

Disease Losses in North Carolina Forests: II. Losses in Hardwoods, 1973–1974

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ABSTRACT

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A survey of hardwoods in North Carolina showed many species to be in poor health. A few, such as yellow poplar and white oak, were relatively healthy (80–90% of trees free from damage) and many others, notably red maple, lowland black gum, sweetbay, black locust, and black walnut, were less healthy (59–75% of trees free from damage). Heart rot and poor form accounted for most damage to hardwoods. Diffuse-porous hardwoods showed a greater incidence of heart rot than ring-porous species; this difference was most conspicuous in the coastal plain region of the state. The amount of cull associated with heart rot was greatest in trees with "other basal defects" and top breaks. Canker diseases caused moderate (1–2%) damage throughout the state.

Hardwoods cover 65% of the forest land in North Carolina—some 5.7 million ha (12.6 million acres)—and provide slightly more than half the total timber harvested in the state. If present trends continue, more and more lands will revert to hardwoods after harvesting of softwoods (6). The most recent statewide estimates of losses due to disease in hardwoods have been based on data gathered in 1952 (4). To remedy this deficiency, a cooperative effort was initiated by university, state, federal, and Renewable Resource Evaluation personnel to assess the incidence and amount of damage to North Carolina forests from disease, insects, and other causes (5).

MATERIALS AND METHODS

Data were collected by Renewable Resource Evaluation 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. The following data were recorded for each living tree at least 2.5 cm in diameter: 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. Details of methods are given elsewhere (5,6).

RESULTS

Poor form and heart rot of sawtimber-size trees were the most prevalent types of damage (Table 1). Insects, animals, "other diseases," cankers, and suppression and stagnation each caused damage to a small number of living trees.

Relative health of hardwoods. Hardwoods generally are in poorer health than softwoods throughout North Carolina (5). The relative health of the major hardwood timber species varied substantially (Table 2). For example, red maple, lowland and upland black gum, sweetbay, elm, black locust, and black walnut were often damaged, only 59–82% being relatively healthy. Of the 10 most

abundant species in the state, only yellow poplar and white oak appeared relatively healthy (80–90%). These findings are in good agreement with the observed health of species included in an earlier sweetgum blight survey (2). The values for relative health did not vary greatly from region to region, ie, species of low or high relative health in one region were in similar condition elsewhere.

Specific diseases. *Heart rot.* Heart rot was the most prevalent pathogen-caused damage in North Carolina hardwoods (Table 1). The most susceptible were red maple, lowland and upland black gum, sweetbay, and black locust; least affected were most oaks, yellow poplar, and hickory (Tables 2 and 3). In general, heart rot was less prevalent in ring-porous (12–14%) than in diffuse-porous (13–21%) species (Table 4). These observations are in general agreement with earlier assessments of susceptibility to heart rot in these species (1,7).

The geographic distribution of heart rot in diffuse- and ring-porous species, apparent infection courts, and volume of cull are given in Table 4. Geographic differences in incidence were seen among the diffuse-porous species listed in Table 2; this observation may reflect regional differences in the frequency with which trees are wounded (7).

Some differences may be noted between the results of this study and those of earlier ones on the incidence of heart

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

Type of damage	Percentage of trees affected			
	Sapling ^a	Pole ^b	Sawtimber ^c	All trees
Cankers	0.2	0.6	0.8	0.3
Heart rot	0.9	7.0	16.9	2.4
Other diseases	0.07	0.08	0.33	0.08
Insects	0.01	0.12	0.01	0.02
Animals	0.006	0.050	0.009	0.008
Weather	0.09	0.90	0.80	0.25
Suppression and stagnation	0.8	1.0	0.4	0.9
Poor form	60.4	7.8	6.9	48.9

^a 2.5–12.7 cm (1–5 in.) in diameter at breast height (dbh).

^b 12.7–28 cm (5–11 in.) in dbh.

^c > 28 cm (11 in.) in dbh.

