table 1). Intermingled ownership of these lands occurs throughout the state. Of the federally managed acres, almost 80% are managed by the Forest Service (Figure 2 & Table 2).

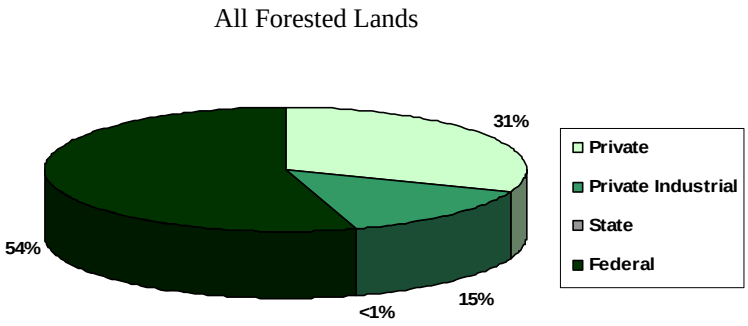


Figure 1. Percent ownership of forest acres.

Ownership	Acres
Private Non-industrial	9,500,000
Private Industrial	4,500,000
State	33,813
Federal	16,900,000
Total	30,933,813

Table 1. Number of forested acres by ownership.

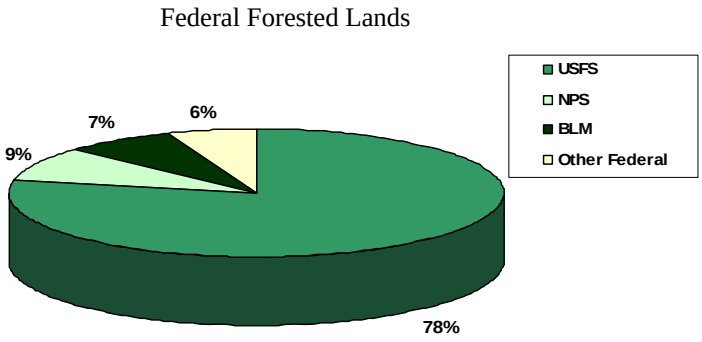


Figure 2. Percent federal ownership of forest acres.

Federal Agency	Acres
USFS	13,200,000
NPS	1,500,000
BLM	1,200,000
Other Federal	1,000,000
Total	16,900,000

Table 2. Number of acres managed by federal agency.

BARK BEETLES AND VEGETATION MANAGEMENT

Common Forest Types

The diversity in California's forests cannot be equaled by any other state in the nation. There are over 11 million acres of hardwoods, 6 million acres of mixed conifer type, and over 3 million acres of pines (Figure 3). In addition, our forests include the worlds tallest trees in the coastal redwoods, the oldest trees in the bristlecone pines and largest trees in the giant sequoias.

