



# FOREST HEALTH NOTES

A Series for the Nonindustrial Private Forest Landowner

## Annosus Root Disease

*(Heterobasidion annosum, Fomes annosus)*

**Hosts:** All coniferous species.

*Highly susceptible:* Grand fir, mountain hemlock, western hemlock

*Moderately susceptible:* Subalpine fir, western white pine, ponderosa pine, lodgepole pine

*Less susceptible:* Douglas-fir, larch, spruce, western redcedar, hardwoods

### Quick ID:

- Crown yellowing and thinning
- Distress crops of cones
- Trees killed in disease centers
- Windthrown trees
- Conks on declining live trees, dead trees, and stumps
- Annual rings separate with pits on one side of sheets

### Field Identification

**Tree & Stand:** Symptoms vary by species. In hemlock, crown symptoms are uncommon and trees often look healthy until they are windthrown. In other species such as pine, affected trees show marked reduction in height and diameter growth. The crown thins and yellows, and may frequently produce a distress crop of cones. Resinous hosts, particularly pines, may have pitch soaking of root wood, and crown symptoms are more apparent than in nonresinous species such as true firs. Decay appears initially as a reddish-brown stain with an irregular margin in the interior of butts and roots. In the roots, decay has several symptoms: the bark separates easily from the wood, the wood is streaked with darker brown lines and the surface of the inner bark has numerous small silver to white flecks. Later, the roots may have small, shallow pockets of white fibers with black flecks. In the trunk, wood will often separate into annual rings with small oval pits on one side (as opposed to the pits of laminated root rot, which are on both sides). Advanced decay of the trunk

is stringy with large white streaks, and black flecks are usually found in decayed wood. Disease centers where the disease has spread out over time from an initial infection are common. In the center, an old stump or empty area may be found. Trees within several yards to hundreds of feet (depending on the size and age of the infection) will be dead or dying, and trees further out will show early crown symptoms. Trees within 50 feet of the apparent edge of a disease center are very probably infected as well. Trees in the disease center may be windthrown, either living or dead.

**Fungus:** The most obvious sign of Annosus root rot is the fruiting body (conk), found inside old stumps or in the duff layer on the exterior of roots and root collars of infected or dead trees. The conk may take several forms. Small, button-like conks may be found on the wood beneath the bark of pine stumps and on the surface of small pine roots in the soil. On the root collar of infected trees, conks ranging from 1/2 to 2" in size may be found under the litter layer. Inside rotted stumps or on the underside of exposed roots of windthrown trees, conks tend to be large (up to 10" wide) and irregularly shaped. The conks, which are perennial, have a dark upper surface and a creamy white lower surface covered with tiny pores.

**May be confused with:** Laminated root rot, Armillaria root rot.

**Disease cycle:** Annosus root rot is considered third in severity in the Pacific Northwest, after laminated root rot and Armillaria root rot. Researchers have identified at least two host-specific forms of the disease: an s-type that infects mostly spruce, firs, Douglas-fir, western redcedar, and hemlock, and a p-type that occurs mainly on pines but will infect the same species as the s-type, as well as brush and hardwood species. Unlike laminated or Armillaria root rot, Annosus spreads both by root contact and by spore infection. When the roots of a healthy individual touch the roots of a diseased individual, a new infection results. As well, windborne spores that are deposited on freshly-cut wood surfaces such as stumps or basal wounds germinate and infect the surface. Annosus can live for 50 years in large stumps of resinous trees; in smaller stumps and nonresinous species survival time is shorter. Species susceptibility to attack varies. In some

species such as hemlock, the host is rarely killed because of its ability to compartmentalize the decay in the butt log. In other species, notably pines and grand fir, the disease causes tree death. Trees are often killed standing rather than being windthrown.

**Predisposing agents:** Certain management practices such as harvesting old growth can create heavy inoculum levels. If the old stumps become infected subsequent regeneration will also become infected. This creates a potential for future disease spread that is very serious, as windborne spores could be carried for some distance. Stumps less than 18" in diameter rarely become established infections. Partial or selective harvesting increases the likelihood of infection by creating new stumps and causing basal wounds from mechanical injury. Annosus is itself a predisposing factor for bark beetle (particularly fir engraver) attack, and is frequently found on the same tree with Armillaria root rot or laminated root rot.

**Impact:** Total losses in board feet are not known, but Annosus causes damage by tree killing, butt rot, windthrow, and decrease in growth of affected trees. Losses due to Annosus are known to be increasing, probably as a result of intensified logging. Bark beetle epidemics mask the incidence of root disease by being the obvious killer, but many if not most trees killed by bark beetles are predisposed by root diseases. Additionally, bark beetle epidemics become established in diseased trees and spread out to healthy ones.

**Management:** It is important to search carefully for signs of other root diseases once Annosus has been diagnosed, as they often occur together. The presence of Armillaria or laminated root rot will affect choice of species for reforestation and silvicultural methods to follow. Unlike the other two major root diseases, there is a chemical control for Annosus. Borax powder spread 1/8" thick on a cut stump within two days of harvest will prevent colonization by Annosus spores. Stumps smaller than 18" in diameter need not be treated with borax as they rarely become sources of inoculum. Pine stumps should only

be treated if they are within one mile of an infected pine stand.

Control of Annosus disease centers is best attempted at final harvest. A systematic survey of the stand can be used to identify the borders of the disease center; every infected tree should be marked low on the trunk so the mark remains after logging. A buffer strip 50 feet wide beyond the border of the disease center should be established. It is suggested that disease centers should be mapped as well as marked to enable them to be tracked over time. Global Positioning Systems (GPS) may make mapping centers and tracking them over time easier, and that technology is rapidly becoming affordable. Within the disease center and the buffer strip, every tree should be cut and stumps treated with borax unless they will be excavated. During the harvest, trees outside the designated boundary should be checked for symptoms and the boundaries adjusted accordingly. Following harvest, stumps may be excavated if it is economical and practical considering species desired, terrain, and soil type. Otherwise, another, more resistant species may be planted. This is where detecting the presence of other root diseases is critical: Douglas-fir is not seriously damaged by Annosus, but is highly susceptible to Armillaria and laminated root rot. Ponderosa pine is moderately susceptible to Annosus, but in south central Washington is highly susceptible to Armillaria. The best bet is blister rust resistant western white pine in stands with high mortality. If the previous stand was true fir, ponderosa pine or lodgepole pine may be planted as the strain of Annosus affecting true firs will not infect pines. Short rotations of 40 to 120 years in stands of grand fir and white fir will also minimize problems with Annosus, especially if the number of intermediate stand entries that may cause wounds is reduced. Thinning to increase stand vigor is recommended early in the rotation before the potential for wounding becomes significant; small stumps from thins do not need to be treated with borax. In mixed-species stands, favor species other than true fir. Salvage logging should be minimized in true-fir stands as it increases wounding.

**Forest Health Notes** were prepared by Donna Dekker-Robertson, Peter Griessmann, Dave Baumgartner, and Don Hanley, Washington State University Extension. The assistance of Robert L. Edmonds and Robert I. Gara, University of Washington College of Forest Resources, is gratefully acknowledged.

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## An overview of forest health

Many of us would agree that, whatever our personal objectives when managing a forest, the end result we seek is a healthy, sustainable forest. In a healthy forest, the risk of present or future damage from natural or human-caused agents has been minimized. Forest health has been defined as the condition of a forest when it is:

- Resilient to change
- Biologically diverse over a large area (landscape diversity)
- Able to provide a sustained habitat for vegetation, fish, wildlife, and humans

A healthy forest is made up of healthy trees. Just as humans need a certain combination of food, water and exercise to maintain physical health, trees require certain inputs to maintain their health and growth. If one or more of these inputs is missing or insufficient, the tree experiences **stress**. Forest managers can help trees by practicing **silviculture** (from Latin *silva*, forest) to influence these inputs. The number one health problem in Washington forests is stress caused by having too many trees to the acre, or **overstocking**. Overstocking causes tree stress because it forces trees to compete with their neighbors for light, water and nutrients. Many silvicultural practices are effective because they reduce the number of trees to the acre and hence the competition for these essential elements.

The first requirement for healthy tree growth is **light**. Plants manufacture their own food by using the sun's energy to convert carbon dioxide and water to a usable food source. Heavy shade, such as is found underneath the closed canopy of the forest, provides insufficient energy for the smaller, less dominant trees to grow very fast. Some species which are called **intolerant** cannot grow under these circumstances at all. These include pines and larches. Other species such as Douglas-fir, Engelmann spruce and most hardwoods are considered **moderately tolerant**. They can grow in partial shade. The **tolerant** species can grow under conditions of heavy shade, although not very fast. These species include grand fir, hemlock, and western redcedar. Silvicultural practices that increase light include thinning and selective harvesting. A thinning operation can cause small, slow-growing (**suppressed**) trees in heavy shade to receive much more light and to grow much more quickly. This is called a **release operation**. Harvesting by clearcutting or patch cutting permits enough light to reach the forest floor that

the intolerant species such as pine are able to seed in and grow.

The second requirement is **water**. Trees species vary considerably in their need for water and their tolerance for drought. Shade-intolerant species commonly grow in hot, sunny areas and thus are more resistant to drought. Shade-tolerant species, on the other hand, grow naturally in the cool, moist forest. When drought occurs, which happens frequently in all western states, these shade-tolerant species get more stressed than the shade-intolerant species. A forest manager may try to alleviate this type of stress by thinning the stand. Thinning reduces the total number of trees competing for water and thus can relieve drought stress. However, over-thinning (the removal of too many trees) may increase the amount of sunlight reaching the ground and dry out the area more rapidly. This is especially true on slopes and steep terrain. An individual with ornamental trees near their home may wish to water them in dry periods, especially if they are trying to encourage rapid growth.

The third requirement is a good **nutrient supply**. Trees take up minerals through their roots and incorporate them in the developing cells. One of the basic determinants of potential growth of a tree is the level of nutrients available in the soil. Nutrient-poor soils such as serpentine will never produce large trees, but rich soils can't produce large trees if they are overstocked. A forest manager may thin a stand to reduce competition for nutrients. Although it is not always cost-effective, using a fertilizer on forest soils can provide needed tree nutrients.

Light, water and nutrients are essential for tree growth, but a healthy tree is additionally free from agents of stress. Just as an unhealthy person may return to health through natural healing processes and the removal of the organism or situation causing illness, these agents of stress do not necessarily mean the death of the tree. However, depending on the severity, they can kill a tree outright, especially if it has been predisposed by insufficient light, water, or nutrients.

**Temperature extremes.** Either very high or very low temperatures can cause injury to trees. The problem is worse when the temperature extreme occurs suddenly. Late frosts in spring can kill the emerging shoots, while early frosts in autumn can injure shoots that are still growing. In the winter, very cold temperatures can kill trees outright, or periods when the soil is frozen followed by sudden warming trends can severely stress or kill

trees. Additionally, heavy snow can cause breakage of the top or limbs, as can ice storms. In the spring, sudden hot temperatures can kill the emerging shoots. After a thinning or pruning operation, the newly exposed southwest side of the tree may become sunburnt; this is called sunscald. The bark may crack or scale off as it slowly heals, or the tree may be killed.

**Flooding.** Too much water can be as much of a problem as not enough. Tree roots need to be able to “breathe;” there are air spaces in soils, even muddy soils. However, during flood conditions these air spaces fill with water and the tree roots can literally drown. Trees that are naturally adapted to **riparian**, or streamside, areas are usually able to survive a lengthy period of flooding, but most forest trees will be damaged or killed. Local flooding is not simply restricted to storm conditions, but can occur as a result of beavers building dams.