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rot. For example, in 1960, Bryan (1) completed a study of heart rot in Piedmont hardwoods and reported heart and butt rot in 8–13% of red oaks, sweet gum, and black gum. His figures are somewhat lower than those obtained in this study (12–34%). Roth (7) listed black oak as most susceptible to decay (39%), followed by scarlet oak (28%), red oak (22%), and chestnut oak (11%). These estimates are higher than the 3–8% listed in Table 2.

Basal defects other than those caused by fire or logging wounds were by far the most common infection courts for heart rot fungi (Table 3). Top breaks were the next most prevalent, then branch stubs, logging wounds, and fire scars, in order of decreasing frequency. In diffuse-porous hardwoods, top breaks were notably more common in the coastal plain region than in the Piedmont or Mountains; this difference was much less pronounced in ring-porous species (Table 3). The greater than expected incidence of "other basal defects" causing heart rot indicates a possible difficulty in the assignment of "apparent cause" (5).

In terms of the volume of cull associated with heart rot in both diffuse- and ring-porous hardwoods, basal defects other than logging wounds and fire scars were the most damaging and top breaks were only slightly less damaging (Table 4).

The different hardwood species varied substantially in prevalence of heart rot and volume of cull associated with major types of injuries. For example, top breaks caused very high percentages of cull (36–50%) in affected red maple, holly, chestnut oak, northern red oak, beech, willow oak, and cherry bark oak (Table 3). By contrast, top breaks caused much less cull (0–16%) in sweetgum, southern red oak, birch, black cherry, and others.

Canker diseases. Cankers were moderately prevalent on hardwoods throughout the state. Cankering ranged from 0.19 to 14% but averaged 1–2% in the pole- and sawtimber-size trees of affected species (Table 5). The number of cankers on most hardwood species increased progressively with age. Although data for a single species showed slight geographic variations in incidence, no such variations were found for combined species. Various oak species, red maple, black gum, hickory, ash, and black locust tended to have the highest incidence (Table 5), and all except black locust are known to be susceptible to cankering by a number of organisms (3). Damage from locust borer (*Megacyllene robiniae* Forst.) and related secondary decay may cause disfiguring wounds that account for the high incidence of cankers reported on this species.

DISCUSSION

The Renewable Resource Evaluation data presented here provide a means of assessing the condition of North Carolina

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

Species	Number of living trees (millions)	Relative health ^a (%)	Incidence of heart rot ^a (%)	Region ^b
<i>Acer rubrum</i> (red maple)	2,063	64–82	11–20	SCP,NCP,P,M
<i>Liquidambar styraciflua</i> (sweetgum)	1,500	75–82	8–10	SCP,NCP,P
<i>Cornus florida</i> (dogwood)	1,076	74–89	5–16	P,M
<i>Nyssa sylvatica</i> (lowland black gum)	600	66–71	16–18	SCP,NCP
<i>Liriodendron tulipifera</i> (yellow poplar)	525	80–90	3–9	SCP,NCP,P,M
<i>Quercus nigra</i> (water oak)	490	76–88	6–12	SCP,NCP
<i>Quercus alba</i> (white oak)	476	84–91	3–6	SCP,NCP,P,M
<i>Nyssa sylvatica</i> (upland black gum)	411	69–76	13–21	SCP,NCP,P,M
<i>Magnolia virginiana</i> (sweetbay)	410	65–78	22–27	SCP,NCP
<i>Carya</i> spp. (hickory)	367	79–84	7–11	SCP,P,M
<i>Fraxinus</i> spp. (ash)	357	73–90	2–16	SCP,NCP,P,M
<i>Quercus</i> sp. (scrub oak)	307	91	9	SCP
<i>Quercus falcata</i> (southern red oak)	205	83–88	3–8	SCP,NCP,P,M
<i>Ilex opaca</i> (holly)	184	79	15	NCP
<i>Quercus stellata</i> (post oak)	180	74–85	8–12	SCP,NCP,P
<i>Quercus prinus</i> (chestnut oak)	169	83–86	6–7	P,M
<i>Quercus coccinea</i> (scarlet oak)	134	85–94	4–8	SCP,NCP,P,M
<i>Ulmus</i> spp. (elm)	133	67–82	1–8	SCP,NCP,P
<i>Quercus velutina</i> (black oak)	120	85–91	3–8	SCP,NCP,P,M
<i>Betula</i> spp. (birch)	112	81–88	5–6	SCP,P,M
<i>Quercus rubra</i> (northern red oak)	103	88–94	4	P,M
<i>Fagus grandifolia</i> (beech)	100	73–86	6–12	SCP,NCP,P,M
<i>Salix</i> spp. (willow)	79	82	3	NCP,P
<i>Robinia pseudoacacia</i> (black locust)	68	59–73	10–21	P,M
<i>Quercus phellos</i> (willow oak)	67	84	5	P
<i>Acer saccharum</i> (sugar maple)	46	87	4	P,M
<i>Quercus michauxii</i> (swamp chestnut oak)	40	74–84	4–8	SCP,NCP
<i>Quercus falcata</i> var. <i>pagodaefolia</i> (cherry bark oak)	17	88–93	4–5	SCP,NCP
<i>Tilia americana</i> (basswood)	16	93	2	M
<i>Magnolia acuminata</i> (cucumber tree)	14	87	8	M
<i>Platanus occidentalis</i> (sycamore)	12	74–84	11–16	NCP,P
<i>Juglans nigra</i> (black walnut)	9	66	7	M