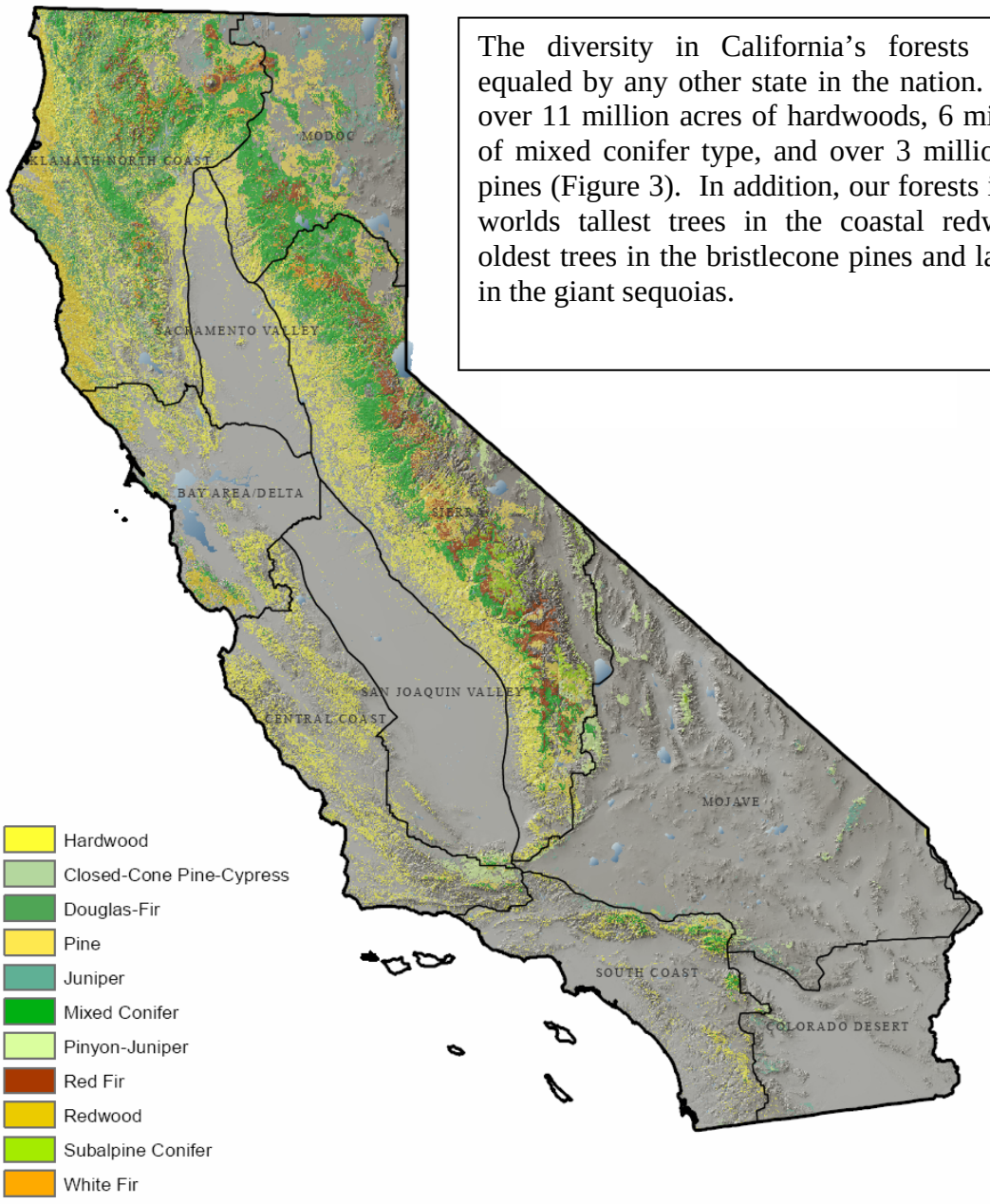


Figure 3. Forest type by bioregion.

BARK BEETLES AND VEGETATION MANAGEMENT

Native Bark Beetles

Bark beetles are small insects, about the size of a grain of rice. Adults bore through the outer bark, etch galleries and lay eggs in the phloem (Figure 4). Adult beetles carry staining fungi which is inoculated into the tree during feeding and gallery construction. Tree mortality occurs from a combination of the fungi invading the water conducting tissue (xylem), and feeding and gallery construction by the adult beetles (Figure 5) and the larvae, which causes disruption of water and nutrient transport.

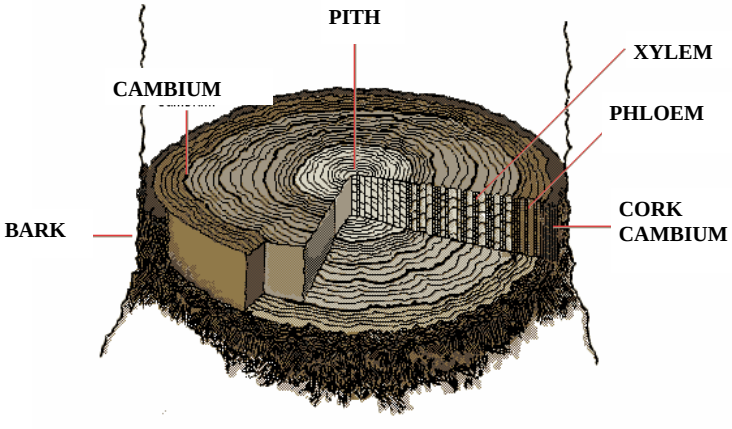


Figure 4. Tree diagram.

Figure 5. Western pine beetle adult galleries.

Figure 6. Pine-infesting bark beetles.

The bark beetle species associated with the highest levels of pine tree mortality in California are the Jeffrey pine beetle, the mountain pine beetle and the western pine beetle (Figure 6). The fir engraver beetle is responsible for much of the white and red fir mortality.