**Fire.** Fires can be beneficial or highly damaging, depending on their intensity. A low intensity fire can effectively thin a stand by removing younger trees and species that are not fire resistant, such as grand fir and western hemlock. However, trees that remain after a fire may be stressed from charring. Pines that have been scorched are often attacked by red turpentine or other bark beetles, which can finish them off.

**Wind.** Wind can be a problem in stands that have recently been thinned or are adjacent to clearcuts. The trees in those stands have developed with many trees acting as windbreaks; when nearby trees are removed the trees left may not be strong enough to hold themselves up in a strong wind. Rather than thinning drastically once, a forest manager can thin regularly through the life of a stand, which will permit the trees to grow strong. When preparing to harvest, a forest manager can design small

clearcuts that will not expose a great deal of the adjacent forest to the effects of wind.

**Insects and diseases.** Many insects and diseases can cause stress to the tree; they are more likely to attack if the tree is already under stress from insufficient light, water or nutrients. See other “Forest Health Notes” in this series for descriptions of specific insects and diseases.

**Pollutants.** Airborne or waterborne pollutants can negatively impact the growth of a tree. Ozone, so scarce in the upper atmosphere, can be in a higher concentration near the ground. It is particularly troublesome near large cities, where it is produced by automobiles. Other types of air pollution include sulfur dioxide, which is serious in the upper Columbia River Valley, and hydrogen fluoride, which has been a problem near Spokane. All these gaseous pollutants cause foliage damage, thus preventing normal growth.

**Logging damage.** Heavy equipment in the woods can cause very serious damage. Trees hit by passing equipment or falling trees can receive extensive scarring, which can lead to problems with rot. Additionally, heavy equipment compacts the soil, crushing the air spaces in the soil that tree roots need to breathe. For this reason it is difficult to preserve trees near construction sites, as is often tried on new homesites developed on former forest lands. See “Animal and Mechanical Damage,” also in this series.

**Animal damage.** Feeding damage caused by bears, deer, gophers, etc. can put a tree under stress as it strives to heal the damage. Young trees often succumb to pocket gophers, while older trees may have reduced growth for some years as they heal over a bear scar. See “Animal and Mechanical Damage,” also in this series.

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## Armillaria Root Rot, Shoestring Root Rot, Honey Mushroom (*Armillaria ostoyae*)

**Hosts:** all coniferous species.

*Highly susceptible:* True firs, Douglas-fir, western hemlock

*Moderately susceptible:* spruces, western redcedar, lodgepole pine, western white pine

*Least susceptible:* ponderosa pine (except in south central Washington), western larch

### Quick ID:

- Resin flow from tree base
- Crown thinning or changing color to yellow or red
- Distress crop of cones
- White mycelial fan under bark
- Black rhizomorphs penetrating root surfaces
- Honey-colored mushrooms near base of tree in fall
- Affected trees often in groups or patches on the east side of the Cascades; usually killed singly on the west side.

### Field Identification

**Tree & Stand:** The crowns of affected trees will begin to thin and change color, turning red, brown or yellowish. Resin blisters may be found on the stems and branches of young Douglas-firs. Dead tissue may be found on the outside of the roots as decay progresses inwards; root centers often remain sound. Decayed wood may be stained grey to brown in the early stages, often with a water-soaked appearance. Later, the wood becomes soft, yellowish, spongy and stringy, marked by frequent black zone lines. Occasionally there will be heavy resin flow from the tree base. A distress crop of cones may be produced in trees of conebearing age. Large trees may be easily windthrown, with roots of down trees often broken crosswise near the base of the tree.

On the east side of the Cascades, *Armillaria* will commonly develop root rot centers, where the disease has spread out over time from an initial infection. In the center will be either an old stump or an empty area, or occasionally new regeneration. Trees within several yards to hundreds of feet (depending on the size and age of the infection) will be dead or dying, trees further out will show early crown symptoms, and trees beyond those will not yet show symptoms though they may be infected. These centers may be many acres

in size. On the west side of the Cascades, trees are more commonly killed singly, and are mostly trees younger than 20 years of age that are under stress.

**Fungus:** In autumn, light brown to honey-colored gill fungi (mushrooms) with stalks 3 to 10 inches in length and caps 2 to 5 inches across may be found in clusters at the base of dead or dying trees and stumps. It is easier to diagnose this disease by stripping away a portion of bark at the root crown. A creamy white “fan” of leathery mycelia (fungal fibers) develops between the bark and wood of the infected host, and may be found beneath the bark of infected roots, root crowns and lower stems.

Rhizomorphs, black shoestring-like structures, also provide another reliable method of diagnosis. These may be found between the bark and the wood, on bark surfaces below the soil line, and in the litter and soil around the roots and root crown. They may be distinguished from rootlets in that they adhere to and penetrate roots as well as branching in a different manner.

**May be confused with:** Mottled rot (*Pholiota limonella*), which has similar mushrooms, but only if mycelial fans not present.

**Disease cycle:** *Armillaria* is the most common root rot in the Pacific Northwest. *Armillaria* is highly pathogenic, able to kill apparently healthy vigorous trees. Airborne spores don’t seem to be very important in disease spread. Most commonly, trees are infected by rhizomorphs or by root contact with a diseased individual. Rhizomorphs grow out through the soil from an established infection and penetrate directly into the root surface of uninfected trees to spread the disease. When roots from a healthy tree touch an infected root or stump a new infection results.

Typically, young trees are quickly killed, while older trees may be able to block the progress of the fungus to the root collar and thus survive for many years, albeit in a weakened state (predisposed to windthrow, other diseases and bark beetle attack). Over time, rotted stumps accumulate in an area; these may retain viable inoculum for decades which may infect regeneration.

**Predisposing agents:** Stress generally predisposes trees to attack by assorted agents; a tree that is not receiving enough water, light, or soil nutrients, or one that has been exposed to temperature extremes, pollution, insect attack, disturbances from partial cutting, or other fungal diseases may have a reduced resistance to *Armillaria* attack. *Armillaria* occurs more frequently in dry areas, on less productive sites,

and on sites disturbed by human activities (including fire suppression). *Armillaria* frequently occurs with other root diseases such as laminated root rot and Annosus root disease. *Armillaria* itself is a predisposing factor for bark beetle attack. Young trees seem to be more susceptible than older trees of the same species.

**Impact:** Eastern Washington, with its dry forests, is among the areas where *Armillaria* occurs most frequently and severely. The problem has probably increased substantially in this century due to incorrect forest management practices such as selective logging of the ponderosa pine/western larch overstory and fire suppression, both of which favor regeneration of Douglas-fir and true fir which are more susceptible to *Armillaria* on most sites. In south central Washington, ponderosa pine is considered to be most susceptible and Douglas-fir appears tolerant, but in other areas Douglas-fir and true fir are the most susceptible. In Douglas-fir/true fir forests mortality begins shortly after regeneration and continues through the life of the stand, but in other species such as western redcedar, mountain hemlock, western larch, western white pine, ponderosa pine, and lodgepole pine, damage tends to diminish with stand age beyond 20-30 years. This is probably more true on the west side rather than the east side of the Cascades.

**Management:** *Armillaria* often occurs with other root diseases and is a predisposing factor for bark beetle attack. For that reason, trees killed by bark beetles should be examined for signs of *Armillaria* or other root diseases, as that may affect choices about which species to replant and silvicultural methods to use. *Armillaria* can remain viable in stumps for 50 years. Chemical treatments have not been shown to be cost-effective. Nor is it possible to eradicate the fungus entirely. The most frequent and effective approach to managing root disease problems is to attempt to control them at final harvest by replanting site-suited tree species that are disease tolerant. In eastern Washington that typically means replacing Douglas-fir or true fir stands with ponderosa pine, western larch, western white pine, lodgepole pine, western redcedar, or spruce. Species susceptibility varies somewhat from location to location, so check what seems to be least affected on the site.

Prior to harvest, root disease centers should be marked by examining outlying trees for symptoms (e.g. mycelial fans, rhizomorphs). Infected trees should be marked low on the bole so the mark remains after harvest. It is suggested that disease centers should be mapped as well as marked to enable them to be tracked over time. Global Positioning Systems (GPS) may make mapping centers and tracking them over time easier, and that technology is rapidly becoming affordable. All trees in the disease center as well as uninfected trees within 50 feet should be cut. During the harvest, trees outside the designated boundary should be checked for symptoms and the boundaries adjusted accordingly. No tree from a highly susceptible species should be planted within 100 feet of a disease center.

Another more expensive alternative to changing species is to remove diseased stumps and trees from the site by pushing them out with a bulldozer. It is not necessary to burn the stumps as air drying will kill the fungus, and any small roots left underground will decay before they can reinfest the new seedlings. After stump removal, any species may be planted.

After planting, the most important control measure is to manage for reduced tree stress. Use silvicultural practices to regulate species composition, maintain biological diversity,

reduce chances for insect pest buildup and increase host vigor. Thinning early in the rotation to promote species diversity is encouraged. Mixed-species forests are more resistant to insect defoliation, and also slow the spread of species-specific pests such as dwarf mistletoe, which are both predisposing agents for *Armillaria*.

Young stands should be checked for root disease symptoms at 15-20 years of age. Stands with four or more disease centers per acre are severely diseased and should not be precommercially thinned; instead, they should be either left untreated until rotation (at a younger age than normal), replanted with a more resistant species, or destroyed and replanted with Douglas-fir or other desirable species after stump removal. Stands with fewer than four disease centers per acre may be thinned by cutting infected trees as well as susceptible trees within 60 feet. However, any precommercial or commercial thinning program that removes existing ponderosa pine while leaving Douglas-fir and/or true fir is not recommended.

Selective harvesting of root-disease infested grand fir stands makes the problem worse by creating a fresh supply of stumps for colonization; for this reason, uneven-age management is not recommended (also because it intrinsically favors Douglas-fir and true fir stands). Salvage operations of grand fir and Douglas-fir in eastern Washington have apparently increased the amount of root disease losses. One major salvage every ten years seems to cause fewer problems than salvages every two to three years.

Adapted from *Armillaria Root Disease*, USDA Forest Service Agricultural Handbook No. 691

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## Diplodia Tip Blight and Canker (*Sphaeropsis sapinea*, *Diplodia pinea*)

**Hosts:** 2- and 3-needle pines, especially ponderosa pine

**Quick ID:**

- Stunted, discolored needles
- Needles attached to branch through winter, usually in clusters
- Shoots bent or curled
- Cankers on branches or stems
- Olive-green streaking on tissue underneath bark  
Small black fruiting bodies

**Field Identification**

**Tree:** The first obvious sign is stunted, discolored needles on the current year's growth. When these shoots are infected early in the season, they show characteristic curled or bent growth. The twigs may be resin-soaked, and olive-green streaking may be found on the tissue below the bark. The disease spreads up the branch, killing older needles up to the main trunk. Cankers, which are sunken dead areas, may form on the branches or the trunk. If a canker girdles a trunk the area above it will be killed. In contrast to needles that drop normally, needles that are killed by *Diplodia* will stay on the branch all winter.

**Fungus:** Tiny black fruiting bodies (pycnidia) are formed on the twigs, recently killed foliage, and the face (umbo) of cone scales. These are spherical, smooth, and slightly nipped, and are imbedded in the tissue.

**May be confused with:** Normal needle browning, drought or frost injury, spittlebug damage, bark beetle damage.

**Disease cycle:** Pycnidia release spores during moist weather from spring to fall. The spores are expelled from the pycnidia in masses and accumulate close by until washed away. The fungus enters the stomata of needles

or elongating shoots, or into small wounds, such as those caused by hail or pine spittlebug feeding. The disease then grows into the twig and causes a dieback or possibly a canker. Once the disease is present it moves along the branch killing other twigs and needles, and may kill the leader. Wood in the trunk may become sapstained. *Diplodia* alone does not usually kill trees. Although massive infection may kill a tree, more commonly the weakened tree is killed by bark beetle attack.

