ANNOSUS ROOT DISEASE

State Forester Forum

Introduction

Root diseases are the most damaging native forest diseases in northern Idaho, and are also the most difficult to manage. Infected trees suffer reduced growth, mortality, and increased susceptibility to bark beetles. At the stand-level, root diseases reduce timber volume and stocking, alter the rate and direction of forest succession, and interfere with short and long-term forest management objectives. Root diseases are caused by fungi that infect and decay tree roots, causing a loss of both root system function and structure. Loss of root function gradually weakens and kills trees. Loss of root structure results in windthrow of live trees and accelerated collapse of dead trees.

The most important root diseases in Idaho are *annosus root disease*, *Armillaria root disease*, and *laminated root rot*. Any combination of these diseases, referred to as "root disease complexes," may be found acting separately in the same stand or even on the same tree. Annosus root disease, caused by the fungus *Heterobasidion annosum*, can be found throughout Idaho. In addition to Armillaria root disease and laminated root rot, it is an important consideration in forest management planning in northern Idaho. It may also affect long-term management of ponderosa pine.

Biology

There are two "types" or "biological species" or "intersterility groups" of the fungus *H. annosum* the spruce S-type and the pine P-type. Conifer species vary in their susceptibility to the S- and P-types, and disease incidence and severity vary greatly by host and forest type. Spore infection occurs on fresh basal wounds and fresh stump surfaces of susceptible trees. Infection in pine is usually limited to stump surfaces, while infection in other species occurs via both stump surface and basal wound infection.

On stump surfaces, the fungus can colonize the woody tissue and grow down into the roots, but not all surface infections reach the roots, since many variables affect growth of the fungus. Once in the roots, it can infect roots of adjacent mature leave-trees or regenerating trees at root contacts and grafts by growth of ectotrophic mycelia. This fungus does not grow freely through the soil, but it can survive for several decades in large roots and stumps and cause disease in consecutive generations of forest (Figure 1).

Figure 1. *Annosus root disease mortality adjacent to a hollow ponderosa pine stump. (Photo from USDA Forest Service archives, www.forestryimages.org)*

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The long-term presence of inoculum, or fungus-infected woody tissue, makes root disease management very difficult. If the roots of non-infected trees contact the infected roots of a living or dead tree, the fungus can grow onto the non-infected root, perpetuating the disease. As root disease spreads from tree to tree, it can form centers of infection where many, but most often not all, of the trees are symptomatic or dead. These areas of concentrated damage are referred to as "*root disease centers*." Numerous annosus root disease centers may be dispersed randomly throughout a stand. In many instances, the disease occurs in a "diffuse" distribution, affecting scattered individual Douglas and true firs.

Annosus root disease centers vary greatly by fungus "type" and forest type. They are found commonly, alone or in conjunction with large Armillaria root disease and laminated root rot centers, in northern Idaho. Infection centers in ponderosa pine, when they occur, are often centered on large pine stumps from previous harvests (Figure 1). Damage in this instance tends to be limited to small spots in sapling and pole-sized stands. Annosus root disease in older ponderosa pine, particularly on dry sites, can result in scattered mortality or predisposition to bark beetles.

There is no evidence that fire has any significant "cleansing" effect on the underground inoculum of annosus root disease. Stumps producing fruiting bodies of H. annosum, particularly if well-decayed and dry, may be consumed by fire, as would well-decayed root channels, but most of the underground inoculum will not be impacted to a large extent.

Hosts

P-type *Heterobasidion annosum*

- Highly susceptible: Ponderosa pine and western juniper.
- Least susceptible: All other species.

S-type *Heterobasidion annosum*

- Highly susceptible: Douglas-fir, grand fir, and subalpine fir.
- Moderately susceptible: Western hemlock, western redcedar, white pine, and spruce.
- Least susceptible: Western larch, ponderosa pine, and lodgepole pine.

Identifying Annosus Root Disease

Descriptions and images of root disease-symptomatic trees can be found in "*A Field Guide to Diseases and Insect Pests of Northern and Central Rocky Mountain Conifers*." Root diseases cause gradual loss of root function and structure, an effect reflected in the symptoms that develop in infected trees (Figures 2 & 3). Symptoms of annosus root disease include:

- Reduced terminal and lateral growth over a span of several to many years

- Thinning of the crown, often proceeding from the bottom up and inside out
- Off-color or chlorotic (yellowing) foliage and
- a flush of small cones, referred to as “stress cones,” which can persist after the tree dies.

Key point: A general rule-of-thumb is only about half of all root disease-infected trees can be detected by above-ground symptoms at any one time.