BARK BEETLES AND VEGETATION MANAGEMENT

Causes of Bark Beetle Outbreaks

Native bark beetles are a vital part of healthy, functioning forest ecosystems. They act as "agents of change" and play an important role in the development, death, decomposition and rebirth of our forests. They also create critical wildlife habitat for species dependent on snags for cavity excavation. During years of normal precipitation bark beetles colonize diseased (commonly root diseased or dwarf mistletoe infected trees), old, slow growing, or fire-injured trees. Individual trees and small groups of trees may be killed, but average mortality levels typically do not exceed one tree per 20 acres (Table 3).

Precipitation Condition	**Number of dead conifers per 20 acres**
Normal or above	~ 1 tree
1 year below normal	~ 3 trees
2 years below normal	~14 trees
3 years below normal	~18 trees

Table 3. Precipitation condition and corresponding expected level of tree mortality per 20 acres.

In California, bark beetle outbreaks and the consequent high levels of tree mortality primarily occur in dense forest stands during drought periods (Figure 7).

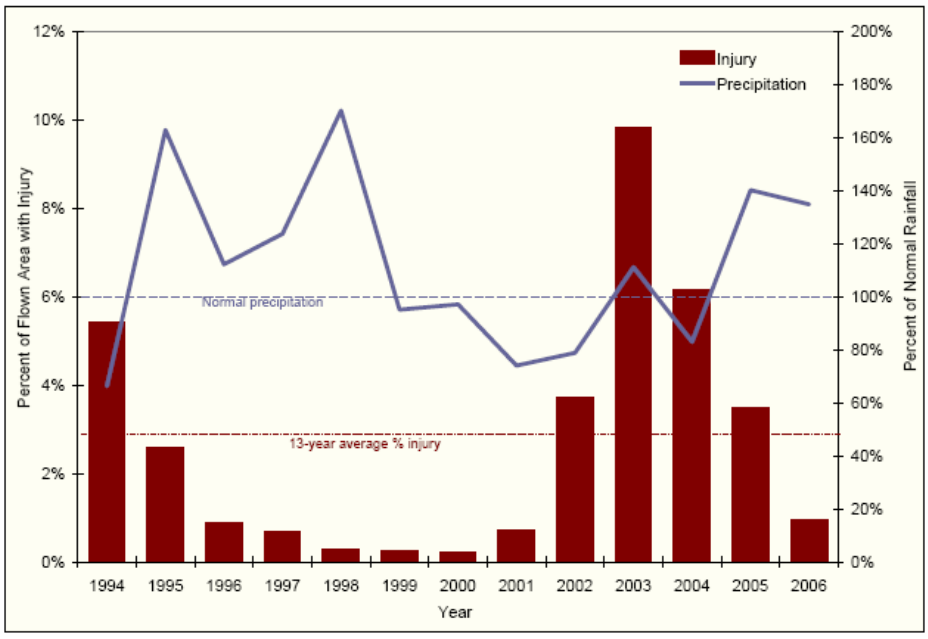


Figure 7. California aerial survey results, 1994 to 2006. Percent of flown area with injury (tree mortality) by percent of normal precipitation.

BARK BEETLES AND VEGETATION MANAGEMENT

Causes of Bark Beetle Outbreaks

Tree susceptibility to bark beetle attack increases as forest stand density increases. The period from 1890 through 1960 was one of the wettest in recorded history for California. This wet period coincided with the period of successful fire exclusion and other management practices (e.g. grazing and high-grading harvesting practices) that resulted in millions of acres of overly dense trees, an unnatural age distribution of trees, and a suboptimal mixture of species (an increase in drought-intolerant, shade-tolerant species; Figures 8 and 9).

Figure 8. Halls Flat, Northeastern California, 1925.

Figure 9. Halls Flat, Northeastern California, 1996.

Trees that appear healthy and green during periods of normal or above normal precipitation can become severely compromised and easy targets for bark beetles during periods of drought. Periodic droughts are a natural feature of California's climate and overly dense forest stands are not sustainable through these events. The recent events in Southern California demonstrate how severe drought can lead to widespread, rapid, and catastrophic levels of bark beetle-caused tree mortality (Figures 10 & 11).

Figure 10. Bark beetle-caused mortality during a severe drought period in Southern California. 2003.

Figure 11. Widespread tree mortality near Lake Arrowhead. 2003.

