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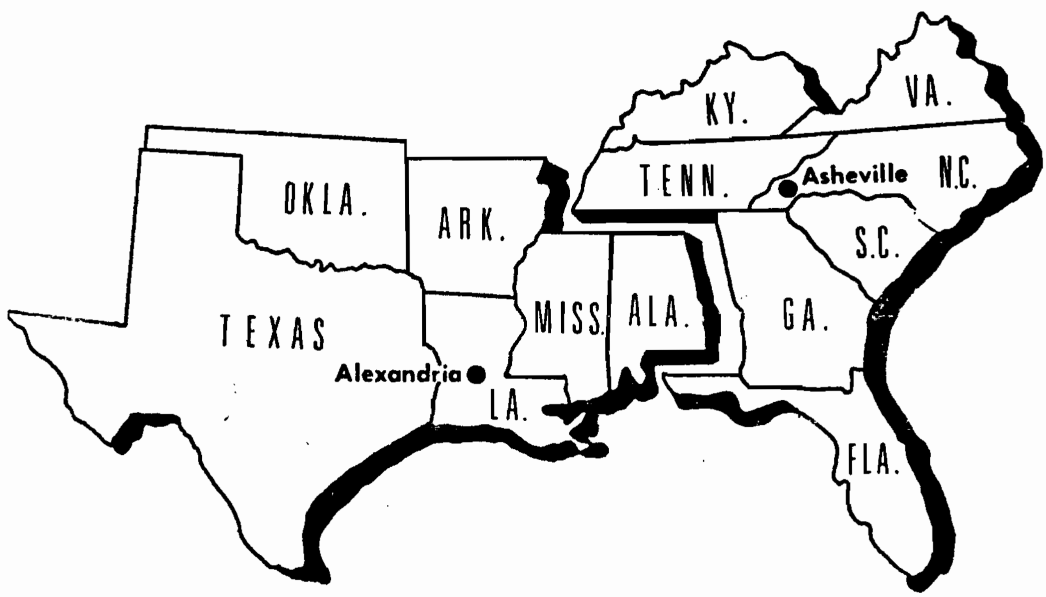
H. D. Brown[1/] and W. E. McDowell[2/]

U. S. FOREST SERVICE
Pineville, Louisiana



U. S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE
SOUTHEASTERN AREA, STATE AND PRIVATE FORESTRY
DIVISION OF FOREST PEST CONTROL

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ABSTRACT

Declining and dying sawtimber-sized loblolly pine have been observed on the Oakmulgee Division of the Talladega National Forest, Alabama, for 10 years. Results of three annual evaluations conducted by the Division of Forest Pest Control on twenty-four permanent plots show that trees are declining on most plots but few are dying. Possible factors involved in the decline are annosus root rot, littleleaf disease, Pythium *spp., and adverse soil-water relationships.*

INTRODUCTION

A decline of loblolly pine, *Pinus taeda* L., (Fig. 1) has been observed on the Oakmulgee and Tuscaloosa Ranger Districts of the Talladega National Forest, Alabama, since 1959. This condition, since named "loblolly pine die-off", occurs most frequently in sawtimber-sized trees over 50 years old. It is present on about 150,000 acres of National Forest land and an undetermined number of acres on private land.

In February 1966, an evaluation of 24 loblolly pine die-off plots was initiated on the Oakmulgee Ranger District (Fig. 2) by the Division of Forest Pest Control. The purpose was to determine the rate of decline and mortality of the trees over a five-year period.

