USDA
United States Department of Agriculture

Bark Beetles in California Conifers

Are Your Trees Susceptible?



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



TREES KILLED BY BARK BEETLES

Tree mortality caused by bark beetles can rise sharply in a short amount of time, similar to that observed in the southern part of the state in 2003. The primary reason for increases in tree mortality have been periods of severe and protracted drought combined with high tree densities. High levels of tree mortality will occur if forests are not altered to improve tree health and resilience.

The bark beetles causing widespread mortality in the forests and forested communities in California are all native. The principal species include: mountain pine beetle, fir engraver beetle, western pine beetle, Jeffrey pine beetle and pine engraver beetles.

HOW CAN SOMETHING SO SMALL KILL SOMETHING SO BIG?

Individual bark beetles are not much larger than a piece of cooked rice. Not only are they small and difficult to see, their activity is often scattered and hardly noticeable.

Bark beetles survive in trees that are stressed, diseased, or injured; either by human activity or during storms or wildfires. Occasionally, small groups of standing trees may be killed but over the landscape they are often unnoticed.

Bark beetles can increase dramatically when sufficient food is available. Typically this is in the form of drought-stressed trees. High numbers of these small beetles (outbreak populations) attack trees *en mass*. Often many trees are killed over the landscape; likened to that of wildfire. In many years, more trees are killed by bark beetles than by fire!

In the battle between trees and tree-killing beetles the two principle interacting factors are tree vigor and beetle numbers. When beetle populations are low, healthy trees often produce enough resinous pitch to drown and "pitchout" the beetles that attempt to enter. When trees are stressed they may be unable to produce sufficient amounts of defensive pitch. When beetle populations are high, even an apparently healthy tree may not be able to produce enough pitch to ward off hundreds of attacks (a mass attack). In addition, many beetles carry fungi that further impair the tree's defense system.



WIDESPREAD TREE MORTALITY NEAR IDYLLWILD, CA - 2003

PITCH TUBES



(SUCCESSFUL ATTACK)



(UNSUCCESSFUL ATTACK)

Does this affect you? Look inside!

WHAT IS A BARK BEETLE?.....PAGE 2
WHAT CAUSES SIMILAR ATTACKS?.....PAGE 4
ARE MY TREES SUSCEPTIBLE?.....PAGE 5
HAVE MY TREES BEEN ATTACKED?.....PAGE 8
HOW TO PREVENT ATTACKS.....PAGE 9
WHAT ARE LAND MANAGERS DOING?.....PAGE 11
WHO SHOULD I CONTACT?.....PAGE 12

This publication was developed to educate the public regarding the principle tree-killing bark beetles in California. With this knowledge, you can make informed decisions concerning improving tree health on your private property and provide meaningful input about proposed actions on public lands.

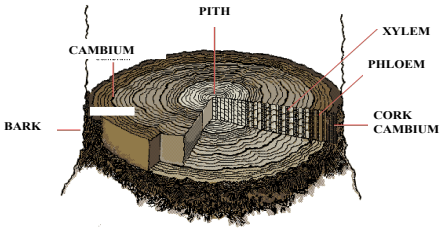
Federal and State Forest Health Staff are available to assist you with additional information. Please see page 12 for a list of contacts and additional information sources.

Forest Service
Pacific Southwest Region

What is a Bark Beetle?

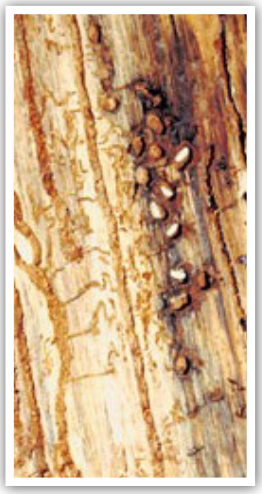
Bark beetles are small (< ¼ inch), hard bodied beetles that bore through the protective bark of a tree to lay their eggs in the moist phloem (inner bark). These beetles and the larvae they produce feed on this living tissue, cutting off the tree's ability to transport nutrients. The gallery pattern on the underside of the bark created by adult beetles and their larvae as they feed are unique for each species of beetle. The parent gallery is typically created by the adult female beetle who deposits eggs along the gallery walls. The eggs hatch and the larvae create 'larval galleries' that tend to increase in width as the larvae increase in size.





Mountain Pine Beetle

The mountain pine beetle is native to forests of western North America and attacks ponderosa, lodgepole, sugar and other species of pine. It does not attack Jeffrey pine. Periodic outbreaks of mountain pine beetles can kill millions of trees.



Mountain pine beetle gallery and life stages

During low population levels, attacks are primarily on trees stressed by injury, poor site conditions, overcrowding, root disease, or old age. As beetle populations increase, attacks may involve most trees 6 inches in diameter or greater in the outbreak area, regardless of their apparent health.

Adults are brown to black in color and about 3/16 inch long with a rounded back end. Larvae are yellowish-white, legless grubs with dark heads, found within galleries under the bark.

Attacking beetles release chemicals called aggregating pheromones that attract other beetles until a mass attack overcomes the tree. Attacks may "spill over" into adjacent trees causing what is known as a "group kill". Crown fade on successfully attacked trees typically occurs within 4 to 10 months. Drought-stressed trees may fade in a shorter period of time.

