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Jeffrey Pine Beetle

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Jeffrey pine beetle (*Dendroctonus jeffreyi* Hopkins) is the primary insect pest of Jeffrey pine (*Pinus jeffreyi* Grev. and Balf.). The beetle is native to North America, with a range that follows Jeffrey pine, its only host, in California, Nevada, Oregon and Baja Norte California, Mexico. As with other aggressive, tree-killing bark beetles, *D. jeffreyi* experiences boom or bust population fluctuations that cause dramatic and extensive mortality of Jeffrey pines following severe or prolonged drought. During outbreaks, any tree greater than 4" diameter at breast height may be attacked and killed; tree mortality tends to occur in groups, with group sizes ranging from 10 to 50 to several hundred trees. Larger diameter trees are often preferred with mortality occurring singly or in small groups (Figure 1). Larger "group kills" frequently occur in pole-size stands (Figure 2). Long term and widespread prevention is dependent on tree and forest resistance related to tree density. Management activities that reduce stand density help lower susceptibility to Jeffrey pine beetle.

Records of Jeffrey pine mortality date back to the early 1920's on the Inyo National Forest (Inyo County, CA), where beetle populations reached outbreak levels in windthrow and subsequently caused the death of more than 13 million board feet of standing timber across 32,000 acres.

Figure 1. Large diameter Jeffrey pines killed by Jeffrey pine beetle, Luther Pass, Lake Tahoe Basin Management Unit, 2007.

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Figure 2. Groups of Jeffrey pines killed by Jeffrey pine beetle, Lake Tahoe Basin Management Unit, 1995.

More recently, outbreaks of Jeffrey pine beetle have typically been associated with drought. During 1965-1966 outbreaks were recorded in Lassen, Modoc, Placer, and Plumas Counties, CA. High levels of Jeffrey pine mortality was also recorded between 1976-1981 throughout much of the range of Jeffrey pine in California and again between 1992 and 1994 on the east side of the Sierra Nevada range from Bishop, CA north to the southern end of the Cascade Range. This outbreak occurred near the end of a 6 year drought period. During a recent (2002-2004) severe drought in Southern California this beetle caused high levels of Jeffrey pine mortality. Many stands historically dominated by Jeffrey pine or a mixture of Jeffrey and ponderosa pines now are much denser and have a large component of white fir. During protracted or severe drought periods, the large diameter pines do not compete well with the smaller trees for water and nutrients and are thus attacked and killed by bark beetles. Jeffrey pine beetle will attack fire-injured trees; however, subsequent outbreaks within the fire perimeter or in surrounding un-injured trees are not common.

Jeffrey pine beetle is native to North America, and is being distributed throughout most of the range of Jeffrey pine from the southern border of Oregon down through eastern California, west into Nevada and south to the Sierra San Pedro Mártir Mountains of Baja Norte California, Mexico (Figure 3). Although Jeffrey pine occurs in the San Jacinto, Santa Rosa and Laguna mountain ranges in Southern California, Jeffrey pine beetle has not been observed there.

Host

Jeffrey pine is the only known host of the beetle. This pine is the dominant yellow pine in forests east of the Sierra Nevada crest, in some parts of the Southern Cascades, southward into the Transverse and Peninsular ranges and into northern Baja California. Forests in the Sierra San Pedro Mártir, Baja Norte California, Mexico are the southern limit for this pine species and the Klamath Mountains in southwest Oregon are the northern limit. Jeffrey pine's distribution is intimately linked with serpentine soils in the northwest portion of the range and strongly reflects climatic and elevational factors in the northeast, central, and southern portions. Jeffrey pine is cold hardy, drought tolerant and adapted to

