

# Diseases as Agents of Disturbance in Ponderosa Pine<sup>1</sup>

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## Abstract

Several diseases affect the growth and survival of ponderosa pine in the Pacific Northwest and serve as agents of disturbance. Probably the most widespread and damaging class of disease agents is dwarf mistletoe, which causes serious growth loss and mortality of ponderosa pine. Dwarf mistletoes (*Arceuthobium* spp.) are seed plants that can parasitize all age classes of pine. Decades of research and observation have shown that although dwarf mistletoes spread slowly within and among trees, their localized effects can be quite spectacular. Root diseases caused by the fungi *Armillaria ostoyae* (Romagn.) Herink, *Heterobasidion annosum* (Fr.:Fr.) Bref., and *Leptographium wageneri* var. *ponderosum* (Harrington & Cobb) Harrington & Cobb cause localized mortality resulting in gaps in affected forests. Root diseases may spread by root contact, airborne spores, or insect vectors depending on the species of root disease fungi. Stem decays caused principally by *Phellinus pini* (Thore.:Fr.) A. Ames and *Fomitopsis officinalis* (Villars:Fr.) Bond. & Sing. result in single-tree gaps if trees break as a result of advanced decay. Decay fungi infect wounds on living trees, and decay may take decades to develop to where tree structural integrity is compromised. Stem diseases caused by rust fungi such as *Cronartium comandrae* Peck and *C. coleosporiodes* Arth. can kill the tops of trees or result in whole-tree mortality. Decayed and cankered trees can serve as habitat for a wide diversity of wildlife. Disturbances in ponderosa pine forests caused by forest diseases can affect forest succession, insect outbreaks, fire frequency and severity, and both animal and plant diversity.

## Introduction

Diseases caused by fungi and parasitic plants are important fine-scale agents of disturbance in ponderosa pine ecosystems. In the absence of periodic wildfire, the resulting dense stands of ponderosa pine often are attacked by several classes of forest diseases including root disease, stem decay, stem disease, foliage disease and dwarf mistletoe. These diseases have a tremendous effect on the structure and ecology of ponderosa pine stands. Root diseases increase windthrow of live trees, live stem breakage, top-killing, bark beetle attack, tree mortality, down wood, wildlife habitat, wildfire, stand opening and regeneration, and shifts in stand composition. Stem decays cause hollows in living stems and branches, and increase tree mortality, amount of down wood, number of hollow logs, diversity of wildlife habitat, stem breakage, and intensity and incidence of wildfire. Dwarf mistletoes are

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parasitic plants that infect conifers and result in increases in live-crown ratios, abnormal branches (witches' brooms), dead branches, top-killing, branch and stem breakage, tree mortality, down wood, wildlife habitat, and intensity of wildfire. Fuel ladders caused by dwarf mistletoe make fires more likely to crown. These fine-scale disturbances created by forest diseases can affect forest succession and alter both plant and animal diversity.

## Root Diseases of Ponderosa Pine

Major root diseases of ponderosa pine in the Pacific Northwest include Armillaria root disease caused by *Armillaria ostoyae* (Romagn.) Herink, annosum root rot caused by *Heterobasidion annosum* (Fr.:Fr.) Bref., and black-stain root disease caused by *Leptographium wageneri* var. *ponderosum* (Harrington & Cobb) Harrington & Cobb. Infection may result in tree growth loss, windthrow, or mortality. Root diseases spread primarily by root to root contact between infected trees or between residual stumps and healthy trees. Root diseases are difficult to detect and require removal of soil and bark at root collars to detect signs and symptoms of pathogenic root-disease-causing fungi. The preferred tool for examining roots is often the pulaski. There is no cure for root disease. Management strategies include prevention of infection, and favoring tree species that are less susceptible or immune to root diseases on the site.

Armillaria root disease is probably the most common and damaging root disease of ponderosa pine in the Pacific Northwest, although pine is considered tolerant to Armillaria when compared to white fir (*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.) or grand fir (*A. grandis* (Doug. ex D. Don) Lindl.). Major mortality centers occur where a particularly virulent clone of the fungus is present or where pine is mixed with infected true firs. Some virulent clones of Armillaria are reported to be very old and cover over 2000 acres of infected forest in northeastern Oregon (Ferguson and others 2003). Symptoms of Armillaria root disease include chlorotic and shortened leaders and lateral branches, and basal resinous (pitching), although the latter symptom is less common in ponderosa pine. Signs include mycelial fans under the bark at the root collar and mushrooms produced at the base of infected trees in autumn. Armillaria management involves maintaining good tree health and vigor, avoiding soil disturbance, and thinning of overstocked young stands.