Mountain pine beetle adults fly from May through October, depending on temperature. Beetles usually take one year to complete their life cycle; at higher elevations 2 years may be required and at lower elevations two generations may occur in one year.

Female mountain pine beetles create straight, vertical (with grain of wood) galleries that can extend up to 3 feet or more in length. Eggs are laid alternately along the sides of the gallery. Larvae feed on phloem, constructing galleries at right angles to the parent galleries. The combination of beetle attacks, gallery construction and feeding, and staining fungi, cause the tree to die.



Galleries constructed by western pine beetles.

Western Pine Beetle

This beetle is also native to western North American forests and primarily attacks ponderosa and Coulter pines in California. During drought periods it can kill trees of all ages and vigor classes. Group killing of trees is common.

Adult beetles are dark brown and about ¼ inch long. Larvae are small, white, legless grubs. Western pine beetle larvae mine a short gallery in the phloem and then turn into the middle bark to complete their development.

Attacking beetles release chemicals called aggregating pheromones that attract other beetles until a mass attack overcomes the tree. Attacks may "spill over" into adjacent trees causing what is know as a "group kill." Western pine beetles typically fly from late spring through late October. One to three generations may occur in a single year.

The adult gallery pattern of the western pine beetle is winding and crisscosses in several directions. It is the only bark beetle that makes this particular type of gallery. Galleries are usually tightly packed with frass. Flaking of the bark by woodpeckers in search of beetle larvae exposes the bright-orange colored inner bark, making infested trees quite apparent. The combination of beetle attacks, gallery construction and feeding, and staining fungi, cause the tree to die.

Jeffrey Pine Beetle

Jeffrey pine beetle is the principal insect enemy of Jeffrey pines. This native beetle occurs throughout most of the range of Jeffrey pine, and similar to the mountain and western pine beetle, it can cause high levels of tree mortality. Adult beetles are reddish-black and about 5/16 inch in length. Larvae are curved in shape, mostly white, and have yellowish colored heads.

Similar to the two previously discussed bark beetles, Jeffrey pine beetles attack trees by boring through the outer bark and into the phloem. Adult galleries run vertical with the grain of the wood and larval galleries extend at right angles acoss

the grain. No other insect that breeds in Jeffrey pine makes galleries like these. Adult galleries may have a characteristic "J" shape and are packed with frass. These bark beetles also use pheromones to communicate and also carry staining fungi. Jeffrey pine beetles typically take a year to complete one generation but two generations per year may occur depending on temperature.

Once a group kill occurs in an area, emerging beetles tend to attack the next closest green trees, so group kills continue to enlarge every year until the infestation collaspes. High levels of Jeffrey pine mortality have been observed over the past several years; primarily corresponding with drought. Large diameter trees may initially be favored, however, if beetle populations are high enough, trees as small as 3 inches in diameter may be attacked and killed.

RED TURPENTINE BEETLE

The red turpentine beetle is the largest of the pine bark beetles in California. It usually attacks trees with poor vigor, those infested by other bark beetles, mechanical or fire-injured trees or those that have injured or poor root systems. It also commonly attacks the stumps of freshly cut trees, but does not typically attack green slash. Adult beetles are about ¼ inch in size and reddish brown. Peak flight activity and attacks usually occur in the spring. Most attacks are on the lower bole near ground line but they can also be higher. Pitch tubes vary in size, texture, and color, depending on the host tree and can be as large as 2 inches across. Eggs are laid in a mass along the side of the parent gallery. Larvae feed together into fresh tissue; their feeding kills a patch (may vary in size from a few to several inches wide) of inner bark (phloem). Galleries can extend below the ground surface into the roots. In most areas there is at least one generation per year. Successful red turpentine beetle attacks alone may not kill trees, however they typically indicate that the tree is stressed or injured, and their attacks may predispose trees to attack by other bark beetles. As with most bark beetle species, maintaining tree health and minimizing tree injuries will reduce the likelihood of attacks.



RED TURPENTINE BEETLE PITCH TUBES

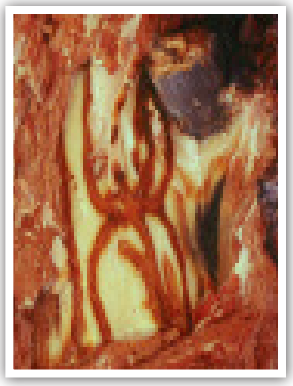
PINYON IPS

Most native pine engraver beetles in the 'ips' group are not very aggressive tree killers. Rather they tend to rely on injured or stressed trees or green slash for food and reproduction sites. Pinyon ips, a native ips, is no exception. Host trees are often found in areas prone to droughts which increases tree susceptibility to attack. During drought periods, pinyon ips are able to overcome weakened defenses and kill high numbers of trees across broad landscapes. This beetle can have two or more generations per year with attacks beginning early in the spring and continuing through early fall. Pinyon ips are about 1/5 inch long, and have a spiny back end typical of all "ips' species (versus a rounded back end). Gallery patterns of most ips are similar; often a Y or H shape. Larvae and adults overwinter under the bark and consume large patches of inner bark.



