Managing stands of Willamette Valley ponderosa pine

R. Fletcher

Both natural and planted stands of ponderosa pine can be managed using thinning, pruning, and fertilization, although little research has been done on these practices for the Willamette Valley race of ponderosa pine. What is known has been gathered from general observation, from small test plots, and from a survey of native stands by OSU Extension forester Max Bennett.

Natural stand development

It is difficult to define what normal stand development means for ponderosa pine in the Willamette Valley.

Historical stands apparently were either scattered groves of large trees in grassy bottoms or mixed-species stands in the foothills. In either case, the indigenous tribes' broad-scale burning shaped those forests in ways not available today.

Current stands have come about by colonizing neglected areas or soils with severe limitations for other tree species. The stands we see today are much denser than their counterparts in the past. What this means for future development and growth is uncertain. However, because ponderosa pine is a shade-intolerant species, preferring open spaces, it is likely that the high stocking will be reduced over time, either through insect and disease outbreaks, or some weather-related event, or by selective thinning.

Expected growth of Valley ponderosa pine stands

Anderson's 1938 study on central Willamette Valley ponderosas reported young ponderosas grew rapidly, but growth rates peaked by about 30 years of age. The small sample of trees had a 20-year-old tree with a 15-inch diameter at breast height (DBH), while a 100-year-old tree was only 34 inches in diameter. The pine races study that Munger began in 1928 showed a height growth spurt between 20 and 30 years of age, but the trees from the best seed source in the study have continued to grow well in height up to their last measurement at 65 years of age.

Max Bennett's recently completed study of 16 native Willamette Valley ponderosa stands on 12 different soil types found a wide variety of growth rates, depending on soil type (Table 3, page 12). Site indexes (estimates of site productivity based on

Figure 13.— Regeneration of a natural stand of ponderosa pine old growth on Willamette National Forest, near Oakridge, OR.

Figure 14.—Native, 40-year-old ponderosa pine stand on wet soil near Lacomb, OR.

how tall a tree of a given species will grow on a site in a given number of years) for each site were extrapolated from existing site index curves from ponderosa pine in southwest Oregon, based on expected total height at 50 years.

On most sites, ponderosas are expected to grow nearly 100 feet in the first 50 years. Exceptions were on very severe sites where the high water table and shallow soils converged. When these trees will slow down or stop growing taller is not known and undoubtedly will vary widely by soil type, but large specimen trees on suitable soils have grown up to 150 feet tall.

Table 3. Growth of Willamette Valley natural stands

Soil type	Height	Age	Site index (50)
Bashaw silty clay loam	98	59	92
Dayton silt loam	84	42	98
Dixonville/Hazelair/Philomath	96	98	63
Dupee silt loam	110	56	101
Hazelair silty clay* loam	93	52	92
McBee silty clay loam	104	59	92
Philomath cobbly, silty clay*	87	42	104
Ritner cobbly, silty clay loam	101	54	95
Salem gravelly loam	111	63	93
Waldo silty clay loam	83	41	96
Witzel very cobbly loam	92	98	59

* An average of more than one site

No studies of volume growth per acre have been done. Currently, large stands of ponderosa are few, but they appear to have volumes similar to local Douglas-fir stands of similar ages. The exception may be on the very severe (either wet or dry) sites, where volumes per acre will be less.

Managing natural stands of Valley ponderosa pine

If you are one of the lucky Willamette Valley landowners with a natural stand of ponderosas on your property, your trees might benefit from thinning or possibly pruning if they are still pole size.

Thinning

Thinning spaces out trees and improves the health and vigor of the overall stand. The key feature is not what you cut but the stand left behind after harvest. It is these trees, generally referred to as crop trees, that will determine future growth and overall stand health. In deciding which will be crop trees, and which ones you'll remove, consider the following factors.

