

# Characteristics of Annosus Root Disease in the Pacific Southwest<sup>1</sup>

Gregg A. DeNitto<sup>2</sup>

**Abstract:** Annosus root disease is mainly a concern in pines and true firs in California. It is most serious on the east side of the Sierra Nevada and Cascade crest, in the mountains of southern California, and in higher elevation fir forests. Symptoms caused by the disease include crown decline and decay and resinosis of roots. Several signs of the fungus may be found. Conks are most common in stumps. Mycelial sheets on the inner bark and popcorn conks on thin-barked roots are diagnostic. Declining trees or recent mortality are best for diagnosis. Wood samples should be symptomatic but not well decayed. Laboratory procedures are available to confirm the presence of *H. annosum*.

---

In the southwestern United States, annosus root disease, caused by *Heterobasidion annosum* (Fr.) Bref., in fir and pine forests is primarily a concern in California. However, stands of these species in areas of western Nevada, Arizona, and New Mexico also are affected. Within this broad area, specific forest types in which the disease is likely to be found and may cause damage have been identified. These higher "hazard" areas are identifiable by host species affected and forest type. The disease is prevalent, mainly in pine (*Pinus* spp.), on the east side of the Sierra Nevada and Cascade mountains. A second area in California with higher levels of the disease is in the mountains of the southern part of the state, again mainly on pine, but also on white fir (*Abies concolor* (Gord. and Glend.) Lindl.). This includes the San Bernardino and San Gabriel mountains. A third, broader area is at higher elevations where true firs (*Abies* spp.) are often infected.

In California, the forest types most severely affected are the mixed conifer (Society of American Foresters forest cover type 243), ponderosa pine (SAF 245), white fir (SAF 211), and red fir (SAF 207) types. In Arizona and New

Mexico, the disease is found in the mixed conifer and southwestern ponderosa pine forest types (SAF 237). Not all areas within these forest types are infested, and not all trees within them are highly susceptible to infection. Therefore, each site must be evaluated individually for incidence of the disease.

A wide range of conifer species are host to this fungus. Within forest types, various species are differently affected depending on the isolate of the fungus involved (Otrosina and Cobb 1989). The main commercial hosts affected in California include ponderosa pine (*P. ponderosa* Laws.), Jeffrey pine (*P. jeffreyi* Grev. and Balf.), white fir, red fir (*A. magnifica* Murr.), and incense-cedar (*Libocedrus decurrens* Torr.) (Bega and Smith 1966, Smith and others 1966, Wagener and Cave 1946). Several hardwoods and brush species have been identified as hosts, including Pacific madrone (*Arbutus menziesii* Pursh) (Bullen and Wood 1979), manzanita (*Arctostaphylos* spp.), and big sagebrush (*Artemisia tridentata* Nutt.) (Smith and others 1966).

## FIELD RECOGNITION

### Symptoms and Silts

Some of the symptoms and signs used to recognize annosus root disease are similar among all hosts. Many of them are present regardless of what root disease or root malfunction is present. The emphasis in this paper will be on the symptoms and signs present on the forest tree hosts in California and the characteristics specific to individual host species. In the Pacific Southwest, two groups of trees show distinct symptoms: resinous species, such as pines, and the non-resinous species, including the true firs.

Following infection, annosus root disease usually takes from several to many years to cause tree mortality of pines and true firs. Mortality of pines is more rapid. During this period, an increasing number of roots are killed and most trees begin to exhibit some evidence of crown decline. Gradual reduction in terminal growth is a good indicator. Decreasing leader growth over a period of several years usually indicates a root-related problem. This is more evident in pines than in true firs. A second characteristic

---

<sup>1</sup>Presented at the Symposium on Research and Management of Annosus Root Disease in Western North America, April 18-21, 1989, Monterey, California.

<sup>2</sup>Plant Pathologist, Shasta-Trinity National Forests, Forest Service, U.S. Department of Agriculture, Redding, Calif.

is the loss of older foliage and shortening of younger foliage. The result is an appearance of the crown thinning and the tree generally shows poor vigor. As the disease progresses, branches begin to die. The pattern of crown thinning and branch mortality usually begins in the lower crown and advances upward.

At the other end of the tree, symptoms can be found in the roots. In roots that have been infected for a while, a white stringy rot will be present. Root decay is more commonly found in true firs than in pines. Other fungi can cause a similar type of decay, so this symptom alone is not sufficient to identify annosus root disease. On the outer bark of infected roots, signs of the fungus may be present (fig. 1). These are usually in the form of "popcorn conks," small white to buff-colored cushions of fungal material that erupt between the bark scales. This fungal material is similar to that of mature fruiting bodies and does not tear readily. These popcorn conks are much smaller, however, and do not have any pore surface. Their presence is highly diagnostic for the disease in California. While searching the roots for signs of *H. annosum*, it is useful to be observant for other problems, especially indicators of other root diseases, that cause similar aboveground symptoms.

