FOREST HEALTH REPORT

ASSESSMENT OF LOBLOLLY PINE DECLINE ON THE OAKMULGEE RANGER DISTRICT, TALLADEGA NATIONAL FOREST, ALABAMA

Alexandria Field Office

USDA Forest Service
Southern Region
Forest Health

Forest Health Evaluation
Alexandria Field Office

Report No. 2004-02-01
December 2003

Assessment of Loblolly Pine Decline on the Oakmulgee Ranger District, Talladega National Forest, Alabama

Prepared by:

Lori G. Eckhardt, Plant Pathologist/Entomologist

Nolan J. Hess, Plant Pathologist

Roger Menard, Biological Science Technician

Arthur J. Goddard, Soil Scientist

Approved by:
For **Wesley Nettleton, Director, Forest Health Protection**
Southern Region, Atlanta, GA

Forest Health Evaluation
Alexandria Field Office

Report No. 2004-02-01
December 2003

ASSESSMENT OF LOBLOLLY PINE DECLINE ON THE OAKMULGEE RANGER DISTRICT, TALLADEGA NATIONAL FOREST, ALABAMA

By

Lori G. Eckhardt, Nolan J. Hess, Roger D. Menard, and Art J. Goddard

Abstract

Declining loblolly pine Pinus taeda L. stands have been a management concern on the Oakmulgee District since the 1960's. The symptoms include sparse crowns, reduced radial growth, deterioration of fine roots and decline and mortality of loblolly by age 50. A three year study was conducted to evaluate the fungal, insect, and/or soil parameters associated with declining loblolly stands and to re-evaluate management options. Sixteen one sixth acre plots were established on the Oakmulgee Ranger District as part of a larger Forest Health Monitoring study. Three dominant/co-dominant trees were selected from each plot for root and soil sampling and data collection. Two primary lateral roots were excavated from each sample tree and the fine roots examined and sampled. Root and soil samples were placed on selective media for isolation of Heterobasidion annosum, Phytophthora cinnamomi, and Leptographium species. Root sampling revealed high levels of root damage, mortality, and staining associated with Leptographium species. Leptographium spp. were recovered from 94% of the lateral roots and 50% from soils of the 16 plots. Phytophthora cinnamomi was not recovered from any of the fine roots and only from 19% of the associated soils. There was no H. annosum found in any of the root samples. Insects were sampled on 8 of the 16 plots using pitfall traps. Insects were identified to species and rolled on selective media for isolation of vectored pathogenic fungi. Hylastes salebrosus, Hylastes tenuis, Pachylobius picivorus and Hylobius pales were significantly more abundant in declining plots than in healthy Pinus taeda L. plots. These root and lower stem-infesting insects consistently carried Leptographium terebrantis, L. procerum, and L. serpens. This evaluation shows that loblolly decline is a sequence of interactions among this complex of organisms, abiotic factors, and site conditions. The upland sandy loam sites of the Oakmulgee are distinctly different from eroded clay sites associated with little leaf disease. Management options on these sites include restoration to longleaf pine or manage loblolly on a short rotation not to exceed 50 years.

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 Brent, 35 miles south of Tuscaloosa, AL. The District consists of 158,000 acres of which approximately 99,000 acres are pine forest type. The dominant forest type in the pre-settlement era was longleaf pine (*Pinus palustris* Mill.) which was extensively cut over. Many of these sites were cultivated for agriculture prior to establishment of the Talladega National Forest (Johnson, 1947). During the 1930's the emphasis was watershed protection and much of this area was regenerated to loblolly pine (*Pinus taeda* L.).

The Oakmulgee Ranger District falls within the Upper Gulf Coastal Plain province, and the first report of declining loblolly pine was in 1959 within the Talladega National Forest. Symptoms include trees with short, chlorotic needles, sparse crowns, and reduced radial growth in the 40-50 year age class. Mortality usually occurres two to three years after symptom expression.

In 1966, a five year study was established on 24 one-quarter 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 1968). Further evaluation of the 24 plots was concluded in 1976. 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 40-50, but fine root deterioration preceded the presence of the foliar symptoms. *Heterobasidion annosum* (Fr.) Bref and *Phytophthora cinnamomi* (Fr.) Bref were recovered from some of the plots but annosum root rot and littleleaf disease were not implicated as the primary cause of the decline. The conclusions from the evaluation and follow-up study showed that fine root deterioration, site conditions and a combination of other interactions caused the decline and mortality and that loblolly pine was not well suited for these upland sites. An increase of southern pine beetle (SPB) (*Dendroctonus frontalis* Zimm.) incidence was also noted. Recommendations were to reduce rotation age of loblolly pine from 70 to 60 years on these sites, maintain a basal area of 60-70 square feet per acre and convert these stands to longleaf pine management type (Loomis, 1976).

During the next 15 years, the Oakmulgee converted an average of 1,000 acres/year of the sites to longleaf pine, but there are approximately 40,000 acres of loblolly pine decline/dieback sites remaining on the Oakmulgee having an estimated loss of 12 MMBF per year to mortality and reduced growth. An additional 10,000 to 20,000 acres of similar sites and conditions exist on the Shoal Creek and Talladega Districts.

In 1998, a study was established on four compartments of the Oakmulgee Ranger District in order to re-evaluate the decline/mortality complex and to update management options (Hess *et al,* 1999). Evaluations of these plots concluded that although, *Phytophthora cinnamomi, Pythium* spp. and *Leptographium* spp. was recovered from these plots, their roles in the decline complex were not clearly defined. Revised management options on these sites included managing for loblolly pine on shorter rotations of 50 years, or converting to longleaf pine managing type.

The National Forests in Alabama recognized that the complexity of managing these sites within the scope of ecosystem management, habitat needs, and enhanced regulatory compliance has greatly affected their ability to achieve the desired future conditions for a sustainable ecosystem. The Oakmulgee District also recognized that declining loblolly stands were putting their red-cockaded woodpecker (RCW) habitat at risk. The Oakmulgee is the home of the state's largest RCW population and the District is targeted with obtaining 394 active clusters. The Oakmulgee RCW population is currently threatened by the forest health concerns due to the projected lack of sustainable nesting habitat in the long-term and lack of suitable foraging habitat in the short-term. During a FHP Management Review, the National Forests in Alabama requested assistance in developing strategies for long-term management of these decline sites.

Forest Health Monitoring plots were established through-out the state in 1990. Assessments made during the mid 1990's reported that many plots were showing extensive decline in central and southern Alabama counties (Appendix A). The Alexandria Field Office of Forest Health Protection, coordinated a 3 year effort with multiple partners to complete a comprehensive evaluation of loblolly decline in central Alabama in 2000. Funding was received from the FHM program to help implement the further assessment of these decline sites. A list of cooperators and partners involved in the loblolly pine decline assessment is shown in Appendix D.

METHODS

Sixteen one-sixth acre plots were established on the Oakmulgee Ranger District as part of a larger Forest Health Evaluation Monitoring study (Table 1). Four of the 16 plots were healthy (no visual decline symptoms) control plots. The FHM-EM plots were selected on federal, state, and private industrial lands. Thirty-nine 1/6 acre sample locations in nine central Alabama counties were selected in the spring of 2000. Plot establishment followed the FHM guidelines (Dunn, 1999), using a cluster of four 1/24 subplots. The plot locations fell within four Physiographic Regions of Alabama; The Piedmont, Ridge and Valley, Upper Coastal Plain, and Cumberland Plateau. At each location, root health assessment was accomplished by selecting three dominant, or co-dominant, symptomatic pines nearest the plot center of the center subplot. Root samples were collected with the modified two-root excavation method (Otrosina and others, 1997). Radial growth measurements were obtained with an increment core at breast height (dbh) of each of the sample trees. Insects were sampled on 8 of the 16 plots using pitfall traps for a 3 year period (2000-2002) on the Oakmulgee from March to May. Insects were collected on a weekly basis for transport to the laboratory for identification and isolation of pathogenic fungi.

Data collected in the plots included tree measurements, site information, and soil profile. Species, diameter at breast height, age, 5 and 10 year growth increments were collected from each of the root sampled trees. Site descriptions included pine and total basal area (10 factor prism), a soil profile description and a vegetation density rating. Tree health/physiology was also assessed by resin sampling, crown rating and root inspection.

Root Pathogen Assessment:

Root and associated soil samples were sent to Louisiana State University Agriculture Center, Plant Pathology Department, where isolations and identifications of Pythiaceous and Ophiostomoid fungi were conducted. Standard laboratory procedures were used as described in (Hess & Others, 2002). Primary lateral root samples were transported to the Tree Root Biology Laboratory in Athens, GA, and plated on selective media for *H. annosum.*

Root Damage Assessment:

During the root excavation and sampling procedures, a sub-sample of eleven plots (4 plots on the Oakmulgee R.D.) was chosen to evaluate the fine root damage through histological examination. Random samples of unwashed fine roots were taken from the primary roots and placed in formalin/acetic acid/alcohol fixative for 14 days. Fixed root specimens were cut, dehydrated, embedded in paraffin and sliced into transverse sections. Slides were stained with a variety of schedules. Stained sections were observed under a light microscope, then catalogued into damage categories (Hess and others 2002).

