

**Management  
Strategies—  
Survey,  
Detection, and  
Control**

# Annosus Root Disease Hazard Rating, Detection, and Management Strategies in the Southeastern United States<sup>1</sup>

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Abstract: Annosus root disease (ARD), is the major root disease of pines in the southeastern United States where severely affected trees exhibit growth loss. Assessing the potential damage of ARD is essential for making effective disease control and management decisions. A soil hazard rating system developed to identify potential for tree mortality is described. The Annosus Sampling Procedure accurately estimates the severity of ARD within a stand. The GY-ANNOSUS computer program estimates growth loss caused by ARD. ARD management strategies are discussed.

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Annosus root disease (ARD), which is the major root disease of pines in the southeastern United States, is most severe in thinned plantations and stands. Thinning creates fresh stump surfaces and root wounds which are points of entry for *Heterobasidion annosum* Bref., the fungus that causes ARD. Severely affected trees grow at a slower rate and are more susceptible to bark beetle attack. Tree mortality tends to occur in localized areas, although the disease may occur throughout severely affected stands. ARD tends to be most severe on well-drained soils. Determining the amount of ARD present in a stand is essential for making effective disease control and management decisions.

In the southeastern United States, symptoms of ARD are for the most part similar to those for any stressed pine tree. Severely affected trees may have thin, light green to yellow crowns, with

tufted branches and short needles. Windthrown trees may be present in affected stands, especially on deep, sandy soils. Most infected trees show no detectable symptoms. Signs of ARD are basidiocarps (often called conks) of the pathogen produced at the base of infected trees or stumps. Conks may be small and difficult to locate unless the duff layer is removed from around the tree or stump. Most infected trees, however, do not produce conks, which are the source of the airborne spores that infect freshly cut stump surfaces. After spore germination, the fungus grows down through the stump and roots, and infects standing trees through root contacts. Wounded roots close to the soil surface also may be infected by spores in the soil. Infected roots initially become resin-soaked and brownish-red. Later, these infected roots become a white, stringy mass of decayed tissue.

The most critical factor in estimating disease incidence and severity within populations of plants is the accuracy of the survey and effectiveness of the detection methods. This is particularly true when working with a root disease of forest trees, because areas are extensive and samples are often large and difficult to collect.

A cursory method of determining the incidence of *H. annosum* in pine stands was used in several major surveys to measure the incidence of infection by *H. annosum* (Powers and Verrall 1962; Powers and Hodges 1963). This method, based upon the observation of basidiocarps of the fungus at the base of infected trees, found that 2.8 percent of the loblolly pines examined within 120 plots from Virginia to Texas were found to be infected (Powers and Verrall 1962). A more direct sampling method was used by Ginns and Gillespie (1962) and later was tested extensively by Cordell and Stambaugh (1966). They used an increment borer to remove four core samples from the root collar of suspect trees and plated out the cores on culture media. This method was used for the determination of disease incidence in

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living trees in 12 plots ranging in size from 0.10 to 0.20 acres (0.04 to 0.08 hectare). A total of 392 trees were sampled of which 254 were white pine (*Pinus strobus* L.), 54 were loblolly pine (*P. taeda* L.), and 15 were red pine (*P. resinosa* Ait.). The increment core method of sampling indicated approximately an 11 percent increase in recovery of *H. annosum* over the use of pathogen signs alone.

A similar study on 71-year-old Norway spruce (*Picea abies* (L.) Karst.) (Dimitri 1970) compared the isolation efficiency from core samples removed by the increment borer method to samples taken from trunk disks. All samples were taken at the 50 centimeter height on the stems of spruce. The disks were removed after felling. Results showed that where increment core sampling procedures indicated only 40 percent of the trees were infected, isolations from trunk disks showed that 85 percent of the 256 trees sampled were infected.