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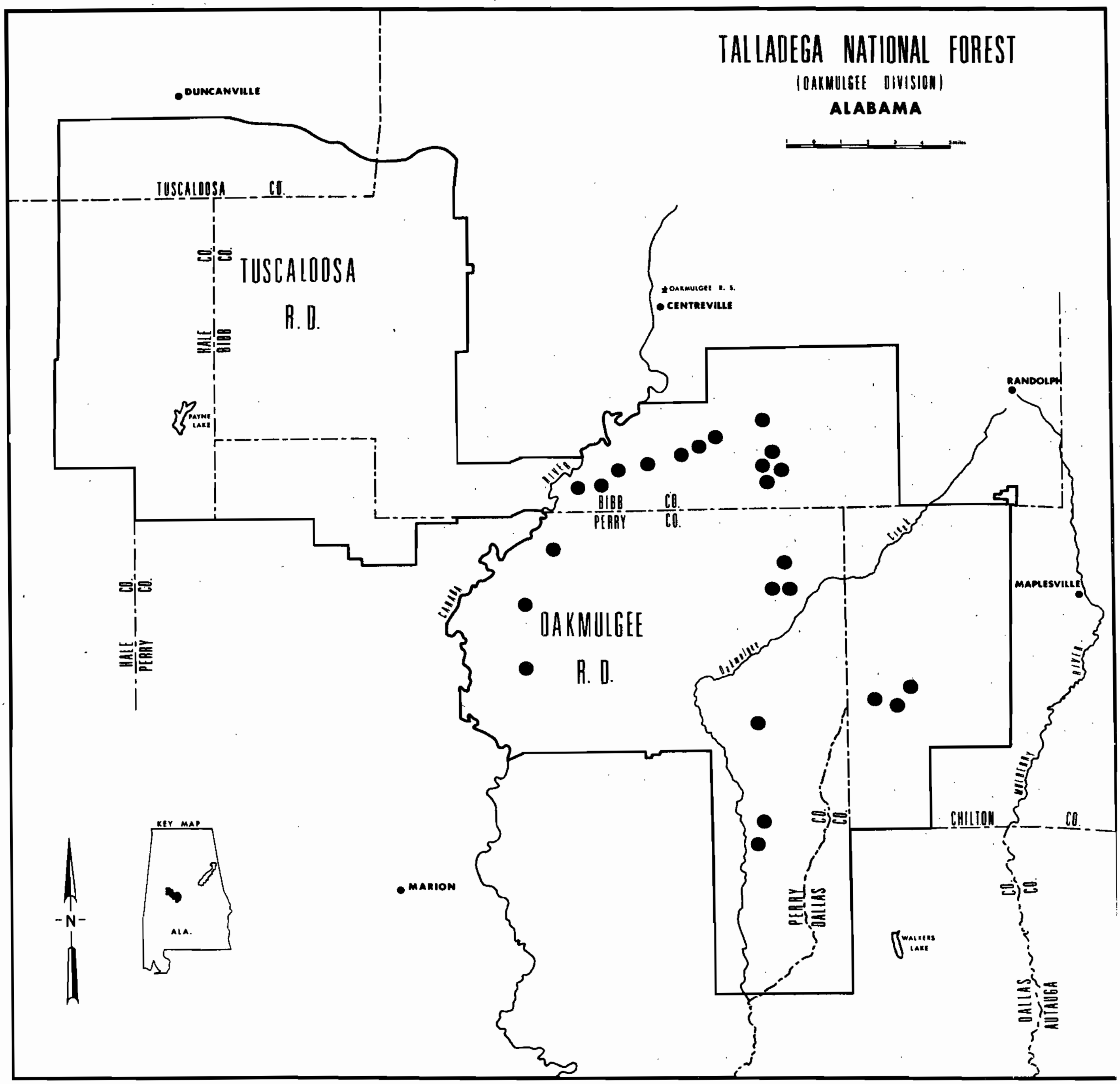
1 Pathologist, U. S. Forest Service, SA, S&PF, Division of Forest Pest Control, Pineville, Louisiana.

2 Technician, U. S. Forest Service, SA, S&PF, Division of Forest Pest Control, Asheville, North Carolina.

Fig. 1 Loblolly pine expressing die-off symptoms.



● Loblolly pine die-off plots

Fig. 2 Location of Loblolly Pine Die-off Plots, Oakmulgee Ranger District, Talladega National Forest, Alabama.

A progress report followed this first evaluation (Anonymous, 1966). Succeeding evaluations were made in February-March 1967 and February 1968. This progress report includes the results of data collected from the three evaluations.

HISTORICAL BACKGROUND

During the years following the first observation of loblolly pine die-off, personnel from the Southern Forest Experiment Station, Southeastern Forest Experiment Station, Alabama National Forests, and Division of Forest Pest Control visited the area, attempting to identify the cause(s) of the problem. No cause was determined, but several conclusions were made. Some of these conclusions are as follows:

1) Lateral root deterioration has preceded the presence of observable foliage symptoms (Roth, 1960).

