

Diagnosis of Annosus Root Disease in Mixed Conifer Forests in the Northwestern United States¹

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Abstract: Recognizing annosus root disease affecting conifers in northwestern United States forests is discussed. Field diagnosis can be made by observing characteristic stand patterns, wood stain and decay, ectotrophic mycelium, and sporophores. Most seriously affected trees include hemlocks, grand fir, white fir and Pacific silver fir. Ponderosa pine and other true firs may also be damaged. Wounded trees, especially hemlocks and true firs, are readily colonized by Heterobasidion annosum and wounds can be used as an indicator of infection. Laboratory analysis can be used to confirm field diagnosis.

Annosus root disease, which is caused by Heterobasidion annosum (Fr.) Bref. (= Fomes annosus (Fr.) Karst.) is a common cause of root and butt decay of conifers in the northwestern United States. All conifers can be infected, but there are species differences in degree of susceptibility and types of damage. Species most susceptible to infection and damage include western hemlock (Isuga heterophylla), mountain hemlock (I. mertensiana), grand fir (Abies grandis), white fir (A. concolor) and Pacific silver fir (A. amabilis). The damage resulting from infection may include butt decay, probably reduced growth rates, windthrow, attack by secondary pests, and direct mortality. Species less commonly infected include ponderosa pine (Pinus ponderosa), noble fir (A. procera), subalpine fir (A. lasiocarpa), and California red fir (A. magnifica) (Hadfield and others, 1986). Other conifers are seldom damaged severely enough to cause a forest management concern.

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RECOGNITION

Recognition and correct diagnosis of annosus root disease is an important step toward reducing current and future root disease losses, and achieving the highest possible productivity from our forests.

Annosus root disease is more difficult to identify than other common root diseases of conifers. The pathogen is found on many host species over a wide range of ecological conditions. Throughout the pathogen's range there is considerable diversity in the symptoms and signs expressed by infected hosts.

On-Site Indicators

In infected conifer stands, annosus root disease usually occurs in discrete infection centers. Verifying infection by H. annosum in these centers can best be done by observing several of the signs and symptoms characteristic of annosus root disease. In resinous species, such as pines, and in true firs, dead or dying trees or both or understocked areas can be readily identified and should be suspect. Upon encountering suspect centers, look for evidence of periodic tree dying in gradually expanding foci. Within centers, old infected stumps, snags and (less frequently) scarred trees may be found. The most reliable method of diagnosing annosus root disease is to locate the fruiting bodies of H. annosum. Trees killed by annosus root disease occasionally have fruiting bodies of the pathogen on their roots or root collar or both. Groups of dead and symptomatic dying trees frequently are found around old stumps containing conks of H. annosum in the interior rotted portions.

Trees in advanced stages of infection may exhibit crown symptoms typical of root-diseased trees: chlorotic and sparse foliage, reduced vertical and radial growth, and distress cones. Crown symptoms are most commonly observed on resinous species. Western hemlock, a non-resinous species, seldom displays obvious crown symptoms, even when extensive butt and root decay is

present. True firs often display typical root-disease symptoms; however, extensive decay without obvious crown symptoms is not uncommon, especially if associated with large wounds.

Identifying annosus root disease with a high degree of certainty requires recognition of indicators more or less specific to the disease and then lowering or eliminating the probability that other primary pathogens may be involved. Secondary pathogens, such as Armillaria ostoyae (Romagn.) Herink (= A. mellea sensu lato), are frequently found on trees infected by H. annosum. Positive verification of infection by H. annosum requires finding fruiting bodies on the trees in question or cross-checking field diagnosis against laboratory identification of the pathogen.

Heterobasidion annosum seldom kills hemlocks directly. Butt rot, the most common damage, is usually found during harvest. Root disease-induced windthrow sometimes occurs. More often, decay caused by H. annosum is found in hemlocks that had large wounds on the lower bole, root collar, or roots; and those large wounds often are colonized by H. annosum. Thus, large wounds are an important indicator of decay caused by H. annosum in hemlock. Most hemlocks with significant amounts of decay are over 120 years old (Goheen and others, 1980). Old-growth hemlocks (150+ years) are occasionally killed or windthrown as a result of infection by H. annosum.

True firs infected by H. annosum usually become infested by fir engraver beetles (Scolytus ventralis LeConte) after they have been weakened by the pathogen. When beetle populations are high, particularly during a drought, firs may be attacked and killed before readily-identifiable indicators of infection can be found.

