TREE NOTES

CALIFORNIA DEPARTMENT OF FORESTRY AND FIRE PROTECTION

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Annosus Root Disease in California

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What Is Annosus Root Disease

Annosus root disease, caused by the fungus *Heterobasidion annosum*, lives in the butt and roots of commercially important forest trees. The fungus is a facultative parasite; that is, it lives primarily as a saprophyte, but is capable of attacking the living tissue of host trees. The maximum life span of *H. annosum* in a coniferous root system is difficult to estimate, but various reports have indicated that it may reach 60-80 years and is usually much less on small root systems. Other root decay fungi such as *Armillaria* sp., while not as efficient as *H. annosum* in colonizing freshly cut woody substrate, may live much longer in the roots of host trees. However, armillaria is a very different fungus and has other mechanisms for long term survival.

Heterobasidion annosum causes a root rot in most pines, and a butt rot in true firs. Root-rotted trees may be killed within several to many years after infection, while butt-rotted trees like the non-resinous true firs, may be subjected to extensive butt decay and eventual wind throw.

Susceptible Plants

Annosus root disease is found throughout the north temperate regions of the world and is known primarily as a root disease of conifers. This highly destructive disease is found on many conifers and several hardwoods in California. The most seriously affected, commercially important conifers in California, are those of true fir (*Abies*) and pine (*Pinus*). Other coniferous hosts affected in California are hemlock (*Tsuga*), Douglas-fir (*Pseudotsuga*), larch (*Larix*), spruce (*Picea*), coast redwood (*Sequoia*), sierra redwood (*Sequoiadendron*), incense-cedar (*Calocedrus*), and juniper (*Juniperus*). Madrone (*Arbutus menziesii*), red alder (*Alnus rubra*), California live oak (*Quercus agrifolia*) and two hardwood shrubs, manzanita (*Arctostaphylos* sp.) and sagebrush (*Artemisia* sp.), have also been found infected.

What's In A Name

For many years annosus root disease had the scientific name of *Fomes annosus*. Recently the name was changed to *Heterobasidion annosum*. The perfect (sexual) scientific name has been changed several times since the fungus was first described in 1821 by Elias Fries, a Swedish mycologist. These name changes have occurred as newer taxonomic criteria have been developed by researchers, and as genetic relationships between wood decay fungi have become clearer. Originally the fungus was called *Polyporus annosus* and in 1885 changed to *Fomes annosus*. Later, the fungus was renamed *Fomitopsis annosa*, but this name was not accepted by other mycologists and was eventually rejected in favor of the present name. This fungus has been called *Tametes radiciperda* in Europe, and also *Ungulina annosa*. A unique feature of the fungus is the presence of an imperfect (asexual) growth form, formerly called *Oedocephalum lineatum* now *Spiniger meineckellus*. This microfungal form of *H. annosum* can occasionally be spotted in the forest on actively decaying stump wood or roots and in the laboratory after a few days on fresh-collected woody tissue, but unlike the conks of the sexual stage it takes a hand lens to see it.

Spores, Disease Spread & Infection

Spore production can occur any time during the year, but most spores are produced during the moist period of late fall. Both basidiospores (sexual) and conidia (asexual) spores of H. annosum are known to initiate colonization of stumps, butt wounds and roots. Viable spores have been collected in soil up to 36" deep, in particle collectors from high-flying aircraft and from ships at sea. It is thought that spores washing through the soil may account for root infections in stands that have no disease or harvesting history. Fungal growth through soil or litter is not known.

Disease spread can occur locally and over long distances by airborne spores, and through root contact or grafts between infected and healthy trees. Successful infection can occur when spores germinate on a freshly cut, moist surface that is not immediately subjected to drying periods or heat. The fungus may then grow into the butt and roots and attack nearby trees through root grafts and touching roots. Thinned stands are especially vulnerable to annosus attack through stump infection and root-to-root spread. Rate of spread along roots has been reported to range between 0.5-2.1 m/yr.

Stand & Host Appearance, Conks & Decay

Annosus root disease centers enlarge by root-to-root contact, and are often characterized by groupings of dead (interior) and dying (outer) trees surrounding an infected stump. This characterization may be masked by bark beetle attack of stressed trees within and outside of the infection center. However, root disease centers are identified by the characteristics of long term stand effects vs. the usually short term bark beetle outbreaks.

Host appearance often gives visual clues as a sign of root problems. Pines, incense-cedar, and true fir foliar crowns will begin to show signs of stress as roots become invaded and killed. As infection severity increases, foliar crowns tend to become chlorotic, thin and rounded, and appear to "die from the bottom up." Resin-soaking of roots is common in infected pine. Black stain root disease (*Ceratocystis wagneri*) and armillaria root rot (*Armillaria* sp.) may also be found associated with dead and dying pine and must be considered in any annosus root disease diagnosis.