2) A large percent of the feeder roots are dead long before the tree dies (Roth, 1960).

3) Generally, trees are 50+ years old before they show symptoms (Wood, 1962).

4) Exceptionally heavy cone crops occur approximately one year before a tree dies (Czabator, 1962).

5) Neither insects, foliage diseases nor heart rots appear to be the cause of the die-off (Czabator, 1962).

6) Neither annosus root rot nor littleleaf appear to be the primary cause of the problem. In an examination by Czabator and Verrall, roots of nine trees expressing typical symptoms of this decline were collected. One tree had *F. annosus* fruiting bodies at its base. Cultures from the roots were all negative for *Fomes annosus* (Fr.)Karst (Czabator, 1962). With regard to littleleaf, Roth reported that the root system deterioration of the die-off trees was more extensive than in littleleaf trees (Roth, 1960). Twenty-four soil samples collected from the die-off area were assayed for *Phytophthora cinnamomi* Rands, a primary factor in the development of littleleaf. The fungus was found in only five of the samples (Campbell, 1965).

In 1964, personnel from the Division of Forest Pest Control, Macon, Georgia, and the Oakmulgee District, Talladega National Forest, selected 24 loblolly pine plots on the Oakmulgee District exhibiting various stages of die-off in order to evaluate the decline and mortality over a five-year period. In 1965, Elmer R. Roth, and William H. Padgett, Division of Forest Pest Control, Atlanta and Macon, respectively, prepared a foliage symptom classification system (Table 1) as the tool for determining the rate of decline and mortality in the loblolly pine die-off plots. This system, as adjusted, (Table 2) has been used in the annual evaluation, which began in 1966.

In the fall of 1966, Chester C. Robinson, Soil Scientist, U. S. Forest Service, Atlanta and Craig Bryan and Donald Marx, Pathologists, Southeastern Forest Experiment Station, visited the die-off plots. Robinson collected soil and related data from nine die-off plots in order to make soil series identifications and interpretations. Marx and Bryan collected soil and root samples from 20 plots to be cultured for soil-borne and root inhabiting fungi. All plots were thoroughly examined for *F. annosus* fruiting bodies by Marx, Bryan, and Division of Forest Pest Control personnel. Results of these examinations are found in the Appendix.

METHODS

A District map and aerial photographs were used to locate the plots. Initial plot information was used to determine numbers for each dominant and co-dominant pine. One typical terminal branch was shot out of the upper-third of the crown of each dominant and co-dominant pine in each plot. For uniformity, the north quadrant of the pine was used. The terminal portion of the branch was examined for needle color, and measured for needle length and needle retention. In recording needle length, an average of three randomly selected needles was made. Observed disease or insect damage to the branch was recorded and the damaged specimens were collected for identification. Damage to and mortality of individual pine was recorded, including cause when known.

RESULTS

During the two-year period (1966-1968), the number of trees in Class 1 decreased 37 percent; Class 2 increased 30 percent; Class 3 increased 23 percent; Class 4 decreased 40 percent; and Class 5 increased 900 percent. In 1966, Class 1 contained the greatest number of trees; in 1968, both Class 2 and 3 had more trees than Class 1 (Fig. 3).

A negative trend, the result of declining trees between 1966 and 1968, is apparent in 58 percent of the plots (Fig. 4). The number of trees in 13 plots both decreased in Class 1 and increased in Class 2 and/or 3 (Table 3).

The average condition of 16 plots decreased over the two-year period (Table 4). In 1966, one plot was Class 3, five plots were Class 3 in 1967, and by 1968, seven plots had fallen to this Class.