1. Overall stand age and stocking Stands that respond best to thinning are young, moderately stocked ones. Older stands (50 years plus) likely have passed the time when thinning will greatly benefit growth rates, unless the stand was previously thinned. Thinning an older stand still might make sense, however, if you want to reduce longer term competition for crop trees or to remove unhealthy trees. Very dense stands may need several light thinnings, spaced by recovery periods, to move the stand gradually to a healthy density.

Possibly the most important thinning is a very early one, while the trees are not yet of merchantable size. This precommercial thinning sets the growth curve for the future stand and can have a dramatic, positive impact on growth if done at the right time.

2. Type of future stand desired If you want an even-age stand, then it makes sense to space crop trees evenly for maximum

growth. If you want to develop an uneven-age stand, your selection may be more in groups, to provide open areas for young trees to establish.

3. Individual tree characteristics The arboricultural principle of "right tree, right place" works well for forest thinning, also. If your need in a particular spot is high growth, then leave the best growers. If you want to leave a wildlife tree, look for one with big branches and good nesting opportunities. Even trees with obvious defects can be valuable in providing habitat for cavity-nesting birds such as woodpeckers. If you plan a continual-selection thinning system to promote natural regeneration, then you want to get rid of the super-dominant trees and keep the vigorously growing medium-size trees that have narrow crowns and fine branches.

4. Individual tree spacing As trees get larger, they need more room to grow. Foresters' rule of thumb for this size–space relationship is based on diameter of the tree at breast height (DBH).

For example, a tree 12 inches in diameter might need 16 feet of space to be happy, while a 20-inch-diameter tree might need 24 feet. This often is referred to as the "D+ rule."

Although there is no known D+ relationship for Valley ponderosa pine, they likely need a bit more space than Douglas-fir because of their intolerance of shade. Ponderosa might be more comfortable at a minimum spacing of D+2 or D+3. For a tree 12 inches in diameter, this means the next closest 12-inch tree should be at least 14 or 15 feet away. You might want to space your 12-inch trees 18 to 20 feet apart (i.e., at D+6 or D+8), anticipating that they will continue to grow in diameter over time and eventually get back to the minimum D+2 spacing.

Other ways to keep track of tree spacings:

- On a per-acre basis, either by total number of trees, or
- Some other measure of density such as basal area (the cross sectional area of a tree, measured at breast height), or
- Relative density (the amount of basal area on a given stand compared to the maximum that can possibly grow)

For more information on measuring stand density, refer to OSU Extension publication EC 1190, "Stand Volume and Growth: Getting the Numbers" (see page 39).

As more becomes known about the Valley ponderosas, better per-acre guidelines will be developed.

Managing plantations of Valley ponderosa pine

During the past decade, thousands of acres of Valley pine plantations have been established in the Willamette Valley. These represent a very different type of forest stand than has ever existed naturally.

Historical records indicate that natural stands were widely spaced groves of large trees, intermixed with hardwood species such as oak and ash. The pine plantations of today represent fast-growing monocultures whose growth far exceeds that of their natural cousins. No management history of similar stands exists, so only time will reveal how these plantations will develop. Experience to date, however, suggests some practices that are useful in tending young plantations.

Thinning

One genetic trait in the Valley pine population is a wide variance in tree forms. Progeny from various parent trees differ vastly in such characteristics as forking, branch angle, number of branches, and growth rate. By years 5 to 10, characteristics of individual trees in plantations are easily distinguishable, and you can favor trees with characteristics suited to your objectives. For example, if timber production is a primary goal, trees with high wood-to-branch ratios and good growth can be favored in thinning programs. Likewise, in riparian plantings where lots of branching can be good for

