# REASSESSMENT OF LOBLOLLY PINE DECLINE ON THE OAKMULGEE RANGER DISTRICT, TALLADEGA NATIONAL FOREST, ALABAMA'

Nolan J. Hess, William J. Otrosina, John P. Jones,
Arthur J. Goddard, and Charles. H. Walkinshaw[2]

**Abstract**—Loblolly pine (*Pinus taeda* L.) decline has been a management concern on the Oakmulgee Ranger District since the 1960's. The symptoms include sparse crowns, reduced radial growth, deterioration of fine roots, decline, and mortality of loblolly pine by age 50. Reassessment of the decline sites began in May of 1998 in order to evaluate the cause of the decline/mortality complex and to re-evaluate management optlona Fifteen variable radius plots were established on four compartments, representing five declining stands. Three dominant/co-dominant symptomatic trees were selected from each plot for root sampling and data collection. Two primary lateral roots were excavated from each sample tree and the flne roots examined and sampled. Root samples were placed on selective media for Isolation of *Heterobasidion annosum*, *Phytophthora cinnamomi*, *Pythium* spp. end *Leptographium* species. *Pythium* spp. and *Phytophthora cinnamomi* were recovered from the fine mot samples of all 15 plots. *Leptographium* spp. were recovered from the primary lateral root samples of 7 of the 15 plots. No *H. annosum* was found in any of the root samples. Littleleaf disease appears to be the primary cause of the loblolly dedine symptoms and mortality. Management options on these sites include managing for loblolly pine on shorter rotations of 50 years, or accelerating harvest of damaged stands with conversion to longleaf pine type and fertilization to mitigate root disease.

## INTRODUCTION

The Oakmulgee Ranger District is part of the Talladega National Forest. It is located in portions of six west-central Alabama counties with the district office at Centreville, 35 miles south of Tuscaloosa. AL The Ranger District consists of 158,000 acres, of which approximately 99,000 acres are pine forest type. The dominant forest type in the presefflement era was longleaf pine (*Pinus palustris* Mill.), which was extensively cut over and the land cultivated prior to establishment of the Taliadega National Forest (Johnson 1947). During the 1930's forest practice emphasized watershed protection and much of this area was regenerated to loblolly pine(*Pinus taeda* L).

The Oakmulgee Ranger District fails within the Upper Gulf Coastal Plain province and during the 1940's and 50's, surveys found extensive damage to shortleaf pine (*Pinus echinata* Mill.) stands caused by littleleaf disease. The disease is associated with *Phytophthora cinnamomi* Rands and soils with poor internal drainage (Campbell and Copeland 1954, Roth 1954). The first reports of declining lobloliy pine on the Talladega National Forest were in 1959. Symptoms included short, chlorotic needles, sparse crowns, and reduced radial growth in the 40 to 50 year age class. Mortality *occurred 2 to 3* years after symptom expression.

In 1988, a 5-year study was established on twenty-four 1/4-acre plots on the Oakmulgee Ranger District to determine the cause, rate of decline, and degree of the mortality of loblolly pine stands (Brown and McDowell 1988). Further evaluations of the 24 plots were concluded in 1978. Results of these studies did not confirm a specific pathogen as the causal agent: however, several important observations were made. Decline symptoms appeared at approximately age 50, but lateral and fine mot deterioration preceded the presence of foliage symptoms of decline. *Heterobasidionannosum* (Fr.) Bref. and *P. cinnamomi* were recovered from *some* of the plots but annosum root disease and littleleaf d&ease were not implicated as the primary cause of the decline. The conclusions from the evaluation and follow-up study indicated reductions in growth of lobloliy pine by age 50 and that site conditions and a combination of other interactions caused the dedine and mortality. Recommendations were to reduce rotation age of loblolly pine from 70 to 80 years on these sites, maintain a basal area of 80 to 70 $ft^2$ per acre, and convert these stands to longleaf pine (Loomis 1978).

