

# Root Diseases

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A Field Guide to Diseases & Insect Pests of Northern & Central Rocky Mountain Conifers



## About Root Disease

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**Armillaria root disease:** *Armillaria ostoyae* (Romagnesi) Herink

**Laminated root rot:** *Phellinus weirii* (Murrill) R.L.Gilbertson

**Annosus root disease:** *Heterobasidion annosum* (Fr.) Bref.

**Schweinitzii root and butt rot:** *Phaeolus schweinitzii* (Fr.:Fr.) Pat.

**Tomentosus root disease:** *Inonotus tomentosus* (Fr.:Fr.) Teng.

**Black stain root disease:** *Leptographium wageneri* (Kendrick) M.J.Wingfield

**Damage--** Root disease spreads from roots of diseased trees to those of healthy ones. The result is usually several to hundreds of trees dying or dead in groups called root disease patches. Trees of all sizes, ages, and species are killed by root disease. Detection of this disease is of critical importance in stand management. Susceptibility varies among tree species, age groups, individual trees, and pathogens present. These aspects of root disease are discussed in the sections dealing with each pathogen as they relate to identification of pathogens. There are general stand and tree symptoms which can be used to detect most root diseases.

Root disease occurs in two patterns in stands. The first is in root disease patches, and the second is scattered individual tree and small group mortality. Both types may occur in the same stand creating a mosaic effect.



Figure 103. Typical root disease patch (or pocket) with dead and symptomatic trees, especially at the margins, and younger trees in the center of the patch.



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a.

Figure 104. Root disease is often easily distinguished from afar. Changes in tree density (a) and clusters of young trees or brush associated with tree mortality (b) are good indicators of root disease.



b.

**Stand symptoms of root disease--** Root disease patches (also referred to as centers or pockets) range in size from a fraction of an acre to hundreds of acres. They usually have abundant regeneration or dense brush growth in the center. This is ringed with dead and dying trees intermixed with apparently unaffected trees along the margin of the patch (figs. 103-104). Root disease patches have various shapes. They range from essentially round to long, narrow strips, to irregular patches. They are often restricted to particular aspects, drainages, and timber types within a given area. Less susceptible tree species abundant in infested stands sometimes mask the presence of a root disease patch because only the most susceptible species are killed. Such stands simply appear to be under stocked or irregularly stocked.



Figure 105. Aerial photograph of root disease patches. Ringworm pattern in an otherwise uniform canopy.

On aerial photographs, root disease centers sometimes resemble doughnuts or ringworm-like patches within otherwise uniform forest canopies (fig. 105). Generally only the largest root disease centers will be detected from aerial photographs. Where a mosaic of scattered and pocket mortality is occurring, the stand will have a coarse texture using aerial photographs with occasional large snags visible if the scale of the photograph is large enough.

**Diffuse patterns--** Scattered root disease often goes undetected because of the subtle nature of expression. There may be only a few trees per acre dying at any one time and these are scattered among the apparently unaffected trees (fig. 106a). The eventual toll of this type of root disease can be even greater than that of root disease pockets because it is usually more extensive throughout a stand (106b, c), drainage or timber type. It takes a trained eye to detect scattered root disease using aerial photographs. The texture of the canopy is a little coarser and more large snags are visible in the photographs.



a.



b.



c.



d.



e.

Figure 106. Root disease mortality in young stands often goes undetected before about 20 years of age. From the scattered or small groups of mortality (d, e), the disease generally progresses to large mosaics of poorly-stocked forest by age 80-100.

Tree crown symptoms of root disease vary according to rapidity of death, involvement of bark beetles, and season of death. As a general rule, trees with root disease have shortened terminal growth resulting in somewhat rounded (rather than conical) crowns. Trees lose their needles beginning with the oldest and progressing to the youngest. The appearance is that trees are thinning from the lowest part of the crown up, and the innermost part of the crown (nearest the stem) out, toward the branch tips (figs. 107-109). Stress cone crops are sometimes produced by dying trees. In this case a heavy crop of cones may be seen in chlorotic or dead trees even if it is not generally a good cone-producing year for that species (fig. 108). (These are poor cones for seed production.)



Figure 107. Crown symptoms of root disease (right) are most evident when compared to a healthy crown (left).



Figure 108. A stress cone crop produced on a tree with thinning foliage and shortened terminal growth is an indication of root disease.



109. If bark beetles attack dying trees they often hasten mortality. If mortality is hastened, the trees may not have time to shed many needles before they die. In this case, the crown may turn uniformly yellow or red.