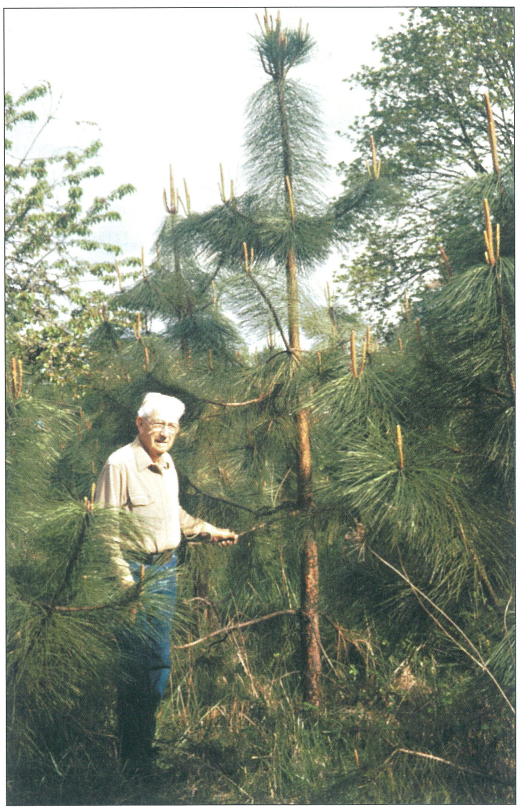

Figure 15.—Five-year-old pine plantation on a good site near Albany, OR.

birds and other wildlife, the heavily branched trees can be favored.

When to thin and how many trees to remove is largely unknown at this time. Answers will depend to some degree on what types of future products and stand are desired. Guidelines for thinning in plantations are similar to those discussed under thinning natural stands (pages 13–14). The same D+ relationship applies; i.e., D+2 minimum and D+6 desirable.

Figure 16.—Pruned 8-year-old ponderosa pine stand near Albany, OR. Orange paint marks branch scars where live limbs were removed.

One feature that is particularly observable in young pine plantings is the much lower ratio of needle biomass to wood compared with other species such as Douglas-fir. Thinning is best timed according to live crown ratio (the percent of the total tree height that is occupied by green limbs); try to keep it at 30 percent or higher.

You also might want to take periodic increment core samples to determine growth rate. Ponderosa pine is an excellent producer of diameter growth and might maintain rates of three to six rings per inch in vigorously growing, young pole-size stands. Thinning directs this growth into the most productive trees in the stand.

For more information on harvesting and marketing, see Chapter 8.

Pruning

The fact that ponderosa is a naturally limby species, combined with the fact that clear pine wood has high value, makes pruning important in young Valley pine stands.

If done correctly, pruning scars will heal quickly, and the tree will produce a rind of clear, valuable wood outside the pruning scars. You might also improve the form of young trees—the taper point of the tree is at the base of the live crown, so when you remove live limbs, you are pushing the bottom of the live crown up the tree.

Pruning ideally should begin once the trees reach 10 to 15 feet tall. Carefully clip all lower limbs as near the stem as possible without damaging the branch collar. Removing too many limbs in one pruning may impair tree growth, so leave at least 30 to 50 percent live crown at all times. For example, if your trees are 16 feet tall, you could prune up about 8 feet without being concerned about harming growth. If you delay limb pruning too long, the limbs will be larger and harder to remove. This also will increase the size of the knotty core of wood in the center of the tree and reduce recovery of clear wood.

Prune between September and March to avoid pitch moth attacks on pruning wounds. Pile and burn larger limbs and stems to avoid bark beetle infestations.

For information on potential insect problems, see Chapter 5. For a fuller description of proper tree pruning, refer to OSU Extension publication EC 1457, "Pruning to Enhance Tree and Stand Value" (see page 39).

Fertilizing

To date, not much is known about fertilizing Valley pine. A few growers have had some success applying balanced fertilizers, based on foliar and soil analyses, but you should get professional assistance from a fertilizer dealer or professional consultant before investing too much in fertilizers.

In any case, apply fertilizers only to well-weeded trees that have good root systems to take up the fertilizer.

Fire and Willamette Valley ponderosas

J. Mair

Historically, fire played a significant role in shaping the Willamette Valley landscape. Though lightning fires are rare in the Valley's lower slopes, there is substantial historical evidence of annual burning by the indigenous populations before white settlement.

