Disease Losses in North Carolina Forests: I. Losses in Softwoods, 1973–1974

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ABSTRACT

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Renewable Resource Evaluation data provided useful estimates of the incidence of certain diseases in North Carolina softwoods. Poor form, suppression and stagnation, fusiform rust, and heart rot were the primary causes of damage to softwoods. Fusiform rust was most prevalent in the Southern Coastal Plain on slash, loblolly, and pond pines, affecting 17, 9, and 6%, respectively. Sapling- and pole-size trees were affected most commonly except for pond pine, which had a high incidence on sawtimber-size trees. Basal injuries of various types, including fire and logging wounds, provided infection courts for most of the heart rot observed. The average percentage of cull in heart-rotted trees was highest on those with broken tops, fire scars, and other basal injuries. Littleleaf disease caused moderate damage (0–4%) to shortleaf pine in all regions of the state. With the exception of pond pine, slash pine, and baldcypress, most of the softwood species were relatively healthy (85–90%).

Forests in North Carolina produce more than 17.5 million m^3 (600 million cu ft) of softwood sawlogs, veneer bolts, and pulpwood—raw materials for state industries that have an annual payroll of $755 million (6). Even though diseases, insects, and other damaging factors limit both the productivity of North Carolina forests and the quality of timber produced, the most recent estimates of disease losses in the state have been based on data gathered in 1952. To remedy this deficiency, a cooperative effort to assess the incidence and amount of damage in North Carolina forests was initiated by university, state, federal, and Renewable Resource Evaluation (formerly Forest Survey) personnel.

MATERIALS AND METHODS

Data were collected by Renewable Resource Evaluation (RRE) personnel between November 1972 and January 1975 (fourth survey of North Carolina) from nearly 5,000 permanent study plots distributed throughout the commercial forest land of the state. A 10-point cluster of plots, measured with a basal area factor of 37.5 sq ft/acre, was systematically spaced on an acre at each sample location. The following data were recorded for each living tree on the cluster of plots: 1) species, 2) form, 3) diameter at breast height, 4) merchantable volume, 5) damage (any sign or symptom of disease, insect, or other harmful agent), and 6) percentage of cull due to damage. All data for each tree and plot were summarized by diameter class, county, survey unit (Fig. 1), and state. Details of methods are given elsewhere (6).

RESULTS

Poor form, suppression and stagnation, fusiform rust, and heart rot were the primary causes of damage to softwoods in North Carolina (Table 1).

Poor form (lack of straightness) in young trees is influenced by genetic determinants, site conditions such as competition for light, and other factors. Poor form was by far the most prevalent type of damage to softwoods in North Carolina (Table 1) and was most common in saplings; by the time softwoods grow to pole or sawtimber size, many of the most poorly formed trees have been eliminated from the stand by competition.

Damage attributed to suppression and stagnation, which result mainly from overstocking, was most prevalent on the

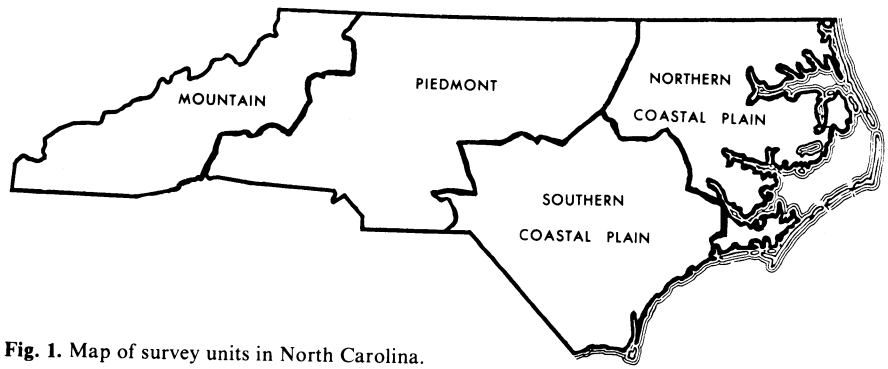

Fig. 1. Map of survey units in North Carolina.