Results of another study that involved the sampling of borax- or urea-treated stumps showed that culture plating of chips removed from individual roots did not significantly change the percent recovery of *H. annosum* over results obtained with the increment core technique (Artman and others 1969). However, isolation of the pathogen from the roots of check (untreated) stumps demonstrated a nearly threefold higher detection of the pathogen by the root chip isolation method than by the increment core isolation method. Alexander and Skelly (1973) compared the methods used for surveying the incidence of ARD in loblolly pine stands. A total of 79 trees were evaluated. The methods compared were: 1) to count conks, 2) to extract and culture increment core samples (two per tree) from the root collar zone, and 3) to remove 18 inch sections of two primary roots and make isolations from the samples. The results were, respectively, 2.5, 10.1, and 31.6 percent trees infected. In other studies, that involved the excavation and sampling of root systems, the average incidence of ARD was 80 percent. Assuming the 80 percent number to represent the actual level of infection, the lower percentages detected by the other methods show how little of the actual ARD was detected. Without doubt, the current estimates of the impact of ARD on pine forests in the southeastern United States are low.

Tree mortality is the most visible result of annosus root disease, and for many years it was considered to be the

only impact of ARD on southeastern pine forests. Morris (1970), for instance, described timber volume losses caused by this disease on several sites by measuring only dead trees. Growth losses sustained by infected living trees were not considered. Alexander and Skelly (1973) provided the first evidence of the potential impact of ARD on the radial growth of loblolly pine. Alexander and others (1975) demonstrated that loblolly pines infected by *H. annosum* produced 19 percent less radial growth during the preceding 5 years in thinned, coastal plain plantations. Alexander and others (1981) later reported that loblolly pines in southern pine beetle (SPB)-infested plots, with an average ARD incidence of 65 percent and an average ARD severity (percentage of roots colonized by *H. annosum*) of 23 percent, produced 6 percent less radial growth during the preceding 10 years than control plots with an average ARD incidence of 73 percent and an average ARD severity of 11 percent. Between SPB-infested trees (54 percent ARD severity) and SPB-uninfested trees (11 percent ARD severity), the SPB-infested trees grew 20 percent less for the preceding 10 yrs than the SPB-uninfested trees. Trees infected by *H. annosum*, regardless of SPB presence, produced 36 percent less radial growth than noninfested (healthy) trees during the preceding 10 years. Bradford and others (1978) excavated the root systems of 25 loblolly pine trees in 14 thinned plantations and measured their infection by *H. annosum*. The average ARD incidence was 85 percent and the average ARD severity was 30 percent. The majority of the trees showed no above-ground symptoms or signs. Trees infected by *H. annosum* produced 19 percent less radial growth (the same as reported by Alexander and others 1975) during the preceding 5 yrs than noninfested (healthy) trees. Three plots were on intermediate ARD hazard soils; the average ARD incidence level was 70 percent with a severity level of 33 percent. Froelich and others (1977) evaluated 65 slash pines for ARD in one thinned plantation and found a 20 percent reduction in radial growth of trees with greater than 50 percent of their root system colonized by *H. annosum* and a 40 percent reduction in height growth 6 years after thinning.

#### SOIL HAZARD RATING SYSTEM

Morris and Frazier (1966) developed a field hazard evaluation system based on soil characteristics which identified soils associated with high mortality

caused by ARD. Froelich and others (1966) identified the characteristics of healthy and high ARD plantations. In an examination of high- and low-hazard disease sites Alexander and others (1975) measured 14 soil parameters at depths of 10 to 20 centimeters. Sand, porosity, organic matter, and field capacity had the highest correlation when compared with disease incidence. Because of the simplicity and ease of use, the soil ARD hazard system has been extensively used, and misused, in the southeast. Many have assumed that ARD is a problem only on high ARD hazard soils. This belief is unfounded because most southern pines can be significantly infected and show no outward sign of the disease. We now know that ARD can reduce growth without causing any outward signs of infection.