Early journals of trappers and explorers describe the difficulty of traveling through the Willamette Valley during August and September due to the prairie fires that had been set by the Native Americans. David Douglas, on an 1826 expedition through the Willamette Valley, made this entry in his journal on September 27.

> *Country undulating; soil rich, light with beautiful solitary oaks and pines interspersed through it and must have a fine effect, but being burned and not a single blade of grass except on margins of the rivulets to be seen.*

Ponderosa pine in the Valley, like its eastside cousin, depends on fire or other natural disturbances to stimulate regeneration, eliminate competition, and provide some control of insects and diseases. Indigenous burning benefited stands of large ponderosas in the Valley. Evidence is that these low-intensity fires very seldom turned into the devastating wildfires that we can have during drought periods today. To manage ponderosa successfully over time in the Valley will require close attention to fuel buildup and other conditions that result when the landscape isn't burned regularly.

Fire injury

Ponderosa pine is a relatively thick-barked species that can tolerate moderate fires. Generally it is more fire resistant than Douglas-fir and grand fir, which often are associated with it in the Willamette Valley.

Because the ponderosa's sapwood and inner bark have high water content, ground fires often char the bark surface but do not burn into the trunk. The fire's heat, however, can kill the inner bark and cambium, with or without charring the bark surface. Determining whether a tree will survive fire damage can be difficult.

Figure 17.—Young ponderosa pine stands are sensitive to fire damage and must be protected until they develop thick bark.

Young, thin-barked pines are more likely to be killed or damaged by ground fires than older mature trees with thick bark. Mature trees can tolerate charring and extensive needle scorch as long as the cambium and buds are not killed. Generally, ponderosa pine will survive a fire if 50 percent or less of the crown is scorched. Early-season fires tend to cause more damage than late-season fires because buds and new growth are more susceptible to injury.

Fire hazard in ponderosa pine

Planted stands of young pine tend to be dense and to need thinning. For the most part they are on south-facing slopes, which are drier sites and more prone to more extreme fire conditions.

When these stands are thinned, the slash created becomes a fire hazard as soon as it dries. The hazard is high to extreme for the first 5 years after thinning or pruning. (In experiments, fresh ponderosa pine slash burned at the second highest intensity of five species tested.) Fire intensity declines significantly as needles drop off the branches.

Although historically fire played a significant role in ponderosa pine's development in the Willamette Valley, we do not recommend underburning in new pine stands. Until the stand is mature and less dense, the amount of fuels would enable the fire to climb into the tree crowns, burn through the stand, and continue on to neighboring properties. If you are thinking of burning, get advice from the local fire district office of the Oregon Department of Forestry.

Fire prevention

Eliminating fire as part of the natural Valley ecosystem has created a buildup of fuels and has increased brush and dense fir stands which today are part of the rural–urban interface settings. Fire prevention, particularly in young stands, can help protect a sizable investment in tree planting.

You can take several steps to minimize the risk of a fire on your forest land.

1. Minimize possible sources of ignition. This includes keeping motorcycles and other vehicles out of dry grass during the dry summer months. It also might mean gating roads and patrolling your property during periods of high fire danger.
2. Decrease the volume of combustible fuels by:
   - Minimizing slash concentrations when thinning
   - Piling and burning slash accumulations along roadways
3. Establish fire breaks in strategic locations.
4. Upgrade road systems so that fire-fighting equipment can have better access to your stand.
5. Develop water sources that could be used to fight fires.
6. Maintain basic fire suppression equipment such as a pump, tank, and shovel in a convenient location.

Insects and Willamette Valley ponderosas

D. Overhulser and C. Niwa

Valley ponderosas are generally hardy trees, well suited to local conditions and able to tolerate attacks from insect pests. From time to time, insect populations increase to the point of killing individual trees or small stands. Maintaining trees in healthy growing condition and avoiding insect buildups through salvaging or other methods is generally the best prescription for avoiding loss to insect attacks. Native stands of Valley ponderosa seem to tolerate the current array of insects, but it is unknown how the even-age plantations being planted today may fare in the future.