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youngest trees and tended to decrease progressively with increasing age of the stand.

Insects, animals, "other diseases," and weather damaged a small number of trees. This does not mean that loss from such damage has been small since 1952 but rather that damage to still-living trees has been negligible. In fact, mortality has been considerable, with about 317,000 MBF (million board feet) of sawtimber lost annually (10).

Many estimates of the prevalence of *Fomes annosus* (Fr.) Karst. in living trees were markedly low because sporophores are rarely formed on living trees and symptoms are difficult to identify.

Relative health of softwoods. Table 2 shows the relative health and the incidence of heart rot in merchantable trees of the most important softwood timber species in North Carolina. Softwoods are relatively healthy; 85–90% of the individual trees of most species showed no evidence of damage by disease (Table 1). Longleaf pine (*Pinus palustris* Mill.) and pitch pine (*P. rigida* Mill.) were the healthiest, and pond pine (*P. serotina* Michx.), slash pine (*P. elliottii* var. *elliottii* Engelm.), and baldcypress (*Taxodium distichum* [L.] Rich.) were the least healthy. Pond and slash pines were affected by fusiform rust, and pond pine and baldcypress suffered from poor form. Heart rot was prevalent in baldcypress (8–11%) and pondcypress (9%). The results confirm past observations on the general health of these species (4).

Specific diseases. *Fusiform rust.* Fusiform rust (*Cronartium fusiforme* Hedgc. & Hunt ex Cumm.) is distributed throughout the South from Maryland to Florida and westward to Texas (3). Among the three common host species—slash, loblolly, and pond pines—slash pine was infected most often (Table 3). Because many more loblolly than slash or pond pines grow in North Carolina, however, the amount of damage on loblolly was much greater than on slash or pond pines (Tables 2 and 3). Trees on the Southern Coastal Plain were more frequently infected than those on the Northern Coastal Plain. The disease was of no significance in the Mountains and was much less abundant in the Piedmont than in the coastal plain regions (Table 3).

A recent special survey of loblolly and slash pine plantations indicated a similar decreasing trend in the incidence of fusiform rust northward along the Coastal Plain and westward through the Piedmont (9,11). This generally good agreement between the results of special surveys and those of the RRE indicates that reliable data on the incidence of fusiform rust can be obtained by RRE methods.

In all regions of the state, fusiform rust was more prevalent on sapling- and pole-size than on sawtimber-size loblolly pine. On pond pine, however, the disease was most prevalent on sawtimber-size trees (Tables 1 and 3). These data suggest that pond pine may be tolerant to the disease, explaining the higher incidence of infection in older trees.

Littleleaf disease. Littleleaf disease of shortleaf pine (*Pinus echinata* Mill.) is caused by a deficiency of nitrogen induced by loss of feeder roots infected by *Phytophthora cinnamomi* Rands; economic damage is restricted to soils with poor internal drainage (1). The disease was found throughout most of the range of shortleaf pine in North Carolina (Table 4). Surprisingly, the disease was more prevalent in the Southern Coastal Plain and Mountains than in the Piedmont region; none was detected in the Northern Coastal Plain, where the population of shortleaf pine is sparse (9 million trees). In the Piedmont, where shortleaf pine is the predominant softwood (437 million trees), <1% of the trees were affected.

These observations stand in distinct contrast to those of Campbell and Copeland (1), whose disease hazard maps show littleleaf disease being limited to the Piedmont. The higher incidence of littleleaf symptoms on sapling-size than on pole- and sawtimber-size trees on the Southern Coastal Plain contradicts earlier observations that littleleaf disease primarily affects trees more than 20 yr old or with a diameter at breast height (dbh) of at least 12.7 cm (5 in.) (1).