Tree mortality and to some extent high disease incidence are associated with: (1) high sand content, (2) high percentage of noncapillary pores, (3) high soil bulk density, (4) low organic matter, (5) a deep A-horizon, (6) a low water table, and (7) dense grass or similar vegetation cover. The most important independent variables are sand content, organic matter, and water table depth (Alexander and others 1975).

Low ARD caused mortality is related to (1) high clay content, (2) high percentage of capillary pores, (3) high organic matter, (4) ground cover, (5) a high water table.

#### ARD Hazard Rating

Low	- clay and clay loams
Intermediate	- loams and silt loams
High	- sandy loams, loamy sands, and sands

Soil Saturation--If the soil is saturated for 2 months, or if the soil shows indications of poor drainage at 18 inches (46 centimeters) or less, the soil is low hazard, regardless of texture.

Clay Content--If field examination shows that clay is detectable at 10 inches (25 centimeters) or less, the soil ARD hazard rating is intermediate to low for ARD.

Soil ARD hazard rating was developed and utilized only to identify the potential for tree mortality. It should be used only as a general guide to the potential impact of ARD in thinned pine stands. For example, in an evaluation of Forest Inventory and Analysis plots in

the southern piedmont area, a low ARD hazard soil type, an estimated 30 percent of the trees had ARD (Alexander, unpublished data)<sup>3</sup>.

#### ANNOSUS SAMPLING PROCEDURE

The Annosus Sampling Procedure (ASP) provides an objective approach to estimating ARD severity in a stand of trees (Alexander and Anderson 1985). The ASP was developed from data collected in Virginia, Alabama and Mississippi. The percent severity from the ASP plots were compared, in the same plantations, with two or three systematically placed 1/20th acre (0.02 hectare), circular plots in which all the plot trees were excavated and their root systems were measured for infection. The ASP estimates ARD severity to within 10 percent of the baseline estimate at P = 0.05.

Two methods may be used for the ASP: the 20-plot method and the variable-plot method. With the 20-plot method, 20 sample plots are systematically distributed within the stand and sampled. With the variable-plot method, 10 plots are systematically distributed within the stand, the data are collected, and the degree of variation is calculated. Once the variation between the 10 plots is known, the number of plots needed to support the probability level required for any particular operation can be calculated. The advantage of the variable-plot method is that usually fewer plots are required to obtain the necessary level of probability. With the 20-plot method, however, only one pass is required.

Once a plot center has been located, the actual sampling point is moved to a position that maximizes the number of tree root systems sampled. Sampling begins with the removal of the duff layer over an area 12 inches (30.5 centimeters) square. A 1 cubic foot (0.028 cubic meters) sample of soil is removed for evaluation. All pine root segments 1/8 inch (0.317 centimeters) in diameter or larger are separated, counted and examined for typical symptoms of ARD: resin soaking and a stringy white rot. Roots with other symptoms, or which are symptomless, are classed as noninfected.

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The sampling process is repeated at each of the plots, and the results are averaged to provide an estimate of the severity of ARD in the stand.

#### Outline of ASP

1. Determine stand size.
2. Decide on plot location (establish a systematic grid distribution to represent the entire stand).
3. At each plot location, adjust sample location to obtain roots from the maximum number of trees (try to include three or four dominant or codominant trees each within 15 feet (4.6 meters) of plot center).
4. Remove 1 cubic foot (0.028 cubic meters) sample of soil and roots with a shovel.
5. Separate the pine root segments from the soil and examine them for symptoms of ARD.
6. Record the total number of root segments and the number of segments with symptoms of ARD.
7. If the GY-ANNOSUS growth and yield model is selected, collect additional data on (a) site index (base age 25 years) (b) current stand age, and (c) pine basal area.
8. Repeat steps 1-7 for all 20 plots.
9. Sum the infected and noninfected root segments from all plots and calculate the mean annosus root disease severity percentage for the plantation.

It may be advantageous to conduct a timber cruise as part of the ASP. By so doing, only one pass through the stand is necessary; standard cruise data can be collected along with such things as mortality, the presence of other diseases and insects, e.g. fusiform rust and the southern pine bark beetle; and increment cores for determining the rate of radial growth may also be taken at this time.