TABLE 1
SYMPTOM CLASSIFICATION FOR LOBLOLLY PINE DIE-OFF

Needle Color

Green	-	0
Greenish-Yellow	-	.7
Yellow	-	1.2

Needle Length

6+"	-	0
5" - 6"	-	.5
3" - 4"	-	1.0
1" - 2"	-	1.5

Needle Retention

4+"	-	0
3" - 4"	-	1.0
2" - 3"	-	1.7
1" - 2"	-	2.4

Conditions

0 - 1.9	- Class 1 - Healthy
2.0 - 2.9	- Class 2 - Light
3.0 - 3.7	- Class 3 - Moderate
3.8 - 4.9	- Class 4 - Severe
5.0	- Class 5 - Dead

A tree is considered healthy if the sum of the values of the above factors does not exceed 1.9, lightly infected if above 1.9, and does not exceed 2.9, moderately infected if above 2.9 and does not exceed 3.7, severely infected if above 3.7 and does not exceed 4.9. 5.0 indicates dead.

TABLE 2
SYMPTOM CLASSIFICATION FOR LOBLOLLY PINE DIE-OFF
(Adjusted)

Needle Color			
	Green	- 0 (0.00 - 0.35)*	
	Greenish-Yellow	- .7 (0.36 - 0.95)	
	Yellow	- 1.2 (0.96 - 1.20)	
Needle Length			
	6.00+"	- 0 (0.00 - 0.25)	
	5.00" - 5.99"	- .5 (0.26 - 0.75)	
	3.00" - 4.99"	- 1.0 (0.76 - 1.25)	
	0.00" - 2.99"	- 1.5 (1.26 - 1.50)	
Needle Retention			
	4.00+"	- 0 (0.00 - 0.50)	
	3.00" - 3.99"	- 1.0 (0.51 - 1.35)	
	2.00" - 2.99"	- 1.7 (1.36 - 2.05)	
	0.00" - 1.99"	- 2.4 (2.06 - 2.40)	
Conditions			
	0.00 - 0.66	- Class 1+	
	0.67 - 1.33	- Class 1	Healthy
	1.34 - 1.99	- Class 1-	
	2.00 - 2.33	- Class 2+	
	2.34 - 2.66	- Class 2	Light
	2.67 - 2.99	- Class 2-	
	3.00 - 3.26	- Class 3+	
	3.27 - 3.53	- Class 3	Moderate
	3.54 - 3.79	- Class 3-	
	3.80 - 4.19	- Class 4+	
	4.20 - 4.59	- Class 4	Severe
	4.60 - 4.99	- Class 4-	
	5.00+	- Class 5	Dead

* These figures are necessary when converting an average numerical classification to the corresponding average needle classification.

Fig. 3 Symptom Classification of 338 Loblolly Pine in 24 Die-off Plots, Oakmulgee District, Talladega National Forest, Alabama: 1966-1968.