The figures for littleleaf disease in the Piedmont (Table 4) are consistent with earlier reports of scattered occurrence throughout that region (1,5). Furthermore, G. H. Hepting (*personal communication*) has observed "pockets

Table 1. Incidence of damage to living softwoods in North Carolina, 1973–1974

Type of damage	Percentage of trees affected			
	Sapling[a]	Pole[b]	Sawtimber[c]	All trees
Fusiform rust	3.1	1.6	1.0	1.9
Fomes annosus rot	0.005	0.010	0.008	0.007
Heart rot	1.0	2.1	4.6	1.6
Other diseases	0.6	0.7	1.0	0.6
Insects	0.1	0.3	0.5	0.3
Animals	0.003	0.03	0.09	0.04
Weather	0.6	0.9	1.4	0.6
Suppression and stagnation	5.1	2.0	0.6	4.0
Poor form	16.6	2.3	2.6	13.7

[a] 2.5–12.7 cm (1–5 in.) in diameter at breast height (dbh).
[b] 12.7–22.8 cm (5–9 in.) in dbh.
[c] > 22.8 cm (9 in.) in dbh.

Table 2. Relative health and incidence of heart rot in merchantable trees of important softwood timber species in North Carolina, 1973–1974

Species	Number of living trees (millions)	Relative health[a] (%)	Incidence of heart rot[a] (%)	Region[b]
Pinus taeda (loblolly pine)	1,527	83–89	0.8–2	SCP,NCP,P
Pinus virginiana (Virginia pine)	681	87–39	1–2	P,M
Pinus echinata (shortleaf pine)	507	86–91	0.5–1	SCP,NCP,P,M
Pinus serotina (pond pine)	434	69–82	4	SCP,NCP
Juniperus virginiana (red cedar)	194	85	5	P
Pinus strobus (white pine)	103	83	2	M
Pinus palustris (longleaf pine)	93	91–93	2–3	SCP,NCP
Pinus rigida (pitch pine)	25	91–96	2	P,M
Taxodium distichum (baldcypress)	26	80–89	8–11	SCP,NCP
Pinus elliottii (slash pine)	38	74–79	0.2	SCP,NCP
Tsuga canadensis (hemlock)	34	91	4	M
Chamaecyparis thyoides (Atlantic white cedar)	12	92	4	NCP
Taxodium distichum var. *nutans* (pondcypress)	12	87	9	SCP
Cupressaceae (other cedars)	24	81	4	SCP

[a] Includes only trees of pole size (12.7–22.8 cm, 5–9 in. in dbh) and sawtimber size (> 22.8 cm, 9 in. in dbh).
[b] SCP = Southern Coastal Plain, NCP = Northern Coastal Plain, P = Piedmont, M = Mountains.

of littleleaf in the Mountains." Thus, occurrence of the disease in the Mountains is not new. In addition, the incidence of littleleaf disease in the Piedmont may be decreasing. The land area containing shortleaf pine in the state has dropped dramatically (30%) in the last 10 yr. Also, the composition of many areas with a high incidence of littleleaf during the 1940s and 1950s has changed from predominantly shortleaf pine to other species. Both factors tend to lessen the chances of detecting littleleaf and reduce the incidence. In addition, soil rehabilitation during the two to three decades since the disease became widely recognized may have decreased the likelihood of littleleaf on previously high-hazard sites in the Piedmont.

The Southeastern Coastal Plain has not previously been recognized to harbor littleleaf disease (G. H. Hepting, *personal communication*). The RRE survey crews were carefully trained before the fourth survey was started, and the personnel were probably seeing littleleaf symptoms or symptoms of a similar disease problem. Furthermore, the three ingredients for the disease—poorly drained soils, *P. cinnamomi*, and shortleaf pine—are common, and the fungus affects certain other crops on the Coastal Plain, including woody ornamentals (2,7,8). The data shown in Table 4 should encourage reappraisal by skilled forest pathologists of the condition of shortleaf pine, especially on the Coastal Plain.