Annosum root rot is most damaging in ponderosa pine in southern Oregon and northern California, usually on low-quality sites (Schmitt and others 2000). The disease is associated with tree harvesting where freshly cut stumps are susceptible to infection by windborne spores. Infection results in tree mortality or windthrow. Stumps can be protected from annosus spore infection by treating freshly cut surfaces with a boron-containing product with 48 hours of cutting. There are actually two types of the fungus: one type infects primarily true firs (S-type) and the other infects primarily pine (P-type). Usually only the drier pine sites are seriously affected by annosum root rot.

Black-stain root disease is most common in central and eastern Oregon and in the Sierras of California. It spreads underground but may also be vectored long distances by insects. More research is needed to identify the vectors and clarify their roles. Best management practices also are being identified, especially the use of prescribed fire (Filip 1999). Symptoms and signs of the disease include a basal resinous and a black stain in the wood that occurs only in the first few annual rings.

Black-stain root disease management may include thinning or pruning pine in August and September to avoid insect flights and disease spread. More research is needed to confirm this. There are two types of the fungus: one that infects the 2- or 3-needle pines and one that infects Douglas-fir (*Pseudotsuga menziesii* (Mirbel) Franco). Clearcutting of diseased areas and a buffer may help to sanitize black stain-affected ponderosa pine stands. Any resistant-appearing trees should be retained. Treated areas can be regenerated immediately since the fungus dies when the trees are cut. Prevention strategies are especially important with black stain, since alternative conifer species are often lacking on sites where this disease occurs.

## Stem Decay of Ponderosa Pine

Stem decays are less serious in ponderosa pine than in other conifer species (Filip 2001). Because of the resinous nature of pine wood, most decay-causing fungi are not able to successfully colonize wound surfaces and deeper tissue. A few species, however, such as *Phellinus pini* (Thore.:Fr.) A. Ames, cause of red ring rot or white pocket rot, can infect and decay ponderosa pine. Early stages of decay result in reduced wood quality, and advanced decay results in cull logs and loss of merchantable material. Hollow logs and decayed trees, however, serve an important role as wildlife habitat for birds and mammals. Living pines with internal decay may stand for centuries and provide habitat longer than dead and decayed trees (Bull and others 1997).

Other less common stem decays of ponderosa pine include red-brown butt rot or velvet top fungus caused by *Phaeolus schweinitzii* (Fr.:Fr.) Pat., and brown trunk rot or quinine fungus caused by *Fomitopsis officinalis* (Villars:Fr.) Bond. & Sing. On sites with a high incidence of conks, management recommendations include harvest rotations less than 150 years and preventing bole wounds that give decay-causing fungi easy access for infection, while saving some decayed trees for wildlife.

## Stem Diseases of Ponderosa Pine

Several species of fungi called rusts cause stem disease of ponderosa pine. The most common are western gall rust caused by *Endocronartium harknessii* (J. P. Moore) Y. Hirat., comandra blister rust caused by *Cronartium comandrae* Peck, and stalactiform blister rust caused by *Cronartium coleosporioides* Arth. Unlike the well-known and introduced white pine blister rust (*Cronartium ribicola* J. C. Fisch.), all of the ponderosa pine rusts are native. Rust diseases can cause tree growth loss, top-kill, and sometimes tree death. Seedlings, saplings, and mature trees can be affected. Rust fungi have complex life cycles that often require two hosts to complete their life cycle (Allen and others 1996). Western gall rust, however, does not require an alternate host: pine to pine spread can occur. Although more common on lodgepole pine (*Pinus contorta* Dougl. ex Loud.), galls do occur on ponderosa pine, especially in riparian communities. Stalactiform blister rust also is more common on lodgepole than ponderosa pine. Alternate hosts for stalactiform blister rust include several species of Scrophulariaceae including giant red Indian paintbrush (*C. miniata* Dougl.).

The most damaging rust disease of ponderosa pine is comandra blister rust. It gets its common name from its alternate hosts, bastard toadflax (*Comandra umbellata* (L.) Nutt.) and other species in the genus *Comandra*. The disease can kill

seedlings, but it is most commonly seen as stem cankers on young trees or top-kill on older trees. The fungus will girdle the stems of trees resulting in tree mortality or top-killing. If tops are killed, the fungus will grow down the living stem and kill branches. This is diagnostic and distinguishes top-killing by comandra blister rust from top-killing by bark beetles or animals. Management for stem rusts includes selective removal of trees with infections, favoring lightly infected trees or disease-free trees, or pruning of infected branches.