Conks, when present, are usually found at the base of stumps and on roots of pine and may be found internally in fir stumps. Presence of conks is strongly dependent upon consistency of available moisture; as moisture becomes limiting, conks become harder to find. Conks may even be several or more feet deep on roots, or well inside the stump itself.

Decay by this white rot fungus is highly variable depending upon the host species and decay conditions. The earliest sign of infection is an abnormal coloration of affected wood, usually bluish to purple to reddish. Later small elongate white decay pockets, often with tiny black flecks, appear in these discolored areas. In advanced decay the white pockets coalesce leading to a white stringy, delaminated mass of decayed wood.

Identifying Annosus Root Disease

Field identification of *H. annosum* is made by finding conks of the fungus. A delaminating white rot associated with decay caused by this fungus is usually also present. Conks can be of any size from small (popcorn conks) to large (to 8-10 in.). Mature conks are generally shelf-like with a smooth to irregular outline, although on some surfaces the shelf may be much reduced. Conks are poroid on the lower surface; the pore surface is white to yellowish, often appearing to have a golden sheen when held properly to the light. The pores are very small; about 2-3 to occasionally 4 pores per mm. The conk upper surface is tough and corky, and is of various shades of light to dark brown. Resin production may be associated with infections of resinous tree species. Laboratory identification is based on conk and basidiospore characteristics, or finding the asexual Spiniger form on artificial media or on infested wood chips held under high humidity.

Control of Annosus Root Disease

Chemical treatment of the freshly cut stump surface with Sporax® (sodium tetraborate decahydrate, EPA Reg. No. 2935-501) to prevent stump surface colonization is used in California and elsewhere. Sporax® acts as a toxin after leaching into the top several inches of freshly cut stumps and remains effective for several years. It has no eradicative effect on established infections. Recommended guidelines for use of Sporax® with pine in California call for a light application completely covering the stump surface within several hours of tree felling on stumps larger than 8 in. True fir stumps are usually not treated because annosus root disease is often already well established in roots of this host. Sporax® is a registered pesticide and all laws applicable to pesticide use must be followed.

Several factors could render field use of Sporax® less effective. Application of Sporax® to a stump surface during heavy rain could wash off the chemical before it has had time to penetrate and impart fungal toxicity to the stump. Untreated wounds on the stump below the treated area are still possible infection courts as are roots below the soil surface. Sporax® use is more effective in younger stands than in older stands, because trees of younger stands are less likely to have *H. annosum* already on their roots.

Biological control through application of saprophytes or weak pathogens to the stump surface has been practiced in Europe and in the southeastern states. One such fungus that has been used in the United States is *Phlebia* (*Peniophora*) *gigantea*, a vigorous competitor. Spores and mycelial fragments are applied to the freshly cut stump surface to protect against spore-generated colonization of the stumps by *H. annosum*.

A source of silvicultural control may come from knowledge of the kind(s) of *H. annosum* colonies present in the stand of concern. There are at least two non-compatible groups known within *H. annosum*: S and P. The letters stand for the tree genera, spruce and pine, from which they were first identified. This means that within the fungal species, there are two known groups that are reproductively and genetically different and may behave differently as pathogens toward the same hosts. In short, P group members seem more likely to attack pine and other tree genera, while S group members seem more restricted to spruce and true fir. This is a very complex area of active study by researchers in both Europe and the U.S., which hopefully will lead to a better understanding of annosus root disease and disease control recommendations.

Present silvicultural control methods within pine stands includes protecting residual trees from annosus root disease by treating freshly cut stumps with Sporax®. With true fir it is best to encourage maximum stand vigor to attempt to keep root growth ahead of root decay. Prescribed burns, stump removal, soil fumigation, and non-host hardwood planting on infested sites are other control methods that have been used successfully.

The oak root fungus (*Armillaria mellea*) is often associated with annosus root disease. Workers in British Columbia found that *A. mellea* may already be present on the roots of recently felled Douglas-fir and western hemlock, rapidly colonizing the roots to the exclusion of *H. annosum*. Thus the oak root fungus, which is usually looked upon as a harmful pathogen may at times play a beneficial role in the forest ecosystem.

Further Reading

Proceedings of the Symposium on Research and Management of Annosus Root Disease (Heterobasidion annosum) in Western North America. USDA Forest Service. Pacific Southwest Forest and Range Experiment Station. General Technical Report PSW-116. April 18-21, 1989, Monterey, CA.

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