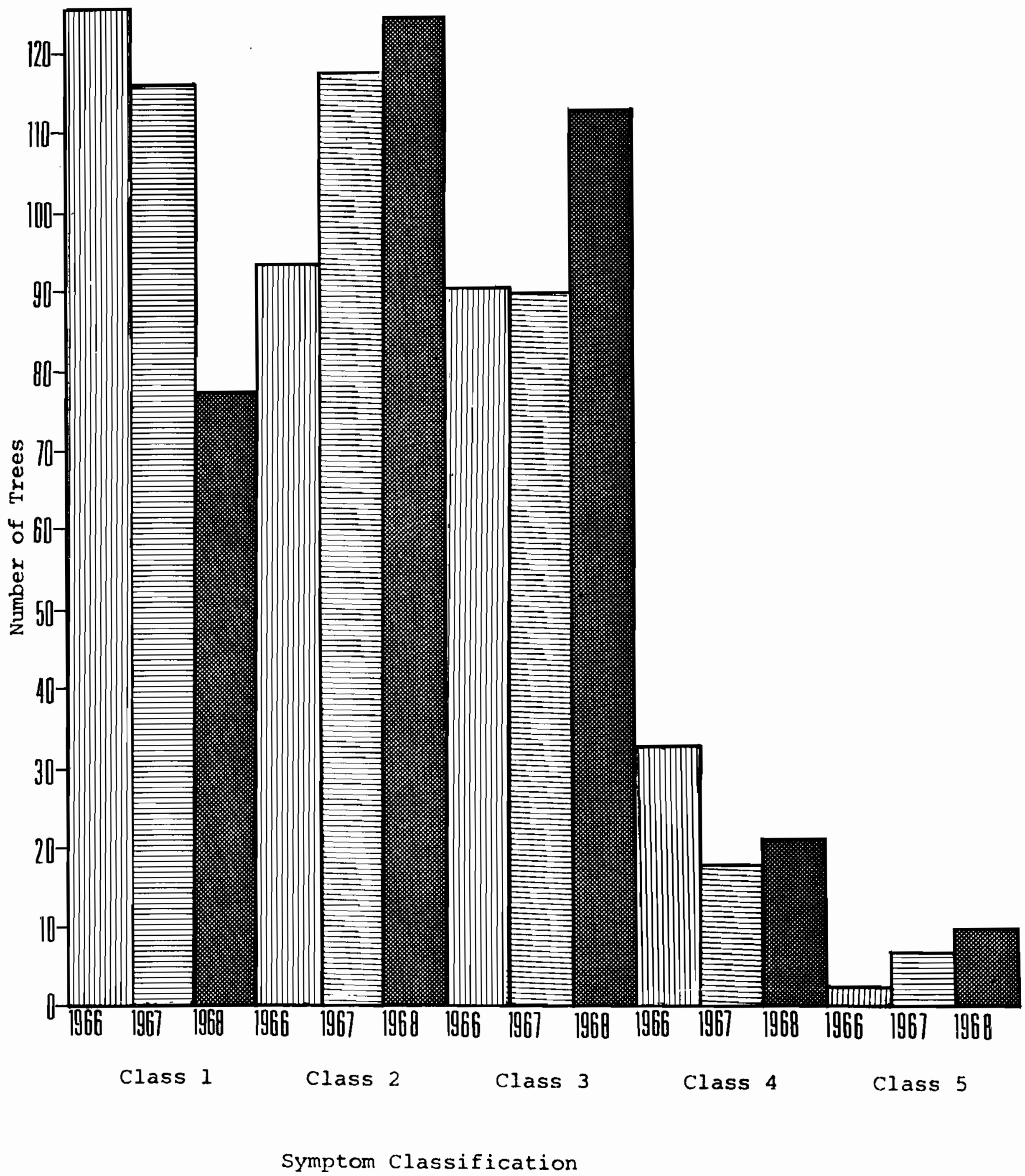


Fig. 4 Loblolly Pine Die-off Classification Distribution by Individual Plots, Oakmulgee District, Talladega National Forest, Alabama: 1966 and 1968.