Soil Profile Classification:

Soil series classifications were completed at each of the plot locations by Art Goddard, Soil Scientist for N.F. in Alabama, and Emily Carter, Soil Research Scientist, Southern Research Station. A three inch bucket ager was used to profile the soils to a depth of 60 inches with color, texture, and structure described in 10 inch increments. (See Appendix B).

Soil Analysis:

Soil samples were removed from the established plots for the evaluation of physical and chemical characteristics of decline sites. Soil physical properties related to bulk density, porosity, and soil moisture content were evaluated as indicators of internal aeration and water holding capacity (Carter and Others, 2003). Soil sampling consisted of removal of four soil cores from selected plots to a depth of 0.60 m and subdivided into 0.10 m increments and measured for bulk density, total porosity, and moisture content, at the time of sampling.

Soil chemical analysis were conducted on collected samples at each center subplot and sent to the University of Missouri Soil Characterization Laboratory. Analysis was completed using standard laboratory procedures required by Forest Health Monitoring protocols (Palmer and Others, 2001).

Leptographium spp. incidence rating (LIR) was developed from biological data and correlated to the plot topographical features derived from Digital Elevation Models (DEMs). The LIR for each plot was associated with percent slope and aspect. The mapped locations represent areas of risk for a particular incidence rating of *Leptographium* and associated probabilities of decline over a definable geographic landscape. The Loblolly Decline Risk Map (LDRM) was developed by correlating the LIR with the topographic map features.

RESULTS

The average diameter range of sampled trees within the Oakmulgee plots was 10 to 15 inches (Table 2). The stand age ranged from 30 to 65 years. Stand density ranged from 55 to 100 square feet. The average five year growth increment for these sites ranged from 4.5 to 14 mm and 10 year growth increment was 10 to 27.5 mm.

Phytophthora cinnamomi was not recovered from any root samples of the study plots. It was recovered from the associated soils from 3 of the 16 plots (Table 3).

Leptographium spp. was recovered from the primary and fine roots from 15 of the 16 plots and from the soil of 8 of the 16 plots (Table 3). The fungal species isolated from the root samples were *L. terebrantis* Barras & Perry, *L. procerum* (Kendr.) Wingfield, *L. serpens* (Goid.) Wingfield. The overall proportion of stain fungi isolated was significantly higher in symptomatic plots than in asymptomatic plots and when all *Leptographium* species were pooled; they were found significantly more often in symptomatic (86%) as compared with asymptomatic trees (40%) (Table 4). Only *L. procerum* was isolated from the soil samples, and was generally more common in symptomatic than asymptomatic plots (Eckhardt, 2003).

Leptographium spp. was also recovered from fourteen species of root-feeding bark beetles and weevils trapped on the plots (Table 5). Eighty-one percent of the fourteen insect species trapped carried *Leptographium* spp. *Leptographium* incidence was positively correlated with high populations of root-feeding bark beetles and weevils. Insect population trends were also seen when insects trapped were evaluated by timing of prescribed burns. Increased root-feeding bark beetle and weevil populations were seen during the same year of burning and the year following, but once the plots were three years past burn date, plot insect populations returned to a low steady population as seen in unburned plots as well as asymptomatic plots. Also, beneficial insect populations trapped were inversely related to the insect pest populations. The increase of insects after burning allows for a greater number of point inoculations of vectored *Leptographium* into loblolly pine on these plots. These point inoculations are accumulative overtime resulting in increased stressed and declining loblolly pines.

Root system damage was statistically higher in symptomatic trees than in asymptomatic trees. Symptomatic trees had consistently fewer fine roots with more fire and/or insect damage and staining to the primary root systems than did the asymptomatic trees and were positively correlated with the number of insects and the incidence of *Leptographium.* Poor root systems and staining were also correlated with low scores for crown density and high scores for foliage transparency ($r = 0.9076$). These foliar symptoms were also positively correlated with increased insect capture, decreased vegetation density ratings and increased *Leptographium* incidence ($P<0.05$). Trees with declining symptoms had very poor root systems (absence of feeder roots, dead or decaying lateral roots) and obvious staining compared to apparently healthy stands, which had good root systems essentially free of stain. There was a significant difference of resin flow among *Leptographium* infected trees ($F_{3,116} = 246.50$, $p<0.0001$) and a direct positive correlation between resin flow and foliar symptoms with the incidence of *Leptographium* (Eckhardt, 2003).

H. annosum was not found in any of the root samples, nor were any fruiting bodies of the fungus found during the field survey.

The histology of the fine roots revealed extensive wounding, poor root health, and starch starvation preceding root death. The relationship between wounded roots and reduced radial growth was shown to be significant (Hess and Others, 2003).

The soil evaluation showed that decline plots had higher bulk density values and lower total porosity with depth compare to the control plots. Soil pH (water) ranged between 4.0 and 5.7 in each depth increment of sampled plots. The ratio between exchangeable calcium and aluminum was consistent with depth in the control plots but shifted to aluminum in the decline samples. Higher levels of aluminum were evident in the decline plots (Carter and Others, 2003).

The soil profiles and classifications (Table 3 and Appendix B) show that all of the Oakmulgee plots are located on sandy loam or loamy sand, moderately well drained to well drained soils.

DISCUSSION

This study shows that a variety of interactions lead to loblolly pine decline. Specifically, we propose that loblolly pine decline results from the debilitation of root systems by *Leptographium* species, which are vectored by root feeding insects, which in turn are affected by site conditions. *Leptographium* species were consistently associated with declining trees in symptomatic, but not asymptomatic stands, and the damage in these root systems were statistically higher in symptomatic trees. Symptomatic trees consistently possessed fewer fine roots and generally more insect and fire damage and staining to the primary root systems than the asymptomatic trees. Root system damage was positively correlated with insect abundance, which may have led to increased *Leptographium* incidence. We did not find insect damage sufficient to seriously affect the trees, but colonization by *Leptographium* spp. were extensive. Symptomatic plots also had lower vegetation ratings, apparently due to prescribed burns, than did asymptomatic plots. Plots with low vegetation ratings and high insect numbers also exhibited high incidence of *Leptographium*, which correlate with crown rating, resin flow, and root condition. The above-ground symptoms of radial growth reduction, foliar transparency, and crown density, within symptomatic plots as compared to controls, corresponded to the root conditions, and are consistent with work done in other pines associated with *Leptographium* spp. (Leaphart and Gill, 1959; Wagener and Mielke, 1961). *Leptographium procerum* is the only species we recovered from the soil and may be less dependent upon vectors to initiate root infection. It is possible that wounding caused by root initiation, or presence of dead or decaying lateral roots could serve as openings for infection by this fungus (Hessburg and Hansen, 2000). We did frequently observe damaged roots in the field during excavations, but *L. procerum* was also found on the insects in this study and presumably is also vectored by them.

Littleleaf disease, as described in the literature (Campbell and Copeland, 1954) and loblolly pine decline are not the same disease. Littleleaf typically occurs in poorly drained eroded clay soils, but loblolly decline occurs on relatively well drained sandy loam soils. Littleleaf is associated with the occurrence of *P. cinnamomi*, while *P. cinnamomi* could not be isolated from loblolly decline trees (Eckhardt and Others 2003). Soil bulk density was generally higher in decline plots, and reduction in total porosity was also evident. Bulk density and total porosity values did not reach growth limiting levels (Carter and Others, 2003). Soil nutrient analysis showed the soil pH range to be between 3.73 and 5.59 with aluminum levels ranging from 7 - 234 ppm. These ranges have been shown to reduce the virulence of *Phytophthora* spp.(Erwin, 1996).

The role of *P. cinnamomi* in littleleaf disease was attributed to its ability to kill feeder roots (Campbell and Copeland, 1954) and thus inhibit root growth and nutrient absorption. Torrey and Clarkson (1975) and Zimmerman and Brown (1971) determined that fine roots generally live from 1 to 4 yrs, and associated mortality is with cold weather, excessive soil moisture, poor soil drainage and aeration, drought, attacks by insects, fungi and other organisms, and foliage loss. The recovery of *P. cinnamomi* from the Oakmulgee plots was limited to soils on three plots. Since the histology of the fine roots showed significant wounding, cellular damage, and starch starvation, this indicates that other factors and not *P. cinnamomi* are playing a key role in the deterioration of the fine roots.