BARK BEETLES AND VEGETATION MANAGEMENT

Tree Defenses

Trees possess defense mechanisms that help them fend off attacks by bark beetles. When beetle populations are low and adequate moisture is available, trees have the advantage. Healthy trees can produce enough resin (pitch) to overcome attacks by "pitching out" beetles (Figure 12) that are attempting to bore in through the bark. During drought or when trees are severely stressed by other factors (competition, diseases), they are not able to produce enough resin to defend against numerous attacks (Figure 13).

Figure 12. Unsuccessful bark beetle attack. Beetle is stuck in resin.

Figure 13. Successful bark beetle attack.

Effects of Bark Beetle Outbreaks

Elevated levels of tree mortality are only a concern when they affect management goals and objectives or conflict with societal values. Maintaining recreational opportunities, visual corridors, timber resources, defensible space from fire, habitat for wildlife, and property values are all valid objectives. The goals of forest management in wildland and forested communities may differ, but they are equally important.

Bark beetle outbreaks can be devastating to forested communities. Dead trees are hazardous and often must be removed at very high costs. Wildfire severity and intensity can be altered by the increase in dead trees, so mitigating fuel loads also becomes a high priority. A lack of nearby mills, and other finacially viable opportunities that utilize wood products in urban areas can complicate emergency responses and increase the costs of tree removal. Replacing bark beetle-killed trees in communities can also increase post-outbreak restoration costs.

BARK BEETLES AND VEGETATION MANAGEMENT

Tree Mortality

The pattern of bark beetle-caused tree mortality in forests depends largely on the tree species and stand composition. Large areas of mixed species can be killed in a short time span, a single tree species can be killed over thousands of acres in a mixed composition forest (Figure 14), or small to large "group" kills of trees can occur over large areas (Figure 15).

A bark beetle outbreak can alter the appearance of forest landscapes, their stand structure, and their species composition. Changes can be beneficial, detrimental, or both, depending on one's perspective and management goals; however, if untended the beetles will manage the forests. Short and long-term values for recreation, tourism, wildlife, and water quality can be greatly impacted. Bark beetle outbreaks may also lead to increases in fire intensity and severity.

Over the past five years, tree mortality has been detected on over 6 million acres in California's forests (Table 4). The peak year was in 2003 when mortality occurred at very high levels in concentrated areas. Much of it was in dense forests in Southern California where thousands of trees were killed.

During the same time period in Northern California, patterns of tree mortality caused by bark beetles were similar. Since 2002, more than 400,000 forested acres in the Warner Mountains on the Modoc National Forest have suffered significant bark beetle-caused tree mortality. Again, mortality was most severe in dense stands suffering through a protracted drought period.

Figure 14. Scattered white fir mortality. Lake Tahoe Basin. Nevada. 1994.

Figure 15. "Group" kills by Jeffrey pine beetle. Lake Tahoe Basin. Nevada. 1994

Year	Acres
2002	958,782
2003	2,484,270
2004	1,648,327
2005	923,920
2006	307,299
Total	**6,322,598**

Table 4. Number of acres with tree mortality by year.

BARK BEETLES AND VEGETATION MANAGEMENT

An Assessment of the Current Situation

Over 3 million acres of forests in California are at risk (25% or more volume killed) to bark beetle-caused tree mortality over the next 15 years (Figure 16). At-risk areas span across all ownerships and have been identified using models that incorporate stand characteristics (primarily density and species composition) and historical precipitation patterns. Similar models accurately predicted areas that sufferered high levels of bark beetle-caused tree mortality during 2003-2004 in Southern California, as well as others areas of the state (e.g. Warner Mountains in Northeastern CA). Because current forest stand conditions favor the beetles, the models need only be "triggered" by drought to set off a series of events that results in high levels of tree mortality.