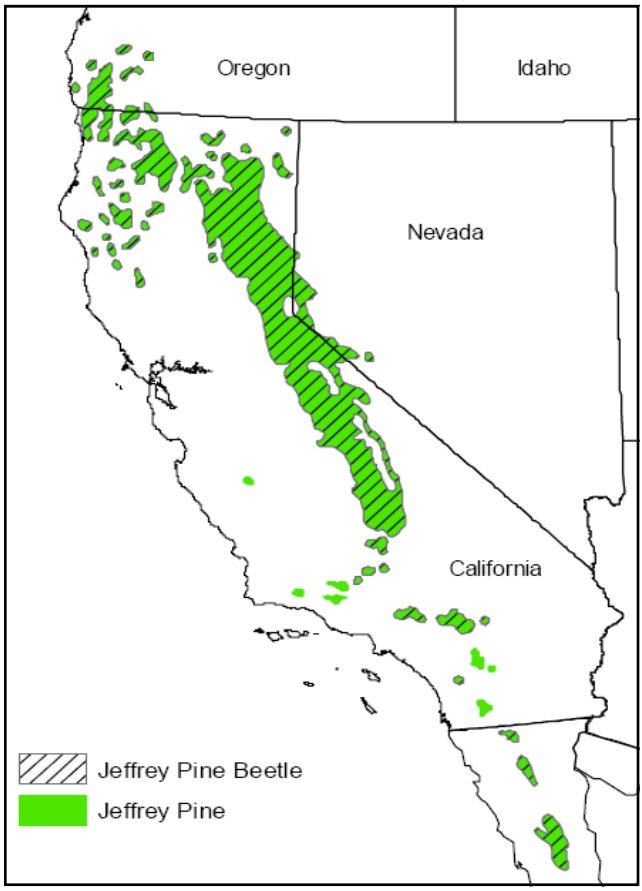

Figure 3. Distribution of Jeffrey pine and Jeffrey pine beetle in North America.

short growing seasons. It competes well and typically dominates other conifers on cold and xeric sites, and those with poor soil conditions. Jeffrey pine's innately short growing season, limited nutrient and water demands, and extensive root growth are adaptations to poor sites; however, they are slow growing, which makes the loss of large trees a long-term impact.

Evidence of Attack and Infestation

Jeffrey pine beetle-attacked trees are not usually detected until their crowns fade from green to yellow to reddish-brown. Foliage on trees attacked successfully during early summer may begin to fade during late fall of the same year. Trees attacked later in the summer typically do not fade until late spring or early summer of the following year. Trees killed by Jeffrey pine beetle usually fade evenly throughout the crown. Crown fading does not typically occur until Jeffrey pine beetle larvae are well developed; offspring beetles have likely already vacated a tree when the crown turns reddish-brown.

Large, reddish pitch tubes (Figure 4) are readily observed on the bark surface of infested trees. Pitch tubes mark the points of attack and can be found long before crown fading. Attacks are made on the mid-bole with additional attacks extending high up on the bole and down to ground line. Successful attacks are indicated by pink to dark-reddish pitch tubes containing boring dust and frass, while unsuccessful attacks ("pitchouts") are typically creamy white to yellow and may lack boring dust and frass. Confirmation of successful vs. unsuccessful attacks is gained by removing bark and looking for life stages or galleries. During droughty periods trees may lack sufficient resin to produce pitch tubes. In these cases boring dust in bark crevices and around the tree base may be the only visible indicators of successful attack.

Successful attacks can be confirmed by removing a section of bark and examining the gallery pattern in the phloem or inner bark. Galleries are constructed by adult beetles and serve as sites for egg deposition. Gallery patterns created by *Dendroctonus* bark beetles are typically species-specific and can be used to identify which beetles have attacked the tree. Jeffrey pine beetle galleries are predominantly straight, vertically oriented with the tree bole, packed with frass and usually have a characteristic "J" shape (Figure 5). The length of galleries varies greatly but typically they range from about 10 to 40 inches. Larval mines are much

Figure 4. Jeffrey pine beetle pitch tube on outer surface of bark.

smaller, extending across the grain at right angles from the parent gallery, and terminating in open, oval-shaped pupal cells. Circular emergence holes can be seen on the outer bark surface following adult emergence. Larger holes, caused by woodpeckers scaling and drilling for food, may also be observed on the tree bole (Figure 6). It is estimated that over 20,000 beetles can emerge from a single, large-diameter Jeffrey pine tree (Josep Riba, unpublished data).

When diagnosing Jeffrey pine beetle as the cause of tree mortality, it is important to establish that the infested tree is a Jeffrey pine. Ponderosa pines look very similar to Jeffrey pines but are attacked by the mountain pine beetle (*Dendroctonus ponderosae* Hopkins), a closely related species that is similar in appearance and habit to Jeffrey pine beetle. Ponderosa and Jeffrey pines are often found growing in mixed stands and a closer look is often needed to differentiate between these trees. Jeffrey pines can often be distinguished from ponderosa pines by their aromatic bark that smells like vanilla. Other distinguishing characteristics are foliage color; Jeffrey pine needles are more blue-green compared to the yellow-green

Figure 5. Jeffrey pine beetle galleries are predominantly straight, vertically oriented and usually have a characteristic "J" shape.

Figure 6. Holes in the bark created by woodpeckers drilling to feed on Jeffrey pine beetles.

needles on ponderosa pines; the under surface of the bark scales on Jeffrey pines are red-brown compared to powdery-yellow on ponderosa pines; and the cones (3-6" in length) on ponderosa pines have spines pointing outward which are prickly, whereas Jeffrey pine cones (5-9" in length) have recurved spines. Ponderosa pines are

also attacked by the western pine beetle (*Dendroctonus brevicomis* LeConte) which has a sinuous gallery pattern. This beetle does not attack Jeffrey pine.