The GY-ANNOSUS PROGRAM (Fanelli and others 1984) (a computer program for the Apple II series) allows the manager to project the growth of the thinned pine stand. Program outputs compare year-by-year yields of diseased and

disease-free stands. If values cannot be determined for cubic-foot yields, the percent reductions can be applied to your own timber merchandising table or tree diameter distribution model.

The decision whether to thin a commercially managed timber stand is based on the expectation of a predicted improvement in yields resulting from an improved yield of merchantable volume and early returns on reforestation investment. The model allows a forest manager to estimate the shortfall of these predicted yields and to adjust the management strategy for the infected stand accordingly. Further, the model can be used to simulate the potential investment impact of not treating stumps to prevent infection. Thus, management guidelines can be developed to account for both the biological conditions and the economic factors affecting a particular loblolly pine stand.

#### MANAGEMENT RECOMMENDATIONS

##### Treatments

Chemical and biological controls have been used effectively in preventing the spread of ARD (Kuhlman and others 1976).

Chemical--granular borax applied to stumps immediately after cutting is effective in preventing infection through stump surfaces. Borax offers no below-ground protection. Treated stumps may still become infected through root contacts with infected untreated stumps. Borax treatment is not effective in stands severely infected with ARD.

Biological Control--*Phlebia gigantea* is a vigorous fungal competitor of *H. annosum* and has been used effectively as a biological control on infected stands when applied in a spore suspension spray.

##### Regeneration Areas

###### High Hazard Sites

Use wide spacing to delay the thinning date. Consider longleaf pine, which is somewhat less susceptible. Site can be regenerated immediately after harvest.

###### Low Hazard Sites

Use normal management practices.

## Existing Stands

### Plantation or Natural Stands

#### High ARD Hazard Sites

- a) > 30 percent ARD - Do not thin; either harvest now or when practical.
- b) 10 - 30 percent ARD - Treat new stumps with *Phlebia gigantea*.
- c) < 10 percent ARD - Use borax on all new stump surfaces.

#### Low ARD Hazard Sites

#### ARD-Related Tree Mortality Present--

- a) > 30 percent ARD - Do not thin; either harvest now or when practical.
- b) < 30 percent ARD - Treat new stumps with *P. gigantea*.

#### No ARD-Related Tree Mortality Present--

- a) Normal management.

## Seed Orchards

#### High ARD Hazard Sites

Remove stumps and treat remaining roots with *P. gigantea*. Minimize traffic in orchard. Use herbicides within row to reduce mowing damage.

#### Low ARD Hazard Sites

Always treat fresh stumps with borax.

## Recreation and Other High Value Areas

- > 10% ARD - Treat new stumps with *P. gigantea*.
- < 10% ARD - Always treat new stumps with borax.

## SUMMARY

Losses in southern pines to ARD include both the obvious tree mortality and the more insidious growth loss. Present management practices risk serious errors by not treating the stumps from thinning on high ARD hazard sites to prevent the disease. Costs of prevention are offset by increased growth and reduced mortality. The use of microcomputer software facilitates the analysis by forest managers and consultants by allowing the financial and biological assumptions for each situation to be evaluated.

Several points should be noted concerning ARD in pines in the southeastern United States. It has been

almost 30 years since the only extensive survey for and evaluation of ARD was made. The techniques used in that survey, although considered to be the best available at the time, have since been found to be insufficient for accurately estimating ARD infection levels. Since that survey, we have found that ARD can cause reduced growth without producing any signs or symptoms of infection, and that, in many circumstances, bark beetle damage increased significantly in the presence of ARD. ARD stresses trees in a way that often makes the primary cause of the disorder appear to be bark beetles, air pollution, drought, or poor site conditions. All of these factors make it even more important that accurate and effective techniques and procedures be used for estimating the severity and impact of ARD in pine stands in the southeastern United States. A forest manager who can not accurately measure whether root disease is present often concludes that he has no problem.