For the past 15 years, the Oakmulgee Ranger District has converted an average of 1,000 acres per year of these sites to longleaf pine. but there are approximately 40,000 acres of loblolly pine decline/dieback sites remaining. These sites have an estimated loss of 12 mmbf per year due to mortality and reduced growth. There are an additional 10,000 to 20,000 acres of similar sites and conditions on the Shoal Creek and Talladega Ranger Districts.

The National Forests in Alabama have recognized that the complexity of managing these sites within the scope of ecosystem management, wildlife habitat needs, and enhanced regulatory compliance has greatly affected their ability to restore the desired future conditions consistent with sustainable ecosystems. Forest Heal'h Protection, Alexandria Field Office; Southern Research Station, Tree Root Biology Unit In Athens, GA, and National Forests in Alabama implemented a field evaluation of four compartments on the Oakmulgee Ranger District in May 1998, This paper presents the results of the field evaluation and discusses biological limitations present on these decline sites.

---

[1] Paper presented at the Tenth Biennial Southern Silvicultural Research Conference, Shreveport, LA, February 16-18, 1999.

[2] Plant Pathologist, USDA Forest Service, Forest Health Protection, Pineville, IA 71360; Supervisory Research Plant Pathologist, USDA Forest Service, Southern Research Station, Athens. GA 30602; Professor, Department of Plant Pathology, Louisiana State University, Baton Rouge, LA 70893; Soil Scientist, USDA Forest Service, National Forests in Alabama, Montgomery, AL 36107; and Emeritus Scientist, USDA Forest Service, Southern Research Station, Pineville, LA 71360. respectively.

## METHODS

Oakmulgee Ranger District personnel selected four compartments that included five stands representing a range of loblolly decline/dieback symptoms. The five stands represented 135 acres on which 15 randomly placed 10-factor prism plots were established. The three dominant/co-dominant symptomatic trees nearest plot center were selected for root sampling and data collection. Two primary lateral roots were excavated from each tree for fine root and lateral root samples. Root samples were put in plastic baggies and placed in an ice chest for transport to laboratories for isolation of pathogenic fungi. Additional root samples were collected from two stands by pushing over six trees with a dozer. Random samples were taken from the whole root mass of these trees.

Data were collected in each plot and included tree measurements, site information, and soil profiles. Species, diameter at breast height (d.b.h.), age, 5- and 10-year growth increments were collected from each of the root-sampled trees. Site descriptions included pine basal area and total basal area (10-factor *prism*), and a soil profile description.

### Pythlaceous Fungal Assay

Isolations and identifications of pythiaceous fungi ware conducted at Louisiana *State* University Agriculture Canter. Portions of the 225 pine feeder root samples were cut into 1-cm pieces, surface sterilized in a 10 percent commercial bleach, 10 percent 95 percent ETOH and 80 percent $H_2O$ for 1 minute, and rinsed with distilled water. Ten i-cm root pieces per plot sample were plated on the following selective media: PARPH medium (Pimaricin 5 mg; Sodium Ampicillin 250 mg; Rifampicin 10 mg in 1 ml DMSO; PCNB 25 mg in 5 ml of 95 percent ETOH; Hymexazol 50 mg of 70 percent WP), which is selective for *P. cinnamomi*, and PV medium (Vancomycin 300 mg/1 ; Pimaricin 0.4 mls of 2.5 percent SOLN/1 ; PCNB 25 mg in 5 ml 95 percent ETOH), which is selective for *Pythium* species.

### *Leptographium* and *H.* annosum Isolations

The primary lateral root samples were transported to the Tree Root Biology Laboratory in Athens, GA to determine the presence of *H. annosum* and *Leptographium* species.

Lateral woody mot samples from each plot ranged from 2 to 6 cm in diameter. The root samples were cut into 10-cm long segments and surface sterilized by dipping in 95 percent ethanol followed by brief flaming. The outer bark was then removed and pieces of root wood from each sample were plated onto 1.25 percent malt extract agar (12.5 g malt extract broth and 17 g agar per L of distilled water) or 1.25 percent malt extract agar amended with 200 ppm cycloheximide. The latter medium is selective for Ophiostomoid fungi. Plates were left to incubate on a laboratory bench at 22 °C for approximately 10 days or until fungal growth was observed. Ophiostomoid fungal presence was recorded after viewing cultures growing on either medium under a stereomicroscope.