Figure 2. *Annosus root disease symptoms in mature ponderosa pine*

Figure 3. *Typical root disease crown symptoms in Douglas-fir. (Photo by Susan K. Hagle, USDA Forest Service, www.forestryimages.org)*

The size of an infected tree will affect expression of disease symptoms. Larger trees, with more expansive root systems, will develop symptoms more gradually than a sapling or seedling, which may succumb relatively quickly and develop few if any crown symptoms. Large trees may not show symptoms for years after infection until much of their root system has been compromised. Any susceptible tree within 30 feet of an infected tree is likely infected.

Incipient, or early, decay caused by annosus root disease can be seen on stump surfaces or within roots of live trees as yellow-brown to red stain, depending on the host (Figure 4).

Advanced decay is generally a white, stringy, or spongy mass often containing small black flecks that run parallel to the grain (Figure 5). Decayed wood of subalpine or grand fir will tend to separate along the annual rings and have small pits on one side of the delaminations.

Figure 4. *Stain on stump caused by incipient decay. (Photo by James W. Byler, USDA Forest Service, www.forestryimages.org)*

Positive identification of annosus root disease can be made by locating fruiting bodies, or conks, of the fungus. Conks of the S-type are typically formed inside hollow stumps of host species, within decayed wood of stumps, or on the underside of roots of windthrown trees. Those of the P-type are commonly found in stumps or in the duff layer at the root collar of infected trees. Conks are perennial, woody to leathery, light-gray to dark-brown on top, with a creamy-white, small-pored underside (Figure 6). They are often shelf-like and vary in size from very small "button-conks" to fairly large ones.

Management

Root disease management should be site-specific and based on stand management objectives, the root disease or disease complex present, estimates of root disease severity, stand structure and composition, and stand history. Management of annosus root disease varies by forest type and location so the following recommendations should be viewed as guidelines.

Figure 5. *Advanced decay caused by H. annosum. (Photo by John W. Schwandt, USDA Forest Service, www.forestryimages.org)*

Figure 6. *Fruiting bodies, or conks, of S-type H. annosum. (Photo by Robert L. James, USDA Forest Service, www.forestryimages.org)*

Ponderosa pine forests:

The impact of annosus root disease in ponderosa pine forests in Idaho is not clear. The fungus can be found in decayed stumps, but mortality of adjacent, mature trees, as observed in other areas of the west, is not frequently observed. The fungus might be infecting trees adjacent to infected stumps but acting more as a "root nibbler" instead of a "tree killer." Even then it could reduce growth and increase susceptibility to bark beetles.

If a landowner decides to manage for annosus root disease in ponderosa pine, the focus should be on preventing disease, a goal which can be achieved by treating stump surfaces with a borax formulation immediately after cutting. Spores of H. annosum can still land on the stump, but they do not succeed in causing infection. Powdered formulations such as Sporax® are registered for this use and can be applied from a shaker can across the stump surface (Figure 7).

Stumps should be treated with a light coating within 48 hours after cutting, but it is probably most efficient to apply borax at the time trees are felled.

> **Key point**: Stump treatments prevent the fungus from infecting stumps. It does **not** have any effect on fungus **already present** in stumps and roots.

Only stumps 14" and greater in diameter are recommended for treatment due to the greater likelihood of root contact between roots of large stumps and surrounding leave-trees, and because smaller material decays faster and will be available as sources of infection for less time.

Figure 7. *Pine stump treated with borax to prevent spore infection*

Use of stump treatments to guard against infection by the "P-type" of *H. annosum* represents a cheap, relatively easy-to-apply "insurance policy" to help ensure long-term site productivity. Private landowners managing small parcels of ponderosa pine might well consider it. Managers of large public or private forests need to balance potential risks against added cost.

Homeowners and recreation area managers **should use stump treatments** any time they remove ponderosa pine due to the high value of residual trees, particularly large ponderosa pine, on these sites.

If annosus root disease is already present and causing damage, then management must revert to selection of less susceptible species. However, ponderosa pine is often most suited to the dry sites where it dominates, so preventing disease from becoming established is paramount.

Douglas-fir and true fir forests:

Formulate management objectives for the fir stand in question. A timber production objective requires very careful consideration of root disease; other objectives may not.

Estimate "root disease severity": An estimate of root disease severity (Table 1) provides a "snapshot" of current root disease impact and mortality rates, as well as the best estimate of future mortality and the trajectory of stand structure and composition. Root disease severity, and thus appropriate management, can vary throughout a stand.

Regeneration harvest: If root disease is severe and few disease-resistant species are available to select as leave-trees, and your objective is timber production, then the best option from a disease management standpoint is to clearcut the stand and start over.