**Predisposing agents:** Wounding of the tree permits spores to enter. The most susceptible trees are those with reduced vigor, e.g. those planted off-site or stressed by drought, snow damage, or insect activity. As noted above, this disease is itself a predisposing factor for bark beetle attack.

**Impact:** This disease is found internationally, and causes a great deal of damage in exotic pine plantations. In this country, it hits plantings of Scotch pine, Austrian pine, and mugo pine more seriously than ponderosa pine. No figures for its impact on ponderosa pine in Washington are available, nor would it be easy to quantify as death is often associated with bark beetles.

**Management:** Trees under stress are most susceptible, so managing stress should reduce the likelihood of infection. Trees should not be planted on sites for which they are not adapted, nor should they be planted in unfavorable locations, on poor soils, or in densely shaded areas. Stocking levels can influence tree stress as well, so stands should be thinned to prevent overstocking. Mechanical injury should be avoided. Pruning high-value trees (e.g. those near houses, campgrounds, etc.) will not decrease the spread of *Diplodia*. As this disease is not in and of itself a tree killer, do not take hasty action but watch for signs of more serious problems such as *Armillaria* or successful bark beetle attack.

Adapted from *Diplodia Tip Blight on Ponderosa Pine*, University of Idaho Cooperative Extension bulletin by Chris Schnepf.

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## Douglas-fir Beetle (*Dendroctonus pseudotsugae*)

**Hosts:** Douglas-fir, western larch

### Quick ID:

- Galleries straight, vertical, packed with frass
- Larval galleries fanning out from egg gallery
- Red or yellow boring dust in bark crevices or at base of tree
- No pitch tube
- Resin streamers on upper bole attacks
- Foliage discolored

### Field Identification

**Tree:** Boring dust from the beetle's entry may be found in bark crevices or at the base of the tree; it will be reddish or yellowish. No pitch tube is found on the trunk, but resin streamers may form from attacks on the upper trunk. Egg galleries are similar to those of the mountain pine beetle in that they are long and straight, running with the grain, and have the same 90 bend at the bottom; they are typically 6 to 30 inches in length. Larval galleries fan out from alternate sides of the egg gallery, moving across the grain. These galleries are packed with frass (mixed sawdust and insect droppings). A pupal chamber may be found at the end of the larval mine. The foliage of attacked trees turns yellow and then fades to reddish-brown by late summer or fall, though it may hang on until the following spring.

**Insect:** Adults are 4.4 to 7 mm in length, dark brown to black, and rather hairy. Larvae are small, white, and resemble grains of rice.

**May be confused with:** Nothing else on Douglas-fir.

**Life cycle:** Adult insects emerge and fly from April through August. Normally, Douglas-fir beetle only breeds in felled, injured or diseased trees, although epidemics occur where apparently healthy trees are colonized. In Washington, this is generally the result of a population explosion following drought, windstorm with extensive windthrow, or large fire. Western larch is also attacked,

but brood is produced only in down trees. Females attack the tree, bore through the bark and release pheromones that attract both other females and males. A pair of beetles will work together to construct the egg gallery, which will be mostly in the inner bark but will slightly etch the sapwood. Eggs are laid in groups on alternating sides of the gallery. Larvae hatch and tunnel individually out from the egg gallery; as they get further from the egg gallery, larval mines fan out. Both the egg gallery and the larval galleries become packed with frass. After the larvae has developed, it hollows out a pupal chamber at the end of the mine and pupates. The new adults congregate together under the bark, sometimes for long periods. Eventually they bore through the bark and fly off to find another host. There is one generation every year, and larvae and adults overwinter inside trees.

**Predisposing agents:** Douglas-fir beetles successfully attack trees that have been weakened by some stress. These agents of stress can be abiotic (such as drought and fire) or biotic (overstocking causing competition, diseases, insect attack, etc.). Root diseases are heavily implicated in predisposing trees to bark beetle attack. The presence of Armillaria root disease is indicative of advanced stand degeneration, but laminated root rot is also a predisposing factor. Dwarf mistletoe also weakens trees and reduces growth. Douglas-fir beetles will breed in down trees that have been felled by wind, as well as fire-injured trees. Insect defoliators such as Douglas-fir tussock moth and western spruce budworm can severely weaken trees and predispose them to attack. Lastly, logging damage on residual trees can also predispose trees to attack.

**Impact:** This is the most important bark beetle on Douglas-fir throughout its range. Losses on larch are insignificant as brood are not hatched in standing trees. According to the USFS, in 1990 Douglas-fir bark beetles killed 23,200 trees over 29,300 acres in Washington, causing a loss of 3.086 million cubic feet. In 1991, they killed 16,097 trees over 16,991 acres causing a loss of 2.067 million cubic feet.

**Management:** Direct control (e.g. felling, spraying, etc.) has not been attempted often due to its poor success. In Washington, it is possible to prevent damage by removing the windthrown trees that permit a large population

of beetles to develop. Trees can also be protected by attaching capsules of MCH, a Douglas-fir beetle repellent, to their boles.

Douglas-fir beetles are a natural part of western ecosystems. Total eradication is neither possible nor desirable, as the beetles normally remain at a steady level and are responsible for thinning weak trees and thus opening the stand for regeneration. The death of a few trees on your property may tip you off about a root disease problem, which will influence your choice of species and silvicultural treatment used to regenerate. Information about root disease symptoms is also available in WSU Cooperative Extension's "Forest Health Notes." Or in the absence of root disease it may be a hint that your stand is overstocked. It doesn't necessarily mean the bark beetles are going to have an epidemic outbreak on your property.

Many site management techniques work well to prevent outbreaks. Attention to root disease centers and overstocking are two big steps towards a healthy, insect-resistant stand. To minimize stand stresses and maintain vigorous growing conditions, stand managers should: (adapted from Berryman: Forest Insects, 1986)

- Choose tree species that are adapted to the area on which they'll be planted.
- Harvest trees in a way that mimics natural processes, such as cutting small patches to mimic a fire (for pine and larch management) or selective cuts such as seed tree or shelterwood cuts (for Douglas-fir). Particularly with shade-tolerant species like Douglas-fir, keep in mind other stand health issues such as discouraging dwarf mistletoe and regenerating other species on root disease centers.
- Remove diseased and unhealthy trees and logging debris, and minimize damage to residual trees.

Salvage logging of beetle-killed trees is fine except in root disease areas where that could increase the severity of Armillaria, Annosus and laminated rot (see WSU Extension "Forest Health Notes" on root rots for more thinning/salvage tips).

- Practice "good housekeeping" in the forest by removing windthrown and fire-damaged material before Douglas-fir beetles breed in it and create an outbreak. Large numbers of cull stems should not be left in the forest after a logging operation, especially if they're shaded.
- Encourage diversity in species and age classes. A mixed-species stand is much more resistant to insect pests and diseases than is a pure stand.
- Use thinning, fertilization, prescribed fire, etc. to maintain stand diversity and vigor.

Patch cutting 6 to 10 acre blocks every few years and managing these as small even-aged stands helps keep the total number of older trees low and creates a variety of age classes that discourages bark beetle attack. It has additional benefits for wildlife by creating small openings and edges. This may not, however, be a good strategy if trees at the edges of the cut are heavily infested with dwarf mistletoe and the species to be planted or naturally regenerated is the same species.

*Note: Use pesticides with care. Apply them only to plants, animals, or sites listed on label. When mixing and applying pesticides, follow all label precautions to protect yourself and others around you. It is a violation of the law to disregard label directions. If pesticides are spilled on skin or clothing, remove clothing and wash skin thoroughly. Store pesticides in their original containers and keep them out of the reach of children, pets and livestock.*

**Forest Health Notes** were prepared by Donna Dekker-Robertson, Peter Griessmann, Dave Baumgartner, and Don Hanley, Washington State University Extension. The assistance of Robert L. Edmonds and Robert I. Gara, University of Washington College of Forest Resources, is gratefully acknowledged.

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# FOREST HEALTH NOTES

A Series for the Nonindustrial Private Forest Landowner

## Douglas-fir Tussock Moth (*Orgyia pseudotsugata*)

**Hosts:** Douglas-fir, grand fir, subalpine fir; rarely pine, western hemlock, western larch, Engelmann spruce

### Quick ID:

- Foliage appears scorched or off-color
- Defoliation from top down and from outside in
- Thin crowns and topkill
- Defoliation from hairy caterpillar up to 1" in length
- Grey cocoons and webbing present on branches

### Field Identification

**Tree:** From a distance, trees appear scorched or off-color, often with a noticeably thin crown. Tussock moth larvae prefer new foliage, especially when they are young, hence the defoliation occurs from the top down and from the tips of the branches inwards. As the top of the crown has a high percentage of new foliage each year, it is severely defoliated and often killed. Larvae spin webs enclosing leader and branch tips. When the population density is normal, grey cocoons may be found on the underside of old foliage. When the population density is high, additional cocoons may be found on branches, on the trunk, or on understory vegetation.

**Insect:** Adult insects are charcoal-brown moths. The male has a wingspan of about 1-1/4" (31 mm), and the female has stubby, vestigial wings. Egg masses are greyish as they are mixed with black hairs from the female's abdomen; they are laid on the female's cocoon. Larvae go through several stages of development. They hatch as tiny, black-headed caterpillars and finish as larvae about 1" in length, with four distinct tufts of white hair with red tips in the middle of the back, two "horns" of hair in front, and two tufts at the end of the abdomen, one of which may be reddish. All stages of development are hairy. If you have a defoliator which has no hair, it's not tussock moth.

**May be confused with:** Western spruce budworm, sawflies

**Life cycle:** The female, who does not fly, lays eggs on her cocoon anywhere from August through October.

These eggs are mixed with hairs from her abdomen, held together with a gelatinous substance. Eggs overwinter in a mass and hatch from late May to late June. Larvae initially feed on the underside of new needles, then switch to older needles and next year's buds. Young larvae may be dispersed to other trees by a "ballooning" effect, where the wind carries them on a strand of webbing for some distance. Fully developed larvae spin a cocoon and pupate from mid-August through September, emerging to mate and die soon thereafter. Only one generation occurs each year.

**Predisposing factors:** The probability of defoliation for a given stand in Eastern Washington may be related to certain factors. Geographically, those stands which are lower in elevation, on east-facing slopes, or on ridgetops are more likely to be defoliated. Tussock moths are favored by stands of high density, a high percentage of true fir and Douglas-fir, or many trees with a large crown diameter. Naturally, the probability of defoliation increases when adjacent or nearby stands are defoliated, or have a high probability of defoliation. Water deficiency also predisposes trees to attack. Defoliation by tussock moths is itself a predisposing factor for bark beetle infestation, particularly fir engraver and Douglas-fir beetle. Bark beetle outbreaks often occur shortly after tussock moth outbreaks, once trees have been weakened.

**Impact:** The magnitude of outbreaks in terms of infested acreage is known to be increasing. Smaller trees suffer more mortality from the effects of defoliation, and larger trees suffer more mortality from subsequent bark beetle attack. In a major outbreak in the Blue Mountains, 72% of the trees heavily defoliated were killed. Growth loss after defoliation can be significant, with percentage lost varying from 58% to 40%, depending on severity of defoliation.