### Soil Profile

A soil profile was described at the center of each of the 15 plots (Art Goddard, Soil Scientist for the NF's in Alabama). The profiles were established by coring with a 3-in. diameter bucket auger down to 60 In. (National Cooperative Soil Sampling Standards). Soil color description were compared to the Munsell color charts.

### Soil Analysis

One-pt soil samples were collected from the top 12 in. of each profile core from the 15 plots. Air dried and screened (4-mm mesh), soil samples were then sent to a commercial soil testing laboratory (A&L Analytical Laboratories in Memphis, TN) for nutrient analysis.

### Histology of Fine Root Pieces

Random samples of unwashed fine roots were taken from each plot and placed in formalin/acetic add/alcohol fixative (FAA) and left for 14 days (Sass 1951). Fixed root specimens were cut to 1 to 3 mm, dehydrated in an alcohol series, embedded In paraffin, and sliced into 7- to-10 $\mu$m transverse sections. Slides ware stained with a variety of schedules, including Papanicolaou's hemotoxylin-eosin or an acid-Schiff procedure (Hass 1980): Stained sections were then observed under a compound microscope and evaluated for signs of abnormalities.

## RESULTS

The average range of (d.b.h.) for the trees sampled were 9.1 to 14.3 in. (table 1). The stand age for the four compartments ranged from 43 to 58 years. Stand density ranged from 37 to 55 ff. for pine and total basal area ranged from 40 to 57 ft$^2$. The average 5-year growth increment for these sites ranged from 8 to 10 mm and 10 year growth was 16 to 20 mm.

Table 1—Range of growth and age

| Stand data/averaged by compartments | Average d.b.h. | Age | Growth increment | | Basal area | |
|---|---|---|---|---|---|---|
| | | | 5 years | 10 years | (10 *factor*) | Total |
| | ---- *Inches* ---- | | ------ *mm* ------ | | ----- *Sq. ft.* ----- | |
| C-20, stands 29 & 25 | 9.1 | 56 | 10 | 19 | 55 | 55 |
| *C-137*, stand 6 | 13.2 | 51 | 8 | 16 | 43 | 50 |
| *C-125*, stand 10 | 13.1 | | 9 | 19 | 45 | 45 |
| C-128, stand 28 | 14.3 | 53 | 10 | 20 | 37 | 40 |

Table 2—Recovery of pathogenic fungi from root samples by plot and soil series

| Comp/plot # | Soil series | *Pythium* spp. | *P. cinnamomi* | *Leptographium* Yes | *Leptographium* No |
|---|---|---|---|---|---|
| | | Percent | | | |
| GPO/plot 1 | Smithdale, fine sandy loam | 70 | 10 | | X |
| C-20/plot 2 | Smithdab, fine sandy loam | 40 | 10 | | X |
| C-20/plot 3 | Saffell, gravelly sandy loam | 85 | 40 | | X |
| C-20/plot 4 | Maubila, sandy loam | 55 | 38 | | X |
| C-137/plot 1 | Smithdale, fine *sandy* loam | 50 | 20 | X | |
| CI 37/plot 2 | Smithdale, fine sandy loam | 45 | 30 | X | |
| C-137/plot 3 | Smithdale, fine sandy loam | 70 | 25 | X | |
| CI 25/plot 1 | Suffolk, fine sandy loam | 50 | 25 | X | |
| CI 25/plot 2 | Troup, loamy sand | 10 | *20* | X | |
| C-125/plot 3 | Troup, loamy sand | 30 | 10 | X | |
| C-125/plot 4 | Saffell, gravelly sandy loam | 20 | 40 | | X |
| C-126/Plot 1 | Maubila, sandy loam | 60 | 50 | X | |
| CI 26/plot 2 | Luveme, fine sandy loam | 60 | 10 | | X |
| C-126/plot 3 | Smithdale, fine sandy loam | 70 | 40 | | X |
| CI 26/plot 4 | Luveme, fine sandy loam | 90 | 20 | | X |

*Pythium* species were isolated from 64 percent of root samples (range 10 to 90 percent). *Phytophthora cinnamomi* was recovered from 10 to 50 percent of the mot samples with an average of 26 percent. *Pythium* spp. *and P. cinnamomi* were recovered from mot samples *in* all plots (table 2).