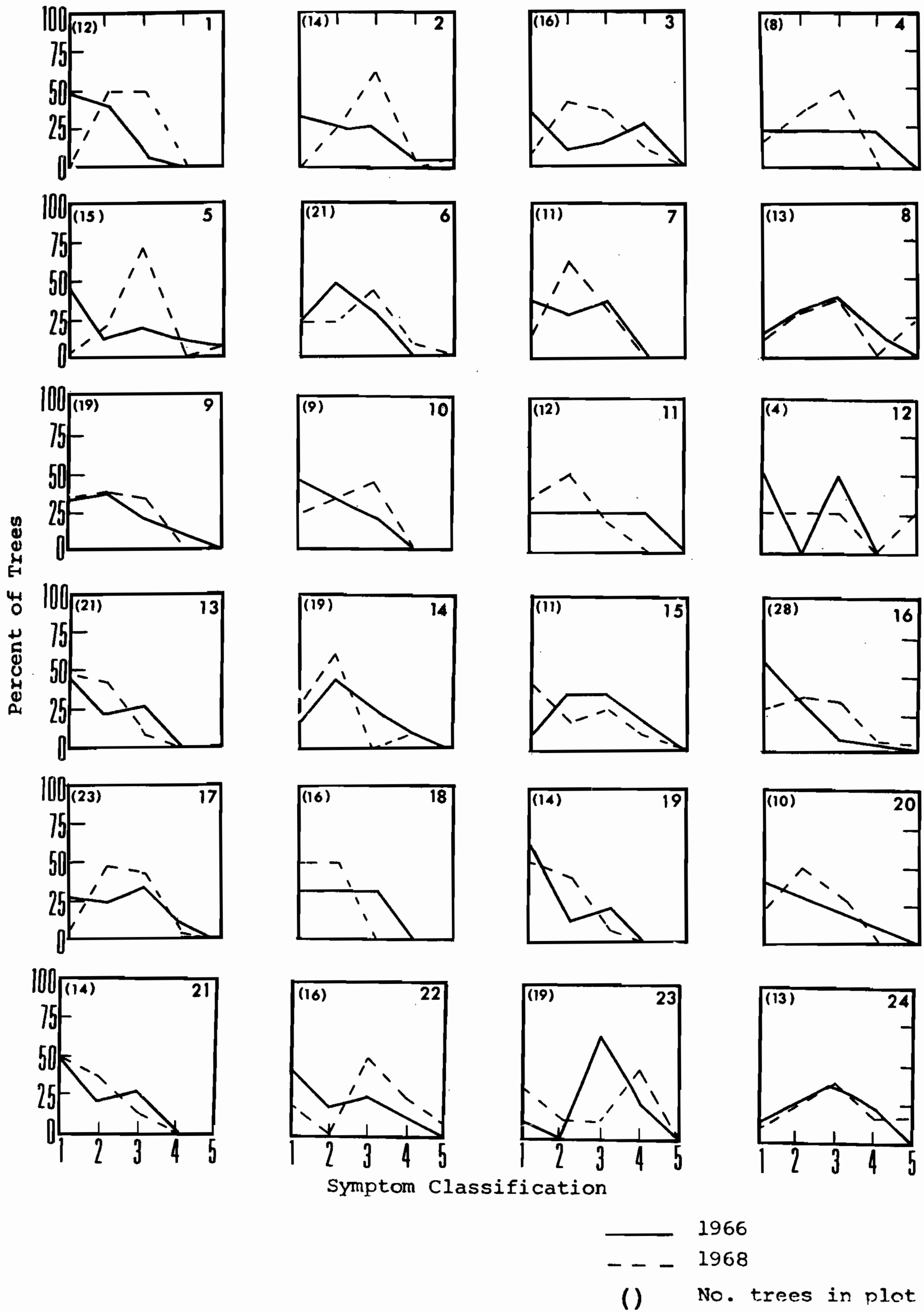


TABLE 3 SYMPTOM CLASSIFICATION OF TREES IN EACH LOBLOLLY PINE DIE-OFF PLOT, OAKMULGEE DISTRICT, TALLADEGA NATIONAL FOREST, ALABAMA: 1966-68.

Plot	No. Trees	Class 1			Class 2			Class 3			Class 4			Class 5		
		66	67	68	66	67	68	66	67	68	66	67	68	66	67	68
1	12	6	2	0	5	7	6	1	3	6	0	0	0	0	0	0
2	14	5	4	0	4	5	4	4	4	9	1	0	0	0	1	1
3	16	6	3	1	2	6	7	3	5	6	5	2	2	0	0	0
4	8	2	3	1	2	3	3	2	2	4	2	0	0	0	0	0
5	15	7	5	0	2	5	3	3	4	11	2	0	0	1	1	1
6	21	5	8	5	10	2	5	6	7	9	0	3	2	0	1	0
7	11	4	0	1	3	8	7	4	3	3	0	0	0	0	0	0
8	13	2	0	1	4	6	4	5	3	5	2	4	0	0	0	3
9	19	6	9	6	7	7	7	4	3	6	2	0	0	0	0	0
10	9	4	3	2	3	3	3	2	3	4	0	0	0	0	0	0
11	12	3	4	4	3	6	6	3	1	2	3	1	0	0	0	0
12	4	2	1	1	0	0	1	2	3	1	0	0	0	0	0	1
13	21	10	13	10	5	4	9	6	3	2	0	1	0	0	0	0
14	19	3	7	5	9	7	12	5	4	0	2	1	2	0	0	0
15	11	1	2	5	4	7	2	4	2	3	2	0	1	0	0	0
16	28	16	16	7	9	8	10	2	4	9	1	0	1	0	0	1
17	23	7	5	1	6	6	10	8	12	11	2	0	1	0	0	0
18	6	2	5	3	2	1	3	2	0	0	0	0	0	0	0	0
19	14	9	8	7	2	3	6	3	3	1	0	0	0	0	0	0
20	10	4	3	2	3	5	5	2	2	3	1	0	0	0	0	0
21	14	7	10	7	3	4	5	4	0	2	0	0	0	0	0	0
22	16	7	1	3	3	7	0	4	6	8	2	1	4	0	1	1
23	9	1	0	3	0	1	1	6	6	1	2	2	4	0	0	0
24	13	2	2	1	3	4	3	5	5	5	3	1	2	0	1	2
TOTAL	338	121	114	76	94	115	122	90	88	111	32	16	19	1	5	10