Table 1. Oakmulgee Loblolly Pine Decline Plot Locations

Plot Number	Comp.	Location	County	Sub-sample
12	13	N 32° 58".802 W 87° 27".123	Bibb	
13	14	N 32° 58".249 W 87° 23".180	Bibb	
14	24	N 32° 57".928 W 87° 24".715	Bibb	
15	19	N 32° 59".835 W 87° 29".780	Hale	PFT
16	20	N 32° 59".741 W 87° 29".733	Hale	H, PFT
17	31	N 32° 57".850 W 87° 22".933	Bibb	PFT
18	30	N 32° 57".767 W 87° 22".805	Bibb	H, PFT
19	31	N 32° 55".911 W 87° 23".147	Bibb	PFT
20	49	N 32° 54".484 W 87° 22".836	Bibb	
21	43	N 32° 55".818 W 87° 25".595	Hale	H
22	42	N 32° 56".113 W 87° 26".420	Hale	
32	129	N 32° 47".302 W 87° 01".456	Perry	H
Control 4	26	N 32° 58".511 W 87° 20".751	Bibb	PFT
Control 5	26	N 32° 58".392 W 87° 20".811	Bibb	PFT
Control 6	49	N 32° 54".307 W 87° 22".788	Bibb	
Control 7	12 9	N 32° 46".117 W 86° 59".283	Chilton	PFT

Sub-sample Legend: H = Histology of fine roots
PFT = Pit Fall Traps

Table 2. Range of Average Tree Growth and Age per Plot

Plot and Compartment Numbers	dbh (avg. of plots in inches)	Age	Growth Increment (mm) 5 Years	10 Years	Basal Area sq. ft. (pine)	Total BA
Plot 12, C-13	10	54	7	14	90	90
Plot 13, C-14	13	59	8	15	60	70
Plot 14, C-24	10	62	6	13	50	70
Plot 15, C-19	13	59	10	19	100	110
Plot 16, C-20	15	59	7	16	70	80
Plot 17, C-31	12	59	7	14	80	100
Plot 18, C-30	15	65	11	24	70	90
Plot 19, C-31	10	55	7	12	90	110
Plot 20, C-49	9	65	2	4	110	110
Plot 21, C-43	13	56	10	19	70	90
Plot 22, C-42	12	46	6	15	50	70
Plot 32, C-129	16	60	5	10	40	60
Control 4, C-26	10	31	12	23	40	50
Control 5, C-26	11	30	16	32	70	80
Control 6, C-49	18	64	7	17	100	100
Control 7, C-129	10	54	5	10	100	130

Table 3. Recovery of Pathogenic Fungi from Root, Soil, and Insects, by Plot and Soil Series.

Plot and Compartment	Soil Series (See Appendix B for soil descriptions)	Leptographium Species						P.c. %
		Roots		Soil		Insects		
		Yes	No	Yes	No	Yes	No	
Plot 12, C-13	Maubila flaggy sandy loam	X		X		NT	NT	0
Plot 13, C-14	Maubila flaggy sandy loam	X		X		NT	NT	1
Plot 14, C-24	Wadley loamy sand	X		X		X		0
Plot 15, C-19	Smithdale sandy loam	X		X		X		0
Plot 16, C-20	Riverview sandy loam	X			X	NT	NT	0
Plot 17, C-31	Maubila flaggy sandy loam	X			X	X		6
Plot 18, C-30	Maubila flaggy sandy loam	X			X	X		0
Plot 19, C-31	Suffolk loamy sand	X		X		X		0
Plot 20, C-49	Maubila flaggy sandy loam	X		X		X		0
Plot 21, C-43	Smithdale sandy loam	X		X		X		0
Plot 22, C-42	Maubila flaggy sandy loam	X		X		NT	NT	0
Plot 32, C-129	Suffolk loamy sand	X			X	NT	NT	0
Control; 4. C-26	Suffolk loamy sand	X		X		NT	NT	0
Control 5, C-26	Wadley loamy sand		X		X	NT	NT	0
Control 6, C-49	Wadley loamy sand	X		X		NT	NT	0.3
Control 7, C-129	Smithdale sandy loam		X		X	X		0

NT = Pitfall traps were not installed on these plots.
P.c. = *Phytophthora cinnamomi*

Table 4. Percentage of Blue-Stain Fungi Isolated from Loblolly Pine.

Fungal Species	Asymptomatic		Symptomatic		P-value
	2000	2001	2000	2001	
Leptographium procerum	43	43	84	92	0.001
Leptographium serpens	14	14	42	44	0.001
Leptographium terebrantis	43	36	81	84	0.01
Pooled *Leptographium* spp.	43	38	88	86	0.003
Graphium spp.	57	50	72	79	0.05
Pooled spp.	57	50	97	93	0.01

Table 5. Insects Trapped and Percentages of Blue-Stain Fungi Isolated.

Insects	*Leptographium*	*Graphium*
	-percent insect with fungi-	
Corthylus punctatissimus[1]	29	14
Dendroctonus terebrans	100	75
Gnathotrichus materiorius[1]	67	0
Hylobius pales	91	9
Hylastes salebrosus[1]	87	11
Hylastes tenuis[1]	84	9
Monarthrum mali[1]	50	29
Nitidulid spp.[1,2]	78	6
Orthotomicus caelatus[1]	50	0
Pachylobius picivorus	97	98
Rhizophagus spp.[1]	93	0
Xyleborinus saxesini[1]	70	0
Xylosandrus compactus[1]	67	0
Xylosandrus crassiusculus[1]	67	0

[1] **Not previously associated with *Leptographium***

[2] **Seventy-eight percent of these insects also carried an un-described *Leptographium* species that was recovered from hardwood roots.**

CONCLUSIONS

Loblolly decline is a complex of interactions of biotic and abiotic stresses. Predisposing factors include site condition and host. The decline sites are predominantly upland sites with history of previous agriculture and not well suited for long term management of loblolly pine. The inciting conditions include fine root deterioration and soil factors. Loblolly decline symptoms are similar to littleleaf symptoms; however, these upland sites are not the characteristic eroded clay soils associated with littleleaf disease. The final phase contributing to the decline complex includes root feeding insects on the primary roots and the vectoring of *Leptographium* species. Other factors to consider are landform, drought, and impact of prescribed fire on root feeding insect populations. As loblolly stands decline with increased stresses and stand age, they also become more susceptible to attacks by southern pine beetle. The dominant forest type on these upland sites was longleaf pine prior to the initial harvesting in the early 1900's and longleaf restoration is recommended for long term management of these sites.

Management Options:

1. Utilize the Loblolly Decline Risk Map (LDRM) to determine condition class of existing loblolly stands and their projected life expectancy. The LDRM will assist the District in planning for RCW habitat needs by projecting the age classes, stand health, and rotation ages that can be integrated with the habitat needs. The LDRM will help define the severe decline sites and stands with high southern pine beetle risk and aid in developing a priority list of sites for conversion to longleaf pine management. The risk model will also identify the loblolly sites that can continue to be managed for this species with minimum risk of decline (Fig. 1 – Loblolly Decline Risk Map). The Arc View project file will be installed on the District's computers and can be used to assess decline risk at the stand level.

2. Longleaf pine is the preferred management species for the upland pine sites on the Oakmulgee Ranger District. Restoration of the longleaf pine ecosystem on these sites will provide for long-term RCW habitat needs, reduce SPB risk and will allow the District to manage for desired future conditions of a healthy forest.

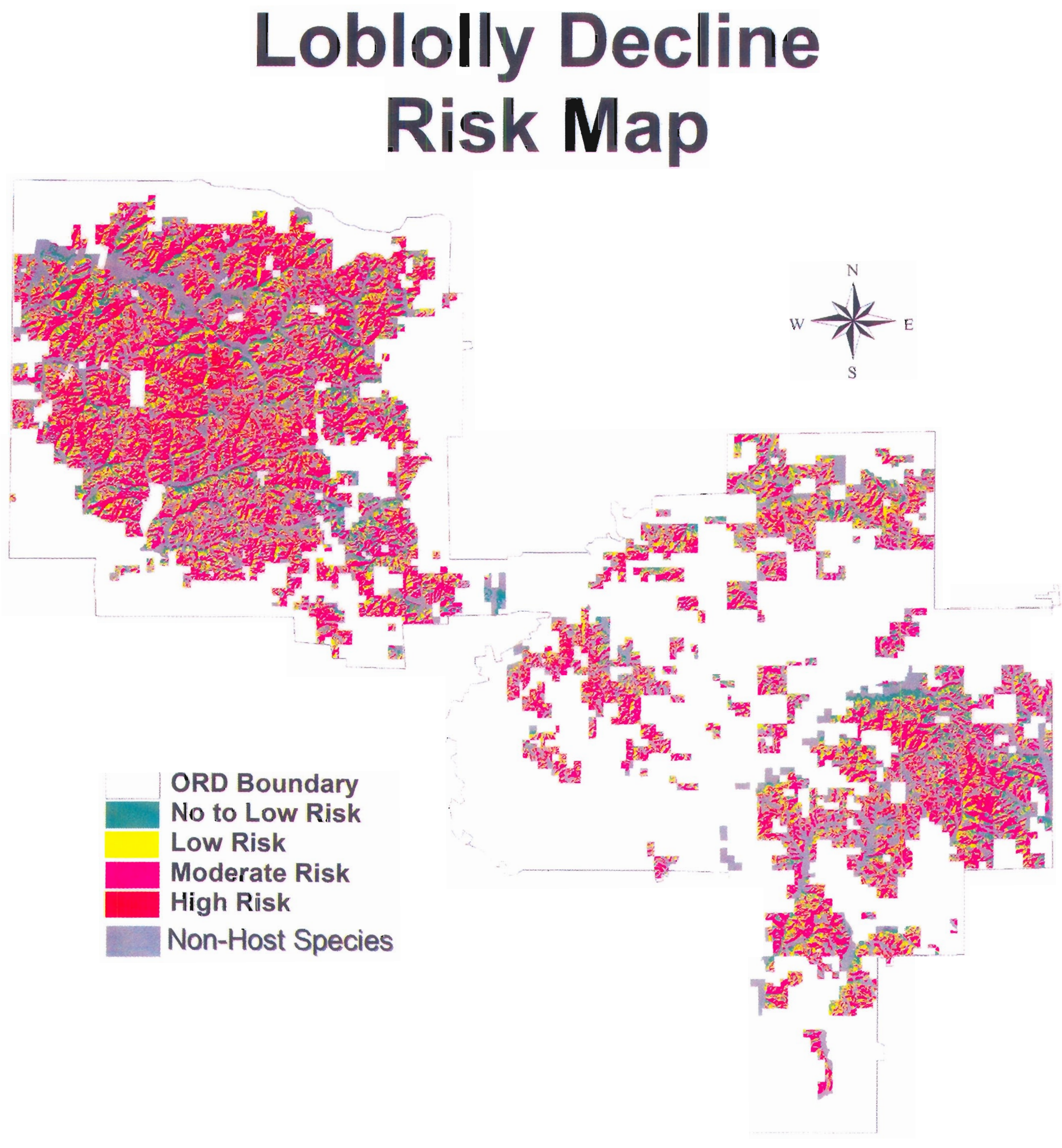
3. Reducing the loblolly decline acres by restoring to longleaf pine ecosystem management will reduce the acres at risk for SPB. Thinning the overstocked loblolly stands in the 20 to 40 year old age classes will also reduce the risk of southern pine beetle attacks. SPB risk models are available to identify high risk sites and give basal area guidelines for reducing the risk (Appendix C).