> **Key Point:** Salvaging trees dead and dying due to root disease will capture the volume before it decays, but due to the biology of the fungi that cause root disease, salvage does not reduce continued mortality or halt spread of root disease.

Stand Establishment: Trees planted on sites with root disease need to be disease-tolerant. Western larch or pine species would be good choices, depending on the site. Douglas-fir, subalpine fir, and grand fir will be severely damaged. Ensure quality-control during planting, as "J-rooted" seedlings of any species are readily damaged by root disease. Soil compaction appears to increase root disease damage, so plan skid trails carefully and minimize the area occupied by landings.

> **Key Point:** Managing for disease-tolerant species is usually the most effective and cost-efficient means of managing root diseases.

Precommercial stands: Many stands composed of disease-susceptible species have been established, either by planting or natural regeneration, in the presence of moderate to severe root disease. Such stands often show few symptoms of disease until age 10-15, after roots of the growing trees have contacted inoculum from the previous stand and numerous pockets of annosus root disease begin to appear. In such instances, whether precommercial thinning has been done or not, the best option may be to destroy the current stand and start over with disease-tolerant species; a better yield will almost certainly result.

If a young stand has extensive root disease mortality but includes well-distributed, disease-tolerant species, delay thinning at least several years to allow the root disease time to "select" trees that will survive before you invest in thinning. If thinning is eventually done, lease a higher-than-normal stocking of disease-tolerant trees in anticipation that more will die as the stand matures. In many instances, however, root disease will reduce stocking to where only "clumps" may need thinning.

Young stands with a "light" root-disease severity rating can be thinned without delay, but emphasize selection of disease-tolerant species over maintaining uniform spacing.

Achieving root disease management objectives during precommercial thinning requires close administration of thinning crews to make sure disease-tolerant tree species are favored.

Commercial stands: **Thinning is not recommended in stands impacted by annosus root disease if Douglas-fir or grand fir will compose more than 30% of leave-trees.** Many susceptible trees in such a stand will already be infected, even if not displaying symptoms, and may die within a few years of thinning.

A landowner may be sorely tempted to thin a root-diseased stand, leaving the best-looking Douglas-fir and grand fir, with the expectation these trees will experience "increased vigor" and thus resist root disease. The evidence is not clear at this time whether thinning accelerates damage in such a situation, but it is clear that **mortality rates <u>will</u> <u>not</u> <u>decrease</u> in disease-susceptible species.**

Management of stands impacted by annosus root disease should emphasize promotion and maintenance of seral species. Silvicultural approaches that achieve this objective are recommended even for stands with a light root disease severity rating. Managing for disease-susceptible species, and harvesting the disease tolerant species, will result in ever-increasing amounts of disease inoculum and only serve to worsen root disease severity and reduce management options for the next rotation.

> **Key Point:** Long-term root disease management should take a "**do no harm**" approach by maintaining and promoting mature seral species and their natural regeneration, planting carefully with disease-tolerant species suited to the site, and avoiding actions that will increase inoculum levels.

Inoculum removal: Using heavy machinery to remove stumps and large roots from the ground in root-diseased stands can reduce short-term damage in the subsequent stand due to reduction in inoculum, but long-term results are mixed.

Inoculum removal requires **very careful** consideration based on slope, soil moisture and type, and site productivity. While it is not considered economically practical in commercial forests of Idaho, private landowners with small parcels of land impacted by root disease might consider this option under the right circumstances.

Fertilization: At this time, there is no evidence that fertilizing reduces either spread or severity of annosus root disease.

Table 1. Root disease severity categories

Root Disease Severity	Range of Conditions
Light	Includes stands with no evidence of root disease, stands with no mortality but numerous trees displaying symptoms, and stands with up to 20% canopy reduction due to root disease mortality.
Moderate	Includes stands with 20-75% canopy reduction due to root disease mortality. At the lower end of this range, there will also be many trees with root disease symptoms, while at the upper end, much of the remaining overstory canopy consists of disease-tolerant species. Moderate-severity stands are changing quickly; mortality rates are high.
Severe	Includes stands with at least 75% canopy reduction due to root disease mortality. These stands are usually composed of only the most susceptible species. At the lower end of this range, only a few susceptible overstory trees remain, although there may be densely stocked, susceptible regeneration; at the upper end, no susceptible species remain in the overstory. Mortality rates in this category will begin to slow because most susceptible species are already dead.