**Management:** Both direct and indirect methods of control have been used against the Douglas-fir tussock moth. Direct methods include chemical, viral and bacteriological sprays, usually applied aerially. Chemical sprays have been effective in knocking back the population, but do not address the underlying cause of outbreaks and hence will not prevent recurrence. They have fallen out of favor as questions have arisen about their toxicity in the environment.

Attention has shifted recently to viral and bacterial controls, as these naturally-occurring agents have historically caused populations to crash. These can be highly effective but are somewhat more expensive than chemical sprays. However, they are specific to butterflies and moths and hence do not disturb other insects, nor other members of the ecosystem. Preparations of a bacteria, *Bacillus thuringiensis*, are available commercially. Again, like chemical sprays biological agents knock populations back but do not treat the underlying cause of the outbreak.

The US Forest Service and others have made the decision to concentrate on silvicultural measures to control insect pests. Some recommendations for reducing the hazard of serious defoliation include:

- Thin to generate a low-hazard stand. An appropriate stocking level will reduce stress from intertree competition, particularly water stress. Stands less than 50 years of age and without a high proportion of grand fir will be more resistant to defoliation.
- Do not use equipment that causes soil compaction or erosion. Match equipment to site to minimize damage on trees that would favor insect and disease attacks.
- Lop and scatter slash, pile and burn largest pieces (greater than 6" in diameter) only if fuel load

is unsatisfactory. The idea here is to encourage nutrients to cycle rather than to remove them (by removing the slash) or to permit them to be leached (by burning everything).

- Under even-aged management systems, schedule harvest cuts to minimize adjacent stands' exposure to heat and wind and to improve snow retention.
- Favor establishment of species adapted to drought, such as ponderosa pine in place of Douglas-fir on dry sites, and ponderosa pine, lodgepole pine, Douglas-fir and larch on sites capable of supporting true fir species.

*Adapted from The Douglas-fir Tussock Moth: A Synthesis, USDA Forest Service Technical Bulletin 1585, M. Brookes, R.W. Stark, and R. Campbell, eds.*

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# FOREST HEALTH NOTES

A Series for the Nonindustrial Private Forest Landowner

## Dwarf Mistletoe (*Arceuthobium spp.*)

**Hosts:** Ponderosa pine, lodgepole pine, western larch, Douglas-fir, western hemlock, mountain hemlock, rarely western white pine and spruce.

### Quick ID:

- Pronounced “witches’ brooms”
- Spindle-shaped swellings on branches
- Swollen areas on trunks that may be twice the normal diameter of the tree 1/2- to 6 inch
- Green shoots protruding from swollen areas on branches and trunks

### Field Identification

**Tree:** In response to branch infections, trees often produce “witches’ brooms,” abnormal proliferations of many small twigs which appear as a mass of twigs and foliage. These vary in appearance from tight clumps to large loose fans. The dwarf mistletoe species that infect Douglas-fir, ponderosa pine, lodgepole pine, western larch, and hemlock cause large witches’ brooms. Dwarf mistletoe infections on branches have a spindle-shaped, swollen appearance. On trunks, infections may cause the tree to swell to twice its original diameter.

**Plant:** Shoots of the plant protrude from the swellings on branches and trunks. These are leafless and vary in color and size according to species; they have different male and female forms on the same tree. Douglas-fir dwarf mistletoe has 1/4- to 1/2-inch olive green shoots, while ponderosa pine dwarf mistletoe has 3- to 8-inch olive green to yellow shoots. Lodgepole pine dwarf mistletoe has 2.5-inch yellow to olive-green shoots and western larch dwarf mistletoe has shoots that are dark purple and 1.5 to 4 inches long. Hemlock dwarf mistletoe has 2-inch shoots that are either green or red, and true fir dwarf mistletoe has shoots that are yellow-green and 3 to 8 inches long.

**May be confused with:** Elytroderma needle blight on ponderosa pine, simulation brooms caused by release of suppressed trees on hemlock or lodgepole pine, brooms caused by viruses on Douglas-fir, fir broom rust.

**Disease cycle:** Dwarf mistletoe is probably the most damaging disease of larch and lodgepole pine in

Washington, causing growth loss, wood quality reduction and tree killing. Dwarf mistletoe is a plant, but is entirely dependent on its host tree. Death of the tree also means death of the mistletoe, so mistletoes tend to coexist with their hosts. Dwarf mistletoes are fairly host specific; there is limited crossover from one species of tree to another. Seeds are sticky and are forcibly shot from shoots growing on swellings. These seeds may travel up to 100 feet depending on the species and wind. When they land on the proper host, they sprout in the spring and penetrate the thin bark, forming a new infection. Spread is fastest in multi-storied stands that are somewhat open; in single-story stands the spread averages 1-2 feet per year. Birds may be responsible for long-distance spread by carrying seeds stuck to their feet or feathers. Trunk infections cause swelling and cracking that permits rot fungi to be introduced into the heartwood. Trees that are less than 3 feet in height or 10 years in age generally escape infection.

**Predisposing agents:** The classic problems with dwarf mistletoe have occurred as a result of a multi-storied forest structure, with older trees raining seed down on younger ones. This is problematic in Eastern Washington as there are many Douglas-fir/grand fir or pure Douglas-fir stands that have this type of structure. These stands are typically regenerated by cutting the overstory and allowing the infected understory to grow up to form the new crop, thus perpetuating the disease. Because of the dwarf mistletoe’s host specificity, pure stands or stands with only a few species have more problems than mixed stands of several species.

**Impact:** Dwarf mistletoe infests 42% of stands of Douglas-fir on the East Side. While dwarf mistletoe on Douglas-fir is unusual on the west side of the Cascades, it is a problem on hemlock. In the Pacific Northwest, it infests 47% of western larch stands, 42% of lodgepole pine stands, 21% of hemlock stands, and 26% of ponderosa pine stands. True fir dwarf mistletoe infestations are uncommon in Washington. The major impact of dwarf mistletoe infestation is in growth loss. An estimated 148 million cubic feet are lost annually in all species to dwarf mistletoe in Washington and Oregon, and 40 million cubic feet are lost in Douglas-fir in the Inland Empire.

**Management:** Choice of silvicultural method depends upon the management goals for the stand, keeping in mind the stage of the cutting cycle and the damage being inflicted by the disease. With young stands, the objective

is generally to protect them from infection. With middle-aged stands, efforts are usually directed towards reducing infection levels and halting spread. When the stand has reached harvest age, the objective is to eliminate mistletoe and thus prevent the subsequent crop from being infected. When evaluating the condition of the stand, determine two things: whether the stand is made up of more or less than 50% of the host species, and whether more or less than 50% of the trees of the host species are infected. As the infection may be clumped inside a stand, sometimes it is easier to subdivide the stand and deal with small areas separately. These treatments would be appropriate for dealing with dwarf mistletoe infections in all species:

- **Lightly sanitize.** This is a good option if the stand is made up of less than 50% of the host species, and less than half of the host species is infected. Remove the diseased individuals to halt the spread. This can be done by combining sanitizing with a thinning or selective harvesting operation. It may be necessary to return a couple of years later to remove trees that were not noticeably infected until thinning allowed more light into the stand and stimulated shoot growth.
- **Stand conversion.** If the stand is made up of less than 50% of the host species, but more than half of them are infected, it would be best to convert the stand to another species by cutting all the trees of the infected species, including the regeneration. This may be done in a thinning or partial harvest. Choosing this option depends in part on stocking levels and stand age, as cutting all the trees of one species may leave the stand unacceptably stocked; in that case it may be better to cut the most heavily infected individuals and permit the lightly infected to stay until rotation age.
- **Sanitize.** If the stand is made up of more than 50% of the host species, and less than half of the host species are infected, a thinning/sanitation cut of diseased individuals would be appropriate in a well-stocked or overstocked stand. In an

understocked stand it may be better to wait until a commercial harvest may be made, especially if the stand is nearing rotation age.

- **Clearcut.** If the stand is made up of more than 50% of the host species, and more than half of them are infected, and the stand is still quite young (less than 20 years,) clearcutting and starting over may be the best option. If the stand is middle-aged, it may be best to cut the most seriously infected trees and leave the more lightly infected until rotation age.
- **Do nothing.** If the host species is more than 50% of the stand, and more than half of the trees are infected, a sanitation cut of diseased individuals may leave stocking levels too low. In that case, if the trees are nearly merchantable, it is better to do nothing.

When regenerating a stand, a seed tree or shelterwood cut may be used if the overstory is removed before the young trees are greater than 3 feet in height or have reached 10 years of age, as they will probably escape infection. Delaying removal of the overstory, however, can seriously jeopardize the new stand. It is beneficial to establish a single-storied, mixed-species stand when regenerating as that sharply slows the spread of mistletoe from surrounding stands, and will also help manage some problems such as root diseases and damaging insects. Combining a seed tree cut with planting may be an inexpensive way to get a mixed-species stand. Lastly, if the stand to be regenerated is surrounded by dwarf mistletoe infected trees, and the species desired is the same species as the infected trees, a buffer strip wider than the projectile range of the seeds should be planted with another species around the perimeter of the new stand.

Adapted from J.W. Schwandt, *Dwarf mistletoe management strategies for inland Douglas-fir and Grand fir types*. In: *Silvicultural management strategies for pests of the interior Douglas-fir and Grand fir forest types*, proceedings of a symposium held February 14-16, 1984 and available from WSU Extension.

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# FOREST HEALTH NOTES

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## Elytroderma Needle Cast (*Elytroderma deformans*)

**Host:** Ponderosa pine, rarely lodgepole pine

### Quick ID:

- Narrow, long black spots on 2-year-old needles
- Reddened, dead 1-year-old needles (“flags”)
- Current season needles green
- Witches’ brooms
- Inner bark of older twigs has dead patches

### Field Identification

**Tree:** In the spring, needles infected the previous fall die and turn red-brown. This color fades through the summer. At the tip of the twig, the current year’s needles remain green. If the tree is infected year after year, witches’ brooms, or abnormal proliferations of many small twigs which appear as a mass of twigs and foliage, may form. These are more compact and rounded than the witches’ brooms from dwarf mistletoe infections, and have upward-turning branches and many dead needles. Twigs that have been infected for more than three years have small patches of dead tissue under the inner bark.

**Fungus:** Dull black, elongated fruiting bodies appear as spots on dead needle surfaces in the late summer.

**May be confused with:** Dwarf mistletoe, Dothistroma needle blight, Lophodermella needle cast.

**Disease cycle:** Elytroderma needle blight is the most important foliage disease of ponderosa pine in Washington. Windborne spores are disseminated from the hysterothecia in late summer and autumn, infecting the current year’s foliage. The fungus grows from the needle into the twig without initially killing either one. The following spring, the needles die and new hysterothecia form on the dead needles.

Infections in the woody twigs can remain for many years, reinfesting needles that produce spores that infect other trees. The spread of the disease in the twigs causes the characteristic brooming and deformation.

**Predisposing agents:** Cool temperatures and high humidity in the late summer and fall promotes infection by the windborne spores. Certain sites that typically have these conditions such as around lakes, in stream bottoms, in canyons, near meadows and in other cool moist areas have more problems with the disease, especially as the air recirculates in the stand. Elytroderma is itself a predisposing factor for Armillaria root disease and bark beetle attack as it weakens the tree.

**Impact:** Infection becomes damaging around 3,500 feet of elevation in Washington, though it occurs at lower elevations. The damage from this disease occurs mainly as growth loss and predisposition to disease and bark beetles, although infections year after year can kill the tree. No information is known about the disease’s impact in terms of cubic feet lost each year, but trees with 30% to 60% of the crowns infected lose 52% to 65% of normal diameter growth, and trees with more than 60% of the crown infected lose 93% to 99% of normal diameter growth.