Careful monitoring and prompt action are the best hedges against an insect epidemic.

This chapter covers some of the primary pests currently on Willamette Valley ponderosa pine and recommends treatments. Other information, including pesticide recommendations, is in the current edition of the "Pacific Northwest Insect Management Handbook" (see page 39).

Bark beetles

Red turpentine beetle

Dendroctonus valens LeConte

Red turpentine beetle, the largest bark beetle in Oregon, commonly infests ponderosa pine and many ornamental pines grown in the Willamette Valley. Infested trees vary from saplings only a few inches in diameter to old-growth ponderosa pine. Most often, beetles attack trees under stress from drought, flooding, or some other type of site disturbance. Pines can survive the occasional attack, but repeated attacks over several years or attacks in conjunction with other bark beetles often are fatal.

Hosts Ponderosa pine, sugar pine, western white pine, lodgepole pine, and many ornamental pines.

Damage potential to Willamette Valley ponderosa pine Low to moderate

Symptoms The most visible sign of red turpentine beetle is large, reddish white pitch tubes on the tree bark (Figure 18). Beetle attacks concentrate on the lower trunk and root collar area within 6 feet of the ground. Beneath the bark, beetles bore irregularly shaped vertical galleries in the cambium and phloem tissues and introduce blue stain fungi into the sapwood. Fungi, which grow in the sapwood immediately beneath the gallery, interfere with water conduction to the tree's crown. As the number of red turpentine beetle attacks increases, the pine gradually is girdled and dies.

Figure 18.—Pitch tubes on ponderosa pine tree bark indicate presence of red turpentine beetle.

Description If you remove bark from an infested tree or stump, you might see the adult beetle (6 to 10 mm long) or its immature stages (Figure 19, page 18). Larvae are legless white grubs with brown heads that feed beneath the tree's bark. It takes several months of active feeding for larvae to completely develop and transform into pupae. Pupae usually require several weeks or longer to develop into adult beetles.

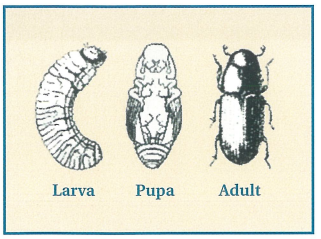

Figure 19.—Life stages of the red turpentine beetle.

Once mature, the reddish brown beetles bore out of the tree and fly to other hosts.

Management The best way to prevent red turpentine beetle infestations is to maintain healthy, vigorous trees by thinning overstocked stands. When healthy trees are attacked, the beetle often is forced out of the tree by flowing pitch (foresters commonly refer to this as "pitching out"), and any eggs or larvae are killed. Since beetles are attracted to fresh pitch, it is important to avoid wounding leave trees during harvesting, thinning, or pruning operations in spring and summer. Do not pile green slash near trees.

If beetles are attacking freshly cut stumps, debarking the infested stumps will kill the beetles and their brood. This mechanical treatment can help reduce a local buildup of beetle populations after harvesting or salvage operations.

The insecticide carbaryl has proved effective at preventing beetle attacks on trees and stumps. Spray a solution of carbaryl, as indicated on the label, to the point of runoff on the lower 6 feet of trunk and the root collar area to protect trees from beetle attacks for up to 1 year. Recommended timing is April, before beetle flight, but because beetles attack pines throughout spring and summer, treating pines any time during this period can prevent new attacks.

California fivespined ips

Ips paraconfusus Lanier

The California fivespined ips *(Ips)* is potentially a threat to managed stands of Willamette Valley ponderosa pine. At present, documented *Ips* infestations in the Valley are confined to scattered attacks on saplings and larger pine. In California and southwest Oregon, populations of this beetle build up in slash and emerge to attack leave trees. This species of *Ips* is very aggressive during drought years and often kills the tops of mature trees or clumps of overstocked pole-size pine. As more acreage in the Willamette Valley is planted to ponderosa pine, this beetle is likely to become a significant pest.