True firs that become infected via bole wounds often have compartmentalized stem decay caused by H. Annosum. In such cases, H. annosum is not acting as a tree-killing root disease. Cambium killing on roots and root collars of true firs is usually associated with pathogen spread via root contacts and ectotrophic mycelium colonizing the surfaces of root systems. Such trees are readily weakened and killed (Schmitt and others, 1984). Annosus root disease in true fir stands frequently is centered around large stumps of true fir trees that were cut at least 20-25 years ago. Stumps larger than 18 inches (2.54 cm/in.) are almost always the source of infection. These stumps commonly contain conks of the fungus in hollow pockets.

Ponderosa pine is most susceptible to infection and damage on xeric, marginally productive sites. Infection centers usually occur around large pine stumps. Because of the

wide-reaching root systems of old open-grown pines, these disease centers may be up to 100 feet across.

Douglas-fir stands generally are not sufficiently damaged by H. annosum that the disease becomes a management concern. However, Douglas-fir saplings and small poles may become infected and killed on certain sites. Specifically, Douglas-fir planted on several high-elevation mixed-conifer sites in Washington and Oregon that were at the upper elevation range of naturally occurring Douglas-fir were found to have a moderate to high incidence of infection and mortality. Infection was associated with true fir stumps that had become infected at time of harvest.

Signs

Conks

Heterobasidion annosum produces fruiting bodies, or conks, on infected host material. In the Pacific Northwest, the presence of fruiting bodies of the fungus is the easiest and most reliable way to verify presence of the fungus. On most infected pines and less frequently on true firs killed by annosus root disease, conks may be found on the outer bark at the root collar in the duff layer. Conks found in such locations usually are small and buff-colored, leathery, and 0.125-0.25 inch (25.4 mm/in.) in diameter. On most infected species of conifers, small buff-colored pustules that resemble fruiting bodies can be found scattered on the surface of dead infected roots.

Conks, 2 to 3 inches across, may be found in crevices of the root collar of infected, dead western hemlocks. Large conks, up to 10 inches across, can be found in the interior of old hollow or extensively decayed hemlock, true fir, and ponderosa pine stumps. On pine stumps they are frequently found just under the bark or at the sapwood-heartwood interface. Conks have concentric furrows, a buff- to dark brown-colored upper surface, and a smooth, cream-colored under-surface that has tiny pores and a narrow sterile (non-pored) margin. Conks are perennial and may have more than one tube layer.

Ectotrophic Mycelium

A dull white ectotrophic mycelium may be found on the exterior of infected roots of pines, true firs, and Douglas-fir. This growth is one mechanism of spread across root contacts. Some other root disease fungi also form similar ectotrophic mycelium so its occurrence alone cannot be used to diagnose the disease.

Stain and Decay

The appearance of wood stain and decay caused by H. annosum is quite variable. In true firs and hemlocks, infected roots and butt wood usually develop a red-brown to purplish heartwood stain that has an irregular outer margin. Stain is not common in pines, although a resinous flecking is sometimes present. Advanced wood decay in pines and true firs is initially laminated, separating at the annual rings. Small, elongated pits roughly 0.04-0.08 inch (25.4 μ m/in.) long may be found, but only on one side of delaminated sheets. Commonly in hemlock, true firs, and Douglas-fir, but less common in pine, advanced decay will be wet, spongy, and stringy with large white streaks and scattered small black flecks. This type of decay is often found in the interior of infected roots.

Laboratory Verification

Laboratory techniques for diagnosis of H. annosum infection may be needed because conks cannot always be found, decay appearance is highly variable and "masked" by other pathogens. Fortunately, H. annosum-infected wood readily yields characteristic asexual fruiting structures (conidia and conidiophores) of its imperfect stage, Spiniger meineckellus (Olson) Staplers (= Oedocephalum lineatum Bakshi), where incubated in high humidity, or cultured on nutrient media.

CONCLUSIONS

Recognition and diagnosis of annosus root disease will most likely remain difficult in many affected forest stand types. General increased awareness of forest pests through training and intensive forest resource management should also improve the recognition

skills of foresters, silviculturists, and field crews. Field diagnosis skills can be improved by cross-checking signs and symptoms found on hosts with culturing or incubation of suspect material. This is especially true in timber types not yet well investigated for susceptibility to annosus root disease.

Investigators need to look more closely at the role of H. annosum in root disease complexes. Field diagnosis of root disease will frequently miss the presence of H. annosum when other pathogens are present. This pathogen is probably responsible for considerably more damage than has yet been attributed to it.

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