PINYON IPS

There are several other native pine engraver beetles that infest pines and green pine slash. They can cause top kill or whole tree mortality. Adults have various numbers of spines on the back end depending on the species. Number of generations per year varies by species and temperature.



TYPICAL IPS GALLERY

FIR ENGRAVER BEETLE

Also a native bark beetle, this species attacks true firs. It does not attack Douglas-fir (not a true fir).

About 1/8 inch in length, these small, shiny, black beetles are distinguished by having a truncated, spineless, back end. The parent gallery cuts across the grain of the wood (horizontally) for 4 to 12 inches and the larval galleries extend up and down with the wood grain. Shortly after attack (no pitch tubes), a fungus carried into the tree by the beetles starts to stain the area a yellow-brown color. Larvae overwinter under the bark and adult beetles emerge from June through August. There is typically one generation per year. Larvae and pupae are similar to those of other bark beetles.



FIR ENGRAVER



FIR ENGRAVER BEETLE GALLERY

DOUGLAS-FIR BEETLE

This beetle is a native to forests of western North America and only attacks Douglas-fir trees. Outbreaks in California typically occur in areas of wind-thrown trees.

Adult beetles are brown to black in color and about 3/16 inch long. The larvae are whitish, legless grubs with brown heads found within galleries under the bark. Eggs are laid in groups on alternative sides of the parent gallery, creating a unique pattern.



DOUGLAS-FIR BEETLE GALLERIES

OTHER AGENTS . . .
THAT ATTACK TREES

Other insects or animals can cause injuries to trees that may resemble bark beetle activity. Listed below are a few of these to help you discern between bark beetles and other agents.

Because bark beetles have often left the tree by the time you see red needles, your inspection of a dead tree may find insects that were not directly responsible for the tree's death. Many of these insects live under the bark of dead and dying trees and are important in recycling nutrients.

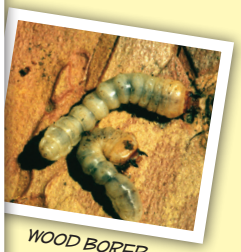
Most often confused with bark beetles are the metallic and longhorned **WOOD BORERS**. Wood borers are much larger than bark beetles. Wood borers can feed on the phloem, sapwood and into the heartwood. Larvae may drill large oval or round holes into the wood. Their life cycle may take from one to several years to complete.



A BARK BEETLE (LEFT) AND WOOD BORER (RIGHT)



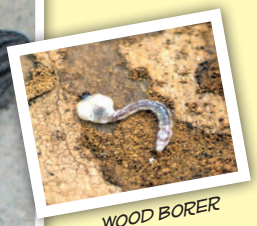
LONGHORNED WOOD BORER



WOOD BORER LARVAE



SCULPTURED WOOD BORER



WOOD BORER LARVA

WOOD WASP larvae make large holes in dead wood similar to wood borers but larvae do not feed in the phloem.



WOOD WASP OVIPOSITING IN WOOD



AMBROSIA BEETLE AND GALLERIES

AMBROSIA BEETLES are very small and create multiple pin holes in wood where they cultivate a fungi (ambrosia) to feed on. White boring dust in bark crevices and in webbing on the bark surface is easily visible.

Woodpeckers (**SAPSUCKERS**) can make holes in the bark that may look like a bark beetle entrance/exit hole.



TREE INJURY CAUSED BY SAPSUCKER FEEDING



SAPSUCKER DRILLING TREE FOR SAP

Are Your Trees Susceptible to Attack by Bark Beetles What Should You Do?

STEP 1: IDENTIFY YOUR TREES

The first step in determining if your tree is susceptible to attack by bark beetles is to know what species of tree you have. The principal conifers found in forested communities in California are highlighted below.

PINES:

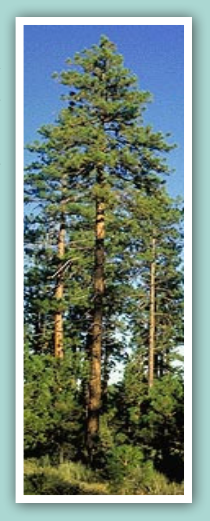
Most pines have more than one needle attached to the tree in a 'bundle'. The number of needles per bundle is often important in determining the pine species.

PONDEROSA PINE

Ponderosa needles are 2-3 to a bundle, ranging from 3-10 inches in length. Cones are 3-5 inches long and armed with small spines.
Range in California: Widespread in the lower and middle elevation forests throughout the State.



PONDEROSA PINE CONE



PONDEROSA PINE

JEFFREY PINE

Very similar to ponderosa pine. Needles are in bundles of 3, occasionally 2. Cones are larger and stouter (5-9 inches) and have incurved spines (prickly ponderosa; gentle Jeffrey).
Range in California: Dominates on serpentine throughout the Klamath Mountains and north Coast ranges. In the southern Cascade and Sierra Nevada ranges it is found in the mixed conifer forest. It is the dominant pine on much of the eastside of the Sierra Nevada from Lake Tahoe south and commonly mixes with ponderosa pine. It occurs with Coulter pine and replaces ponderosa pine in the interior forests in southern CA.