In pines, resin soaking of roots is indicative of some type of injury, and often it is caused by fungal infection. Copious amounts of resin may be produced and actually infiltrate the surrounding soil. On the wood surface of pine roots, brown streaks may be found that run parallel with the axis of the root. Small silver-to-white mycelial sheets may develop on the inside of the inner bark. These sheets are not thick like mycelial fans, but are small accumulations of mycelia that fill pits in the inner bark.

Root decay is more commonly found in true firs and incense-cedar. Even roots several inches in diameter may be completely decayed before aboveground symptoms become obvious. Stumps of fairly recent origin, infected by *H. annosum*, have a distinct decay pattern. They exhibit laminar decay, usually of the center of the stump or a sector of the center of the stump. Decay of the more recent sapwood is not normally seen, unless the entire stump is involved. Other individual tree symptom characteristics are not diagnostic for annosus root disease in true firs.

Some stand and site characteristics have been identified in true firs where it appears that *H. annosum* is more common. Stands that are relatively pure fir, especially red fir, have a higher incidence of the disease. Dense, older stands with a history of logging also are more likely to be infected. These are discussed in greater detail in other papers in these symposium proceedings (Slaughter and Parmeter 1989).



**Figure 1**--Small, white popcorn conks of *H. annosum* on roots of ponderosa pine seedlings.

#### Field Diagnosis

When trying to detect the presence of annosus root disease it is best to look at recent mortality or trees with advanced symptoms. Older mortality may be too far gone to reveal useful symptoms. I have found that the best type of tree to examine is a declining or recently dead seedling or sapling, if available. This is true for pines and firs. Because of their smaller roots, symptoms seem to advance to the root collar more rapidly. Also, the smaller roots have thinner bark, and popcorn conks and other symptoms are easier to find. More of the root system can be dug up and examined when a tree is smaller. Lastly, digging up a small tree is a lot easier than digging up a big tree. If a sapling is not available, a main lateral root must be excavated and examined for two to three feet outward from the bole.

After examining the total stand, mortality pockets, and individual trees, if another cause has not been identified and indicators suggest annosus root disease, it is time to become a

stump buster and look for conks. It is not worth the effort to try to break up hard stumps of pines, unless only the surface is case hardened and it is obvious that there are decay pockets within the stump. More recently cut stumps of pines that have not started to decay may have fruiting bodies of *H. annosum* in the wood-bark interface, if they have them at all. Peeling the bark off these stumps may be fruitful. Stumps that have decayed may have conks in decay pockets within the stump where there are higher moisture levels. In California, only rarely do we find conks exposed above ground around the root collars of trees.

Conks occur in a variety of sizes, shapes, and stages of development. On pines, they are usually attached to relatively solid wood and not on wood that is already decayed. Pulling decayed wood away from these solid columns in a stump often reveals conks, especially popcorn conks. In true firs, annosus root disease produces a heart rot, and conks usually can be found in the hollow center of stumps. Removing some decayed wood in the center of these stumps or just looking into them when they are hollow often reveals conks.

The time of year often determines the ease of finding and the condition of conks. Fresh, well-developed conks are usually found in the spring and early summer when moisture levels are high. Later, as stumps dry out, one has to dig deeper into the stump and conk remnants may be easier to find than fresh ones. Conk remnants may be the only signs of the pathogen that are present. They can be recognized by their chocolate brown color, characteristic nonporoid margin, and pores on the lower surface. Elevation also influences the ease of finding conks. At higher elevations, fresh conks can be found later in the growing season because stump drying is delayed.

#### Laboratory Diagnosis

In some cases, definitive evidence of annosus root disease cannot be found. From your experience, however, you feel quite certain that it is present. At these times, you may need to involve a forest pathologist who can perform the necessary laboratory work. What is done in the laboratory is not a secret or necessarily difficult, but does require a microscope and drawings or pictures of what to look for. If you can get a forest pathologist on the site, do so, and let them collect the material that they consider most useful. The alternative is to collect some suspicious roots and send them to the appropriate laboratory. The following are some general suggestions. Collect woody tissue from declining or recently dead trees. Do not collect from older dead trees or rotted wood. It is usually more productive to find roots that are still solid, but have symptoms or signs of infection, such as resinosis, mycelial felts, or brown streaking. Collect root segments 8 to 12

inches (20 to 30 cm) long, shake off the loose soil, wrap them in newspaper, and mail them as soon as possible. Do not let them dry out or expose them to the sun. If all goes well, you should expect an answer within 3 to 4 weeks. A negative result does not necessarily indicate the absence of annosus root disease, but it may suggest the need for a visit by an experienced forest pathologist.

When root samples are received at the laboratory, two methods can be used to determine whether *H. annosum* is present. The first of these methods is the use of standard isolation techniques on artificial media. Semi-selective media are available for isolating the fungus (Hendrix and Kuhlman 1962). Wood chips from symptomatic tissue are plated on the media and incubated for 1 to 2 weeks (fig. 2). Conidiophores of the imperfect stage of the fungus are produced on the surface of the media and on the wood chips. The second method involves washing the woody tissue samples with water and incubating them. Incubation involves wrapping the woody tissue in some material that holds moisture---moist newspaper is ideal---and keeping them moist in plastic bags. After incubation for 7 to 10 days at room temperature, examine the material for the presence of the imperfect stage of *H. annosum* (fig. 3).