4. Loblolly pine can be managed on the Oakmulgee upland pine sites on a rotation age of 50 years. Age classes beyond age 50 will have increased risk for growth loss, mortality, and susceptibility to southern pine beetle. The Loblolly Decline Risk Map can be used to identify sites/stands that may exceed the 50 year age class with minimal risk.

5. FHP recommends that the impacts of prescribe fire be reduced in loblolly stands on the upland sites. The FHM study showed a strong correlation to prescribed fire, increased root feeding insects and vectoring of *Leptographium spp.* Additional studies to evaluate the impacts of fire, insects, and root pathogen interactions are ongoing.

6. Annosum root disease may also be a risk on sandy, sandy loam well drained sites, especially areas scheduled to be thinned. Nolan Hess and Art Goddard will provide the District with an Annosum Risk map (ARM) based on soil series descriptions. With the ARM the District can monitor management on high risk annosus sites and provide mitigation when needed.

Figure 1


Loblolly Decline
Risk Map
N
W
E
S
ORD Boundary
No to Low Risk
Low Risk
Moderate Risk
High Risk
Non-Host Species

LITERATURE CITED

Brown H.D.; McDowell, W.E. 1968 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, W. A., and Copeland, O. L., Jr. 1954. Littleleaf disease of shortleaf and loblolly pines. Circular No. 940, United States Department of Agriculture.

Carter, E.A., N.J. Hess, A.J. Goddard, W.J. Otrosina, J.P. Jones, L.G. Eckhardt and A.M. Weber. 2003. Soil characteristics of loblolly pine decline sites in central Alabama. Abstract. Twelfth Biennial Southern Silvicultural Research Conference. Biloxi, MS. February 25-27, 2003.

Dunn, P.H. 1999. Forest Health Monitoring field methods guide. U.S. Department of Agriculture, Forest Service, Washington, DC. National Forest Health Monitoring Program-Research Triangle Park, NC 27709.

Eckhardt, L.G. 2003. Biology and ecology of *Leptographium* species and their vectors as components of loblolly pine decline. Ph.D. Dissertation, Louisiana State University, Baton Rouge, LA.

Eckhardt, L.G.; Menard, R.D.; Weber, A.M.; Jones, J.P.; and Hess, N.J. 2003. Insect-fungal complex associated with loblolly pine decline in central Alabama. In press. Forest Science, Society of American Foresters, Bethesda, MD.

Erwin, D.C. 1996. *Phytophthora* Diseases Worldwide. Riverside, CA: University of California. APS Press, St. Paul, Minnesota. pp. 184.

Hess, N.J., W.J. Otrosina, J.P. Jones, A.J. Goddard and C.H. Walkinshaw. 1999. Reassessment of loblolly pine decline on the Oakmulgee Ranger District, Talladega National Forest, Alabama. In: Haywood, J.D., ed. Proceedings of the Tenth biennial southern Silvicultural research conference; 1999 February 16-18, Shreveport, LA. Gen. Tech. Rep. SRS-30. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 560-564.

Hess, N.J., W.J. Otrosina, E.A. Carter, J.R. Steinman, J.P. Jones, L.G. Eckhardt, A.M. Weber and C.H. Walkinshaw. 2002. Assessment of loblolly pine decline in central Alabama in Outcalt, K.W. ed. Proceedings of the Eleventh Biennial Southern Silvicultural research conference, 2001 March 20-22, Knoxville, TN. Gen. Tech. Rep. SRS-48. Asheville, N.C: U.S. Department of Agriculture, Forest Service, Southern Research Station. 558-564.

Hess, N.J., C.H. Walkinshaw, E.A. Carter and A.J. Goddard. 2003. Soil variables and fine root histology from loblolly decline sites in central Alabama. Abstract. In: Phytopathology, Volume 93, Number 6 (Supplement). St. Paul, MN. 535.

Hessburg, P.F., and Hansen, E.M. 2000. Infection of Douglas-fir by *Leptographium wageneri*. Can. J. Bot. 78:1254-1261.

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.

Leaphart, C.D., and Gill, L.S. 1959. Effects of inoculations with *Leptographium* spp. on Western white pine. Phytopathology 49: 350-353.

Loomis, R.C. 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.

Otrosina, W.J.; Hess, N.J.; Zarnoch, S.J.; Perry, T.J.; Jones, J.P. 1997. Blue-stain fungi associated with roots of southern pine trees attacked by the southern pine beetle, *Dendroctonus frontalis*. Plant Disease. 8:942-945.

Palmer, C., R. Dresbach, M.C. Amacher, and K.P. O'Neill 2001. Forest Health Monitoring soil quality monitoring, manual of soil analysis methods. USDA Forest Service, North Central Research Station, St. Paul, MN.

Torrey, J.G., and Clarkson, D.T. 1980. The development and function of roots. Academic Press, New York.

Wagener, W.W., and Mielke, J.L. 1961. A staining-fungus disease of Ponderosa, Jeffery, and Pinyon pines. Plant Dis. Rep. 45: 831-835.

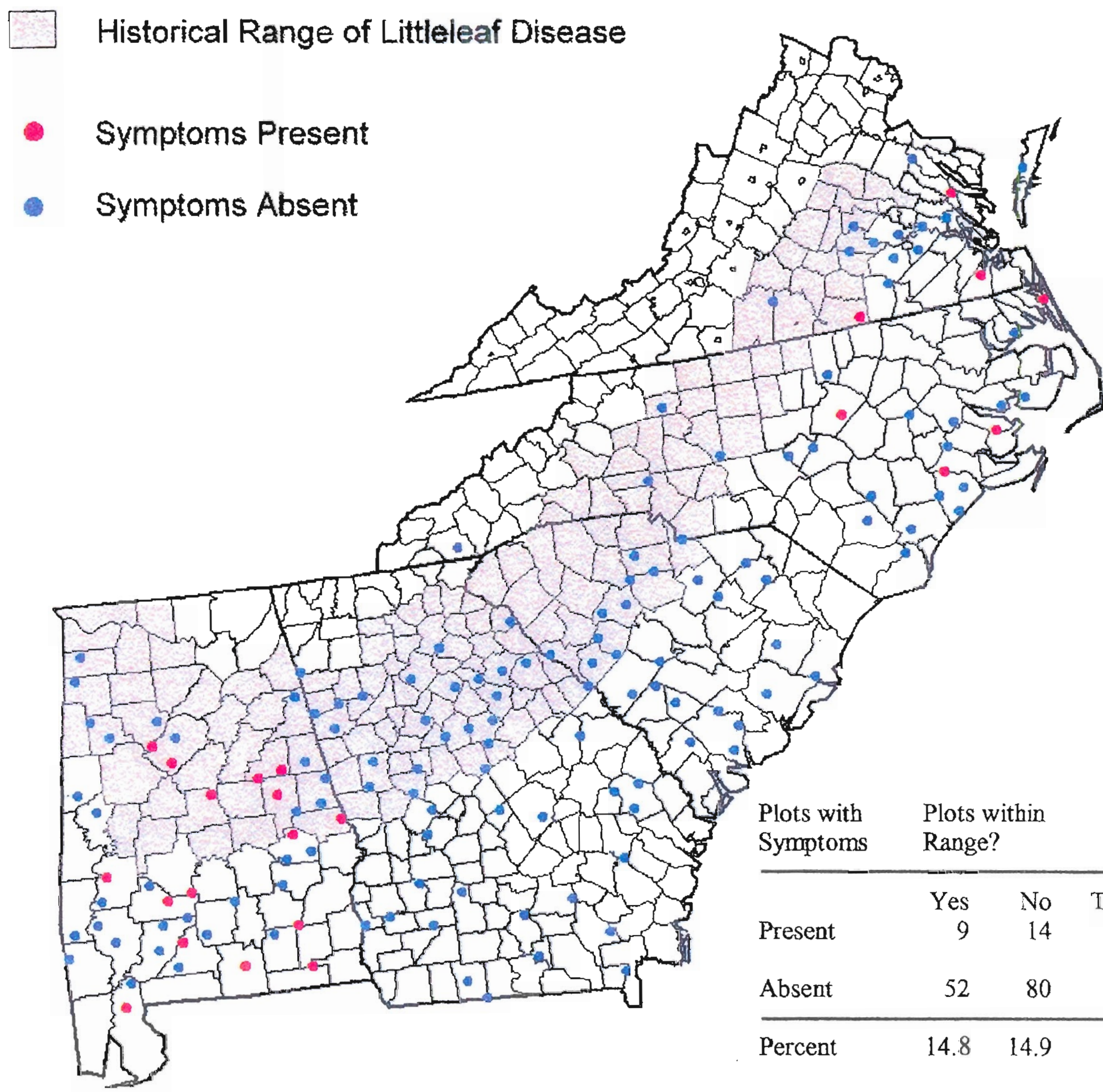
Zimmerman, M.H., and Brown, C.L. 1971. Tree-structure and function. Springer-Verlag, New York.