JEFFREY PINE CONE

LODGEPOLE PINE

Needles are two per bundle; 1-3 inches long. The small ¾-2 inch long cones have very short stalks and stay attached to the tree for many years. Cones are prickly.
Range in California: Scattered distribution along the coast (shore pine). Found in the southern Cascade and Sierra Nevada ranges and in the San Bernardino, San Jacinto and San Garbriel mountains in southern CA. Often found in wet areas or in frost pockets.



LODGEPOLE PINE NEEDLES



LODGEPOLE PINE CONES



SUGAR PINE CONE



SUGAR PINE TREE

SUGAR PINE

Five-needle bundles. Cones are 10-18 inches long. Upper branches on large trees are often sprawling and turned upward.
Range in California: Klamath mountains and north coast ranges, Cascade and Sierra Nevada ranges, and at higher elevations in southern California.



PINYON PINE CONE

PINYON PINE

Singleleaf pinyon: Needles are single, slighty curved and sharp tipped, 1-2 inches long and are green-gray. Cones are reddish-brown and 2-3 inches long. Cones can remain on the trees for many years. Trees are up to 40 feet tall, may be multi-stemmed at the base and branches can be low on the bole near the ground. Parry pine: similar in general appearance, however needles are in bunches of 4.

PINES:

COULTER PINE

Needles occur in bundles of three and cluster toward the end of the branches, giving a tuffed appearance. Cones are 10-14 inches long and have flat, incurved, claw-like spines.
Range in California: Prominent in the southern California mixed-conifer forests. Commonly overlaps with Jeffrey pine.



COULTER PINE CONE

FIRS:

Needles on fir trees are not in bundles but are attached individually to the stem; the shape of the needle can differ by tree species.

WHITE FIR

The single, flat needles narrow to a stalk at their base. The needles tend to be longer (2-3 inches) and flattened on the lower branches and shorter (<2 inches) and curved upward near the top of the tree. The greenish-yellow cones (3-5 inches), are on the upper branches and point upward.
Range in California: Common and often dominant in higher elevation mixed-conifer forests. Mixes with pine on the east slope of the Sierra Nevada and at lower elevations.



WHITE FIR NEEDLES

UPRIGHT CONES STAY ON BRANCHES

DOUGLAS-FIR

Although not a true fir, Douglas-firs are similar to other firs in having short (~1 inch), single, flat needles. Needles are narrow at their base, similar to white fir. Douglas-fir needles are yellow-green and cones are about 3 inches long. The cones have distinct bracts that resemble the tail of a mouse. Range in California: Douglas-fir occurs in extensive stands in the Coast and Klamath Ranges and primarily on the west side of the Sierra Nevada Range.



DOUGLAS-FIR FOLIAGE

RED FIR

Needles are 4-sided and are somewhat flattened on the lower branches, they greatly curve upward on the upper branches. The cones (2-4 inches long) are purplish to yellow and are upright on the upper branches.
Range in California: Dominates in the high elevation forests in the northern ranges and in Cascade and Sierra Nevada ranges. Absent in the Warner Mountains and in southern CA.

RED FIR CONES



RED FIR NEEDLES

CYPRESS:

Trees in this family have small, scale-like leaves that are usually pressed against the branchlet.

INCENSE CEDAR

Scale-like leaves that are opposite each other, overlapping and closely pressed against the branchlets. Leaves are oblong to egg-shaped and are sharply pointed at the tip. Cones are small, yellow to yellowish-green, and hang downward. Range in California: Very common species over a broad elevation range in the Sierra Nevada. Tends to be restricted to serpentine soils in the north Coast Ranges and western portion of the Klamath Ranges. In southern CA it is scattered throughout the mixed conifer forests.



INCENSE CEDAR FOLIAGE

PINES ARE TYPICALLY MORE DROUGHT TOLERANT AND LESS SHADE TOLERANT THAN FIRS.

PLANT TREES THAT ARE NATIVE TO YOUR AREA.

References:
Elias, T. 1989. Grolier's Field guide to North American trees. Grolier Book Clubs. Danbury, CT.
Griffin, J.R. and W.B. Critchfield. 1972.The distribution of forest trees in California. Pacific Southwest Forest and Range Experiment Station Research Paper 82. U.S.D.A. Forest Service.

STEP 2:
DETERMINE YOUR TREES' SUSCEPTIBILITY

Susceptibility is the condition of an individual tree or stand of trees that predisposes it to attack by bark beetles.

INDIVIDUAL TREE SUSCEPTIBILITY

Stressed trees are not able to fend off bark beetle attacks. Tree stress can result from human activity (construction, paving, excavating, etc.), natural causes (DROUGHT, wind, lightning, other insect or disease agents, etc.) or from competition from other trees. The more stressed the tree, the more susceptible it may be. Poor crown condition is often indicative of stress. Susceptible trees are not always attacked by bark beetles, especially if beetle numbers are low. Conversely, it is possible when beetle populations are high, that even apparently healthy trees may be attacked. In a forested community, or on your own property, an individual tree may be of high importance for aesthetic or other values. Several types of treatments may be warranted to improve its health and vigor and protect it from successful attacks by bark beetles.



DIFFERENCES IN CROWN FULLNESS BETWEEN A HEALTHY CROWN (LEFT) AND A POOR CROWN (RIGHT).