Hosts Ponderosa pine, sugar pine, western white pine, lodgepole pine, and knobcone x Monterey (KMX) hybrid.

Damage potential for Willamette Valley ponderosa pine Moderate to high

Symptoms *Ips* prefer to infest green slash or wind breakage. The first sign of beetle activity is orange-brown boring dust pouring out of bark crevices (Figure 20). When bark is peeled off near the boring dust, a characteristic Y-shape gallery usually is apparent (Figure 21). In general, pines **do not** form pitch tubes in response to *Ips* attacks. Trees attacked by *Ips* in summer usually take a month or more to develop crown symptoms. An infested tree's foliage fades from green to yellow (Figure 22a), then to orange (Figure 22b), and finally to a reddish brown. If trees are attacked in late summer or fall, foliage may not fade until the following spring.

Description Beetles are reddish brown and 3 to 5.5 mm long. They have five distinctive spines on the rear of the wing cover (Figure 23). Beetles often are found

Figure 20 (right).—Dust from Ips *beetle boring.*

Figure 21 (below).—The Y-shape gallery under the bark is characteristic of Ips *beetle activity.*

when removing bark and exposing galleries associated with new attacks. Also found beneath the bark are actively feeding larvae approximately 3 mm long. The C-shape larvae are legless white grubs with yellow heads. Mature larvae develop into the ivory-color pupae, approximately 5.5 mm long. The immobile pupal stage lasts several weeks before transforming into the beetle.

Figures 22a (left) and 22b (above).—Foliage of a pine suffering an Ips *attack first turns yellow, then orange, then reddish brown.*

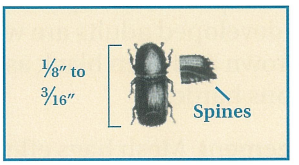

Figure 23.—The California fivespined Ips *beetle.*

Management Preventing the buildup of *Ips* populations is the best way to minimize damage. It is important to thin pine stands periodically so trees have sufficient light, moisture, and nutrients to maintain vigorous growth and resistance to bark beetle attacks. If trees are dying, sanitize the stand by rapidly removing pines with yellowing or orange foliage to reduce bark beetle populations. Pines with yellowing foliage often contain *Ips* broods; removing these off-color trees also removes beetles from the stand.

Properly timed thinning and harvesting can prevent *Ips* attacks on residual trees. Do not leave green slash with diameters greater than 3 inches from January through late July. Slash created during these months holds potential for *Ips* attacks on nearby standing trees. Slash with diameters of less than 3 inches can be created at any time because it does not afford enough breeding area to produce large *Ips* populations.

Rather than piling fresh slash, scatter it in openings to facilitate rapid drying and lower its attractiveness to *Ips*. Also, don't leave green slash around the boles of leave trees. Volatile materials released from green slash attract *Ips* and red turpentine beetles and may result in attacks on nearby trees.

Attacks on standing trees rarely last more than one season and usually are detected only after the damage is done.

Consider using pesticides only in high-value stands where the infestation could persist. Small pines can be treated with carbaryl to prevent *Ips* attacks. Using a ground sprayer, spray to the point of runoff on the main bole of the tree, according to label directions. Because *Ips* have multiple generations, treating trees any time in spring and summer may be beneficial. Carbaryl is not registered for application to slash piles.

Ponderosa pine cone beetle

Conophthorus ponderosae Hopkins

Ponderosa pine cone beetles are the most destructive pests of ponderosa pine cones in the Willamette Valley. High beetle populations have been known to decimate entire cone crops. Cone beetle damage levels generally increase with a decrease in cone production, as beetle populations are concentrated into a more limited resource.