Appendix A	Loblolly decline map from FHM plots.
Appendix B	Soil Series Descriptions by Art Goddard.
Appendix C	National Forest Risk for Southern Pine Beetle - Coastal Plain Model.
Appendix D	List of cooperators and partners in the "Assessment of Loblolly Pine decline in central Alabama."

Appendix A

Loblolly decline map from FHM plots.

Detection of Loblolly Pine Decline Symptoms on FHM Plots



Plots with Symptoms	Plots within Range?		
	Yes	No	Total
Present	9	14	23
Absent	52	80	132
Percent	14.8	14.9	14.8

Appendix B

Soil Series Descriptions by Art Goddard.

Forest Health
Soil Plot Descriptions
Oakmulgee Ranger District

Following are soil profile descriptions taken on April 1 thru 4 with Emily Carter, Southern Research Station, G. W. Andrews Forestry Sciences Laboratory, Auburn, AL, on the Oakmulgee Ranger District, Talladega National Forest. Soil described from an auger. Soil moisture is moist. Soil colors described are for moist soil.

Plot 12 – Bibb County; site has been burned in last three years. Plot located on upper mid side slope with slopes ranging from 10 to 15 per cent.

Maubila flaggy sandy loam – very deep, moderately well drained soils that formed in stratified clayey and loamy marine sediments of the coastal plain. Permeability is slow.

A--0 to 1 inches; brown (10YR 4/3) sandy loam; weak fine granular structure; friable; many fine and few coarse roots; approximately 20 percent angular fragments of ironstone; strongly acid; clear smooth boundary.

E--2 to 11 inches; strong brown (10YR 5/6) sandy loam; weak fine granular structure; friable; common medium and few coarse roots; approximately 30 percent angular fragments of ironstone; strongly acid; clear smooth boundary.

Bt1-11 to 22 inches; yellowish red (7.5 YR 5/8) clay loam; weak medium subangular blocky structure; friable; few fine and medium roots; few faint clay films on faces of peds; approximately 20 percent angular fragments of ironstone; very strongly acid; clear wavy boundary.

Bt2--22 to 31 inches; yellowish red (5YR 5/8) clay loam; moderate medium subangular blocky structure; firm; few medium roots; common faint clay films on faces of peds; common medium prominent red (2.5 YR 4/6) and distinct yellowish brown (10YR 5/8) masses of iron accumulation; common medium distinct light brownish gray (10YR 6/2) iron depletions; approximately 15 percent angular fragments of ironstone; few fine flakes of mica; very strongly acid; clear wavy boundary.

Bt3--31 to 41 inches; yellowish red (5YR 5/8) clay loam; weak coarse subangular blocky structure which parts to strong fine subangular structure; firm; common distinct clay films on faces of peds; many fine and medium distinct yellowish brown (10YR 5/6) and prominent red (2.5 YR 4/8) masses of iron accumulation; many medium distinct light gray (10YR 7/2) iron depletions; approximately 15 percent angular fragments of ironstone; few fine flakes of mica; very strongly acid; clear wavy boundary.

BC--44 to 60 inches; 30 percent gray (10YR 6/1), 25 percent strong brown (7.5YR 5/6), 25 percent yellowish brown (10YR 5/6), and 20 percent red (10R 4/6) clay loam; moderate weak coarse subangular blocky structure; friable; areas with gray color are iron depletions and areas with red and brown colors are iron accumulations; approximately 15 percent angular fragments of ironstone; common fine flakes of mica; very strongly acid.

C--60 to 64+ inches; 40 percent gray (10YR 6/1), 25 percent strong brown (7.5YR 5/6), 25 percent yellowish brown (10YR 5/6), and 10 percent red (10R 4/6) clay; massive; firm; few thin pockets of clay loam; areas with gray color are iron depletions and areas with red and brown colors are iron accumulations; approximately 10 percent angular fragments of ironstone; many fine flakes of mica; very strongly acid.

Plot 13 – Bibb County; site has been burned in last three years. Plot located on upper mid side slope with slopes ranging from 15 to 20 per cent.

Maubila flaggy sandy loam – very deep, moderately well drained soils that formed in stratified clayey and loamy marine sediments of the coastal plain. Permeability is slow.

A--0 to 1 inches; brown (10YR 4/3) sandy loam; weak fine granular structure; friable; many fine and few coarse roots; approximately 15 percent angular fragments of ironstone; strongly acid; clear smooth boundary.

E--1 to 14 inches; strong brown (10YR 5/6) loamy fine sand; weak fine granular structure; friable; common medium and few coarse roots; approximately 20 percent angular fragments of ironstone; strongly acid; clear smooth boundary.

Bt1-14 to 22 inches; yellowish red (7.5 YR 5/8) clay loam; weak medium subangular blocky structure; friable; few fine and medium roots; few faint clay films on faces of peds; approximately 5 percent angular fragments of ironstone; very strongly acid; clear wavy boundary.

Bt2--22 to 33 inches; red (2.5YR 5/8) clay loam; moderate medium subangular blocky structure; firm; few medium roots; common faint clay films on faces of peds; common medium prominent red (2.5 YR 4/6) and distinct yellowish brown (10YR 5/8) masses of iron accumulation; common medium distinct light brownish gray (10YR 6/2) iron depletions; approximately 15 percent angular fragments of ironstone; few fine flakes of mica; very strongly acid; clear wavy boundary.

Bt3--33 to 42 inches; light red (2.5YR 6/8) clay loam; weak coarse subangular blocky structure which parts to strong fine subangular structure; firm; common distinct clay films on faces of peds; many fine and medium distinct yellowish brown (10YR 5/6) and prominent red (2.5 YR 4/8) masses of iron accumulation; many medium distinct light gray (10YR 7/2) iron depletions; approximately 15 percent angular fragments of ironstone; few fine flakes of mica; very strongly acid; clear wavy boundary.

BC--42 to 55 inches; 30 percent gray (10YR 6/1), 25 percent strong brown (7.5YR 5/6), 25 percent yellowish brown (10YR 5/6), and 20 percent red (10R 4/6) clay loam; moderate weak coarse subangular blocky structure; friable; areas with gray color are iron depletions and areas with red and brown colors are iron accumulations; approximately 15 percent angular fragments of ironstone; common fine flakes of mica; very strongly acid.

C--55 to 64+ inches; 40 percent gray (10YR 6/1), 25 percent strong brown (7.5YR 5/6), 25 percent yellowish brown (10YR 5/6), and 10 percent red (10R 4/6) clay; massive; firm; few thin pockets of clay loam; areas with gray color are iron depletions and areas with red and brown colors are iron accumulations; approximately 10 percent angular fragments of ironstone; many fine flakes of mica; very strongly acid.

Plot 14 – Bibb County; site burned in last year. Plot located on upper mid side slope with slopes ranging from 25 to 30 per cent.

Wadley loamy sand – very deep, well drained and somewhat excessively drained soils that formed in sandy and loamy marine sediments. Permeability is rapid in the A and E horizons and moderate in the Bt horizon.

A--0 to 3 inches; brown (10YR 4/3) loamy sand; single grain; loose; few fine and medium and many coarse roots; strongly acid; clear smooth boundary.

E1--3 to 8 inches; yellowish brown (10YR 5/4) loamy sand; single grain; loose; common fine and medium and few coarse roots; approximately 5 percent angular fragments of ironstone; strongly acid; clear smooth boundary.

E2--8 to 65+ inches; yellowish brown (10YR 5/8) loamy sand; single grain; loose; few fine and medium roots; approximately 15 percent angular fragments of ironstone; few fine faint yellow (10YR 7/8) masses of iron accumulation; few fine and medium very pale yellow (10YR 7/4) pockets and streaks of uncoated sand grains; strongly acid.

Plot 15 – Hale County; site burned in last year. Plot located on old field terrace mid side slope with slopes ranging from 5 to 10 per cent.