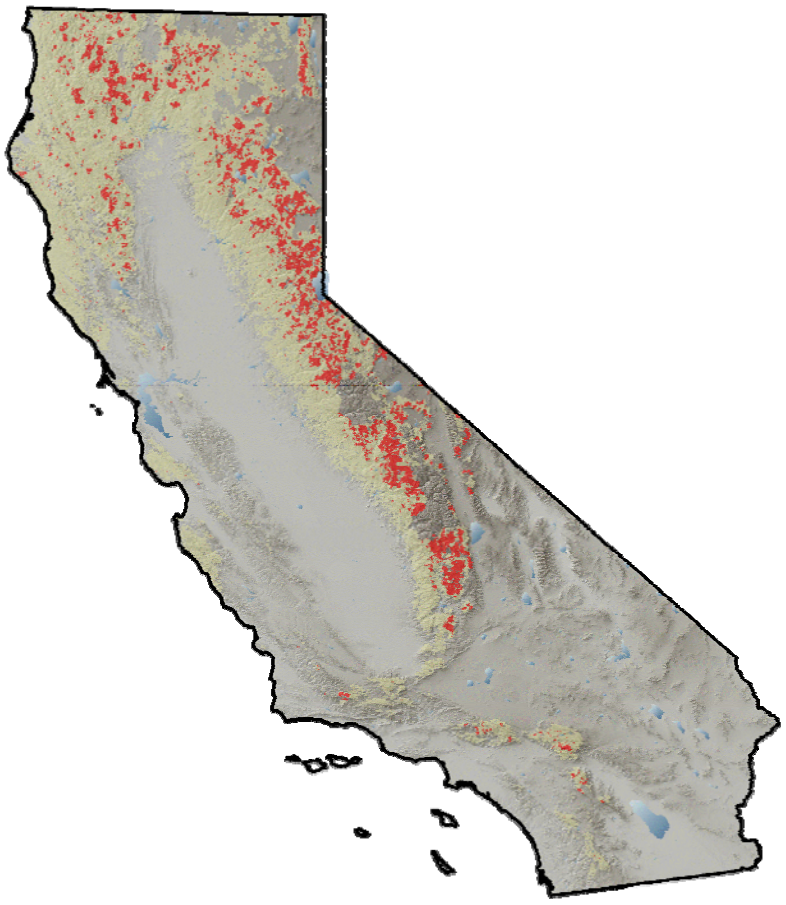


Figure 16. California forest acres at risk (identified in red on the map; risk is defined as 25% or more volume killed) to bark-beetle caused tree mortality over the next 15 years.

BARK BEETLES AND VEGETATION MANAGEMENT

Bark Beetle and Vegetation Management Options

In many areas of California, forest stand conditions are out of balance. At the same time, more and more people are living in or adjacent to forests. These factors point to the need for managing bark beetles and vegetation more actively than in the past. Management alternatives range from "no action," to individual tree protection during an outbreak, to bark beetle prevention thinning. Avoiding large scale tree mortality by implementing proactive prevention thinning treatments is the least costly approach over the long run and allows land managers, not bark beetles, to determine what the residual forest will look like. Reducing fuel accumulations and restorating post-outbreak areas are also critical components of a balanced management approach.

No Action

No action will result in high levels of tree mortality, particularly during severe or protracted droughts. Mortality levels will be exacerbated by stand conditions, with higher numbers of dead trees occurring in denser stands compared to thinned stands. The outcome of "no action" may be acceptable in some areas depending on management objectives; however, our contemporary forests are ripe for catastrophic events and a "no action" policy may have dramatic consequences. Many of our forest trees are older and slower growing, rendering them particularly susceptible to bark beetle attacks. These trees may be very desirable on the landscape but are often the first attacked. In addition, stand densities will continue to increase as forests convert to smaller diameter trees and to more shade-tolerant species. Continued mortality at increasing levels, large, unplanned openings (from the loss of live trees due to bark beetle attacks or from wildfires), continued risks associated with hazard trees, the potential loss of wildlife habitat, more densely stocked stands with smaller diameter trees and an increase in fuel loads are all likely outcomes of a policy centered around "no action." In short, "no action" produces volatility.

Prevention Thinning

Mitigating tree mortality through prevention thinning is the most useful silvicultural treatment available. The long-term health and vigor of residual trees is improved along with tree species diversity and age distributions. Thinning reduces forest susceptibility to large scale-mortality events, including those caused by bark beetles and wildfires. It also opens up forest canopies, thereby altering the ability of bark beetles to follow pheromone plumes. This decreases the likelihood of "group" kills caused by aggregating beetles. Desired future forest conditions can be planned and attained through a proactive thinning management program. Treatments can be designed to retain important forest components (e.g. large, old trees) and a species mix that is better adapted to droughty conditions (higher percentage of pines vs. firs).

Bark Beetle and Vegetation Management Options

To be effective, prevention thinning must be an ongoing program and take place before outbreaks occur; hence the ability to be proactive is critical for success. Reducing stand susceptibility through designed thinning treatments (Figure 17), particularly across larger landscapes and multiple ownerships, will result in long-term reductions in bark beetle-caused tree mortality and lower overall fuel loads. Where appropriate, thinned stands will also benefit from the re-introduction of fire, which can only be accomplished in a safe and controlled manner when stem and crown densities are not too high.