Life History

Jeffrey pine beetle is one of the largest species of bark beetles. Adults are stout, cylindrical beetles about five-sixteenths inch long and dark-brown to black (Figure 7). Beetles develop through four life stages: egg, larva, pupa and adult. Life stages can be observed in an infested tree by removing a section of bark and examining the inner bark. Upon emergence Jeffrey pine beetle adults fly to a new tree and attack it by boring through the outer bark into the phloem. The female beetle arrives first, forms an entrance tunnel, and is then joined by the male beetle. Although not completely understood, evidence strongly suggests that aggregating pheromones are released, attracting high numbers of additional female and male beetles to the same tree. The beetles usually attack at mid-bole; however, attacks on the upper and lower bole are also common. Pole size and larger trees are typically attacked, but trees as small as 4 inches in diameter can be attacked during outbreaks.

In newly attacked trees, beetles etch vertical galleries on the inner surface of the bark by boring diagonally across the wood grain for two or three inches, then vertically upward and parallel to the grain for an additional two to three feet. Each gallery is constructed by a single pair of beetles. As construction of the gallery progresses, the female deposits individual eggs in niches along the sides (Figure 8). The gallery is packed solidly with boring dust and frass. Eggs are oval, pearly-white (Figure 8), and hatch in one to three weeks. Larvae are curved, white, legless grubs with yellow (sclerotized) head capsules (Figure 9). Mature larvae, similar in size to adult beetles, tunnel in the phloem, away from the main gallery, across the wood grain. Pupae are white, slightly smaller than last instar larvae (Figure 10) and mature into adults in about 10 days. Mature larvae, pupae, and new adults are in cells at the ends of the larval galleries. Beetles emerge from the pupal cells by tunneling out through the bark.

Figure 7. Jeffrey pine beetle adults are stout, cylindrical beetles about five-sixteenths inch long and dark-brown to black.

One or two generations can be completed per year depending on location and temperature. One generation may be more common in northern California, whereas a second generation may occur in the same year in warmer areas like Southern California and Baja Norte California, Mexico. The occurrence of multiple generations can be easily confused with an extended emergence period. The principal period of attack is in June and July, but attacks can also occur through September into early October. The beetle overwinters primarily in the larval stage.

Common Associates

Many organisms occur with the Jeffrey pine beetle. Adult beetles carry yeasts along with the mycangial blue-staining fungus, *Ophiostoma clavigerum* Robinson-Jeffrey & Davidson (Six and Paine 1997) into trees. These organisms find a fertile medium for development in the inner bark and sapwood, and their growth decreases the flow of nutrients and water in the tree. This aids in tree death and causes the characteristic crown fading patterns. Bluestain fungi can discolor the sapwood to a bluish-color in one to several months, reducing value for wood products.

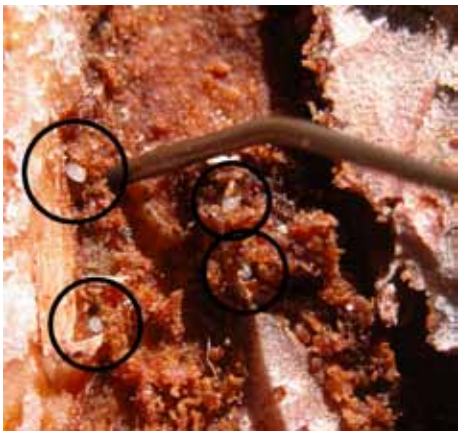

Figure 8. Jeffrey pine beetle eggs.

Figure 9. Jeffrey pine beetle larvae.

Associated insects, mostly minor species that invade after the tree is declining, are also found in trees attacked by the Jeffrey pine beetle. Common associates include the pine engraver (*Ips pini* Say.), the emarginate ips (*I. emarginatus* Lec.), the red turpentine beetle *(D. valens* Lec.)) and the California flatheaded borer (*Melanophila californica* Van Dyke). The pine engraver may precede the Jeffrey pine beetle or attack at about the same time. It mines in the top part of the tree bole, usually above the area infested by Jeffrey pine beetle. The emarginate ips generally attacks shortly after Jeffrey pine beetle and works in the lower part of the stem where its galleries are often intermingled with Jeffrey pine beetle galleries. Attacks by the red turpentine beetle may precede, be simultaneous with, or follow attacks by Jeffrey pine beetle. Attacks by red turpentine beetle are usually on the lower bole near the ground and can extend into the root system. The California flatheaded borer is often found after most bark beetles have emerged, but can also be found prior to attack by Jeffrey pine beetle in slow growing, drought-stressed or diseased trees. Trees attacked by Jeffrey

Figure 10. Pupa in pupal cell on inner surface of bark.

pine beetle also commonly have some level of western dwarf mistletoe (*Arceuthobium campylopodum* Engelm.) infection.