**Management:** In immature stands, good spacing should be maintained but large openings in the stand should not be created. Severely infected trees should be removed when thinning (do not leave trees with flags within 6 feet of the leader). Infected branches should be pruned if it is economically feasible to remove sources of inoculum. In mature stands, it is important to avoid hasty action as infection can occur without catastrophic loss. Watch the stand carefully for signs of more serious damage (bark beetles, Armillaria, etc.). When harvesting damaged or diseased trees, carefully inspect the residual stand taking care to remove all infected trees.

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# FOREST HEALTH NOTES

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## Fir Engraver (*Scolytus ventralis*)

**Hosts:** Grand fir, rarely Douglas-fir, Engelmann spruce, mountain hemlock, western larch

### Quick ID:

- Reddish-brown or white boring dust in bark crevices or at base of tree
- Egg galleries straight, across the grain (horizontal)
- Larval galleries at 90 from the egg gallery
- Galleries deeply etch sapwood
- Galleries free of frass
- Foliage may thin, yellow, or redden

### Field Identification

**Tree:** In Washington this beetle primarily attacks grand fir, although it has been observed on occasion attacking Douglas-fir, Engelmann spruce, mountain hemlock and western larch. Reddish-brown or white boring dust may be found in bark crevices, caught in spiderwebs, or at the base of the attacked tree. No pitch tube is found as true firs are nonresinous. Under the bark, the egg gallery is straight and perpendicular to the grain (horizontal). Midway along its length a larger nuptial chamber is found. Larval galleries are formed at right angles to the egg gallery. The egg gallery and the larval galleries deeply etch the sapwood, leaving marks that can easily be identified well after the death of the tree. Both egg and larval galleries are free of frass (tightly packed boring dust and insect droppings). On successfully attacked trees, the foliage may thin, yellow, or redden. On unsuccessfully attacked trees, the attack may heal over leaving an area of rough bark 1/4 to 1/2 inch across.

**Insect:** Adult fir engravers average about 4 mm in length. They are black and the posterior of the abdomen is prominently concave on the underside. Larvae are small and white.

**May be confused with:** No other bark beetle has straight, across-the-grain galleries.

**Life cycle:** Adult insects emerge and fly in search of new hosts from June to September, with the greatest emergence in mid-July. Attacks seem to be made at random on both resistant and susceptible trees. Females

attack trees first, tunnel into the inner bark, and await the males in the nuptial chamber. Other females will attack the same tree after a first attack, particularly if the first attack was successful. After mating, the female will tunnel horizontally from the nuptial chamber, depositing eggs in niches cut in the walls. Resistant reactions by the host tree may cause the female to abandon the attack at this point; in this case, the attack heals over, leaving a brown pitch pocket in the wood that will degrade the value. In contrast to Douglas-fir and mountain pine beetles, fir engravers are not very tolerant of the resins produced by resistant trees, and will readily abandon the attack if they incur too much resistance. Furthermore, eggs laid in resistant trees will be poisoned by these resins. However, in a susceptible tree, eggs will hatch within two weeks. Larvae tunnel away from the egg gallery to feed, and pupate at the end of the larval mine. Larvae mostly overwinter before pupating and developing into adults in the spring. New adults bore through the bark in summer and seek out new hosts. Normally there is one generation per year.

**Predisposing agents:** Fir engravers are a secondary pest, meaning that they cannot successfully attack and kill healthy vigorous trees (in contrast to other bark beetles such as Douglas-fir, mountain pine and western pine beetles). They prey upon weakened, dying, or recently killed fir trees, and are well-adapted to finding this normally scattered food source. Certain agents of stress have been shown to predispose firs to engraver attack. These include drought; overstocking, especially if a high percentage of the stand is true fir; root disease, particularly Annosus root disease; defoliation, particularly by Douglas-fir tussock moth; and the presence of abundant dead material such as slash and windthrow nearby.

**Impact:** Fir engraver is considered to be a major pest of true fir in western forests, but beetle-induced mortality can mask mortality due to predisposing factors such as drought and root disease. Nevertheless, in 1990 the USFS reported the fir engraver had killed 238,000 trees over 245,000 acres in Washington, with a loss of 12.744 million cubic feet of lumber. In 1991, it was responsible for the death of 68,674 trees over 146,542 acres with a volume loss of 3.684 million cubic feet of lumber.

**Management:** Direct control measures (e.g. felling, burning, spraying) for fir engravers are impractical. Therefore, minimizing stand stresses to keep trees healthy

and vigorous is the only real option for control.

Fir engravers evolved here together with grand fir, and as such will never be completely eradicated. Under normal conditions, they serve to thin out weak trees and open up the stand for regeneration. The species shift in Eastern Washington in the last century away from ponderosa pine and western larch and towards grand fir and Douglas-fir, coupled with the suppression of fire, has created hundreds of thousands of acres of true fir under stress from overstocking and served to create a habitat for fir engravers that is very favorable. Gradual correction of that situation by good stand management practices will bring down the incidence of fir engraver attack.

Many stand management techniques work well to prevent outbreaks. Attention to root disease centers and overstocking are two big steps towards a healthy, insect-resistant stand. To minimize stand stresses and maintain vigorous growing conditions, stand managers should: (adapted from Berryman: Forest Insects, 1986)

- Choose tree species that are adapted to the area on which they'll be planted. Harvest trees in a way that mimics natural processes, such as cutting small patches or making a seed tree/shelterwood cut to mimic a fire. Particularly with shade-tolerant species such as grand fir, keep in mind other stand health issues such as planting other, more resistant species on root disease centers.
- Remove diseased and unhealthy trees and logging debris; minimize soil compaction and damage to residual trees. However, salvage logging of fir

engraver-killed trees should only be undertaken with caution: in Washington fir engravers generally indicate the presence of root diseases, and salvage logging on root disease centers has been shown to worsen their severity (see WSU Extension leaflets on root diseases).

- Practice "good housekeeping" in the forest by removing windthrown and fire-damaged material before fir engraver beetles breed in it. Large numbers of cull stems should not be left in the forest after a logging operation.
- Encourage diversity in species and age classes. A mixed-species stand is much more resistant to insect pests and diseases than is a pure stand.
- Use thinning, fertilization, prescribed fire, etc. to maintain stand diversity and vigor.

Adapted from Berryman, A.A. *Forest insects and Population dynamics of forest insects.*

**Note: Use pesticides with care. Apply them only to plants, animals, or sites listed on label. When mixing and applying pesticides, follow all label precautions to protect yourself and others around you. It is a violation of the law to disregard label directions. If pesticides are spilled on skin or clothing, remove clothing and wash skin thoroughly. Store pesticides in their original containers and keep them out of the reach of children, pets and livestock.**

**Forest Health Notes** were prepared by Donna Dekker-Robertson, Peter Griessmann, Dave Baumgartner, and Don Hanley, Washington State University Extension. The assistance of Robert L. Edmonds and Robert I. Gara, University of Washington College of Forest Resources, is gratefully acknowledged.

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# FOREST HEALTH NOTES

A Series for the Nonindustrial Private Forest Landowner

## Indian Paint Fungus, Brown Stringy Rot (*Echinodontium tinctorium*)

**Hosts:** True firs (especially grand fir) and hemlock, rarely Douglas-fir and spruce

### Quick ID:

- Woody hoof-shaped conks attached to trunk under dead branch stubs
- Early rot: Light brown heartwood stain
- Late rot: yellow or rusty red stringy rot
- Punk knots
- Decay within old wounds

### Field Identification

**Tree & Stand:** Early in the decay process, the heartwood is stained yellowish to light brown. The wood is softer in relation to uninvaded heartwood. The heartwood turns pale reddish-brown and rust-red streaks appear following the grain. Later on, a yellow or rusty red stringy rot is observed. Rotted wood may separate along annual rings. "Punk knots," or swollen knots with red interiors, may be found on the stem.

**Fungus:** The easiest way to diagnose this stem rot is the presence of conks on the infected tree. Conks are large (4 inches by 6-12 inches) perennial woody, hoof-shaped fruiting bodies that are black and cracked on top, grey and toothed underneath, and have a brick-red interior (the common name Indian paint fungus came from certain tribes' use of the interior for red pigment). Conks generally are formed under old branch stubs, and one large conk indicates about 20 feet of cull on either side.

**May be confused with:** Nothing, if conks are present.

**Disease cycle:** Indian paint fungus is considered to be the most serious heart rot of true firs and hemlock in Eastern Washington. Conks release airborne spores which enter new hosts through broken-off branchlets which are very small (0.1 inches). Mycelia (fungal fibers) develop within the branch stub until the stub is overgrown. Once this occurs, the fungus enters a resting state which can last for 50 years or more without causing decay. All fungi require air, moisture and a food source for development, so until

air is readmitted to the interior of the trunk the disease remains dormant. Although a single tree may have several infections, most do not cause trunk decay because they either are not close enough to the trunk or do not become reactivated. Reactivation can be the result of mechanical injuries such as cat faces, frost cracks, the formation of large branch stubs, or even tiny wounds caused by fir engravers (bark beetles), all of which permit air to enter the trunk interior. The amount of decay that follows depends on the tree's age, genetic makeup, habitat type, and wound size.

**Predisposing agents:** This is typically a disease of overmature or mismanaged stands. Trees less than 40 years of age are not affected because of their low proportion of heartwood. Stands that are overstocked and lack vigor are more susceptible, as fast-growing, vigorous trees remain sound. Live crown ratio (percentage of trunk with a full crown, usually a function of stocking level) affects vigor and hence susceptibility. North-facing slopes have a higher incidence of decay than south-facing slopes as they are generally more moist. The species makeup of the overstory influences disease incidence for two reasons: 1) Grand fir and Douglas-fir overstories are generally more dense and moist, while pine overstories are more open and hence drier, and 2) Grand fir old growth trees with conks can infect advanced regeneration (younger trees growing under the older trees that will be left after harvest to form the next crop). These trees are suppressed, growing very slowly as they do not receive much light. For this reason they are slow to heal small branchlet stubs, permitting a longer interval for spores to enter and cause infection. Additionally, they have more dead branchlets in their crowns which, as they are broken off, increases the total number of places the spore may enter. Later, wounding of trees through logging or other silvicultural activities can reactivate a dormant infection.

**Impact:** In mature and overmature grand fir stands in the Blue Mountains, expect a 50% volume loss. About one-quarter of stands sampled in eastern Washington were heavily infected, while two-thirds were lightly infected. Current management practices that favor true firs, such as overstory removal and crop replacement by advanced regeneration, may predispose stands to future volume losses.

**Management:** Advanced regeneration in grand fir stands should be rated for decay hazard. Some factors that may influence infection levels include: percentage of infected trees, species composition in the overstory, stand age, live crown ratio, site aspect, and percentage of trees with wounds.