TABLE 4

SYMPTOM CLASSIFICATION FOR LOBLOLLY PINE DIE-OFF PLOTS, OAKMULGEE DISTRICT, TALLADEGA NATIONAL FOREST, ALABAMA, 1966-68.

Plot No.	1966 Class	1967 Class	1968 Class	Condition Trend
1	2+	2	2-	N(Negative)
2	2+	2	3+	N
3	2-	2-	3+	N
4	2-	2+	2	P(Positive)
5	2+	2	3+	N
6	2+	2	2-	N
7	2+	2-	2	N
8	2-	3+	3	N
9	2+	2+	2	N
10	2+	2	2	N
11	2-	2	2	P
12	2	3+	3+	N
13	1-	1-	1-	None
14	2	2+	2	None
15	2-	2	2	P
16	1-	1	2-	N
17	2	2-	2-	N
18	2+	1-	1-	P
19	1-	1-	2+	N
20	2+	2	2-	N
21	2+	1	2+	None
22	2	3+	3	N
23	3+	3	2-	P
24	2-	3+	3	N

Damage, other than die-off, observed on the trees included fusiform rust, *Cronartium fusiforme* Hedgc. and Hunt, needle gall midge (Cecidomyiidae) infestation and black turpentine beetle, *Dendroctonus terebrans* Oliv., infestation. About two percent of the limbs examined each year have had fusiform rust galls, and 10 percent have had needle gall midge damage.

Two of the dead trees found in 1968 on plot No. 8 had black turpentine beetle pitch tubes; however, the beetles were in neither of the trees. Both trees had been classified as 3- or worse in 1966 and 1967. Two green trees, near the dead ones and classified as 3+ and 2 in 1968, had black turpentine beetle pitch tubes. On plot No. 10, in 1968, two trees classified as 3+ and 2 had been heavily attacked by the black turpentine beetle. There were no recently dead trees on the plot.

DISCUSSION

The impetus for this evaluation resulted from the continuous observation of declining and dying loblolly pines on the Oakmulgee Division of the Talladega National Forest. The results to date help substantiate these observations. Since no cause(s) of the problem have been determined, it would be impossible now to state why the trees are declining in the pattern shown in the results. Apparently even the healthiest trees are affected, as evidenced by the 37 percent decrease in Class 1 trees over the two-year period.

Conversely, there has not been any build-up in the severe (Class 4) range. Class 5 will naturally increase because of additional dead trees. The obvious build-up has been in the light-moderate (Class 2 and 3) range which increased by 49 trees in two years. A few of these trees came up from Class 4, partly because of the small amount of the tree crown examined each year, and probably due, in part, to climate and soil-water relationships.

Based on the evaluation results since 1966, it appears that the die-off condition is present to some extent in practically all of the plots. Many trees have declined to the light and moderate classes, but very few have declined beyond this range. On an average, only 4-5 trees (1.3 percent) have dropped to Class 5 each year. Considering the fact that several plots were located in the worst die-off areas, this is not a high death percentage. Evidently, one or more factors, probably below the soil surface, are causing the trees to be under stress; but, generally, not to the point where they are severely affected or killed. This condition may worsen if the factor(s) become more intense and/or as the trees become older.

Robinson suggests in his soil report (Appendix I) that several of the plots are better suited for hardwood or for longleaf pine; hardwood being better adapted for soils with poor drainage and longleaf being better suited for deep sands. These suggestions, the author believes, are based on the optimum productivity of the site, with regards to the soil-water relationship. They do not infer that loblolly pine will not grow well on these areas, particularly on the hardwood sites. It is possible, however, that the soil-water relationships in some of the plots may be a factor in the stress and eventual decline of the trees, especially as the trees get older.