Figure 17. Thinned trees are less susceptible to attack by bark beetles and stand replacing fires.

Individual tree protection treatments

Individual tree protection treatments can be implemented to address short-term, imminent threats during bark beetle outbreaks. Application of an efficacious insecticide to the tree bole will prevent trees from being attacked and killed by bark beetles. This treatment does not alter forest stand characterstics that are conducive to bark beetle outbreaks. It does, however, protect high value trees when other vegetation management activites are constrained and affords land managers extra time to design thinning treatments.

Restoration

Restoration treatments are designed to accelerate recovery following bark beetle outbreaks and to produce a desirable future condition. Treatments vary depending on the management objectives for the impacted area (Figure 18).


Figure 18. John and Madee Cluck plant a pine seedling near Susanville, CA.

Examples of Cooperative Efforts

In response to recent large-scale forest fires and conifer mortality, funds from Forest Health Protection, U.S. Forest Service, and hazardous fuels reduction programs have been combined to improve stand conditions in forested communities and their surroundings throughout the west. In Southern California, community groups, private companies and government agencies organized to address the concerns of the 2003-2004 tree mortality event. Currently, they are working to restore their forested communities and to develop healthy, sustainable and safe forests. Forest Health Protection funds are also being used, in combination with other funds, to improve tree health on National Forest lands that border communities. These examples of collaborative efforts provide effective models for expanding treatments to other high priority areas across the state.

Mountain Area Safety Taskforce (MAST)

The San Bernardino and Riverside County MAST organizations joined forces to coordinate their responses to the San Bernardino-San Jacinto Mountain area tree mortality emergency. These groups shared the common goals of reducing the risk of a major fire and minimizing the impacts on mountain communities should one occur. Their action plan included assuring public safety, working with local, state and federal legislators to obtain funds, reducing fuels, creating fuel breaks, developing commercial use and disposal options for wood products, and identifying and developing plans to ensure long-term forest sustainability. More information can be found at http://www.calmast.org/mast/public/index.html.

Forest Area Safety Taskforce (FAST)

The mission of the FAST is to promote the protection of life and property and to restore forest health in the San Diego area. Their initial goal was to remove dead, dying and diseased trees and other vegetation from evacuation corridors, safe zones and critical infrastructures. Their current goal is to secure funding to thin green trees and manage brush around structures and roads, and they are committed to leading and implementing area-wide vegetation treatments.

Fire Safe Councils

California's Fire Safe Councils preserve and enhance human made and natural resources by providing leadership and support to mobilize all Californians to protect their homes, communities and environments from wildfires. As a result of the councils efforts, thinning and fuel reduction treatments have been implemented on privately owned acres across the state. The Fire Safe Council membership consists of fifty public and private organizations. For more information regarding this successful and diverse collaborative effort, please go to http://www.firesafecouncil.org/index.cfm.

Examples of Cooperative Efforts

Forest Care

Partners in Forest Care include the San Bernardino National Forest Association, CAL FIRE and the U.S. Forest Service. Professional foresters work with small (< 5 acres) property owners to create healthier, fire-safe forest landscapes around homes (Figures 19 & 20). This innovative forest health and fire safety program recently expanded into Big Bear Valley, following its successful debut in Crestline and Twin Peaks, CA. See http://www.sbnfa.com/forestcare.php for more information.

Figures 19 & 20. Before and after thinning at a private residence. Lake Arrowhead, CA. This thinning project was completed through the Forest Care program.

Planning for Seed Needs and Cone Collections

Recognizing the need to conserve genetic variation in Southern California's native conifer forests that are increasingly threatened, several federal and state agencies created a plan to collect cones and store seeds in quantities sufficient to allow recovery of forested conditions following bark beetle outbreaks or wildfires. Over 5,000 bushels of cones were collected and processed during a recent effort. Seeds are safely stored in seed banks in Davis and Placerville, CA.

Western Bark Beetle Initiative Projects on National Forest Lands

During 2002, the U.S. Forest Service in cooperation with the Western Forestry Leadership Coalition prepared the "Western Bark Beetle Report." The report presented a multi-year, multi-agency, multi-landowner integrated pest management approach to managing vegetation and bark beetles. As a result of this report, funding was made available on a competitive basis to implement green-tree thinnings on several National Forests across the West. Between 2003 and 2006, thinning projects were implemented on 10 National Forests in CA, with over 5,000 acres treated. An updated version of the Western Bark Beetle Report was completed in 2007 and can be found at http://www.wflccenter.org/news_pdf/222_pdf.pdf.