It is extremely important to minimize wound damage when entering a stand to implement silvicultural treatments. As no chemical or biological method will protect a tree, wound prevention is the only effective way to keep from reactivating dormant infections. The following actions should minimize heartrot in Washington:

1. Manage susceptible species on short rotations, not longer than 150 years.
  2. Thin trees early to increase growth and maintain stand vigor, but use care to minimize trunk wounds.
  3. When partial cutting, select crop ("leave") trees with at least 50% live crown ratio, at least 8 inches of current leader growth, and the best form and height.
  4. Minimize wounding in thinning operations, prescribed burns, slash disposal, or overstory removal. Wounds may be prevented by:
    - Not logging in the spring and early summer, when trees are more susceptible to injury than later in the year.
    - Using the proper equipment for the site.
    - Marking "leave" trees rather than "cut" trees.
    - Planning straight-line skid trails before logging,
- and avoid sharp turns. Leave designated "bump" trees or cull logs along the edge of skid trails.
  - Matching log length with final spacing. A close final spacing means skidding short logs, while longer logs are OK for wide spacing.
  - Logging skid trails first, before the rest of the stand, so that the skid trail is clear.
  - Cutting low stumps (less than 3-4") in skid trails, to keep the skidder or logs from being shunted into crop trees.
  - Falling trees so they are at a 45 angle directly towards or directly away from skid trails, to prevent too much maneuvering by the machinery or sharp turns by the log.
  - Cutting limbs flush to the bole before skidding to prevent branch stubs from shunting logs into crop trees.
  - Removing slash and other fuels from around the base of crop trees before underburning the stand.
  - Talking to anyone operating in your stand about minimizing damage to crop trees, and if necessary make contract specifications regarding penalties for damages.

Adapted from G. M. Filip et al, Strategies for reduction of decay in the interior Douglas-fir and Grand fir types, in: Silvicultural management strategies for pests of the interior Douglas-fir and Grand fir forest types, proceedings of a symposium held February 14-16, 1984; available from WSU Extension.

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# FOREST HEALTH NOTES

A Series for the Nonindustrial Private Forest Landowner

## Laminated Root Rot, Yellow Ring Rot (*Phellinus (Poria) weirii*)

**Hosts:** Most conifers

*Highly susceptible:* Douglas-fir, mountain hemlock, western hemlock, grand and Pacific silver fir

*Moderately susceptible:* spruces, larch, noble and subalpine fir, western redcedar

*Tolerant:* lodgepole pine, western white pine

*Resistant:* ponderosa pine

*Immune:* Hardwoods

### Quick ID:

- Crown yellowing and thinning
- Distress crop of cones, especially in Douglas-fir
- Frequent windthrow with “root balls”
- Buff colored mycelia may occur on the outside of roots.
- Outer heartwood stained red-brown
- Annual rings separate
- Reddish brown fungal hairs between sheets of decayed wood (use hand lens to identify)
- Affected trees often in groups or patches

### Field Identification

**Tree & Stand:** Affected trees show marked reduction in height and diameter growth. The crown thins and yellows, and may frequently produce a distress crop of cones. Trees are commonly windthrown after the disease rots off roots just below the root collar, forming a “root ball.” Early in the decay process, crescent-shaped or semicircular reddish brown staining of the wood may be observed. As decay progresses, the wood softens. The earlywood disintegrates more quickly than the latewood in each annual ring, resulting in a laminated ring rot where the annual rings of the wood separate. Small oval pits appear on both sides of the separated wood sheets. This disease forms root rot centers, where the disease has spread out over time from an initial infection. In the center will be either an old stump or an empty area, or in an old center, regeneration. Trees within several yards to hundreds of feet (depending on the size and age of the infection) will be dead or dying, and trees further out will show early crown symptoms. Trees within 50 feet of the apparent edge of a disease center are very probably infected as well, but will not show crown symptoms until

half to 75% of the roots are infected. Root rot centers may be many acres in size, and spread out at the rate of about 1-2 feet per year.

**Fungus:** Fruiting bodies (conks) are uncommon, but when found are located in protected areas such as on upturned roots and on the underside of decayed logs. Conks are flattened and range in color from buff to dark brown, with a white margin. The exposed surface is covered with many small pores. Reddish brown to brown whiskery mycelia (fungal fibers) may be observed between sheets of decayed wood, and white to purple-grey mycelial sheaths may be observed on outer bark surface of roots.

**May be confused with:** Armillaria root rot, Annosus root and butt rot, or animal damage.

**Disease cycle:** Laminated root rot is considered to be the most damaging root disease in the Pacific Northwest, as it kills the greatest concentrations of trees in the areas where it is present. There appears to be two distinct forms, one that causes a root disease in Douglas-fir, grand fir, and hemlock, and another form that causes a butt rot of western redcedar. The western redcedar form has only been identified on the east side of the Cascades, although western redcedar on the west side occasionally becomes infected with the Douglas-fir form, to which it is tolerant. The disease is spread by root contact between a healthy and infected individual. Mycelia of the fungus do not grow through the soil, nor are windblown spores a major factor in disease spread. The fungus may remain viable in stumps for 50 years and thus infect regeneration, although it typically takes 10 to 15 years for root contact with the new trees to be established. The disease kills susceptible hosts by either predisposing them to windthrow by rotting the major roots, or by destroying their ability to take up water and nutrients. Saplings and small poles are usually killed quickly, while older trees may confine the fungus to a small number of roots or to the butt log and survive for many years. Trees of intermediate susceptibility are often infected but rarely killed, while tolerant species are seldom infected and almost never killed.

**Predisposing agents:** Although all conifer species can be infected by laminated root rot, susceptibility varies. Old infected stumps from previously infected stands are a serious problem for regeneration of highly susceptible species. Certain silvicultural procedures such as commercial thinning or uneven-aged management may make infestations worse. The disease often occurs with other root diseases such as Armillaria root rot or Annosus root and butt rot. Laminated

root rot is itself a predisposing agent for bark beetle attack.

**Impact:** On the west side of Oregon and Washington, laminated root rot causes annual losses of 32 million cubic feet of wood; east side damages could be equally high. The incidence of the disease has probably increased substantially with the suppression of fire and subsequent species shift to Douglas-fir / grand fir forests, as these species are highly susceptible to laminated root rot; ponderosa pine and western larch are more tolerant.

**Management:** Laminated root rot often occurs with other root diseases and predisposes trees to bark beetle attack. Always check apparent bark beetle kills for root disease signs as their presence may influence species regeneration and silvicultural methods. Control of laminated root rot is best attempted at the time of final harvest. Prior to harvest, the disease centers should be marked by examining outlying trees for characteristics of the disease (e.g. mycelia on the roots, reddish stain in the heartwood). Infected trees should be marked low on the bole so the mark remains after harvest. It is suggested that disease centers should be mapped as well as marked to enable them to be tracked over time. Global Positioning Systems (GPS) may make mapping centers and tracking them over time easier, and that technology is rapidly becoming affordable. All trees in the disease center, as well as uninfected trees within 50 feet, should be cut. During the harvest, stumps should be examined outside the marked disease center for the characteristic red-brown semicircular staining; the disease center boundaries and buffer strips should be adjusted accordingly. It is important to check within a day or two of harvest as the stain fades quickly upon exposure to air. In Washington, the easiest, most cost-effective control is replacement of Douglas-fir / grand fir stands with other, less susceptible species. One 50-year rotation of tolerant, resistant or immune species such as ponderosa pine, western white pine, lodgepole pine, or western redcedar should result in the disease dying out on the site, provided that susceptible trees are not permitted to be reestablished. Another good alternative is a hardwood species such as alder, which is immune to the disease. A rotation of an intermediately susceptible species such as western larch may permit laminated root rot to remain on the site, though at a lower level than with highly susceptible

species. Interplanting highly or intermediately susceptible trees with tolerant or resistant trees will not help them survive; on the contrary, it is more probable that the tolerant trees will become infected. Susceptible species should not be planted within 100 feet of a disease center. Another alternative is to treat inoculum by removing as many infected roots and stumps as possible. A bulldozer or excavator may be used to push out stumps or push over whole trees; on some sites explosives could be appropriate. Uprooted roots and stumps need not be burned as air drying kills the fungus.

In 10 to 15-year-old sapling stands with less than 25% of the area infected, thinning the diseased trees could be an effective measure. In young stands affected trees will appear scattered rather than in clear disease centers. All trees displaying symptoms, as well as all those adjacent to them (within two normal tree spacings, both high and intermediate in susceptibility), should be cut. This should break the disease pathway to healthy trees by killing the roots on which the disease spreads. It is important to cut the adjacent trees that do not show symptoms as the disease may be in an early stage and thus undetectable, or the tree may become infected later as its roots grow towards the disease center. When precommercially thinning near disease centers, always try to save tolerant or less susceptible species. Silvicultural treatments such as weed control or fertilization to maximize growth will neither help nor hinder the spread of the disease. Heavily infected sapling stands may be grown to harvestable small poles before losses become severe.

Where pole stands have numerous disease centers and more than 20% of the area is visibly affected, do not commercially thin; harvest at a younger rotation age. In pole stands which do not have numerous centers, or in which the centers are widely distributed, infected trees and nonsymptomatic adjacent trees should be harvested in a commercial thinning. The stand should be monitored for windthrown trees, which should be removed yearly to prevent their infestation by bark beetles.

Adapted from Hadfield, J.S. and D.W. Johnson, *Laminated Root Rot*. USDA Forest Service -Pacific Northwest Region, 1977, and from Hadfield, J.S. et al., *Root Diseases in Oregon and Washington Conifers*, USDA Forest Service-Pacific Northwest Region, 1986.

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# FOREST HEALTH NOTES

A Series for the Nonindustrial Private Forest Landowner

## Mountain Pine Beetle (*Dendroctonus ponderosae*)

**Hosts:** Lodgepole pine, ponderosa pine, western white pine, whitebark pine

### Quick ID:

- Egg galleries long and straight, with the grain (vertical)
- Larval galleries at 90 angle from egg gallery
- Yellow pitch tubes on trunk
- Red boring dust in bark crevices
- Pitch streamers on trunk
- Foliage discolored

### Field Identification

**Tree:** Trees from 4 to 5" in diameter and up may be attacked. Attacks usually occur in the middle of the trunk. Yellow pitch tubes are found on the trunk at the point of entry, and red boring dust may be found in bark crevices and at the base of the tree. Pitch streamers on the trunk may also indicate point of entry. Egg galleries within the inner bark are long and straight, and follow the grain. These galleries will be packed with frass (boring dust and insect droppings). Generally there is a bend at the bottom of the egg gallery. Although there may be several egg galleries on the same tree, they do not cross. Larval galleries branch off of the egg gallery at a 90 angle and are 1 to 2" in length. As the successful attack proceeds, foliage discolors from dark green to light greenish yellow and then to reddish brown. The wood of successfully attacked trees becomes discolored by bluestain fungi.

**Insect:** Adults are about 1/5" in length, stout, black, cylindrical beetles. Larvae are about 1/4" long, white and resemble grains of rice. They are found in separate tunnels off the egg gallery; pupal cells with pupae may be found at the end of these tunnels.

**May be confused with:** Red turpentine beetle, western pine beetle.

**Life cycle:** Mountain pine beetles are both a primary and secondary pest, infecting both apparently healthy and disease-weakened trees. In the endemic (constantly maintained) population, beetles preferentially attack trees that are weakened by root diseases, but once an epidemic

gets started beetles attack healthy trees as well. Mountain pine beetles show a strong preference for pines of large diameter more than 80 years in age. In July and August, when trees are most likely to be under stress from water deficiency, adults emerge, females find a new host, and bore through the bark to the cambial area. There, they emit pheromones that attract males and other females. The other females that are attracted will also colonize the tree; this "mass attack" strategy overcomes the tree's defenses. Mating occurs under the bark, then the female constructs an egg gallery and deposits eggs in niches on either side. The gallery becomes packed with frass. When the larvae hatch in 7-10 days, they mine separate feeding tunnels. When fully grown, the larvae hollow out a pupal cell at the end of the tunnel and pupate. New adults bore their way out and the cycle is repeated. One generation per year is the rule in Washington. Insects overwinter in trees as larvae and adults.

