TREE NOTES

CALIFORNIA DEPARTMENT OF FORESTRY AND FIRE PROTECTION

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NUMBER: 13 **August 2003**

The Western Pine Beetle

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Noted for its aggressive, tree-killing behavior, the western pine beetle (WPB), *Dendroctonus brevicomis*, is the bark beetle most frequently found killing larger ponderosa and Coulter pines (*Pinus ponderosa* and *P. cou1teri*) in California. In general, any factor which contributes to tree stress will increase a tree's chance of being killed by WPB, including disease, advanced age, overcrowding, mechanical injury and substantial changes to the tree's environment. During periods of extended drought, the existence of large numbers of moisture-stressed trees typically leads to beetle epidemics. The attacking beetles produce a potent chemical scent (pheromone) capable of attracting large numbers of beetles to an individual tree, resulting in a 'mass attack.' Groups of trees are frequently attacked and killed, as large numbers of beetles concentrate in an area.

Life Cycle and Identification

WPB adults are small, dark brown to nearly black beetles (fig. 1) averaging about 4mm in length. Female beetles initiate attacks and are joined by male beetles. There is one female/male pair per individual attack and thousands of attacks may occur on a tree during a mass attack. Each beetle pair constructs a sinuous gallery (tunnel) in the inner bark, next to the wood, along the sides of which the female lays eggs. This distinct gallery pattern positively identifies the attacking beetles as WPBs (fig. 2).

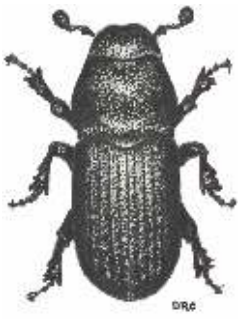

Figure 1. Adult western pine beetle.

Various microorganisms are introduced into the tree by the beetles. One of these, the fungus *Ophiostoma minor* (*Ceratocystis minor*), possibly aids beetles in killing the tree by disrupting the tree's water conducting system.

Figure 2. Galleries of western pine beetle in the inner bark of ponderosa pine.

Its presence is indicated by vertically elongated black patches just beneath the bark and a bluish-gray staining of the sapwood.

Immature WPB, or larvae, are small, off-white, legless grubs with dark heads. After hatching from eggs, the larvae begin feeding in the inner bark, or cambial region, making individual galleries that appear as thin lines perpendicular to adult galleries. After a short time, however, they start tunneling toward the outer bark where they complete their feeding and undergo pupation, the transformation from larva to adult beetle. Newly formed adults, initially a yellowish-brown color, are referred to as 'brood adults.'

Brood adults exit the tree by tunneling out of the bark, leaving its surface peppered with tiny round exit holes. Initially, they fly off and disperse, but after a short period of physiological change they shift from dispersal to attack behavior, and the whole process of tree selection and attack starts over. The beetles are then referred to as 'attack adults.'

The WPB flight season, during which time trees are sought out and attacked, typically begins in April or May and ends by November. During warm weather, the time from initial attack to brood adult emergence is

slightly more than two months. Depending upon climate, there may be from two to four generations a year. Some adult beetles construct galleries and establish broods in more than one tree.

Signs of Attack

Attacks generally start at mid-height on the main stem of the tree and progress up and down. Portions of the stem less than six inches in diameter are usually not attacked. One of the first signs that attack has begun is the presence of white to pinkish-white pitch masses, about half an inch or less in diameter, on the main stem. Referred to as pitch tubes, they mark the locations where beetles have bored into the bark (fig.3). The ability to release pitch is the tree's defense against attack and will largely determine whether or not the beetles can kill the tree. Trees under stress are less able to release a continuous flow of pitch and are more easily overcome by the beetles.

Figure 3. Pitch tubes of western pine beetle on a ponderosa pine. These attacks were unsuccessful and the tree survived.