Informing the Public and Encouraging their Involvement

Participation and "buy-in" on multiple levels are necessary to make our forests healthier and our communities safer. Ongoing work must be ramped up to achieve success. We need to improve and expand education of the general public regarding our forests, the benefits they provide, and the need to be proactive in forest management. Vegetation treatments prevent large-scale bark beetle outbreaks and reduce fire danger; the public must be informed of the likely outcomes of active vs. non-active forest management. Successful organizations have provided a foundation for work within communities and serve as models for other areas in California. These community-based groups provide much needed local support for managing vegetation. Community groups and resource management agencies need to coordinate efforts to develop effective communication tools for a variety of audiences. Information must be distributed via a wide range of media (radio, television, websites, public meetings, etc.) to reach all Californians.

Wood Utilization Facilities

Public and private funds needed to implement the extensive vegetation management program described in this report are limited. Forest health treatments typically cost more as the distance to saw mill wood processing and bio-energy facilities increases. California's wood products and bio-energy processing infrastructure is a valuable partner in helping landowners and managers achieve the desired outcome of preventing undesirable tree mortality and restoring resiliency to our forests. Vegetation treatments are expensive and generate large volumes of woody material. Extracting value from woody by-products in the form of renewable energy or value-added wood products helps to offset treatment costs. California's advanced bio-energy and solid wood processing infrastructure helps offset treatment costs (Figure 21), thereby increasing the value of funding received for treatment implementation.

Existing and emerging markets that use woody biomass material for heat and electrical generation are critical to our success in some locales. Through cooperative efforts across all ownerships, we need to develop a long-term, reliable source of products, identify and articulate the nature and volume of those products, and engage managers of existing or prospective processing facilities to help assess their market value. Ethanol, biofuels and their conversion technologies are being developed and may offer promising future markets. Linking our woody biomass resource with market opportunities such as these is key to improving forest stand conditions.

Figure 21. Burney Forest Power stand-alone powerplant.

An Integrated Approach to Resource Management

Our forests in California have been managed in a variety of ways over the past century. Their current condition reflects past management practices, primarily fire suppression, historic grazing and high-grade harvesting. Our knowledge regarding forest vegetation management and bark beetle outbreaks has increased over time and we now have many science-based tools to improve forest stand conditions and tree health, and to reduce the likelihood of catastrophic wide-spread tree mortality. But……we need to be proactive and increased and consistent levels of financial support must be forthcoming to ramp up thinning treatments across all ownerships.

A great amount of forest management work has been completed, but we still have a long way to go before landscape-level improvements in tree health are realized. An integrated approach that combines thinning, individual tree protection and forest restoration will tip the balance in the favor of the trees in California's forests and mitigate conditions that lead to catastrophic change. Communities, their surrounding areas, and other valued forests in which high levels of tree mortality are unacceptable, will benefit from improvements in tree health and forest resilience.

Conclusion

Forests are fundamental to California's social, economic and environmental well-being. They provide us with a variety of benefits including recreational opportunities, wildlife habitat, timber products, and clean water and air. It is imperative that we work together to ensure sustainable, healthy forests for our future. Our highest priority is to reduce the potential for bark beetle outbreaks and wildfire by thinning trees in and around our forest communities and at high value recreation sites. Flexibility is important to our success and, to the extent possible, local, state, and federal priority areas should be aligned to treat larger landscapes. An urgent, collaborative and financially supported effort among forest land management agencies, private land owners and the general public is needed to implement large scale thinning treatments that will achieve our goals of creating, maintaining and enhancing healthy forests and reducing the loss of life and property during high fire danger years.

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E. Haunreiter, Sanborn, McClellan, CA. Figures 3 and 16.

E. Vallery, Southern Research Station, Pineville, LA. Figure 6.

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A. Taylor, Penn. State University, University Park, PA. Figure 9.

G. Barley, Cal Fire, San Bernardino, CA. Figures 10 and 11.

S. Meyer, San Bernardino National Forest Association, San Bernardino, CA. Figures 19 and 20.

S. Brink, California Forestry Association, Sacramento, CA. Figure 21.

S. Smith, Vallejo, CA., all remaining figures.