*Leptographium* spp. were recovered from 7 of the 15 plots, or 47 percent. No evidence of *H. annosum* was found in any of the root samples, nor were any fruiting bodies of the fungus found during the field survey.

The soil profile descriptions identified six soil series with Smithdale fine sandy loam comprising 40 percent of the plots. The other soil series identified on the plots were Maubila sandy loam, Troup loamy sand, Saffell gravelly sandy loam, and Luveme fine sandy loam. Each of these soil series comprised 13 percent of the plots. with the Suffolk fine sandy loam found on one plot (table 2).

Smithdale. Maubila, Luveme, and Suffolk are described as well-drained to moderately well-drained soils with moderate to slow permeability, with day loam or sandy day loam within 10 to 20 in. of the surface. Troup and Saffell are excessively drained to well-drained soils with moderate permeability. They are deep loamy sands or gravelly sandy loams without a day component near the surface.

Compared to agricultural soils, the soil analysis revealed that 73 percent of the plots were very low in potassium (K), calcium (Ca), and sodium (Na). All plots except for those with the Troup loamy sand were low in Ca. Some of the plots were also low in manganese (Mn) and zinc (Zn). All of these values were within the expected range for forest soils of these types. The pH ranged from 4.6 to 5.2.

The histology of the 95 fine roots that were sectioned found that 13 were dead and 12 had large necrotic zones. Six root samples had one or more dead resin ducts. *The* range in mot mortality observed among plots was 0 to 30 percent.

## DISCUSSION

This study confirmed the conditions found in the evaluations during the 1960's and 70's. The sparse crowns, reduced radial growth, deterioration of fine roots, decline, and mortality by age 50 are conditions that have prevailed on these sites. These symptoms are most commonly associated with littleleaf disease of shortleaf pine. Littleleaf has been reported to affect loblolly pine (Campbell and Copeland 1964, Lorio 1966, Oak and Tainter 1968). Loblolly pine affected with littleleaf symptoms are found most frequently on sites where the disease has been particularly severe on shortleaf (Campbell and Copeland 1964). Littleleaf was first detected in central Alabama in the early 1900's and by 1940 littleleaf occurrence was widespread in Alabama, South Carolina, and Georgia and was causing serious limitations to sustained management of shortleaf pine in the upper Coastal Plain of Alabama (Tainter and Baker 1996), including the Oakmulgee Ranger District (Johnson 1947).

Littleleaf disease symptoms result from nitrogen deficiency in the trees and are characterized by the death of new root tips and fine *roots.* Although *P. cinnamomi* is considered the primary pathogen, other factors, such as poor aeration, low fertility, and periodic moisture stress, are also damaging to fine roots. Zoospores *of Phytophthora cinnamomi* are the putative agents of infection and are produced only under conditions of abundant moisture. High soil moisture associated with poor internal soil drainage is common on

littleleaf sites. *Phytophthora cinnamomi* is pathogenic to many plants other than pine and is commonly found in the absence of pine. It can also be present in pine stands without causing littleleaf disease. *Phytophthora cinnamomi* is more commonly associated with eroded lands, and severity of liffleleaf disease increases as the internal drainage and site index decreases. Cultivation of soils has been shown to hasten the decline of littleleaf disease trees. However, the development of littleleaf disease symptoms in healthy trees has been delayed, and improvement in the conditions of trees in the early stages of the disease has been obtained with soil applications of inorganic nitrogen (Campbell and Copeland 1964).

*Pythium* spp. have also been reported to be associated with littleleaf disease sites (Otrosina and Marx 1975) and with loblolly pine decline (Lorio 1966). *Pythium* spp. have a life cycle similar to *Phytophthora* spp. and are most commonly associated with damping-off (Tainter 1997).