Smithdale sandy loam – deep, well drained soils that formed in thick beds of loamy upper coastal plain sediments. Permeability is moderate.

Ap--0 to 4 inches; brown (10YR 4/3) loamy sand. Weak fine granular structure; friable; common fine and medium roots; approximately 5 percent angular fragments of ironstone; strongly acid; clear smooth boundary.

BE--4 to 8 inches; dark yellowish brown (10YR 4/6) loamy sand; weak fine granular structure; friable; few fine and common medium roots; approximately 5 percent angular fragments of ironstone; strongly acid; clear smooth boundary.

Bt1--8 to 18 inches; yellowish red (5YR 5/6) sandy clay loam; weak fine granular structure; firm; few medium roots; common thin clay films on faces of peds; strongly acid; clear smooth boundary.

Bt2--18 to 38 inches; yellowish red (5YR 5/8) clay loam; moderate medium subangular blocky structure; firm; sand grains coated and bridged with clay and oxides; strongly acid; gradual wavy boundary.

Bt3--38 to 56 inches; yellowish red (5YR 5/8) sandy clay loam; moderate medium subangular blocky structure; firm; sand grains coated and bridged with clay and oxides; approximately 5 percent angular fragments of ironstone; strongly acid.

Bt4--56 to 63+ inches; yellowish red (5YR 5/8) sandy loam; weak medium subangular blocky structure; friable; sand grains coated and bridged with clay and oxides; few medium faint red strong brown (7.5YR 5/8) masses of iron accumulation; approximately 5 percent angular fragments of ironstone; strongly

Plot 16 – Hale County; site has been burned in last three years. Plot (center) located within drainage head (transect dissects the drain, with Maubila soils located on side slopes). He drainage area had been farmed in the past. Slopes range from 2 to 5 per cent.

Riverview sandy loam – very deep, well drained soils that formed in loamy alluvium on floodplains. Permeability is moderate.

Ap--0 to 6 inches; brown (10YR 4/3) sandy loam; weak fine granular structure; very friable; many fine and few medium roots; strongly acid; abrupt smooth boundary.

A2--6 to 12 inches; dark yellowish brown (10YR 4/4) loam; moderate medium granular structure; friable; few fine and common medium roots; few fine flakes of mica; strongly acid; clear wavy boundary

Bw1--12 to 23 inches; dark yellowish brown (10YR 4/6) loam; weak medium subangular blocky structure; friable; few medium roots; common fine flakes of mica; strongly acid; clear wavy boundary.

Bw2--23 to 44 inches; dark yellowish brown (10YR 4/6) sandy loam; weak medium subangular blocky structure; friable; common fine flakes of mica; very strongly acid; gradual wavy boundary.

C--44 to 63+ inches; yellowish brown (10YR 5/6) thinly stratified loamy sand; single grain; loose; common fine flakes of mica; very strongly acid.

Plot 17 – Bibb County; site has not been burned in last 5 years or more. Plot located on upper mid side slope with slopes ranging from 0 to 5 per cent.

Maubila flaggy sandy loam, eroded – very deep, moderately well drained soils that formed in stratified clayey and loamy marine sediments of the coastal plain. Permeability is slow.

Bt1--0 to 3 inches; yellowish red (5YR 4/6) clay loam; weak medium subangular blocky structure; firm; few fine roots; few faint clay films on faces of peds; approximately 5 percent angular fragments of ironstone; very strongly acid; clear wavy boundary.

Bt2--3 to 18 inches; yellowish red (5YR 5/8) clay; moderate medium subangular blocky structure; firm; few medium roots; common faint clay films on faces of peds; common medium prominent red (2.5 YR 4/6) and distinct yellowish brown (10YR 5/8) masses of iron accumulation; common medium distinct light brownish gray (10YR 6/2) iron depletions; approximately 15 percent angular fragments of ironstone; few fine flakes of mica; very strongly acid; clear wavy boundary.

Bt3--18 to 32 inches; yellowish red (5YR 5/8) clay; weak coarse subangular blocky structure which parts to strong fine subangular structure; firm; common distinct clay films on faces of peds; many fine and medium distinct yellowish brown (10YR 5/6) and prominent red (2.5 YR 4/8) masses of iron accumulation; many medium distinct light gray (10YR 7/2) iron depletions; approximately 10 percent angular fragments of ironstone; few fine flakes of mica; very strongly acid; clear wavy boundary.

BC--32 to 49 inches (hit thick ironstone to hard to bore thru); 30 percent gray (10YR 6/1), 25 percent strong brown (7.5YR 5/6), 25 percent yellowish brown (10YR 5/6), and 20 percent red (10R 4/6) clay loam; moderate weak coarse subangular blocky structure; friable; areas with gray color are iron depletions and areas with red and brown colors are iron accumulations; approximately 10 percent angular fragments of ironstone; common fine flakes of mica; very strongly acid.

Plot 18 – Bibb County; site has been burned in last year. Plot located on upper mid side slope with slopes ranging from 30 to 35 per cent.

<u>Maubila flaggy sandy loam</u> – very deep, moderately well drained soils that formed in stratified clayey and loamy marine sediments of the coastal plain. Permeability is slow.

A--0 to 3 inches; brown (10YR 4/3) sandy loam; weak fine granular structure; friable; many fine and few coarse roots; approximately 5 percent angular fragments of ironstone; strongly acid; clear smooth boundary.

E--3 to 16 inches; yellowish brown (10YR 5/4) sandy loam; weak fine granular structure; friable; common medium and few coarse roots; approximately 10 percent angular fragments of ironstone; strongly acid; clear smooth boundary.

Bt1--16 to 23 inches; strong brown (7.5 YR 5/8) clay loam; weak medium subangular blocky structure; friable; few fine and medium roots; few faint clay films on faces of peds; approximately 10 percent angular fragments of ironstone; very strongly acid; clear wavy boundary.

Bt2--23 to 32 inches; yellowish red (5YR 5/8) clay; moderate medium subangular blocky structure; firm; few medium roots; common faint clay films on faces of peds; common medium prominent red (2.5 YR 4/6) and distinct yellowish brown (10YR 5/8) masses of iron accumulation; common medium distinct light brownish gray (10YR 6/2) iron depletions; approximately 15 percent angular fragments of ironstone; few fine flakes of mica; very strongly acid; clear wavy boundary.

Bt3--32 to 44 inches; yellowish red (5YR 5/8) clay; weak coarse subangular blocky structure which parts to strong fine subangular structure; firm; common distinct clay films on faces of peds; many fine and medium distinct yellowish brown (10YR 5/6) and prominent red (2.5 YR 4/8) masses of iron accumulation; many medium distinct light gray (10YR 7/2) iron depletions; approximately 10 percent angular fragments of ironstone; few fine flakes of mica; very strongly acid; clear wavy boundary.

BC--44 to 60 inches; 30 percent gray (10YR 6/1), 25 percent strong brown (7.5YR 5/6), 25 percent yellowish brown (10YR 5/6), and 20 percent red (10R 4/6) clay loam; moderate weak coarse subangular blocky structure; friable; areas with gray color are iron depletions and areas with red and brown colors are iron accumulations; approximately 10 percent angular fragments of ironstone; common fine flakes of mica; very strongly acid.

C--60 to 64+ inches; 40 percent gray (10YR 6/1), 25 percent strong brown (7.5YR 5/6), 25 percent yellowish brown (10YR 5/6), and 10 percent red (10R 4/6) clay; massive; firm; few thin pockets of clay loam; areas with gray color are iron depletions and areas with red and brown colors are iron accumulations; approximately 10 percent angular fragments of ironstone; many fine flakes of mica; very strongly acid.

Plot 19 – Bibb County; site burned in last three years. Plot located mid side slope with slopes ranging from 30 to 35 per cent.

Suffolk loamy sand – very deep, well drained soils that formed in loamy fluvial and marine sediments of the coastal plain. Permeability is moderate.

A--0 to 4 inches; brown (10YR 4/3) loamy sand; weak fine granular structure; friable; common fine and few medium roots; strongly acid; clear smooth boundary.

E--4 to 10 inches; yellowish brown (10YR 5/6) sandy loam; weak fine granular structure; few fine and medium roots; strongly acid; clear wavy boundary.

Bt1--10 to 19 inches; strong brown (7.5YR 5/8) sandy clay loam; weak medium subangular blocky structure; firm; few fine and medium roots; few faint clay films on faces of peds; very strongly acid; clear wavy boundary.

Bt2--19 to 28 inches; strong brown (7.5YR 5/8) sandy clay loam; weak medium subangular blocky structure; firm; few faint clay films on faces of peds; very strongly acid; gradual wavy boundary.

Bt3--28 to 36 inches; brownish yellow (10YR 6/6) clay loam; moderate medium subangular blocky structure; firm; few faint clay films on faces of peds; very strongly acid; gradual wavy boundary.

Bt4--36 to 44 inches; yellowish brown (10YR 5/8) clay loam; moderate medium subangular blocky structure; firm; few faint clay films on faces of peds; very strongly acid; gradual wavy boundary.