### Root disease in young trees--

Small trees which are killed rapidly by root disease may turn uniformly red without having been attacked by bark beetles. Shortened terminal growth and short leaves are often symptoms of root disease infection. These symptoms are especially apparent in seedlings and saplings a year or two before death (figs 110-112).

Mortality of young trees is most likely caused by one of the three of the most common root diseases, *Armillaria*, annosus and laminated root rots. Stumps often serve as a source of inoculum for these pathogens, leading to higher mortality rates near stumps than elsewhere in a stand.



Figure 110. This young western white pine has been killed by *Armillaria* root disease which was probably harbored by the adjacent stump



Figure 111. A cluster of young Douglas-fir and grand fir have been killed by root disease near this old stump.

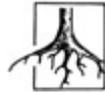


Figure 112. These young ponderosa pines have been killed by annosus root disease. The hollow pine stump is a good indicator of annosus root disease in this stand. Infected roots of this stump may extend 50 feet or more from the stump base.

**Table 3. Comparing Important Root Diseases** From page 77

Fungus	Hosts	Basal Resinosis	Decay	Other Distinguishing Characteristics
<i>Armillaria ostoyae</i>	DF, GF, WF, RF, SAF, ES, sapling pines  All conifers	Yes	White or yellowish, stringy with black zone lines.	Thick fan-shaped felts of white mycelium in cambium.
<i>Phellinus weirii</i>	DF, GF  Other conifers	Yes	Laminated, separating at annual rings, pitted with pinhead-sized holes.	Cream-colored mycelium on outer bark of roots under duff. Cinnamon-yellow mycelium in bark cracks with cream mycelium.
<i>Heterobasidion annosum</i>	DF, GF, SAF, WF, RF  Other conifers	No	White or yellowish, stringy to somewhat laminated. Irregular white pockets with black flecks.	Conks shelving or appressed in hollow stumps or on roots underground. Upper surface brown, lower pored cream color with brown non-pored margin. Cream-colored mounds (button conks) on seedling roots.
<i>Phaeolus schweinitzii</i>	DF  Other conifers	No	Brown cubical rot of root and butt heartwood.	Small roots with red-brown resinous heart; galled roots; large brown, velvety conks with green or brown pore layer on underside produced on ground or tree base.
<i>Leptographium wagneri</i>	PYP, PP  LP, DF	No	No decay produced.	Black or dark brown stain in sapwood follows annual rings.
<i>Inonotus tomentosus</i>	ES, BS, LPP  Other conifers	No	White pocket rot with large, spindle-shaped empty pockets.	Red-brown or brown stain in root. Conks 2-5 inches, yellow to cinnamon upper surface; with short stipe; cream to tan poroid lower surface.

BS=Colorado blue spruce, DF=Douglas-fir, ES Engelmann spruce, GF=grand fir, LPP=lodge pole pine, PP=ponderosa pine, PYP=piñon and singleleaf piñon pines, RF=red fir, SAF=subalpine fir, WF=white fir.



**Hosts--** Primary hosts are Douglas-fir, grand, white, red and subalpine firs. All conifers may be attacked, particularly at ages less than 30 years. Englemann spruce is a common host in southern Idaho, Utah and Wyoming.

**Distribution--** Range of hosts, especially west of the Continental Divide.

**Damage--** This is the most common root disease fungus in the region. It kills the cambium of roots and the root collar, girdling and killing the tree. Causes mortality in groups and scattered, individual trees. Infected trees are often attacked by bark beetles. It decays the roots which can lead to growth loss and windthrow in advance of tree death. It is also sometimes seen to decay butt heartwood in large, living grand fir, western redcedar, and western hemlock. The growth loss, windthrow and butt decay are minor impacts compared to the amount of direct tree mortality attributable to this disease.

**Identification--** Trees infected with *Armillaria* have typical root disease crown symptoms. Resinosus often is extensive on and throughout the bark of the root collar (figs. 113, 114). The most diagnostic feature is the thick, fan-shaped mat of white mycelium (figs. 115, 116, 118) in the cambium of roots and root crown. Cutting away the bark reveals mycelium fans that are thick and leathery enough to be pulled from the wood.

Other signs of the fungus include rhizomorphs on the outside of infected roots and honey-colored mushrooms. The mushrooms may be produced at the base of infected trees during late summer or early autumn (fig.117). The decay is white to yellow and stringy or spongy, sometimes with fine, black lines traversing the decayed wood (zone lines).

**Similar damages--** Laminated root rot causes basal resinosus as well but thick, white mycelium fans are not produced in this disease.

**References--** [2, 25, 64, 77](#)

[Management Guide for Armillaria Root Disease](#)



Figure 113. Fresh and older (dark) resinosus at the base of an *Armillaria*-infected Douglas-fir.