Annosus root rot could be one factor in the declining condition of the die-off pines. Although the culture results by Czabator and Verrall were all negative for *F. annosus*, the number of trees sampled (nine) was relatively small (Czabator, 1962). Also, the die-off plots had not been established at the time of this examination.

Results of the survey for *F. annosus* fruiting bodies in and near the plots show that 50 percent of the plots had fruiting bodies, and another 17 percent of the plots had fruiting bodies within 100 feet of the perimeter (Appendix II). Most of the fruiting bodies were on snags and stumps. Only three of the 338 die-off trees had fruiting bodies; however, two of these trees were dead in 1968.

P. cinnamomi, the primary fungus involved with littleleaf disease, can also be considered as a factor in the cause of loblolly pine die-off. Marx and Bryan isolated this fungus from eight of twenty die-off plots (Appendix III). Five of the plots which were Positive for *P. cinnamomi* (Plots #1,9,14,15,22) are described in Robinson's soil report (Appendix I). All five have soil with periods of moderate-poor air and water movement. This type of adverse soil condition, in conjunction with an abundance of *P. cinnamomi*, can cause littleleaf (Zak, 1957).

Pythium spp., root pathogens of trees and woody plants, were isolated from four of twenty plots by Marx and Bryan (Appendix III). This fungus has been associated with peach decline and with the death or decline of many horticultural woody plants in Georgia (Campbell and Hendrix, 1967). In Louisiana, it has been associated with declining loblolly pine (Lorio, 1966). Although the author knows of no report stating a definite relationship between *Pythium* spp. and the decline of loblolly pine stands, this fungus could be another factor involved with loblolly pine die-off.

Damage to the evaluation trees caused by fusiform rust is negligible since the small number of infections found have been on limbs rather than the main stem. Neither can the needle gall midge damage be considered important, as it has been observed in only a few fascicles of about 10 percent of the limbs each year.

Black turpentine beetle damage to the six trees, two of which later died, indicates probable stress conditions within these trees. These beetles show a preference to weakened trees (Smith and Lee, 1957). The two trees which died were obviously weakened prior to the beetle attack, as indicated by their 3- or worse condition. The four green trees, although classed as 2 and 3+, were probably under stress before the black turpentine beetle attack.

It is presently impossible to identify the cause(s) of loblolly pine die-off. One or more of the possible factors mentioned above may be the causal agent. Other disease organisms, or physiogenic factors not mentioned here, may be partly responsible. A more detailed evaluation is necessary before a causal agent or complex of causal agents could be identified.

RECOMMENDATIONS

1. An intensive survey should be made in the loblolly pine die-off plots to determine the amount of infection caused by *F. annosus*. Cultures should be made from the roots and root collars of several (10-20 percent) of the trees.

2. Evaluations involving *P. cinnamomi*, *Pythium* spp., and soil-water relationships should be made in the plots after the *F. annosus* survey.

CORRECTIONS

In the 1966 loblolly pine die-off report, the figures for plot No. 1 were incorrect. The number of trees in plot No. 2 was incorrect by one; as was the total number of trees evaluated. These corrections have been made in the present report.

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APPENDIX I

The following is a summary of Chester C. Robinson's report on the soil series identifications and interpretations of nine loblolly pine die-off plots. All of the plots examined were composed of Upper Coastal Plain parent material.

PLOT NO. 1

Series: Bexley sandy loam (Aquic Quartzipsamment - sandy, siliceous, thermic).[1]

Floodplain landform position.
2 percent complex slope.
Dry season water table at 37 inches.
Somewhat poorly drained soil.
Site index of 94 for loblolly pine.
Rapid infiltration rate.
Rapid percolation rate.

The water table is near the surface during wet seasons.

This light textured, somewhat poorly drained floodplain site is better suited for hardwood production.

PLOT NO. 5

Series: Wagram loamy sand (Arenic Paleudult - loamy, siliceous, thermic).

Spur ridgetop landform position.
7 percent complex slope.
Occasional water-rounded gravel on surface.
Well-to-excessively drained soil.
Site index of 64 for loblolly pine.
Rapid infiltration rate.
Medium percolation rate.

This light textured, well to excessively drained site is better suited for longleaf pine production.

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1 Series descriptions in parentheses refer to seventh approximation classifications.