The imperfect stage is *Spiniger meineckellus* (Olson) Stalpers (syn. *Oedocephalum lineatum* Bakshi) (fig. 4). The appearance of *S. meineckellus* is distinctive and after some experience can be recognized under a stereoscope. This fungus produces hyaline conidiophores with globose heads of dry conidia. The hyaline



**Figure 2**--Six-week-old culture of *S. meineckellus* on potato dextrose agar.

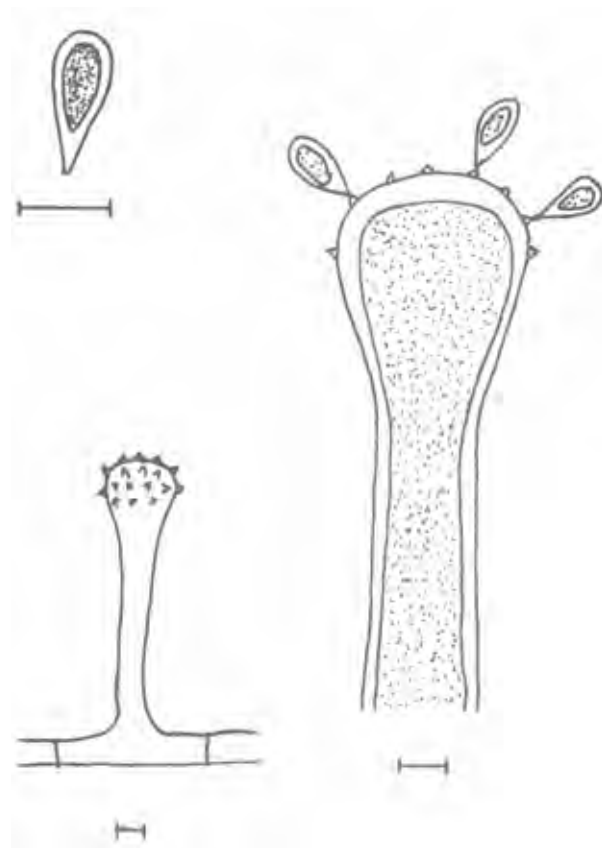


**Figure 3**--Cross-section of white fir incubated for H. annosum. White conidiophores produced around decay column.

conidia are borne on spines on the naked head of the conidiophore. The conidia are 4-8 by 2.5-5  $\mu\text{m}$ . After the spores fall, the spiny heads are quite distinctive and recognizable, although magnification stronger than a stereoscope is necessary. In pines, conidiophores of the fungus are usually found in the sapwood and near the cambium. In the true firs, the fruiting structures can be found anywhere on the woody surface, especially around decayed areas.

#### CONCLUSION

One should not go out into a forest with the intention to diagnose annosus root disease. When you need to make a pest diagnosis, you should do just that. Look at the situation from a broad perspective and use a methodical approach. Examine the stand and site conditions to determine overstocking or low site quality. Decide what insects, pathogenic organisms, and animals are, or have been, present. Evaluate which of these may have caused the type of damage you observe. Do not expect just one organism to be involved in the damage. They often combine forces to overcome a tree.



**Figure 4**--Conidiophores and conidia of S. meineckellus, imperfect stage of H. annosum. Each scale bar = 5  $\mu\text{m}$ .

When you are comfortable with diagnosing pest situations, you may be able to take shortcuts and more readily find the cause. This is true with annosus root disease. In certain areas, such as the eastside pine forests, this disease produces rather characteristic symptoms and you may be able to determine its presence and involvement quickly. However, do not be comfortable in looking at typical aboveground symptoms and determining that annosus root disease is involved. Get down in the dirt and expose some roots. Break apart a stump. Try to find more conclusive evidence of the fungus on the site to confirm your suspicions.

#### REFERENCES

- Bega, Robert V.; Smith, Richard S., Jr. 1966. Distribution of Fomes annosus in natural forests of California. Plant Disease Reporter 50: 832-836.
- Bullen, Susan.; Robert E. Wood. 1979. Fomes annosus on Pacific madrone. Plant Disease Reporter 63: 844.

Hendrix, F.F., Jr.; Kuhlman, E. George. 1962. A comparison of isolation methods for Fomes annosus. Plant Disease Reporter 46: 674-676.

Otrosina, William J.; Cobb, Fields W., Jr. Life cycle, infection biology, ecology, and host specificity in Heterobasidion annosum. 1989 [These proceedings].

Slaughter, G.; Parmeter, John R., Jr. True fir and annosus root disease in California national forests: losses, stand, and tree characteristics. 1989 [These proceedings].

Smith, Richard S., Jr.; Bega, Robert V.; Tarry, Jerry. 1966. Additional hosts of Fomes annosus in California. Plant Disease Reporter 50: 181.

Wagener, Willis W.; Cave, Marion S. 1946. Pine killing by the root fungus, Fomes annosus, in California. Journal of Forestry 44: 47-64.