Figure 114. Resinosus on a young, thin-barked Douglas-fir is often the first sign of infection.



Figure 115. Cutting away the bark reveals white fan-shaped felts of *Armillaria* mycelium in the cambium at the root collar.



Figure 116. Mycelium fans of *Armillaria* are thick and leathery. The cambium often develops fan-shaped ridges which are discernible long after the fungus has died.



Figure 117. Mushrooms of *Armillaria* can be produced in abundance, but are not reliably present.



Figure 118. Even seedlings have mycelium fans in the root or root collar cambium.



## Annosus Root Disease From pages 80-81

*Heterobasidion annosum* (Fr.) Bref.

Syn.: *Fomes annosus* (Fr.) Cke.

Anamorph: *Spiniger meineckellum* (A. Olson) Stalpers (fig. 123)

**Hosts--** S- type annosum: Douglas-fir, grand fir, subalpine fir are killed. Roots of western redcedar are rotted. It causes a butt rot in western hemlock. P- type annosum: Ponderosa pine, primarily. Other pines are rarely affected.

**Distribution--** Range of hosts.

**Damage--** Annosus root disease occurs in trees of all ages. It is particularly lethal in Douglas-fir. The fungus decays roots and colonizes root collar cambium, killing trees. In true firs and western hemlock, the fungus often decays the butts of older trees for many years before causing tree death.

**Identification--** Trees with annosus root disease display typical root disease crown symptoms. Cutting into the heartwood of roots or examining the surface of freshly cut stumps should find staining indicative of incipient decay (fig. 119). Conks are also useful in diagnosing the disease. They are perennial, woody to leathery, with the upper surface dark brown and the lower surface white to cream colored (fig. 121). Pores on the lower surface are very small. There is a rim of brown, non-pored tissue around the edge of the lower surface. Conks are produced in hollows within infected stumps or under the duff at the base of recently killed trees.

Button conks (small, cream-colored mounds of corky fungus tissue) are sometimes found on the root collar of infected seedlings (fig. 120).

If conks cannot be found, culturing of the fungus may be necessary for identification. Advanced decay is a white, stringy to somewhat laminate decay. In the most advanced stage, decayed wood may become wet and spongy with numerous small black flecks (fig. 122).

**Similar damages--** *Armillaria* root disease and laminated root rot cause similar crown symptoms to those of annosus root disease. Decay from these diseases is also superficially similar because all three cause white rot.



a.



b.

Figure 119. An useful sign of annosus root disease is an irregular pattern of staining in root and butt heartwood. In firs, the stain varies from dull gray, to reddish-purple (a). In Douglas-fir the stain is red-brown (b).

**References--** 2, 25, 62

**Management Guide for Annosus Root Disease:**

[Management Guide Fir type](#)



Figure 120. Button conks; tiny, poorly formed conks of *Heterobasidion annosum* are sometimes found near the root collar of killed seedlings. They are also found on small roots of larger trees.



a.

Figure 121. Annosus root disease often is diagnosed by looking in hollows of nearby stumps where the conks are found. The upper surface is gray or brown (a) and the lower surface has tiny pores and is cream colored (b).



b.



Figure 122. *Heterobasidion annosum* advanced decay has irregular white pockets and black fleck. It is somewhat laminate at the beginning but eventually becomes stringy and spongy.

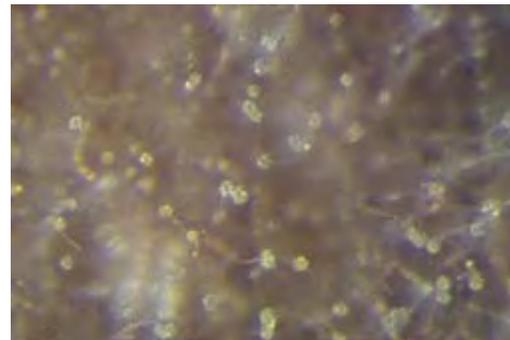
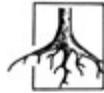


Figure 123. One means of identifying annosus root disease is to incubate freshly cut sections of infected wood in a plastic bag to stimulate production of the asexual stage, *Spiniger meineckellum* (40x).



## Laminated Root Rot From pages 82-83

*Phellinus weirii* (Murr.) Gilb.

**Hosts--** Douglas-fir and grand fir are most susceptible. Western hemlock and subalpine fir are less susceptible and other conifers in northern Idaho and Montana are tolerant or resistant. Also see discussion of cedar laminated butt rot.