**Predisposing agents:** A strong association has been found between root diseases and bark beetles, where disease weakens trees and makes them targets for bark beetle attack. Agents of stress such as drought, overcrowding, overtopping, and defoliation can also weaken trees. Overmature stands are ripe for insect attack, as they are not vigorous and have a thick phloem layer, which beetles prefer. Low-elevation stands are harder hit than high-elevation stands as the warmer temperatures at low elevations are more favorable for insect survival; likewise, unusually warm summers aid bark beetle development. Outbreaks of mountain pine beetle typically get started in overstocked stands or in stands on poor sites, then spread to healthy timber. Essentially, the success or non-success of bark beetle attack has to do with the physiological condition of the tree. Healthy, vigorous trees are able to overwhelm attacking beetles with pitch, while trees that have been stressed may not have the available resources for massive pitch production. However, during outbreak conditions an otherwise healthy tree may simply be overwhelmed by sheer numbers.

**Impact:** Mountain pine beetle has historically been the most damaging of the bark beetles. According to the USFS, in 1990 they were responsible for the death of 289,800 trees totaling 6.5 million cubic feet over 186,600 acres in the state of Washington. In 1991, 298,400 trees were lost totaling 5.6 million cubic feet over 155,422 acres. Outbreaks when mountain pine beetle attacks reach

epidemic levels have been recorded in the west since 1894. Outbreaks can last for more than ten years, and mountain pine beetles are generally in an epidemic condition on at least one of their hosts somewhere in the west.

**Management:** Control methods have shifted away from direct control (e.g. spraying, felling, burning) and towards prevention of outbreaks. This course of action was chosen after thoroughly exploring direct control measures for nearly a century and arriving at a simple conclusion: They don't work. It is possible to prevent infestation with penetrating sprays on individual, high value trees such as those in campgrounds and near houses, but they need to be applied before the tree is infected and the cost of such treatments is prohibitive for any large-scale application.

Once a mountain pine beetle outbreak begins to spread, it can be stopped by thinning the stand ahead of the edge of the outbreak. This is because outbreaks expand on a tree to tree basis where the incoming beetles switch their attacks from a recently attacked-stem to the next largest tree. More importantly, infestations can be prevented by thinning stands before crown closure, an operation that not only increases the vigor of the residual stand, but also prevents the spread of an outbreak if individual trees have been attacked.

Mountain pine beetles are a natural part of western ecosystems, and for this reason will never be completely eradicated (nor should they be, as they serve to create small stand openings which are important for biodiversity of both flora and fauna). As such, the death of a few trees on your property doesn't necessarily mean an epidemic is getting started; check your trees for root disease symptoms. To maintain mountain pine beetles at their normal levels, predisposing factors for outbreak must be removed. Some of these, such as environmental stresses, are not possible to control. However, many stresses are related to stand management practices. First and foremost, two situations need to be addressed: root disease centers and overstocked stands. More details about treatment for root disease centers have been given in other WSU Cooperative Extension "Forest Health Notes;" in summary, they need to be identified and planted with resistant species. Overstocking causes trees to compete for water, light and

nutrients, and thus weakens their defenses against bark beetle attack. To minimize stand stresses and maintain vigorous growing conditions, stand managers should: (adapted from Berryman: Forest Insects, 1986).

- Choose tree species that are adapted to the area on which they'll be planted
- Harvest trees in a way that mimics natural processes, such as cutting small patches to mimic a low-intensity fire (for pine and larch management) or selective or shelterwood cutting (for grand fir and Douglas-fir management)
- Remove diseased and unhealthy trees and logging debris, and minimize damage to standing trees. Salvage logging is fine for beetle-killed trees except in root disease areas where that could increase the severity of Armillaria and Annosus.
- Encourage diversity in species and age classes
- Use thinning, fertilization, prescribed fire, etc. to maintain stand diversity and vigor
- Prevent trees from becoming overmature by harvesting on time

Patch cutting 6 to 10 acre blocks every few years and managing these as small even-aged stands helps keep the total number of older trees low and creates a variety of age classes that discourages mountain pine beetle attack. It has additional benefits for wildlife by creating small openings and edges. This may not, however, be a good strategy if trees at the edges of the cut are heavily infested with mistletoe and the species to be planted or naturally regenerated is the same species.

**Note: Use pesticides with care. Apply them only to plants, animals, or sites listed on label. When mixing and applying pesticides, follow all label precautions to protect yourself and others around you. It is a violation of the law to disregard label directions. If pesticides are spilled on skin or clothing, remove clothing and wash skin thoroughly. Store pesticides in their original containers and keep them out of the reach of children, pets and livestock.**

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# FOREST HEALTH NOTES

A Series for the Nonindustrial Private Forest Landowner

## Pine Engraver (*Ips spp.*)

**Hosts:** Ponderosa pine, lodgepole pine, western white pine, occasionally Engelmann spruce.

### Quick ID:

- Galleries have a central nuptial chamber from which 2-3 egg galleries radiate
- Galleries free from frass
- Yellow or reddish boring dust in bark crevices or on ground
- Foliage discoloration
- Top-killed trees
- Insects small, dark beetles 1/8 to 1/6" in length.

### Field Identification

**Tree:** Yellow or reddish boring dust is found in bark crevices, around entrance holes, or on the ground beneath. Pitch tubes are seldom formed. After attack, the foliage of the tree discolors from green to yellow, reddish, and then reddish brown. This happens rapidly in the summer and more slowly in fall and winter. Ips beetles typically attack near the top of the trunk, and frequently girdle the tree, causing topkill. Galleries mine the bark and score the sapwood. Unlike the galleries of mountain or western pine beetles, ips galleries are free from frass (boring dust and insect droppings). A central nuptial chamber has several egg galleries leading off in different directions.

**Insect:** Ips beetles are reddish brown to nearly black and from 1/8 to 1/6" in length. The posterior of the abdomen is notched and has pronounced toothlike "spines."

**May be confused with:** Mountain pine beetle, western pine beetle.

**Life cycle:** There are a number of species of ips beetles found in Washington. The most common is *Ips pini*, which is generally found attacking and killing ponderosa and lodgepole pine. Adult insects may attack trees or fresh slash over 2" in diameter. A quantity of fresh slash or debris after a windstorm will almost certainly be used to produce a large beetle population, which may subsequently attack living trees. Fortunately, attacks are of short duration, often confined to a single year. A male bores through the bark to the cambium and constructs

a nuptial chamber. Several females then join him and construct separate egg galleries leading off in different directions. Eggs are laid in niches along the sides of these galleries. Larvae hatch and feed in the inner bark, working away from egg galleries. Larval tunnels are packed with frass. Larvae construct oval pupation cells at the end of their tunnels and pupate, emerging as new adults about 1-1/2 to 2 months after hatching. Between two and five generations can be produced in a single year, depending on altitude, latitude and species. Adults may re-emerge after laying eggs and attack a second or even third time in a year. Insects generally overwinter as adults, either in large groups under the bark or in large stumps or bark crevices. Beetles also overwinter in leaf litter on the forest floor.

**Predisposing agents:** Large numbers develop in fresh slash. Warm, drought-like spring weather will lead to ips damage. Ips beetles frequently attack the tops of trees recently killed by western or mountain pine beetles. Sufficient host material will lead to epidemics where living trees are attacked in groups. These may resemble mountain pine bark beetle kills.

**Impact:** In 1991, the USFS estimated that an ips outbreak had affected 23 acres in Washington. However, that doesn't reflect the thousands of single trees that were killed by ips infestations too small to be identified by overflying aircraft. Damage occurs most frequently as killing of trees 2 to 8" in diameter and top-kills on older trees.

**Management:** Direct means of control (e.g. spraying, felling, etc.) are not useful against pine engravers, especially as outbreaks rarely last more than one season. They may be useful in high-value areas like campgrounds or near houses. Outbreaks may be prevented by appropriate slash disposal and thinning in overstocked immature stands. Lopping and scattering slash is the preferred way to dispose of slash from a nutrient cycling standpoint, but can cause problems with ips. However, scattering slash in the open where the sun will dry it out will make it unsuitable as a breeding medium. During the spring and early summer, particularly when precipitation is below normal, slash disposal is critical. Slash should be scattered, not piled, during these times. Windthrown trees should be salvaged promptly. Low fires in late autumn may kill beetles overwintering in leaf litter.

*Note: Use pesticides with care. Apply them only to plants, animals, or sites listed on label. When mixing and applying pesticides, follow all label precautions to protect yourself and others around you. It is a violation of the law to disregard label directions. If pesticides are spilled on skin or clothing, remove clothing and wash skin thoroughly. Store pesticides in their original containers and keep them out of the reach of children, pets and livestock.*

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# FOREST HEALTH NOTES

A Series for the Nonindustrial Private Forest Landowner

## Red Turpentine Beetle (*Dendroctonus valens*)

**Hosts:** Ponderosa pine, lodgepole pine, western white pine, occasionally spruce and larch

Quick ID:

- Large reddish pitch tubes on trunk
- Only in lowermost portion of trunk
- Galleries short, irregular
- Galleries packed with frass
- Adult insect reddish brown, large

### Field Identification

**Tree:** Large (up to 1 1/2"), globular pitch tubes at point of entry, full of frass (a mixture of sawdust and insect droppings) and reddish. Galleries of the insect are irregular and packed with frass, varying between 1/2 and 1" in width and up to several feet in length. Individual larvae galleries are not constructed; instead, a large cavity is formed. Galleries are usually found only in the bottom six feet of the trunk.

**Insect:** Adults are reddish-brown and may be 3/8" in length, the largest of the *Dendroctonus* bark beetles. Larvae are up to 1/2" in length, and feed together in a common brood chamber. Pupal chambers may be found at the base of the host tree.

**May be confused with:** Mountain pine beetle.

**Life cycle:** Attacks occur through the warm weather and peak in midsummer. Adult turpentine beetles bore through the outer bark and excavate short, irregular, longitudinal to cavelike galleries between the bark and the wood. Eggs are laid in groups packed with frass on the sides of the gallery. When the eggs hatch, the larvae remain together and excavate large cavities while feeding. Further development to pupae and adults takes place in the cavity or in short galleries along its margin. Larvae and adults overwinter in the tree. Generations per year varies with climate; in the coldest part of the range, one

generation is produced every two years, while in the warmest areas, two to three generations may be produced in one year. This is not one of the most aggressive bark beetles and attacks do not become epidemic.

**Predisposing factors:** Red turpentine beetles commonly attack trees already weakened by injury, other bark beetle attacks, or disease. Freshly cut stumps, exposed roots and the lower trunk of declining trees are all attacked, as are "leave" trees after logging operations and fire survivors. It is commonly associated with attacks of Ips or mountain pine beetle, which are usually responsible for the actual death of the tree.

**Impact:** As this bark beetle does not become epidemic, losses are not as catastrophic as with the mountain or western pine beetles. Occasionally it kills trees that have been scorched by fire. The Forest Service puts it in a group with a number of other bark beetles for which losses in 1990 in Washington ran about 118.9 million cubic feet.

**Management:** Silvicultural activities designed to maintain vigorous, fast-growing stock will help as these trees are more resistant to bark beetle attack generally. Minimizing injury to "leave" trees during logging and silvicultural operations will keep the tree from being weakened. Pruning dead branches is fine, but pruning live branches opens a wound that may attract turpentine beetles. Bear in mind that root rot diseases often predispose the tree to bark beetle attack; search the roots and root collar for signs of infections. On high value trees near woodland homes or in campgrounds, chemical sprays may be used to prevent attacks. Lastly, salvage logging of beetle-killed trees is acceptable providing root rot is not present.