Heart rot. Decay of stemwood (heart rot) was the fourth most common cause of damage to living softwood trees in North Carolina (Tables 1, 2, and 5). Incidence varied with geographic region, from 5.9 and 5% in the Northern and Southern Coastal Plains, respectively, to 3.0% in the Piedmont and 2.6% in the Mountains (Table 5). This trend may reflect the greater frequency of fires in pine stands on the Coastal Plain than in other regions of the state.

Basal injuries of various types, including logging and fire scars, were more common apparent infection courts for heart rot than broken tops or branches (Table 5). Fire scars were much more important infection courts in the Southern Coastal Plain than in other regions. Based on the average percentage of cull in affected trees, however, top breaks, fire scars, and other basal defects were more serious than branch stubs and logging wounds as infection courts.

The greater-than-expected incidence of "other basal defects" indicates a possible difficulty in assigning an "apparent cause." According to the damage codes set up for use by the RRE crews, "other basal injuries" should have included root rot, parent stump, frost seam, low stubs, and butt bulge as causes of cull below dbh. Thus, the RRE field crews may have used "other basal defects" as a catchall category for wounded trees when they could not identify the specific cause of cull.

White pine blister rust. Although not detected by the survey, white pine blister rust occurs in North Carolina in isolated areas, usually above 900 m (3,000 ft) elevation. The intensity of the disease was too low to be detected by the RRE crews because sampling plots were probably not located in limited areas of blister rust.

Table 3. Incidence of fusiform rust on susceptible pines in Coastal Plain and Piedmont regions of North Carolina, 1973–1974

Region Host	Percentage of trees infected			
	Sapling[a]	Pole[b]	Sawtimber[c]	Total
Southern Coastal Plain				
Pinus elliottii (slash)	16	21	...[d]	17
P. taeda (loblolly)	10	8	5	9
P. serotina (pond)	5	7	13	6
Northern Coastal Plain				
P. elliottii (slash)	...	16	...	...
P. taeda (loblolly)	7	4	2	6
P. serotina (pond)	1	2	2	2
Piedmont				
P. taeda (loblolly)	4	3	1	3

[a] 2.5–12.7 cm (1–5 in.) in diameter at breast height (dbh).
[b] 12.7–22.8 cm (5–9 in.) in dbh.
[c] > 22.8 cm (9 in.) in dbh.
[d] Insufficient sample for reliable interpretation of data.

Table 4. Incidence of littleleaf disease on shortleaf pine (*Pinus echinata*) in North Carolina, 1973–1974

Region	Percentage of trees affected			
	Sapling[a]	Pole[b]	Sawtimber[c]	Average
Southern Coastal Plain	3.9	1.3	2.5	2.9
Piedmont	0.0	0.7	0.6	0.2
Mountains	0.0	1.1	2.3	0.7
All regions	0.2	0.7	0.9	0.004

[a] 2.5–12.7 cm (1.5 in.) in diameter at breast height (dbh).
[b] 12.7–22.8 cm (5–9 in.) in dbh.
[c] > 22.8 cm (9 in.) in dbh.

Table 5. Incidence of heart rot and volume of cull in affected softwood sawtimber in North Carolina, 1973–1974

Apparent cause	Percentage of living trees affected					Volume of cull (%)
	Southern Coastal Plain	Northern Coastal Plain	Piedmont	Mountains	Average	
Branch stubs	0.5	0.07	0.1	0.2	0.2	4.0
Top breaks	0.4	1.0	0.3	0.9	0.6	9.6
Fire scars	3.0	0.5	0.2	0.7	1.1	9.0
Logging wounds	0.3	1.6	0.5	0.5	0.7	4.2
Other basal defects	0.9	2.4	1.5	0.4	1.3	11.4
Total	5.0	5.9	3.0	2.6	4.6	

DISCUSSION

These data and interpretations are examples of information obtainable from RRE studies about the general health of softwood forests. The relative health of softwood species and geographic trends in damage incidence can give a base for a variety of management decisions and research and extension priorities. Changes in disease incidence over time and space indicate a need for reassessing such problems as littleleaf disease. Overall, RRE data can give a good periodic assessment of the quality of North Carolina's softwoods.

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