STAND SUSCEPTIBILITY

A large group of trees, or stand in its entirety, can also be susceptible to bark beetles. Species composition, tree ages, tree density, being in a drought prone area, having root diseases, or other attributes can make one stand more susceptible compared to another. Widely spaced trees are typically less susceptible to successful attack by bark beetles compared to densely growing trees. Less competition for water, light, and nutrients facilitates tree growth and vigor, both of which are important in the defense against bark beetles. Stands with a higher diversity of tree ages and tree species are also typically less impacted, as most bark beetles have only one or a few hosts and they generally are particular about the size of trees they attack. Mortality of one tree or a few trees in a stand may be quite acceptable depending on the management objectives for the area.



THINNED STAND OF PINE TREES



DENSE STAND OF PINE TREES

BARK BEETLES AND THEIR HOSTS

Tree-killing bark beetles often have a preference for specific tree species. In some cases, a single beetle species will attack only one tree type. In other cases a single beetle species may infest a number of similar tree species.

Lodgepole, ponderosa, and sugar pine: These native pines are attacked by mountain pine beetles. **Ponderosa pines** are also attacked by western pine beetles, as are **Coulter pines. Jeffrey pine** is attacked by Jeffrey pine beetles. These bark beetles are all very similar in appearance and successful attacks almost always result in tree mortality. In general, these beetles attack trees that are greater than 8 inches in diameter at breast height; trees that are weakened by drought, competition, disease or injury; or those that are located near existing beetle-infested trees. Red turpentine beetles are common associates in pine trees infested with mountain, western or Jeffrey pine beetles. They also readily attack fire-injured trees and are often indicative of unhealthy root systems or poor soil conditions. Red turpentine beetle attacks do not always cause tree mortality. Dead or downed pines are rarely infested by any of these pine beetles.

Singleleaf and other pinyons: The landscape level pinyon pine mortality that occurred during 2003-2004 was caused by pinyon ips. Severe drought was the "trigger" that initiated the pinyon ips outbreak, resulting in extremely high levels of pinyon mortality westwide.

White fir and Red fir: The fir engraver beetle is the principle beetle that attacks white and red fir. Attacks can result in top kill, branch kill or whole tree mortality. Trees weakened by drought, or other stressors are most susceptible. Root disease, most commonly Heterobasidion root disease, is often associated with these fir trees and serves as a weakening agent.

White fir is much more common in many areas than it use to be. It is a drought-intolerant, shade tolerant tree that readily regenerates in historically pine-dominated landscapes. High levels of white fir mortality are quite common during protracted and/or extreme drought periods.

Incense cedar: These trees are rarely killed by beetles alone. Typically, they are stressed by drought or other weather-related stressors (frost) long before they are attacked by bark or wood boring beetles.

Douglas-fir: Douglas-fir trees can be killed by the Douglas-fir beetle, but woodborers may be more commonly associated with tree mortality throughout much of California. Douglas-fir beetle readily attacks down green and fire-injured Douglas-fir trees and emerging beetles can cause high levels of tree mortality.

STEP 3: DETERMINE IF YOUR TREES HAVE BEEN ATTACKED

Many signs and symptoms of bark beetle attack are similar regardless of the tree or beetle species involved. However, some are more prevalent with certain bark beetles than others. Some of the most common signs and symptoms are described below. The combination of beetle attacks, gallery construction and feeding, and staining fungi, cause tree death.

MOUNTAIN, WESTERN, AND JEFFREY PINE BEETLES

HOSTS: Ponderosa pine is attacked by western and mountain pine beetles. Coulter pine is attacked by the western pine beetle. Lodgepole and sugar pine are attacked by mountain pine beetles and Jeffrey pine is attacked by Jeffrey pine beetles.



PITCH TUBES RESULTING FROM BARK BEETLE ATTACKS

Signs of beetle infestation are pitch tubes, small holes through the bark, or boring dust and/or frass. Most beetle-attacked trees will have pitch tubes scattered over the tree bole. Pitch tubes resulting from successful attacks are typically reddish in color and vary in size depending on the beetle species. White or cream colored pitch tubes may be indicative of unsuccessful attacks. Beetles may attack around mid-bole first and then fill in up and down, so you need to examine the entire bole when looking for pitch tubes. Boring dust (produced by the beetle chewing) and frass (produced by the beetle feeding) is reddish in color but may also be yellowish or white, and is found mixed with resin in the pitch tubes and/or in the bark crevices. If the tree is extremely water- stressed and cannot produce pitch, only boring dust may be visible.



HOLES IN BARK FROM WOODPECKERS FEEDING ON JEFFREY PINE BEETLES

The first symptom of beetle-caused tree mortality is typically fading needles. Needles on successfully attacked trees begin fading and change color over a period of several months. Attacking beetles carry blue-staining fungi into the tree which spreads throughout the sapwood and interrupts the flow of water to the crown. After one to several months, the sapwood also begins to discolor.

Bark flaking or holes in the bark caused by woodpeckers may commonly be found on infested pine trees. Removing a section of the bark reveals galleries created by beetles and their offspring. Galleries are usually packed with frass.

RED TURPENTINE BEETLE

HOSTS: Most pines.