The blackbellied clerid (*Enoclerus lecontei* Wolcott), the redbellied clerid (*E. sphegeus* F.), and the blue-green ostomid (*Temnochila chlorodia* Mannerheim) are important predators of Jeffrey pine beetle. In addition, woodpeckers feed heavily on most life stages (Figure 6).

Long-term Prevention

Normally Jeffrey pine beetle populations are kept in check by natural enemies, climatic factors, and host resistance. During periods with adequate precipitation, Jeffrey pine beetle-caused tree mortality usually goes unnoticed, consisting of only a few trees across the landscape. During drought periods, however, Jeffrey pine beetles can cause high levels of tree mortality across extensive areas. Management activities that promote tree health and vigor will reduce tree susceptibility to successful attack. Reducing stand density and improving tree resistance hampers beetle success; thinning is the only treatment available to increase tree resiliency to drought and bark beetles over the long term. Maintaining an appropriate basal area and a diversity of species and age classes is the best defense against undesirable Jeffrey pine beetle-caused tree mortality, even during outbreaks. Thinning also reduces flammable fuels, thereby reducing fire threat to people and structures during years of high fire danger.

During thinning projects, consideration should be given to the use of a stump treatment to prevent annosus root disease caused by the fungus *Heterobasidion annosum* ([FR] Bref.). Annosus root disease is widespread throughout many areas of California and can cause mortality of infected trees. Windborne spores enter through stump surfaces. The fungus grows into the roots, causes decay, and eventually can kill the tree. The disease spreads from tree to tree through root contacts. The best way to avoid infection is prevention. Treatment of all freshly cut stumps with a registered borate compound prevents infection. Stumps should be treated within 4 hours after trees are cut.

Short-term Prevention

Insecticides

Insecticides are available to prevent bark beetle attacks. Such treatments are typically reserved for high value trees, such as those located in campgrounds, administrative sites, or on private property. Smith (1982) assessed the residual toxicity of carbaryl (2% a.i.) on treated logs and found a 92% reduction in length of egg galleries of Jeffrey pine beetle compared to untreated logs. Additional trials are underway to determine efficacy and duration of insecticides registered for use against bark beetles. Based on circumstantial evidence from Jeffrey pines sprayed in campgrounds in California and Nevada, some of the same preventive insecticides effective against other western bark beetles may also be effective against Jeffrey pine beetle.

Preventive sprays should be applied to the tree bole to bark saturation and should reach as high up the bole as the equipment will allow (at least mid-bole or higher, 30-40 feet). Tree protection can be gained for 1-2 years depending on the insecticide. Insecticide use is governed by the provisions of the Federal Insecticide, Fungicide, and Rodenticide Act, as amended. This act is administered by the Environmental Protection Agency (EPA). Registrations of pesticides are under constant review by the EPA; consult your local forest entomologist, county agriculture agent, or State extension specialist to be sure the intended chemical and use are legal. It is always important to carefully follow all label instructions when using registered pesticides.

Removing infested trees

Removing infested trees can reduce the number of trees infested in the immediate surrounding area the following year.

Successful infested-tree removal projects were conducted in the Lake Tahoe Basin Management Unit, Lassen Volcanic National Park and on the Lassen and Tahoe National Forests during the late 1980's and early 1990's. Subsequent mortality was reduced in all areas when trees were removed prior to beetle emergence. If tree removal is not possible, infested trees may also be cut and burned or chipped to kill beetles.

Additional Information

Private landowners can get information from County Extension Agents, State Agricultural Departments, or their local State Forestry office. Federal resource managers contemplating action against the Jeffrey pine beetle should contact Forest Health Protection, USDA Forest Service (www.fs.fed.us/foresthealth/). This publication and other Forest Insect and Disease Leaflets (FIDLs) can be found at www.fs.fed.us/r6/nr/fid/wo-fidls/.

Six, D.L., and T.D. Paine. 1997. *Ophiostoma clavigerum* is the mycangial fungus of the Jeffrey pine beetle, *Dendroctonus jeffreyi*. Mycologia, 89:858-866.

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Pesticides used improperly can be injurious to humans, animals, and plants. Follow directions and read all precautions on the labels. Consult your local forest health specialist, county agricultural agent, or State extension agent about restrictions and registered uses of particular pesticides.

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