For the attacking beetles to kill the tree, the flow of pitch must stop. On a severely stressed tree, pitch tubes may never form. On other trees, pitch tubes may be produced during initial attacks and then cease to form as increasing numbers of beetles attack the tree and overcome its defenses. As the tree weakens, small, reddish-brown pitch tubes and eventually fine, reddish-brown, non-resinous boring dust will be produced in lieu of white pitch tubes. The dry boring dust, found within furrows on the bark, is an initial sign that the tree has been killed. If the beetles have failed to overcome the tree's defenses, or if an ongoing attack has not yet succeeded, only pitch tubes will be found. Old, unsuccessful attacks are marked by hardened, yellowish pitch tubes.

Another sign that the tree has been killed is woodpecker feeding, although not all dead trees will have it. Large areas of outer bark will be chipped away by woodpeckers as they search for WPB brood to feed on. The bole of the tree will appear light reddish-brown in areas where the woodpeckers have been working, being distinctly different in color and texture from areas of the bark that have not been chipped away (fig. 4). Eventually the foliage of a beetle-killed tree begins to fade in color, changing uniformly from green to straw-yellow to sorrel. Although this is the most obvious sign that the tree is dead, it does not occur until well after the beetles have succeeded at killing the tree.

Figure 4. The ponderosa pine on the right is infested with western pine beetles. Woodpeckers have removed the outer bark in search of beetle larvae.

Predicting Tree Mortality

When beetle populations are low, WPBs appear to be more selective in the trees they attack. During such times, killing of individual trees or small groups of trees by the WPB is readily attributable to tree stress. However, as beetle populations build up, the relationship between stress and mortality frequently becomes less obvious and predicting mortality becomes more difficult.

Some stresses develop gradually and become chronic, resulting in a decline in tree health that manifests itself in the tree's appearance. Indicators of chronic stress include:

- Abnormally short needles
- Poor retention of older needles
- A top that is rounded rather than pointed
- A dead top and/or numerous dead branches scattered throughout the crown
- Small live crown ratio (i.e. a small number of needle-bearing branches relative to the tree's height)

Factors which contribute to chronic stress include disease, advanced age, and overcrowding.

Any sudden and substantial change in the tree's environment may result in stress that is not necessarily reflected in the tree's appearance. Drought is one example. Trees of all levels of vigor may be stressed by drought, so it is not unusual to see trees that appear healthy being killed by WPB. Even trees that are growing in apparently wet environments may be severely stressed when drought causes normally high water tables to drop below the reach of a tree's roots. Construction practices that adversely impact a tree's roots can have a similar effect by suddenly cutting off supplies of air and/or water. The severity and persistence of damage will largely determine the tree's fate.

The WPB is the most aggressive bark beetle attacking ponderosa and Coulter pines, but it does not act alone. A number of bark beetle species may attack the tree either before, during, or after the WPB's attack. Pathogens may be similarly involved, some of which play an essential role by predisposing a tree to beetle attack. Understanding the interrelationships of these different organisms to one another, the tree, and the tree's physical environment provides a better picture of how tree mortality occurs.

Prevention and Control

Recognizing the causes of tree stress and taking steps to insure good tree health is the best approach to preventing bark beetle attack.

When chronic tree stress results from disease, it is important to identify the causal agent of the disease and its likely impact. This will dictate what steps should be taken to alleviate the problem. Root disease and dwarf mistletoe are important disease problems of forest trees in California. Prevention and control of these and other diseases is an important means of maintaining tree resistance to bark beetles (See Additional Information).

Fig. 5. This stand of trees has been thinned and proven resistant to beetle infestation.