The most reliable external sign that your tree has been attacked by red turpentine beetles is the presence of large pitch tubes and boring dust or frass on the lower bole and around the tree base. Pitch tubes vary in size, texture, color, and in the amount of boring dust and frass in the resin. Some pitch tubes may be as large as 2 inches across. Galleries between the bark and the wood are internal evidence of attack.

PINYON IPS

HOSTS: Most pinyon pines.

Crown fading is often the first noticeable symptom of attack. Closer inspection may reveal boring dust; very small pitch tubes may be observed. Attacks can occur from early spring through late fall and this beetle can have several generations per year. Galleries groove the inner bark surface and typically radiate from a central chamber. Inspection beneath the bark surface near the tree base during winter months may reveal adults feeding *en masse*. These beetles readily attack standing green trees and green slash.

OTHER IPS SPECIES

HOSTS: Pines

Most pines are also hosts to many other species of pine engraver (*Ips* sp.) beetles. They are not typically agressive tree killers, but given the right conditions, they can cause tree mortality and may be found in the same trees that have been attacked by mountain, western or Jeffrey pine beetle. Pine engravers tend to attack green pine slash, so prudent slash management should prevent most problems.



RED BORING DUST ON TREE BARK

Small piles of reddish-orange boring dust can readily be seen on tree boles at the attack sites. Pitch tubes are not commonly observed. Infested trees may fade the same year as the attacks occurred or the following spring. Under the bark, galleries can be observed that frequently form a "Y" or "H" pattern. Depth of scoring on the wood surface and adult beetle size vary by species.

FIR ENGRAVER

HOSTS: White fir and red fir.

Evidence of attack before crown fade is often hard to detect. Boring dust may be present on the bole but attacks may occur higher up and are not easily observed from the ground. Pitch tubes that are often formed when beetles attack pines are not produced on fir trees. Pitch streaming on the bole of the tree is not always indicative of fir engraver attacks. Crown fade may occur before attacks or beetle exit holes are visible. Attacks during drought periods typically result in whole tree mortality. However, these beetles also can attack strips or portions of the tree resulting in only branch or top kill. Adults excavate galleries that engrave the sapwood and run horizontal, cutting across the grain. Larval galleries extend at right angles along the grain. This gallery pattern is very distinctive and can be used to identify fir engraver attacks.

DOUGLAS-FIR BEETLE

HOSTS: Douglas-fir.

The most reliable external sign that your tree has been attacked is the presence of boring dust (reddish-brown in color) near beetle entrance holes, in bark crevices, or around the base of the tree. Galleries under the bark lightly engrave the sapwood with adult galleries running parallel to the wood grain and larval galleries cutting across the wood grain.

Crown fade may occur the same year of attack or the following spring. Fresh-down trees and fire-injured trees are highly susceptible to attack.

STEP 4: HOW TO TREAT TREES THAT HAVE BEEN ATTACKED

Once bark beetles have successfully attacked a tree there is generally nothing you can do to save it. There are no chemical insecticides registered or recommended for killing bark beetles under the bark of infested trees. While some trees do survive bark beetle attack, the vast majority are killed. Additional tree mortality in the immediate area may be reduced if trees are removed while still infested. This particularly applies to Jeffrey or lodgepole pines.

Most bark beetles have emerged by the time trees have red-brown needles. Other beetles and larvae may be observed, but they are of little concern in causing mortality of additional trees. Most are beneficial wood decomposers – not tree killers. The tree may be cut down for firewood or left standing for wildlife habitat (see below). The tree should be removed if it hazardous to people or property.

STEP 5: HOW TO PREVENT BARK BEETLE ATTACKS

There are several things you can do to protect your trees from bark beetles. Preventing attack is key because you cannot do anything to save a tree once it has been successfully attacked.



DEAD TREES ARE "HOME" TO MANY FOREST CREATURES

If enhancing wildlife habitat interests you, consider keeping dead trees on your forested lands. Standing dead trees in a forest are called "snags" and many species of wildlife depend on snags for their survival.

Owls, hawks, and eagles use snags to perch and to support their nests. Cavity nesters such as woodpeckers, mountain bluebirds, and chickadees nest in the snag cavities. Chipmunks, squirrels, and other mammals use snags as homes. Bats use areas under loose bark for roosting. Fungi, mosses, and lichens commonly grow in the decaying wood of a snag. Insects chew through the decaying wood, creating tunnels and chambers. Moths and ladybird beetles, and many species of reptiles and amphibians, hide under the bark of snags.

With so many animals and plants living on and in a dead tree, other animals frequently come there to feed. If a tree on your private land does not have the potential to endanger people or property, please consider leaving it standing for our animal friends!

1. Thinning trees to a wide spacing is the best long-term solution to increase tree health and vigor and reduce the likelihood of bark beetle attacks. Thinning can also hamper the bark beetle pheromone communication system that facilitates mass attacks. Residual trees should be the healthiest and most vigorous ones. Increasing age and species diversity will enhance stand resistance to bark beetle attacks and reduce the effects of tree mortality when attacks occur. Select against trees that have high levels of dwarf mistletoe infection. If you are in a drought-prone area, favor leaving trees that are more drought-tolerant, such as pines. Contact your forest health professional (see page 12) for details on proper thinning methods.