**Distribution--** The range of Douglas-fir or true firs in northern Idaho and northwestern Montana.

**Damage--** Mortality or windthrow. Decays roots and kills cambium of roots and root collar. Trees of all ages are killed by girdling the cambium and decaying the sapwood. Mortality occurs in large disease centers and in small groups. Infected trees often are attacked by bark beetles as well.

**Identification--** Infected trees have typical root disease crown symptoms. Freshly cut stumps often have brown or red-brown stain in the sapwood and outer heartwood indicative of the early stages of decay (fig. 124). Conks are rare and indistinct (fig. 125). Most diagnostic is the thin layer of cream to dark yellow colored mycelium covering the outer bark of infected roots (fig. 126). Fuzzy, cinnamon-colored mycelium often occurs in bark crevices along with the cream-colored mycelium. Infected trees occasionally have some basal resinosis. Decayed wood separates easily along the annual rings and is extensively pitted with small white or cinnamon-colored pockets (fig. 127, 128). Trees with rotten roots are prone to windthrow. Some trees develop butt rot from this disease long before they are killed.

**Similar damages--** *Armillaria* root disease also causes basal resinosis but white mycelium of *Armillaria* is present under the bark in the cambial region rather than on the exterior of roots.

**References--** [2, 25, 73](#)

[Management Guide for Laminated Root Disease](#)



Figure 124. Brown stain is sometimes seen in the sapwood or outer heartwood of trees with laminated root rot.

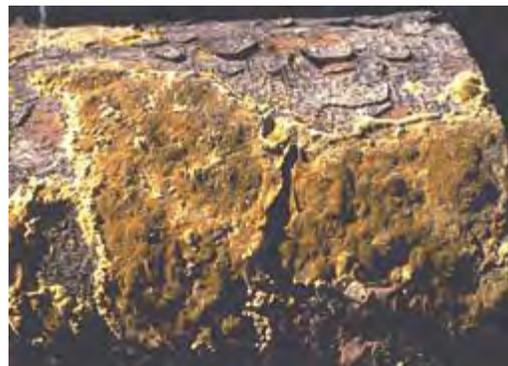


Figure 125. Conks are rare. They grow on a root or fallen stem of a tree killed by laminated root rot. They are thin, leathery when fresh and friable with age, light weight, yellow to cinnamon brown with small pores.



Figure 126. Cream or yellow to cinnamon colored mycelium is found on the outer bark of roots with laminated root rot.



Figure 127. Laminated root rot separates easily at the annual rings and is pitted with tiny holes. Cinnamon brown mycelium and tiny hairlike hyphae are often found in the decay.



Figure 128. Decay from laminated root rot has distinctive round pits about pinhead-size.



*Phaeolus schweinitzii* (Fr.) Pat.

**Hosts--** Douglas-fir is by far the most common host. All conifers are susceptible, especially to butt rot.

**Distribution--** Range of hosts in Idaho and Montana.

**Damage--** Decays inner wood of roots, causes root galling, and decays butt heartwood. Windthrow frequently results from uprooting or butt breakage. Douglas-fir beetles and *Armillaria ostoyae* often attack *P. schweinitzii*-infected Douglas-firs.

**Identification--** Trees infected with *P. schweinitzii* alone seldom have distinct root disease crown symptoms. Those that do are usually found on poor soils or rocky and dry sites. Crowns of extensively infected Douglas-firs are sometimes thin and show poor shoot growth and some branch dieback. Decay is dry and yellow at first, becoming brown and cubically cracked in advanced stages (figs. 129, 131). Thin, resinous felts are often present in cracks of advanced decay.

Conks are occasionally produced on the ground near infected trees stumps. Less often, they develop directly on infected trees or stumps. They are annual, spongy conks with large pores on the undersurface. Caps are brown and velvety (figs. 130, 132); undersides are green when fresh becoming brown with age. Caps are usually 5-10 inches in diameter with short stems. Large clusters often form.

Small roots that are infected have dark red-brown, resinous centers (fig. 133). Roots may be stubbed with gall-like swelling. These stubbed roots have red-brown resinous heartwood which may also show brown cubical decay (fig. 134).

**Similar damages--** The decay caused by *Fomitopsis pinicola* is also brown and cubically cracked. However, *F. pinicola* decays dead trees and decays both sapwood and heartwood. Mycelium felts in *F. pinicola* decay are thick and not resinous, and *F. pinicola* conks are frequently found in association with the decay.



Figure 129. Brown cubical decay in the butt end of the first log is the most common indication of *schweinitzii* root and butt rot.



Figure 130. An old conk resembles a bovine manure pile in size and color.