C--44 to 60+ inches; yellowish brown (10YR 5/8) sandy loam; few, coarse, distinct strong brown (7.5YR 5/8) Fe masses; single grain; loose, strong brown Fe masses are firm and massive; very strongly acid.

Plot 20 – Bibb County; site has been burned in last three years. Plot located on upper mid side slope with slopes ranging from 25 to 30 per cent.

Maubila flaggy sandy loam – very deep, moderately well drained soils that formed in stratified clayey and loamy marine sediments of the coastal plain. Permeability is slow.

A--0 to 2 inches; brown (10YR 4/3) sandy loam; weak fine granular structure; friable; many fine and few coarse roots; approximately 5 percent angular fragments of ironstone; strongly acid; clear smooth boundary.

E--2 to 6 inches; brown (10YR 5/4) sandy loam; weak fine granular structure; friable; common medium and few coarse roots; approximately 25 percent angular fragments of ironstone; strongly acid; clear smooth boundary.

Bt1--6 to 12 inches; reddish yellow (7.5 YR 6/6) clay loam; weak medium subangular blocky structure; friable; few fine and medium roots; few faint clay films on faces of peds; approximately 15 percent angular fragments of ironstone; very strongly acid; clear wavy boundary.

Bt2--12 to 24 inches; yellowish red (5YR 5/8) clay; moderate medium subangular blocky structure; firm; few medium roots; common faint clay films on faces of peds; common medium prominent red (2.5 YR 4/6) and distinct yellowish brown (10YR 5/8) masses of iron accumulation; common medium distinct light brownish gray (10YR 6/2) iron depletions; approximately 15 percent angular fragments of ironstone; few fine flakes of mica; very strongly acid; clear wavy boundary.

Bt3--24 to 42 inches; yellowish red (5YR 5/8) clay; weak coarse subangular blocky structure which parts to strong fine subangular structure; firm; common distinct clay films on faces of peds; many fine and medium distinct yellowish brown (10YR 5/6) and prominent red (2.5 YR 4/8) masses of iron accumulation; many medium distinct light gray (10YR 7/2) iron depletions; approximately 10 percent angular fragments of ironstone; few fine flakes of mica; very strongly acid; clear wavy boundary.

BC--44 to 56 inches; 30 percent gray (10YR 6/1), 25 percent strong brown (7.5YR 5/6), 25 percent yellowish brown (10YR 5/6), and 20 percent red (10R 4/6) clay loam; moderate weak coarse subangular blocky structure; friable; areas with gray color are iron depletions and areas with red and brown colors are iron accumulations; approximately 10 percent angular fragments of ironstone; common fine flakes of mica; very strongly acid.

C--56 to 64+ inches; 40 percent gray (10YR 6/1), 25 percent strong brown (7.5YR 5/6), 25 percent yellowish brown (10YR 5/6), and 10 percent red (10R 4/6) clay; massive; firm; few thin pockets of clay loam; areas with gray color are iron depletions and areas with red and brown colors are iron accumulations; approximately 10 percent angular fragments of ironstone; many fine flakes of mica; very strongly acid.

Plot 21 – Hale County; site burned in last three years. Plot located mid side slope with slopes ranging from 20 to 25 per cent.

Smithdale sandy loam – deep, well drained soils that formed in thick beds of loamy upper coastal plain sediments. Permeability is moderate.

A--0 to 6 inches; brown (10YR 4/3) sandy loam. Weak fine granular structure; friable; common fine and medium roots; approximately 5 percent angular fragments of ironstone; strongly acid; clear smooth boundary.

E--6 to 13 inches; strong brown (7.5YR 4/6) sandy loam; weak fine granular structure; friable; few fine and common medium roots; approximately 5 percent angular fragments of ironstone; strongly acid; clear smooth boundary.

Bt1--13 to 21 inches; yellowish red (5YR 5/6) sandy loam; weak fine granular structure; friable; few medium roots; common thin clay films on faces of peds; approximately 15 percent angular fragments of ironstone; strongly acid; clear smooth boundary.

Bt2--21 to 51 inches; yellowish red (5YR 5/6) clay loam; moderate medium subangular blocky structure; firm; sand grains coated and bridged with clay and oxides; approximately 25 percent angular fragments of ironstone; strongly acid; gradual wavy boundary.

Bt3--51 to 61+ inches; yellowish red (5YR 5/6) clay loam; moderate medium subangular blocky structure; firm; sand grains coated and bridged with clay and oxides; few medium faint red strong brown (7.5YR 5/8) masses of iron accumulation; approximately 10 percent angular fragments of ironstone; strongly acid.

Plot 22 – Hale County; site has not been burned in last five years or more. Plot located on upper mid side slope with slopes ranging from 25 to 30 per cent.

Maubila flaggy sandy loam – very deep, moderately well drained soils that formed in stratified clayey and loamy marine sediments of the coastal plain. Permeability is slow.

A--0 to 2 inches; brown (10YR 4/3) sandy loam; weak fine granular structure; friable; many fine and few coarse roots; approximately 5 percent angular fragments of ironstone; strongly acid; clear smooth boundary.

E--2 to 6 inches; brown (10YR 5/4) sandy loam; weak fine granular structure; friable; common medium and few coarse roots; approximately 25 percent angular fragments of ironstone; strongly acid; clear smooth boundary.

Bt1--6 to 12 inches; reddish yellow (7.5 YR 6/6) clay loam; weak medium subangular blocky structure; friable; few fine and medium roots; few faint clay films on faces of peds; approximately 15 percent angular fragments of ironstone; very strongly acid; clear wavy boundary.

Bt2--12 to 24 inches; yellowish red (5YR 5/8) clay; moderate medium subangular blocky structure; firm; few medium roots; common faint clay films on faces of peds; common medium prominent red (2.5 YR 4/6) and distinct yellowish brown (10YR 5/8) masses of iron accumulation; common medium distinct light brownish gray (10YR 6/2) iron depletions; approximately 15 percent angular fragments of ironstone; few fine flakes of mica; very strongly acid; clear wavy boundary.

Bt3--24 to 38+ inches (hit thick ironstone to hard to bore thru); yellowish red (5YR 5/8) clay; weak coarse subangular blocky structure which parts to strong fine subangular structure; firm; common distinct clay films on faces of peds; many fine and medium distinct yellowish brown (10YR 5/6) and prominent red (2.5 YR 4/8) masses of iron accumulation; many medium distinct light gray (10YR 7/2) iron depletions; approximately 10 percent angular fragments of ironstone; few fine flakes of mica; very strongly acid; clear wavy boundary.

Plot 32 – Perry County; site burned in last three years. Plot located upper side slope with slopes ranging from 4 to 6 per cent.

Suffolk loamy sand – very deep, well drained soils that formed in loamy fluvial and marine sediments of the coastal plain. Permeability is moderate.

A--0 to 5 inches; brown (10YR 4/3) fine sandy loam; weak fine granular structure; friable; common fine and few medium roots; approximately 5 percent gravel; strongly acid; clear smooth boundary.

E--5 to 11 inches; yellowish brown (10YR 5/6) sandy loam; weak medium granular structure; friable; few fine and medium roots; approximately 5 percent gravel; strongly acid; clear wavy boundary.

BE--11 to 18 inches; light yellowish brown (10YR 6/4) sandy loam; weak medium subangular blocky structure; friable; few fine and medium roots; approximately 2 percent gravel; few faint clay films on faces of peds; very strongly acid; clear wavy boundary.

Bt1--18 to 26 inches; strong brown (7.5YR 5/6) sandy clay loam; weak medium subangular blocky structure; firm; few faint clay films on faces of peds; few medium faint yellowish red (5YR 5/6) masses of iron accumulation; very strongly acid; gradual wavy boundary.

Bt2--26 to 32 inches; strong brown (7.5YR 5/6) clay loam; moderate medium subangular blocky structure; firm; few faint clay films on faces of peds; few medium distinct red (2.5YR 5/6) masses of iron accumulation; very strongly acid; gradual wavy boundary.

Bt3--32 to 40 inches; strong brown (7.5YR 5/6) clay loam; moderate medium subangular blocky structure; firm; few faint clay films on faces of peds; few fine faint pale brown and common medium distinct red (2.5 YR 5/6) masses of iron accumulation; few fine mica flakes; very strongly acid; gradual wavy boundary.

Bt4—40 to 55 inches; strong brown (7.5YR 5/6) sandy clay loam; weak coarse prismatic to moderate medium subangular blocky structure; friable; few faint clay films on faces of peds; approximately 2 percent gravel; common medium distinct pale brown (10YR 6/3) and yellowish red (5YR 4/6) masses of iron accumulation; common fine mica flakes; very strongly acid; gradual wavy boundary.

C--55 to 63+ inches; yellowish brown (10YR 5/6) sandy loam; massive; friable; few inclusions of sandy clay loam; common medium distinct strong brown (7.5 YR 5/6) and yellowish red (5YR 4/6) masses of iron accumulation; few medium distinct brownish gray (10YR 6/2) iron depletions; very strongly acid.

Plot C4 – Bibb County; site has not been burned in last 5 years or more. Plot located on upper mid side slope with slopes ranging from 15 to 20 per cent.

Suffolk loamy sand – very deep, well drained soils that formed in loamy fluvial and marine sediments of the coastal plain. Permeability is moderate.