Hosts Ponderosa pine, Jeffrey pine, lodgepole pine, western white pine, limber pine

Damage potential for Willamette Valley ponderosa pine High

Symptoms Damage is from the female beetle's boring into the base of the cone near the petiole. This severs the conductive tissues and kills the cone even if the female

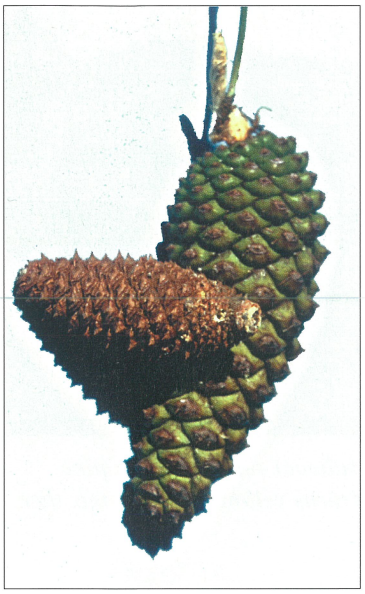

Figure 24.—Pine cone beetle damage.

subsequently is pitched out or if no brood is produced. Dead cones appear brown and stunted and have a small entrance hole, often surrounded by a tube of pitch and frass, where the female entered the base of the cone (Figure 24). Cone beetle symptoms are distinctive and are not likely to be confused with any other type of damage.

Description Mature adults are 2.5 to 4 mm long, shiny, and cylindrical (Figure 25). Color ranges from dark reddish brown to black; most are black. Eggs are milky white and ovoid. Larvae are legless and C-shape. They are soft bodied and white except for a light brown head capsule. Pupae and newly developed adults are white. Adults turn brown and then black as their outer skeletons harden.

Management Mesh bags effectively protect second-year cones from attack by cone beetle females (Figure 26). However, this approach is time consuming and costly, and cones must be reachable. Branch tips with cone clusters are enclosed in a fine mesh bag. Mesh size should be no larger than nine openings per square centimeter. Next to the cone cluster, the branch is wrapped with cotton to prevent openings between the branch and bag through which beetles can enter the bag. The bag is secured over the cotton with a twist tie. To ensure protection, bags must be on before any beetles fly; i.e., before April in the Willamette Valley. Bags are left on the branch until the cones are harvested.

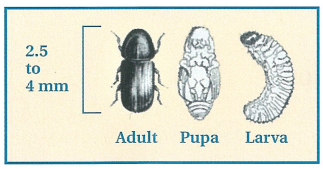

Figure 25.—Life stages of the ponderosa pine cone beetle.

Sequoia pitch moth

Synanthedon sequoiae
(Hy. Edwards)

Sequoia pitch moth causes little serious damage to large trees because larval feeding rarely girdles the trunk or branches. Wounds may cause lumber defects and increase the susceptibility of slender trees to wind breakage. The unsightliness of pitch masses and resin flow on the lower bole is sometimes a concern, as is their possible ignition by ground fires. Repeated attacks over a period of years result in the greatest damage.

Hosts Ponderosa pine, lodgepole pine, shore pine, Monterey pine, sugar pine, ornamental pines, Douglas-fir

Damage potential for Willamette Valley ponderosa pines Moderate to low

Symptoms Larval attacks create white, pink, or yellowish pitch masses from one to several inches in diameter on the bole or large limbs of trees (Figure 27). Attacks near the branch collar area of the bole are very common. Single larvae excavate shallow cavities beneath the bark and often can be exposed by scraping away the pitch mass (Figure 28). After adults emerge, empty pupal cases often are found extruding from pitch masses.

Attacks usually are associated with sites of injury such as pruning wounds and mower or vehicle damage. Infestations are more common on pines growing in the open or on the edge of a stand.

Figure 26.—Mesh bags protect against ponderosa pine cone beetles.

Figure 27.—Pitch masses on the bark indicate attacks of sequoia pitch moth larvae.