## Foliage Diseases of Ponderosa Pine

There are three primary diseases of ponderosa pine foliage in the Pacific Northwest: Elytroderma needle disease, dothistroma needle blight or red band needle disease, and diseases caused by several species of fungi that are loosely termed pine needle diseases. Foliage diseases of ponderosa pine are caused by fungi that cause the loss of 2-5-year-old needles. Infection results in some growth loss, but tree mortality may occur if disease is severe. Infection severity is keyed to proper environmental conditions for the fungi and host genetics that regulate infection, colonization, and disease expression. Control is usually not warranted in forest settings.

Elytroderma needle cast or blight is caused by the fungus, *Elytroderma deformans* (Weir) Darker. Infection begins in the needle from windborne spores, then progresses to the twig. Twig infection becomes perennial and results in misshapen and upturned branches resembling an “arthritic hand.” Infections in pine resemble those caused by dwarf mistletoe, but branches with live mistletoe plants present are green or yellow rather than red or brown as with Elytroderma infections. Severely infected pines have poor form, experience some growth loss, and can be thinned to leave alternative conifer species and pines with the least infection.

Red band needle disease is distinguished by the red or brown banding pattern on infected needles rather than the whole needle being discolored. The disease is caused by the fungus *Mycosphaerella pini* Rost. in Munk. Severely infected trees have thin crowns, and when environmental conditions are favorable for infection, the disease can spread rapidly. Repeated infections over many years can result in tree death.

Other pine foliage diseases are caused by several species of fungi including *Lophodermella concolor* (Dearn.) Darker, *L. morbida* Staley & Bynum, and *Lophodermium pinastri* (Shrad.:Fr.) Chev. These fungi periodically cause discoloration of 2-3-year-old needles if environmental conditions are favorable for infection. Some tree growth loss occurs. Off-site trees are more severely affected.

## Dwarf Mistletoe of Ponderosa Pine

Infection by dwarf mistletoe (*Arceuthobium campylopodum* Engel.) is probably the most serious disease affecting ponderosa pine in the Pacific Northwest. Dwarf mistletoes are higher seed plants that have stems, leaves, seeds, and a root system that colonizes branch and stemwood of living trees. Male and female plants occur with pollination in the spring, seed development throughout the summer, and seed dispersal in the fall. Seeds are explosively shot from ripe fruit and adhere to needles of the same tree or adjacent trees. Infection from overstory to understory trees commonly occurs in infested pine stands. Seeds adhere to needles and slide to the needle fascicle with fall rains. Seeds then germinate to produce a “penetration

wedge” that enters the bark and subsequently becomes embedded in successive layers of xylem (Hawksworth and Wiens 1996). Once established, shoots are formed and then seeds on female plants. The entire life cycle from twig infection to seed production takes about five years.

Dwarf mistletoe infection severity (DMR) is rated on a scale from 1 to 6. DMR 1 trees have light infections only in one third of the crown, whereas DMR 6 trees have severe infections throughout the entire crown. Tree growth is reduced proportional to infection severity. DMR 6 trees can experience growth impacts such that growth is 20% of similar uninfected pine. Severe infections can cause tree mortality especially in sapling to pole-size understory trees. Because dwarf mistletoes are obligate parasites (require a living host), once the host tree has died or has been killed, the mistletoe also dies.

The abnormal branches caused by dwarf mistletoe infections (witches’ brooms) are used by birds, owls, and mammals for hiding, roosting, and nesting. Although this is more common in tree species that form large, dense brooms like Douglas-fir, old infections in ponderosa pine cause brooms that can serve as wildlife habitat. Girdling trees with brooms will kill the tree and prevent mistletoe spread, but the function of the broom as wildlife habitat ends earlier than a living tree.

Although dwarf mistletoe is one of the more damaging diseases of ponderosa pine, it is one of the easiest to manage. Silvicultural techniques such as thinning, sanitation harvesting, and clearcutting have been used for decades to remove infected trees and reduce the spread of the parasite. In young pine, removing moderately to severely infected trees and creating gaps of 18 feet between residual trees have been shown to significantly reduce spread and impact of dwarf mistletoe (Barrett and Roth 1985, Roth and Barrett 1985).

## Summary

Several diseases affect the growth and survival of ponderosa pine in the Pacific Northwest and serve as agents of disturbance. These include root diseases, stem decays, stem diseases, foliage diseases, and dwarf mistletoes. Forest diseases serve as fine-scale disturbance agents by causing host trees to form structures that are infrequent in disease-free stands: dead trees, down wood, abnormal branches (witches’ brooms), dead branches, dead tops, and broken stems. Disease also promotes insect attack, diversifies wildlife habitat, and increases risk of wildfire.

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