In determining whether littleleaf disease is a primary consideration in the decline of loblolly pine on the Oakmulgee Ranger District, two sits factors are important. These are the internal drainage of soils and the isolation factors of P. *cinnamomi*/*Pythium* spp. from the fine roots.

The Oakmulgee Ranger District soils having clay loam close to the surface horizon and exhibiting slow to moderate permeability generally maintain high moisture content and would favor *Pythium*/*Phytophthora* fungal populations (table 3). The Troup and Saffell soils are described as deep, well-drained loamy soils without a clay component and moderate permeability. However, the absence of an A horizon, low soil fertility, and evidence of a plow layer on some sites indicate U-tat these areas were heavily farmed prior to planting of pines. The Oakmulgee Ranger District soils are located in the upper Gulf Coastal Plain province and the soil series descriptions do not generally indicate high risk sites for littleleaf disease: however, the agricultural history and it's effect on soil nutrients and permeability may explain the occurrence of liffleleaf disease.

Isolations and detection procedures for pythiaceous fungi have become more efficient since the early surveys of the Oakmulgee Ranger District sites in the 60's and 70's.

Quantitative methods of soil dilutions for propagule counts and soil population assays have been developed. The use of selective media to isolate *P. cinnamomi* and *Pythium* spp. from necrotic root tips more accurately relates fine root mortality associated with the pathogens (Tainter and Baker 1996). The isolations of *Pythium* spp. and *P. cinnamomi* from the survey (table 2) in general show a greater concentration of *Pythium* spp. than of *P. cinnamomi* in the fine roots. *Phytophthora cinnamomi* is considered the primary pathogen, as the fungus attacks and quickly kills only the succulent root tips of the pine host.

*Leptographium* spades have been assodated with conifer mortality, primarily as associates of root-feeding bark beetles (Scolytidae) and weevils (Curculionidae) that attack living trees. Some of the *Leptographium* species are weak pathogens and further damage roots already damaged by insects. Pines respond to this damage by producing resin, and *Leptographium* spp. are most often recovered from these resin-soaked tissues and may exacerbate the damage by indudng further resin production (Harrington and Wingfield 1997). Because of these characteristics, these fungi may serve as indicators of site stress and predispose infected trees to attack by southern pine beetle (*Dendroctonus frontalis*, Zimmerman) and other agents (Otrosina and others 1997).

Histology studies indicate that a high proportion of loblolly pine roots are in poor condition or are dead. Death of resin canals is unusual in loblolly pine roots but can indicate root damage.

## CONCLUSIONS

*Phytophthora cinnamomi* and *Pythium* spp. appear to be the primary pathogens associated with the deterioration of loblolly fine mot systems. This, coupled with the restricted internal drainage of the soils as a result of past agricultural practices within the historical range of littleleaf disease and the extensive planting of loblolly pine to recover these sites indicate that liffleleaf disease is the primary cause of the loblolly decline symptom and mortality on the Oakmulgee Ranger District. Bulk density test of the soils and foliar analysis of symptomatic trees for nitrogen deficiency would be helpful to confirm this diagnosis.

Table 3—Soil series descriptions relative to recovery of root pathogens

| Soil series | Range of *Pythium* | Range of *Phytophthora* | *Leptographium* spp. Yes | *Leptographium* spp. No |
|---|---|---|---|---|
| | ------- Percent ------- | | | |
| Smithdale FSL | 40-70 | 10-40 | X | |
| Suffolk FSL | 50 | 25 | X | |
| Maubila SL | 55-60 | 35-50 | x | |
| Luveme | 60-90 | lo-20 | | X |
| Saffell GSL | 20-85 | 40 | | X |
| Tmup LS | 1 0-30 | 10-20 | X | |

The *Leptographium* spp. recovered from the larger root systems exacerbate the decline of the loblolly stands. Declining stands can be more susceptible to *southern* Pine beetle attacks.