Pitch moth symptoms are distinctive and not likely to be confused with any other type of damage.

Description Adults are clear-wing moths with black and yellow markings on the body, much like a yellow jacket wasp (Figure 29). Brownish eggs are laid in bark crevices or wounds. Larvae are creamy white or yellowish with a brown head, growing to about 1 inch long. The pupal stage occurs near the surface of the pitch mass in a tunnel constructed by the mature larva. Old pupal cases are 15 to 20 mm long and look like brown paper. They are near the surface of the pitch mass.

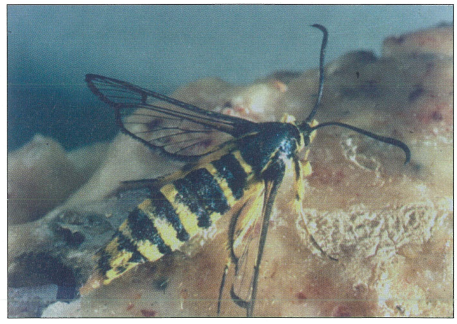

Figure 29.—Adult sequoia pitch moth.

Management Insecticides have not been effective in controlling pitch moth attacks due to the moths' summer-long breeding schedule and ability to encase themselves in a protective pitch coating. Manually removing new pitch masses and destroying larvae is practical if only a few trees are involved and masses are easily reached. Any step to prevent mechanical wounding will help reduce pitch moth infestations.

If pruning or other practices that injure trees are necessary, restrict them to the fall and early winter, well before adult moths are active (Figure 30). Immediately after pruning pines, pitch moth attacks can be common; however, infestation levels, measured by new attacks, typically decline sharply within 1 to 2 years.

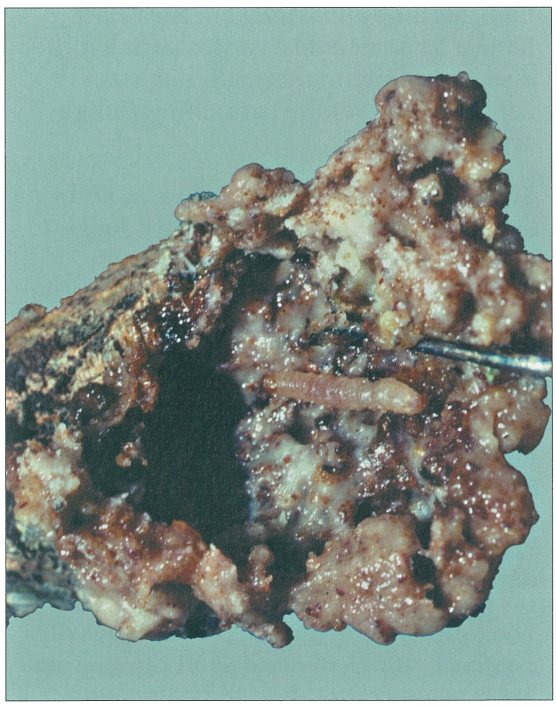

Figure 28.—A cavity under the bark holds sequoia pitch moth larvae.

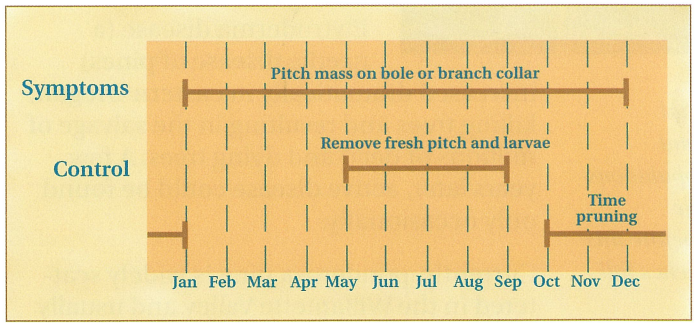

Figure 30.—Timing of symptoms and controls on sequoia pitch moth attacks.