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## REFERENCES

- Alexander, S.A.; Anderson, R.L. 1985. How to: identify and control annosus root rot in the south. Forestry Bull. R8-FB/P 19. U.S. Department of Agriculture, Forest Service, Southern Region.
- Alexander, S.A.; Skelly, J.M. 1973. The effect of *Fomes annosus* infection on diameter growth of *Pinus taeda* L.: An initial report. In: Proceedings IV Conference on *Fomes annosus*. Southeast. Forest Experiment Station, U.S. Department of Agriculture; September 17-22, 1973. Asheville, NC. pp. 30-40.
- Alexander, S.A.; Skelly, J.M.; Morris, C.L. 1975. Edaphic factors associated with the incidence and severity of disease caused by *Fomes annosus* in loblolly pine plantations in Virginia. Phytopathology 65: 585-591.
- Alexander, S.A.; Skelly, J.M.; Webb, R.S. 1981. Effects of *Heterobasidion annosum* on radial growth in southern pine beetle-infested loblolly pine. Phytopathology 71: 479-481.

- Artman, J.D.; Frazier, D.H.; Morris, C.L. 1969. *Fomes annosus* and chemical stump treatment in Virginia--A three year study. Plant Disease Reporter. 53:108-110.
- Bradford, B.; Skelly, J.M.; Alexander, S.A. 1978. Incidence and severity of annosus root rot in loblolly pine plantations in Virginia. European Journal of Forest Pathology 8: 135-145.
- Cordell, C.E.; Stambaugh, W.J. 1966. Increment core sampling reveals more *Fomes annosus*. Plant Disease Reporter 50: 589-592.
- Dimitri, L. 1970. Valuation of butt rot of spruce by boring cores. In: C.S. Hodges and others, eds. Proceedings of the 111 International Conference on *Fomes annosus*. Aarhus, Denmark. Ashville, N.C. Southeastern Forest Experiment Station, U.S. Department of Agriculture. pp. 13-15.
- Fanelli, E.S.; Hokans, R.H.; Alexander, S.A. 1984. Cubic-Foot Volume Projection for Thinned Loblolly Pine Plantations on High Annosus Hazard Sites (GY-ANNOSUS) version 1.0. School of Forestry and Wildlife Resources, Virginia Polytechnic Institute and State University. Blacksburg, Virginia.
- Froelich, R.C.; Dell, T.R.; Walkinshaw, C.H. 1966. Soil factors associated with *Fomes annosus* in the Gulf States. Forest Science 12(3): 356-361.
- Froelich, R.C.; Cowling, E.B.; Collicott, L.V.; Dell, T.R. 1977 *Fomes annosus* causes substantial loss in growth of planted slash pine. Forest Science 23: 299-306.
- Ginns, J.A.; Gillespie, W.H. 1962. *Fomes* root rot found in five thinned native white pine stands in West Virginia. Plant Disease Reporter 46: 734.
- Kuhlman, E.G.; Hodges, C.S. Jr.; Froelich, R.C. 1976. Minimizing losses to *Fomes annosus* in the Southern United States. Forest Service Research Paper SE-151. U.S. Department of Agriculture Southeastern Forest Experimental Station. Asheville, North Carolina.
- Morris, C.L. 1970. Volume losses from *Fomes annosus* in loblolly pine in Virginia. Journal of Forestry 68: 283-284.
- Morris, C.L.; Frazier, D.H. 1966. Development of a hazard rating for *Fomes annosus* in Virginia. Plant Disease Reporter 50: 510-511.
- Powers, H.R., Jr.; Verrall, A.F. 1962. A closer look at *Fomes annosus*. Forest Farmer 21: 8-9; 16-17.
- Powers, H. R., Jr.; Hodges, C. S. 1963. Annosus root rot in eastern pines. Forest Pest Control Leaflet 76: 7p. U.S. Department of Agriculture.