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# FOREST HEALTH NOTES

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## Western Gall Rust (*Endocronartium harknessii*)

**Hosts:** Two and three needle pines, especially lodgepole and ponderosa pine

**Quick ID:**

- Yellow-orange spore pestules on galls in spring and summer
- Swollen galls on branches or trunks
- “Hip” cankers on trunk
- White or colorless ooze between bark fissures in spring

**Field identification:** This disease does not affect five-needle pines such as western white pine. Round to pear-shaped galls are formed on branches and trunks. These may be greater than 12” in diameter, and increase in size each year. When they form on the trunk, they may develop large, hard burls, or a portion may partially girdle the stem and die, producing a “hip” canker. An inconspicuous white or colorless ooze of pyenia (a type of spore) may be found between bark fissures in the spring. In the spring and early summer, yellow-orange spore pestules (aecia) may be observed in cracks on the outside of the galls.

**May be confused with:** Dwarf mistletoe

**Disease cycle:** This is probably the most commonly observed disease of lodgepole pine. Aecial spores are windborne and may travel hundreds of miles to infect other pines; no alternate

host is required (as opposed to white pine blister rust). Moist conditions promote spore release and infection. Succulent stem tissue is infected, and will begin to show symptoms within two years. The galls enlarge and produce a new layer of aecia each year until they girdle and kill the branch or the trunk, which happens quickly with seedlings. However, the fungus and the tree may survive for 200 years. The disease may also damage the tree by producing enough branch galls to diminish the tree’s growth, or by weakening the trunk and predisposing it to breakage.

**Predisposing agents:** Moist weather stimulates spore production and favors infection. The fastest growing trees are more susceptible to infection than suppressed trees, probably because they have a higher proportion of succulent stem in each growing year.

**Impact:** Practically all of the lodgepole pine stands in the Pacific Northwest are infected to some degree. Severe infection causes stem malformation (and loss of value), breakage, and tree killing, particularly of seedlings. Loss in cubic feet per year is not known.

**Management:** Western gall rust is impossible to eradicate, as its spores may spread for miles and directly infect other pines. Remove trees showing numerous galls, especially stem galls. During thinning operations, favor lightly infected trees without stem galls, and if it’s practical, prune off branch galls on “leave” trees. Because of the hazard associated with wind breakage, watch for large stem infections on pines growing near structures and, if desired, prune off galls to increase vigor and improve form.

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# FOREST HEALTH NOTES

A Series for the Nonindustrial Private Forest Landowner

## White Pine Blister Rust (*Cronartium ribicola*)

**Hosts:** Western white pine, whitebark pine

### Quick ID:

- Branch flagging
- Swellings and blisters on branches; also on trunk of small trees
- Diamond-shaped cankers on trunks
- Cankers with greenish-yellow to orange margins
- Pustules of orange spores on cankers and branch swellings
- Resin flow from branch and trunk on advanced infections

### Field Identification

**Tree:** This disease does not affect species outside of the white (5-needle) pine group (similar symptoms on lodgepole or ponderosa pine may be caused by western gall rust). The foliage may have red or yellow needle spots. On the branches, spindle-shaped swellings or cankers with small cup-like indentations are frequent. Often infections kill the branch, resulting in bright red “flags” in the crown. On the trunk, a diamond-shaped canker with dead roughened bark and greenish-yellow to orange margins develops.

**Fungus:** A honey-colored ooze (pycnia) or pustules of powdery orange spores (aecia) develop on the swellings or cankers in the spring. As the disease develops, cankers will have dead centers, surrounded by pustules of aecia, surrounded by drops of pycnia, and with a yellowish zone outermost. The canker grows in size every year.

**May be confused with:** Resin flow at the base from Armillaria root rot.

**Disease cycle:** This disease is the most serious pest of 5-needle pines in the Pacific Northwest. The rust has a five-spore cycle that requires an alternate host, members of the Ribes family. These include species of gooseberry and currant. On the pine in spring, pycnial spores give rise to aecial spores, which may fly 400 to 800 miles to infect the leaves of Ribes plants. On the plant, two spore stages follow, then give rise to another airborne spore stage

which infects the pine again. These spores infect needles, then grow down to the twig and from there to the branch. Branch infections within 4” of the trunk will spread to the trunk in time. Once the trunk is infected and a canker has developed death of the tree is inevitable, though there is some genetic variability in rate of canker growth and some trees have survived many years before being girdled and killed. Once a tree gets beyond 20-30 years of age, the disease most frequently causes only branch flagging.

**Predisposing agents:** Cool, moist weather late in the summer or early fall is required for infection of the pine host, with 48 hours of temperatures not above 68F.

**Impact:** White pine blister rust was introduced in the east from Europe between 1898 and 1908, although the disease is believed to have originated in Asia. In 1910 it was introduced into British Columbia and has since spread through the West. In North America as a whole, it has caused more damage and more money has been spent to control it than any other conifer disease. Thousands of white pine stands have been seriously damaged and many have been entirely lost. In the Pacific Northwest, losses are estimated at 5 million cubic feet annually.

**Management:** Historically, control efforts have focused upon removing the alternate host, members of the Ribes family, from stands of white pine. However, this never proved to be very effective, despite the thousands of hours of work that were invested. Likewise, effective chemical controls have never been developed. As blister rust is an introduced species, rather than one that evolved here, genetic resistance is limited in the white pines. For this reason the mortality from this disease has been extremely high. However, some naturally resistant white pines were found and breeding programs to bulk up the seed have been in place for some time. Resistant seedlings are finding their way onto the market. When cutting in infected stands, any tree that is uninfected or only lightly infected should be retained as a seed tree, as it may be naturally resistant and pass that resistance along. On young ornamental trees, branches with infections may be pruned to arrest the spread of the disease. The pruned branches should be subsequently burned.

Blister rust resistant western white pine is a good choice for replanting root disease centers and for incorporation in mixed-species stands. However, it probably should not be planted in pure stands.

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# FOREST HEALTH NOTES

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## Western Pine Beetle (*Dendroctonus brevicomis*)

**Host:** Ponderosa pine, rarely lodgepole pine

### Quick ID:

- Egg galleries winding, branched, crossing
- Small yellow pitch tubes
- Red boring dust in bark crevices and at base of tree
- Larval galleries short, entering bark
- Large patches of bark often removed by woodpeckers
- Foliage discolored

### Field Identification

**Tree:** Small yellow pitch tubes mark the point of entry of the beetle. Red boring dust may be found in the bark crevices and at the base of the tree. In the phloem (inner bark region), egg galleries wind and branch randomly, crossing over the galleries of other beetles. These galleries will be packed with frass (boring dust and insect droppings). Sapwood markings from larval galleries off the egg gallery will be short as the larvae quickly enter the bark to feed. On a successfully attacked tree, the foliage will discolor first to yellowish-green, then to reddish-brown. By that point, the trunk may have many small round emergence holes indicating the beetles have gone.

**Insect:** Adults are 3 to 5 mm in length and dark brown, with a cylindrical shape. Larvae are white and resemble grains of rice with a yellow-brown head. Larvae may be found in the outer bark of infested trees.

**May be confused with:** Mountain pine beetle

**Life cycle:** Western pine beetles attack and kill living trees. In an endemic (normal) population, adults preferentially choose weakened trees, especially those experiencing water stress. Once an epidemic outbreak gets started vigorous trees may be attacked as well. Western pine beetles prefer trees at least 10" in diameter. Adult insects emerge and attack trees late in spring or in early summer. Females attack the tree, bore through the bark to the

phloem (inner bark), and emit pheromones that attract both other females, who also colonize the tree, and males. Attack usually occurs on the midbole. "Mass attack" of the tree by many beetles overcomes the tree's resistance. Trees resist colonization by pitching out and immobilizing the beetles. Generally, trees that are not under water stress can fend off an attack. During an epidemic, however, all trees can be overwhelmed. Beetles mate inside the tree and the females construct winding, "S-" shaped egg galleries. Niches are cut into the sides of each gallery and eggs are laid singly, about 1/4" apart. These niches and the egg gallery itself are packed with frass behind where the adults are working. Larvae hatch in 7 to 10 days and begin mining the phloem at right angles to the egg gallery. After a quarter of an inch or less, the larvae enter the bark where they develop through a number of larval stages. At last, a pupal chamber is hollowed into the outer bark, the larva pupates, and a new adult emerges. Unlike mountain pine beetles, western pine beetles may have two generations develop to maturity and a third overwinter as larvae in the same year.

**Predisposing agents:** Western pine beetles have greater success in attacking trees that are under water stress. Root rot infections may predispose trees to water stress during drought. Beetles selectively attack trees that have been weakened by drought, lightning strike, or other agents that interfere with the water balance of the tree. A tree is in water balance when as much water is taken up by the roots as is transpired. Trees out of water balance are preferentially attacked as these trees cannot mobilize strong defenses to expel beetles. Historically, epidemics occur as a result of prolonged drought, as drought weakens trees across large areas. Warm temperature aids development of larvae, hence a hot summer will permit faster maturing of a generation and a greater likelihood of multiple generations in a single summer.

**Impact:** As it prefers ponderosa pine, western pine beetle is somewhat less damaging than mountain pine beetle which preys upon all kinds of pines. According to the USFS, in Washington in 1991 the western pine beetle was responsible for the death of 21,679 trees over 28,159 acres resulting in a loss of 1.267 million cubic feet of lumber.

**Management:** Methods of control have shifted away

from direct control (felling, burning, etc.) and towards indirect methods that discourage beetle habitat and keep populations at endemic (normal) levels. It is possible to prevent infestation with penetrating sprays on individual, high value trees such as those in campgrounds and near houses, but they need to be applied before the tree is infected and the cost of such treatments is prohibitive for any large-scale application.

Western pine beetles are a natural part of western ecosystems; they evolved here together with the pines they feed on. In the forest, they kill slow-growing, drought-stressed trees and act as natural thinners, opening up the stand for new trees and wildlife. Even outbreak conditions are “normal” as cycles of drought have been predisposing factors for beetle epidemics for thousands of years, as have root diseases. For this reason bark beetle attacks will never be eliminated (nor should they be). The death of a few trees on your property doesn’t necessarily herald the beginning of an outbreak; check the trees for signs of root disease (there are other WSU Cooperative Extension “Forest Health Notes” dealing with symptoms of root diseases).

To maintain western pine beetles at their normal levels, predisposing factors for outbreak must be removed. Environmental stresses are not controllable, but many stress factors are associated with stand management practices and therefore may be changed. One important situation that can be addressed is having too many trees to the acre, or stand overstocking. Overstocking creates inter-tree competition for water, light and nutrients, and reduces their ability to resist attack by bark beetles. A judicious thinning can show good results in ponderosa pine stands even 90 years of age. To minimize stand stresses and maintain vigorous growing conditions, stand managers should: (adapted from Berryman: Forest Insects, 1986).

- Choose tree species that are adapted to the area on

which they’ll be planted.

- Harvest trees in a way that mimics natural processes, such as cutting small patches to mimic a fire (for pine and larch management) or selective or shelterwood cutting (for grand fir and Douglas-fir management).
- Remove diseased and unhealthy trees and logging debris, and minimize damage to residual trees. Salvage logging of beetle-killed trees is fine except in root disease areas where that may worsen the severity of root diseases such as Armillaria and Annosus.
- Encourage diversity in species and age classes.
- Use thinning, fertilization, prescribed fire, etc. to maintain stand diversity and vigor.
- Prevent trees from becoming overmature by harvesting on time.

Patch cutting 6 to 10 acre blocks every few years and managing these as small even-aged stands helps keep the total number of older trees low and creates a variety of age classes that discourages western pine beetle attack. It has additional benefits for wildlife by creating small openings and edges. This may not, however, be a good strategy if trees at the edges of the cut are heavily infested with dwarf mistletoe and the species to be planted or naturally regenerated is the same species.

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