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Useful links:

Forest Insect and Disease Leaflet

USFS Region 1 Field Guide

USFS R1 Management Guide (Fir type)

USFS R1 Management Guide (Pine type)

FOR MORE INFORMATION CONTACT THE IDAHO DEPARTMENT OF LANDS
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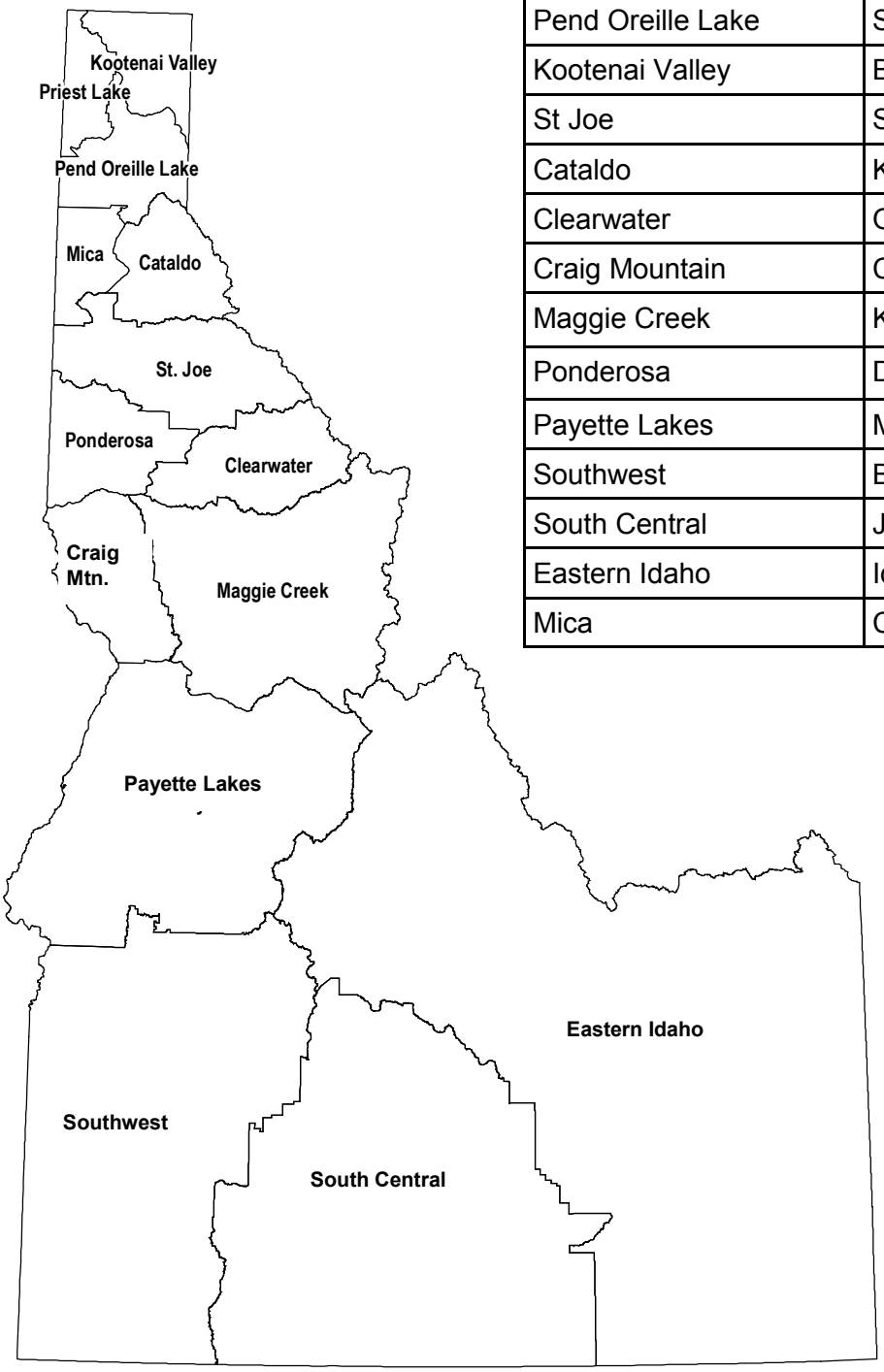
Area Office	Location	Phone
Priest Lake	Coolin	(208) 443-2516
Pend Oreille Lake	Sandpoint	(208) 263-5104
Kootenai Valley	Bonners Ferry	(208) 267-5577
St Joe	St Maries	(208) 245-4551
Cataldo	Kingston	(208) 682-4611
Clearwater	Orofino	(208) 476-4587
Craig Mountain	Craigmont	(208) 924-5571
Maggie Creek	Kamiah	(208) 935-2141
Ponderosa	Deary	(208) 877-1121
Payette Lakes	McCall	(208) 634-7125
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South Central	Jerome	(208) 324-2561
Eastern Idaho	Idaho Falls	(208) 525-7167
Mica	Coeur d'Alene	(208) 769-1577