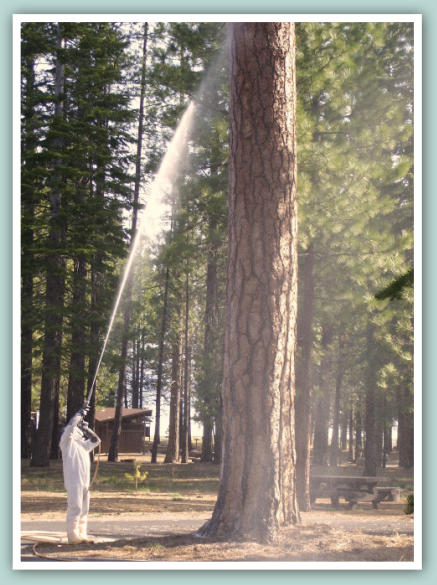
STAND OF THINNED PINE TREES

2. Always clean up any recently blown down trees or fresh slash to avoid creating more habitat for beetle development.
3. Avoid causing injuries to trees, such as knocking off bark, compacting/excavating soil near trees or disturbing the root system.
4. Remove all trees that currently contain beetles. The effectiveness of this treatment greatly depends on the bark beetle species, however, removing trees promptly when they have been successfully attacked will reduce the pheromone (chemicals beetles use to communicate) source associated with attacked trees. All infested green material >3 inches in diameter should be removed from the site, chipped, buried or burned.
5. During severe of protracted drought periods it may be prudent to use insecticides to protect unattacked trees. Applied as a preventive treatment, certain insecticides are effective in preventing bark beetle attacks (see page 7). Treatments should be performed by a commercial applicator and limited to high value, susceptible host species.
6. Watering your trees during severe or protracted drought periods can also give your trees a boost. Watering should occur early in the growing season by saturating the soil down to two feet near the outer edge of the tree branches. Be careful not to over water!

Chemical Treatments

INSECTICIDES

- **Carbaryl:** Application of this insecticide will protect trees from the beetles described in this pamphlet. Due to the need for special high pressure equipment, this treatment is generally used only on individual, high value trees, and is generally applied by certified pesticide applicators. All tree bole surfaces must be completely soaked up to a height where the tree is too small in diameter to be suitable host material. On tall trees, at least 3/4 of the length of the lower bole should be treated. Note: only the part of the tree trunk that receives insecticide application will be protected; bark beetles can still attack high on the trunk if areas are left unsprayed. Carbaryl prevents attacks for up to two years. Contact your State or Federal forest health specialist (see page 12) to determine if this is an appropriate treatment for your trees. Contact your state's pesticide department (see page 12) for assistance finding qualified pesticide applicators. Note: In California, carbaryl is a restricted-use pesticide and can only be applied by a certified pesticide applicator. If applying this pesticide in a different state, please check with your state's Pesticide Department to determine applicable regulations.
- **Other insecticides for bark beetles:** Other insecticides such as pyrethroids are registered for use to prevent bark beetle attacks. Most pyrethroids prevent attacks for one year and some are not as effective as carbaryl.
- **Systemic treatments** applied to the soil around the tree or inserted into holes drilled in the tree have **NOT** been shown to be effective.
- **Other treatments:** Be aware of any treatments that have not been scientically proven to be effective against bark beetles. If in doubt, call a forest health specialist. Don't fall prey to someone claiming to be able to save your trees using unproven methods. Any treatments that occur after the tree is infested with bark beetles will NOT save your tree!
- **Stump treatments** can prevent Heterobasidion root disease, caused by the fungus *Heterobasidion annosum.* This 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 can spread 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 immediately after trees are cut.



INSECTICIDE APPLICATION ON TREE BOLE TO PREVENT BARK BEETLE ATTACKS



BORATE COMPOUND ON STUMP TO PREVENT INFECTION BY HETEROBASIDION SP.

PESTICIDE PRECAUTIONS

Pesticides used improperly can be injurious to humans, animals, and plants. Follow directions and read all precautions on the label. Some states have restrictions on the use of certain pesticides and pesticide registrations are under constant review by the Federal Environmental Protection Agency so please consult your local County agriculture agent or State extension agent prior to any applications.

EXPLANATION OF UNFAMILIAR TERMS

boring dust *– produced by beetles chewing through material but not feeding on it (see frass below)*
conifer *- any tree that produces seeds in cones*
dwarf mistletoe *– parasitic flowering plants that grow in tree bark and wood, absorbing water and nutrients of the host tree that otherwise are used for growth (see http://ceres.ca.gov/foreststeward/pdf/treenote11.pdf for more information)*
frass *– produced by beetles feeding on material (the solid form of insect excrement)*
gallery *– a tunnel or pathway in host tissue in which an insect lives, feeds, mates, and/or deposits eggs*
group kill *– a group of trees killed by bark beetles during the same time period or over multiple years*
pheromone *– a chemical produced by insects (and other animals) that serves as a signal between members of the same species*
pitch tube *– a mixture of tree resin, other tree bole components (bark, xylem, phloem), and frass and boring dust that forms on the outside surface of the bark when a tree is attacked by bark beetles*
slash *- branches and other woody material left after cutting a tree*
tree bole *– the trunk or main stem of a tree*

Challenges of a Bark Beetle Outbreak – What are Land Managers Doing?