## MANAGEMENT OPTIONS

### Maintain Loblolly as a Short Rotation Crop

- Age 50 is the recommended rotation age on the decline sites.
- Use periodic salvage/sanitation cuts of symptomatic trees until stands reach rotation age.
- Convert to longleaf pine management type upon final harvest at age 50.

### Accelerate Conversion of Loblolly to Longleaf Management Within 10-15 Year Planning Cycle

- Convert 7 to 10 percent par year of loblolly decline sites to bngleaf pine management.
- Select most severely damaged stands as a priority for conversion.

### Disease Abatement/Conversion by Condition Class

- Inventory the remaining 40,000 acres of decline sites and classify by ageclass and conditionclass.
- Schedule harvest and conversion based on stand age and condition class.
- Stands in age classes 40 and older with a condition class of sparse, damaged, or diseased are high risk sites and should be given first priority for management conversion to bngleaf pine.
- Second priority should be poletimber stands of age classes 25 to 40 having some symptomatic trees. Most of these stands will already have some fine foot damage due to littleleaf disease but may not be showing advanced symptoms or mortality. Use a fertilization program to reduce disease impact and extend rotation age beyond age 50 for RCW habitat management
- Stands in age classes 15-25, use standard silvicultural practices of prescribed burning and thinnings to maintain stand vigor.

## REFERENCES


Brown, H.D.; McDowell, W.E. 1955. Status of loblolly pine die-off on the Oakmulgee District, Talladega National Forest, Alabama. Rep. 69-2-28. Pineville, LA: U.S. Department of Agriculture, Forest Service, Forest Insect and Disease Management Group. 21 p.

Campbell, WA.; Copeland, O.L., Jr. 1954. Littleleaf disease on shortleaf and loblolly pines. Circ. 940. Washington, DC: U.S. Department of Agriculture. 41 p.

Haas, W. 1980. Fifty diagnostic special stains for surgical pathology. Los Angeles: Ail-Type Editorial. 86 p.

Ha&ton, T.C.; Wingfield, M J. 1997. Other *Leptographium* species associated with conifer roots. In: Hansen, E.M.; Lewis, K.J., ds. Compendium on conifer diseases. St. Paul, MN: The American Phytopathological Society. 101 p.

Johnson, S.R. 1947. Timber management plan, Cahaba Working Circle, Talladega National Forest, Alabama. R-8 period 7-1-46 to 6-30-56. Intern. Doc. Montgomery, AL: U.S. Department of Agriculture, Forest Service, National Forests in Alabama. 16 p.

Loomis, RC. 1976. Loblolly Pine "die-off", Oakmulgee Ranger District. Eval. Memo. Pineville, LA: U.S. Department of Agriculture, Forest Service, Forest Insect and Disease Management Group. 2 p.

Lorio, P.L. 1966. *Phytophthora cinnamomi* and *Pythium* species associated with loblolly pine decline in Louisiana. Plant Disease. 50: 596-597.

Oak, S.W.; Tainter, F.H. 1955. Risk prediction of iobioliy pine decline on littleleaf sites in South Carolina Plant Disease. 72: 289293.

Otrosina, WJ.: Marx, D.H. 1975. Populations of *Phytophthora cinnamomi* and Pythium spp. under shortleaf and lobioity pines in littleleaf disease sites. Phytopathology. 65: 12244228.

Otrosina, WJ.; Hess, NJ.; tmoch, SJ. [and others]. 1997. Blue-stain fungi associated with roots of southern pine trees attacked by the southern plne beetle, *Dendroctonus frontalis*. Rant Disease. 8: 942-945.

Roth, E.R. 1954. Spread and Intensification of the iiffleiesf disease of pine. Journal of Forestry. 52: 592696.

Sass, J.E. 1951. Botanical microtechniques. 2d ed. Ames, IA: Iowa State College Press. 228 p.

Tainter, F.H. 1997. Diseases of fomst trees, root diseases. In: Hansen, E.M.; Lewis, KJ., eds. Compendium on conifer diseases. St Paul, MN: The American Phytopathological Society. 101 P.

Tainter, F.H.; Baker, F.A. 1995. Principles of forest pathology. New York. John Wiley. 804 p.