If trees are overcrowded, prevention involves thinning the stand to a density that insures good tree growth and increased resistance to beetle attack (fig. 5). Tree overcrowding is a common problem in residential and other developed areas were landowners are reluctant to remove trees. Landowners are often unaware of a problem because many sites will support a high density of trees during years of normal or above normal precipitation. When the inevitable drought strikes, however, overcrowded trees are forced to compete for limited water and some will die at the hand of bark beetles. Bark beetles, thus, are a natural thinning agent, but they seldom thin stands to a landowners liking. By being proactive and thinning trees before this happens, a landowner can choose which trees to keep and hopefully avoid the often disastrous effects of a beetle outbreak. The method of thinning and final spacing of trees will depend upon a number of considerations which should be assessed on a case by case basis, preferably with the assistance of a forester. Although thinning is generally beneficial, some precautions may be necessary to avoid potential problems:

- Thinning during a drought is not recommended. The best time to thin is during non-drought years when trees are less likely to be stressed and are best able to respond to and take advantage of additional space.
- Under certain conditions, thinning may favor the development of root diseases such as annosus and blackstain root diseases. Refer to Tree Notes 6 and 25 respectively for information on managing these diseases. Blackstain root disease is not known to occur in ponderosa pine south of US Highway 50 (south of Lake Tahoe), whereas annosus root disease could occur anywhere in the state.

Sanitation is a logging method that can be used either in conjunction with thinning or other timber harvest operations. In this method, trees exhibiting advanced symptoms of stress (high-risk trees) are removed from the stand before the beetles have a chance to kill them. Not only is the average stand vigor increased, but greater timber value is realized by harvesting trees while their wood is still sound.

For high value trees on non-timberland sites, supplemental irrigation may help alleviate stress resulting from drought and increase the tree's ability to resist bark beetle attack. During periods of average or above average precipitation, however, it is not necessary to water native forest trees and generally it is not recommended. Spring precipitation is especially important to native trees since it

helps them survive California's long, dry summers. When spring precipitation is below normal, this is a good time to provide supplemental water.

When irrigating, it is important to deliver a sufficient amount of water to a location where the tree can utilize it. For native trees, this generally means deep irrigation. Frequent, superficial irrigation that penetrates only a few inches in to the soil is not likely to benefit these trees and may have negative impacts such as promoting disease, decreasing oxygen exchange for deeper roots, and encouraging shallow rooting. As a rule of thumb, a single irrigation should penetrate 1-2 feet into the soil and the upper foot of soil should be allowed to thoroughly dry before repeating. Soil conditions and other factors will determine the appropriate time between irrigations – in general, allow at least a couple of weeks. It is also important to keep water away from the main stem or bole of the tree. Water should be applied to an area that encircles the tree and is bordered by the drip line and an imaginary line half the distance between the bole and the drip line. It is OK to water outside the drip line, but avoid watering in the other direction, i.e. toward the bole. Water should be applied continuously, but not running off, until it has soaked in to the desired depth. Under all but the harshest drought conditions, it is best to cut back and cease supplemental irrigation by early to mid-summer.

Certain pesticide formulations containing carbaryl, chlorpyrifos, or permethrin when applied to the bark of a tree have been proven effective at preventing bark beetle attacks. Such treatments can be useful at protecting high value trees during drought or other periods of acute stress. There are a number of factors to consider before choosing to use pesticides for this purpose:

- Only those portions of the main stem of the tree that are sprayed will be safe from attack, so thorough coverage is important. Effective treatment of a large pine tree will likely require the services of a professional pesticide applicator.
- It is important to use a pesticide specifically formulated for use against bark beetles. All pesticides must be applied according to label instructions, and if the pesticide is a restricted material it must be applied by a Certified Applicator or under their direct supervision. Pesticides that are injected into the tree have not been proven effective against the western pine beetle.
- It is important to treat trees before they come under mass attack. One treatment in the spring, generally in April or May before bark beetle flight begins, is usually sufficient to protect trees for the duration of the beetles' flight season. A common mistake is to spray pesticides on a tree that is already dead or dying.
- The use of pesticides against bark beetles is best viewed as a temporary measure for protecting trees during periods of temporary stress and concurrent beetle outbreaks. Once the threat of beetle attack has passed, pesticide treatment should be discontinued. Trees that have little or no chance of recovering from the effects of chronic stress should not be treated with pesticides, as such attempts to save them eventually fail.

Additional Information

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