A--0 to 6 inches; very dark grayish brown (10YR 3/2) sandy loam; weak fine granular structure; friable; common fine and few medium roots; strongly acid; clear smooth boundary.

E--6 to 15 inches; yellowish brown (10YR 5/4) sandy loam; weak fine granular structure; few fine and medium roots; strongly acid; clear wavy boundary.

Bt1--15 to 24 inches; dark yellowish brown (10YR 4/6) sandy clay loam; moderate medium subangular blocky structure; firm; few fine and medium roots; few faint clay films on faces of peds; very strongly acid; clear wavy boundary.

Bt2--24 to 36 inches; strong brown (7.5YR 5/6) sandy clay loam; weak medium subangular blocky structure; firm; few faint clay films on faces of peds; very strongly acid; gradual wavy boundary.

Bt3--36 to 45 inches; reddish yellow (5YR 5/8) sandy clay loam; moderate medium subangular blocky structure; firm; few faint clay films on faces of peds; common medium distinct red (2.5Yr 5/8) masses of iron accumulation; few fine quartz pebbles; strongly acid; gradual wavy boundary.

Bt4--45 to 60+ inches; yellowish red (5YR 5/8) sandy clay loam; moderate medium subangular blocky structure; firm; few faint clay films on faces of peds; common medium distinct reddish yellow (7.5YR 5/8) masses of iron accumulation; few fine quartz pebbles; strongly acid.

Plot C5 – Bibb County; site has not been burned in last 5 years or more. Plot located on upper mid side slope with slopes ranging from 25 to 30 per cent.

Wadley loamy sand – very deep, well drained and somewhat excessively drained soils that formed in sandy and loamy marine sediments. Permeability is rapid in the A and E horizons and moderate in the Bt horizon.

A--0 to 4 inches; brown (10YR 4/3) loamy sand; single grain; loose; few fine and medium and many coarse roots; strongly acid; clear smooth boundary.

E1--4 to 28 inches; yellowish brown (10YR 5/6) loamy sand; single grain; loose; common fine and medium and few coarse roots; approximately 5 percent angular fragments of ironstone; strongly acid; clear smooth boundary.

Bw--28 to 55 inches; strong brown (7.5YR 5/8) sandy loam; weak medium subangular blocky structure; friable; few fine reddish yellow (7.5YR 6/6) pockets and streaks of uncoated sand grains; strongly acid; diffuse wavy boundary.

C--55+ inches; strong brown (7.5YR 5/8) and reddish yellow (7.5YR 6/6) sand; single grain; loose; few fine pink (7.5YR 7/4) pockets and streaks of uncoated sand grains; strongly acid.

Plot C6 – Bibb County; site has been burned in last 3 years or more. Plot located on upper mid side slope within a colluvial (drain) site with slopes ranging from 10 to 15 per cent.

Wadley loamy sand – (this soil closely resembles Wadley except for the surface layers being sandy loam) very deep, well drained and somewhat excessively drained soils that formed in sandy and loamy marine sediments. Permeability is rapid in the A and E horizons and moderate in the Bt horizon.

A--0 to 6 inches; brown (10YR 4/3) sandy loam; weak fine granular; very friable; few fine and medium and many coarse roots; strongly acid; clear smooth boundary.

E1--6 to 14 inches; brown (7.5YR 5/4) sandy loam; weak fine granular; very friable; common fine and medium and few coarse roots; strongly acid; clear smooth boundary.

E2--14 to 51 inches; yellowish brown (10YR 5/4) loamy sand; single grain; loose; few fine and medium roots; few fine faint yellow (10YR 7/8) masses of iron accumulation; few fine and medium very pale brown (10YR 7/3) pockets and streaks of uncoated sand grains; strongly acid.

Bt--51 to 65+ inches; strong brown (10YR 4/6) loamy sand; single grain; loose; few fine and medium roots; few fine faint yellow (10YR 7/8) masses of iron accumulation; few fine and medium very pale brown (10YR 7/3) pockets and streaks of uncoated sand grains; strongly acid.

Plot C7 – Chilton County; site burned in last three years. Site is an old farm field, terraces on site. Plot located upper side slope with slopes ranging from 12 to 15 per cent.

Smithdale sandy loam – deep, well drained soils that formed in thick beds of loamy upper coastal plain sediments. Permeability is moderate.

Ap--0 to 8 inches; yellowish brown (10YR 5/6) loamy sand. Weak fine granular structure; friable; common fine and few medium roots; strongly acid; clear smooth boundary.

Bt1--8 to 21 inches; reddish yellow (7.5YR 6/8) sandy loam; weak fine granular structure; friable; few fine and medium roots; few thin clay films on faces of peds; strongly acid; clear smooth boundary.

Bt2--21 to 38 inches; reddish yellow (5YR 6/8) sandy clay loam; moderate medium subangular blocky structure; firm; few faint clay films on faces of peds; few medium distinct red (2.5YR 5/8) masses of iron accumulation; strongly acid; gradual wavy boundary.

Bt3--38 to 50 inches; reddish yellow (5YR 6/8) sandy clay loam; moderate medium subangular blocky structure; firm; few faint clay films on faces of peds; common medium distinct red (2.5Yr 5/8) masses of iron accumulation; few fine quartz pebbles; strongly acid; gradual wavy boundary.

Bt4--50 to 60+ inches; red (2.5YR 5/8) sandy clay loam; moderate medium subangular blocky structure; firm; few faint clay films on faces of peds; common medium distinct reddish yellow (7.5YR 5/8) masses of iron accumulation; few fine quartz pebbles; strongly acid.

Appendix C

National Forest Risk for Southern Pine Beetle Coastal Plain Model.

National Forest Risk (COASTAL PLAIN)

Stand classifications for southern pine beetle losses for National Forests in the Coastal Plain were developed through the cooperation of the Southern Research Station and Forest Health Protection. Because it cannot be predicted exactly when and where infestations will occur, the following classifications are intended to identify those stands in which infestations are most likely to occur, cause significant losses, and produce the most beetles—if and when an outbreak develops—over the next three to five years.

Table 3: Southern Pine Beetle Risk (Coastal Plain)

A. Stands with forest type **loblolly pine** (31), **shortleaf pine** (32), **loblolly pine-hardwood** (13), or **shortleaf pine-oak** 912) will have a high or medium hazard classification according to total stand height and pine basal area as follows:

Total Height	High Hazard	Medium Hazard
	Pine Basal Area	
56-65		>80
66-75	>90	80 – 90
76-105	>90	70 – 90
106+	>100	70 – 100

B. Stands with forest type **slash pine** (22), **longleaf pine** (21), or **bottomland hardwood-pine** (46) will have a medium hazard classification according to total stand height and pine basal area as follows:

Total Height	High Hazard	Medium Hazard
	Pine Basal Area	
66-75		>80
76-105		>90
106+		>100

C. Seedling-sappling stands (CC13) of **loblolly** (31), **slash** (22), and **shortleaf** (32) pine age 5 to 15 and immature poletimber stands (CC11) age 15 to 25 with average dbh 5"-10" that are over stocked and have not been pre-commercially thinned will be rated as HIGH hazard for SPB. Pre-commercially thinned will be rated as MEDIUM to LOW risk.

Appendix D

List of cooperators and partners in the "Assessment of Loblolly Pine decline in central Alabama."

Appendix D

"Assessment of loblolly pine decline in central Alabama". Forest Health Monitoring-Evaluation Monitoring 2000-2003 Project.

Partner/collaborator	**Affiliation/participation**	
Nolan Hess, Plant Pathologist	USDAFS/FHP	Project Leader
Dale Starkey Plant Pathologist	USDAFS/FHP	Forest Health Monitoring training and oversight
Ron Kertz Biological Science Technician	USDAFS/FHP	Field Measurement FHM/data collection
Roger Menard Biological Science Technician	USDAFS/FHP	Field/Lab and GIS oversight
Tim Haley Entomologist	USDAFS/FHP	SPB Biological Evaluations and tree growth measurements
William Otrosina Research Plant Pathologist	USDAFS/SRS	Tree Root Biology Unit
Catharine Cook, Biological Science Laboratory Technician	USDAFS/SRS	Laboratory Assessment
Emily Carter Research Soil Scientist	USDAFS/SRS	Soil assessment physical and chemical
Art Goddard, Soil Scientist National Forest in Alabama	USDAFS	Soil classification
Charles Walkinshaw, (Retired) Plant Pathologist	USDAFS/SRS	Histology

Appendix D continued:

John P. Jones Pathology/Mycology Professor	Louisiana Agri. Experiment Station Graduate student oversight and mycology expertise
Lori G. Eckhardt Ph.D. Graduate student	LSU – insect vectors and *Leptographium* investigation
Ann M. Weber Master Graduate student	LSU – *Phytophthora cinnamomi* investigation
Jim Hyland Pest Management Chief	Alabama Forestry Commission State Cooperator and FHM oversight
Sam Hopkins Research Forester	Gulf State Paper Corporation Provided land base oversight
Bruce DeHaan Research Forester	Gulf State Paper Corporation Plot coordination
National Forest in Alabama District Rangers	USDAFS/National Forests Land base and coordination