**References--** [2, 25](#)

[Management Guide for Schweinitzii Root & Butt Rot](#)



Figure 131. *Schweinitzii* root and butt rot is the most common brown cubical decay of Douglas-fir. It is common in other conifers species as well. The disease often starts in the roots when trees are young but is seldom seen causing butt rot until trees are mature or overmature. The cull usually only extends eight feet or less above the ground. Fruiting bodies are present on both of these examples but they are not commonly produced in this way. Usually they are found on the ground within a few feet of an infected tree. A single conk may indicate extensive infection throughout a stand.



Figure 132. *Phaeolus schweinitzii* conks are yellow-green when fresh but age rapidly to a yellow-brown and finally dark brown color. They have a velvety cap, a short stem (stipe) and a pored green to brown lower surface.



Figure 133. Small diameter roots sometimes have a dark red resinous heart when infected by *Phaeolus schweinitzii*.



Figure 134. Roots of windthrown trees with *Schweinitzii* root rot commonly are stubbed and have gall-like swelling.



## Blackstain Root Disease From page 86

*Leptographium wagneri* (Kendrick) Wingfield

**Hosts--** Douglas-fir, ponderosa pine, piñon and singleleaf piñon pines are the principal hosts in the region. Infections in other species are rare.

**Distribution--** This disease has been found in relatively few locations in Idaho and Montana. Also found in southern Utah, Nevada and California.

**Damage--** Trees are killed by the fungus growing in tracheids and blocking water conduction. Bark beetles usually attack infected trees. This fungus does not decay infected wood.

**Identification--** Trees with black stain root disease may have crown symptoms typical of root diseases (fig. 135), but small trees sometimes die too quickly for crown symptoms to develop. In this case crowns remain full and needle length near normal, while the entire crown fades uniformly to yellow and then red.



Figure 135. Piñon pines killed by blackstain root disease.

The disease is indicated by a dark brown or black stain in roots and root collar sapwood (fig. 136a) which follows the annual rings. In cross section the stain forms concentric crescents in the sapwood (fig. 136b). Black stain root disease sometimes affects trees on the edge of root disease centers caused by other pathogens.

**Similar damages--** Blue stains caused by non- or weakly-pathogenic fungi are common in dying and dead trees. Contrary to their name 'blue' stains can be black, brown, or even red. Blue stains do not follow the annual rings. They are wedge-shaped and follow the rays inward from the cambium.

**References--** [2](#), [28](#), [34](#)



a.



b.

Figure 136. Blackstain pattern in wood. Blackstain in piñon sapwood just under the cambium (a). Stain follows annual rings and is restricted to sapwood (b).



*Inonotus tomentosus* (Fr.) Teng.

**Hosts** -- Engelmann spruce and lodgepole pine are the primary hosts. Douglas-fir, western white pine, and blue spruce are occasional hosts.

**Distribution**-- Englemann spruce throughout the range. Lodgepole pine and blue spruce in southern Idaho, Utah and Nevada. Douglas-fir and western white pine in Idaho and western Montana.

**Damage**-- Lodgepole pine and Engelmann spruce may have typical root disease crown symptoms. This is known as stand-opening disease in Canada. The heartwood of roots and butts of trees are decayed by this fungus. Distinct disease centers are produced in stands of these hosts. The disease is especially common in old Englemann spruce, causing extensive butt rot and leading to windthrow of trees in which roots have been weakened by heartwood decay. Douglas-fir and white pine are seldom damaged beyond a few rotted roots. *Inonotus tomentosus* infections are often seen in trees with other, more aggressive, root diseases such as *Armillaria* and annosus root rots.

**Identification**-- Incipient decay produces a red-brown or brown stain in the heartwood of roots and butts (fig. 137). Advanced decay is a white pocket rot which forms large, empty, spindle-shaped pockets with firm wood between the pockets (fig. 138). This decay has a distinctive honeycombed appearance in cross-section. Conks are annual, produced in the fall on the ground near infected trees; rarely, on exposed roots. They have 2-5 inch diameter, velvety caps and a short stem (stipe). Fresh they are yellow to cinnamon (fig. 139); darker with age. The lower surface is poroid, cream colored when fresh; darker with age.

**Similar damages**-- *Heterobasidion annosum* causes root and butt rot in spruce but tomentosus decay is very firm between the pockets. Pini rot is also a white pocket rot but is not a root disease and the pockets are white.

**References**-- [25, 45, 74](#)

[Management Guide for Tomentosus Root Disease](#)



Figure 137. Stain in root indicating tomentosus root disease.



Figure 138. Advanced decay.



Figure 139. Pair of *Inonotus tomentosus* conks.