Federal and State Land Managers

Effective management of bark beetles and vegetation is a difficult challenge. Federal and State land managers know a great deal regarding characteristics that make stands susceptible to bark beetles. Unfortunately, having this knowledge does not mean that they are able to prevent outbreaks.

The most effective way of dealing with bark beetle outbreaks over large, forested areas is through preventive vegetation management. Treating vast areas such as entire National Forests with chemicals to reduce bark beetle populations is not practical, feasible, or desirable.

Land management planning is a required process for all Federal and State administered lands. Public involvement is a required – and encouraged – part of Federal planning efforts. During the Federal planning process, some areas are excluded from vegetation management (i.e. wilderness areas, roadless areas). Within these areas, treatments to manage vegetation and bark beetles are limited.

Where vegetation management activities are permitted, Federal and State land managers can reduce the likelihood of high levels of bark beetle-caused tree mortality. Examples of management activities being implemented to reduce forest susceptibility to bark beetles include:

- Thinning out some of the trees in dense stands to improve tree vigor and reduce susceptibility to bark beetles.
- Promoting a diversity of tree species, which also reduces stand susceptibility to bark beetles.
- Promoting a diversity of age classes.
- Promoting drought tolerant species.

Private Landowners

Private landowners have different objectives for their property and trees and have their own opinion about possible management techniques. Some will choose to do nothing; others will adopt bark beetle prevention strategies that may include thinning and the use of insecticides. Thinning during normal precipitation years is better than waiting to thin during a drought when trees are stressed and bark beetle-caused tree mortality is on the rise. Insecticide treatments need to be applied prior to beetle attack and additional applications may be required if drought or other stress-causing conditions persist.





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WHERE TO GO FOR HELP OR ADDITIONAL INFORMATION

ORGANIZATIONS

■ For on-the-ground technical assistance with insect and forest management on private lands:

CALIFORNIA
- Don Owen, CAL FIRE, 530.224.2494, don.owen@fire.ca.gov
- Tom Smith, CAL FIRE, 916.599.6882, tom.smith@fire.ca.gov
- Kim Corella, CAL FIRE, 808.550.8583, kim.camilli@fire.ca.gov
- Chris Lee, CAL FIRE, 707.726.1254, christopher.lee@fire.ca.gov

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■ For on-the-ground technical assistance with insect and forest management on Federal lands.

Northeastern CA
Danny Cluck, USDA Forest Service, Forest Health Protection, 530.252.6431, dcluck@fs.fed.us

Northwestern CA
Cynthia Snyder, USDA Forest Service, Forest Health Protection, 530.226.2437, clsnyder@fs.fed.us

South Sierras
Beverly Bulaon, USDA Forest Service, Forest Health Protection, 209.532.3671, ext. 323, bbulaon@fs.fed.us

Southern CA
Tom Coleman, USDA Forest Service, Forest Health Protection, 909.382.2871, twcoleman@fs.fed.us

■ For information on professional pesticide applicators and insecticide registration contact your County Agriculture Commissioner's Office and see: California Department of Pesticide Regulation: www.cdpr.ca.gov

■ For general National Forest information: www.fs.usda.gov/main/r5/about-region/offices

■ For information on USDA FS Forest Health Protection programs in California: www.fs.usda.gov/main/r5/forest-grasslandhealth

■ Additional pictures of various trees and insects: www.bugwood.org/ or www.forestryimages.org

PUBLICATIONS

■ Bark Beetles and Vegetation Management in CA: www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev3_045320.pdf
■ Forest Insect and Disease Leaflets: www.fs.usda.gov/goto/fhp/fidls
■ Tree Notes: http://calfire.ca.gov/foreststeward/treenotes.html
■ California Forest Pest Conditions: www.fs.usda.gov/detail/r5/forest-grasslandhealth/?cid=fsbdev3_046704

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THE ROLE OF FIRE

Dead trees with red needles, whether killed by bark beetles or other agents, are more flammable than live trees. However, once the needles are gone, the standing dead trees generally do not pose an increased risk of wildfire. As the trees eventually fall to the ground, increasing downed fuel loads have the potential to again increase fire severity.

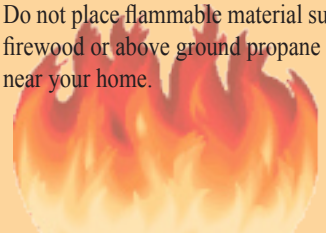
Fire is a fundamental part of the natural ecosystem. Most of the vegetation in California has evolved with fire and, in many cases, relies on fire to sustain its health and presence on the landscape. However, fire around your home or other infrastructures is usually not desirable.

The most critical factors for a home surviving a wildfire are the construction of the home and the vegetation near the home.

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.

Some general recommendations are:

1. Roofs should be made of non-flammable material.
2. Enclose places where fire embers can accumulate, such as soffits and underneath porches.
3. Thin out dense trees or shrubs.
4. Remove brush or dried grasses close to your home.
5. Landscape with fire resistant plants.
6. Do not place flammable material such as firewood or above ground propane tanks near your home.



For more information regarding protecting your home from wildfire contact your local fire department.