^aIncludes only trees of pole size (12.7–28 cm, 5–11 in. dbh) and sawtimber size (> 28 cm, 11 in. in dbh).

^bSCP = Southern Coastal Plain, NCP = Northern Coastal Plain, P = Piedmont, M = Mountains.

Table 3. Percentage of cull^a from heart rot associated with injuries in affected hardwood sawtimber in North Carolina, 1973–1974

Species	Branch stubs	Top breaks	Fire scars	Logging wounds	Other basal defects
<i>Acer rubrum</i> (red maple)	21	36	25	10	30
<i>Liquidambar styraciflua</i> (sweetgum)	16	16	5	6	25
<i>Nyssa sylvatica</i> (lowland black gum)	20	28	15	8	33
<i>Liriodendron tulipifera</i> (yellow poplar)	16	22	5	7	23
<i>Quercus nigra</i> (water oak)	23	30	0	17	25
<i>Quercus alba</i> (white oak)	18	26	12	1	27
<i>Nyssa sylvatica</i> (upland black gum)	10	23	0	65	29
<i>Magnolia virginiana</i> (sweetbay)	16	26	0	35	30
<i>Carya</i> spp. (hickory)	14	20	8	14	25
<i>Fraxinus</i> spp. (ash)	17	33	0	9	25
<i>Quercus</i> sp. (scrub oak)	10	0	0	0	8
<i>Quercus falcata</i> (southern red oak)	16	10	10	0	30
<i>Ilex opaca</i> (holly)	0	48	0	0	29
<i>Quercus stellata</i> (post oak)	18	26	18	7	28
<i>Quercus prinus</i> (chestnut oak)	27	48	5	5	31
<i>Quercus coccinea</i> (scarlet oak)	22	27	22	20	21
<i>Ulmus</i> spp. (elm)	15	24	0	21	26
<i>Quercus velutina</i> (black oak)	19	19	35	0	30
<i>Prunus serotina</i> (black cherry)	0	0	0	0	26
<i>Betula</i> spp. (birch)	19	12	2	10	20
<i>Quercus rubra</i> (northern red oak)	29	48	0	8	21
<i>Fagus grandifolia</i> (beech)	20	47	0	10	25
<i>Robinia pseudoacacia</i> (black locust)	21	31	15	17	24
<i>Quercus phellos</i> (willow oak)	20	41	0	0	25
<i>Acer saccharum</i> (sugar maple)	10	12	0	0	25
<i>Quercus michauxii</i> (swamp chestnut oak)	8	13	0	1	20
<i>Quercus falcata</i> var. <i>pagodaefolia</i> (cherry bark oak)	5	50	0	10	26

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Table 3. (continued from preceding page)

Species	Branch stubs	Top breaks	Fire scars	Logging wounds	Other basal defects
<i>Halesia</i> spp. (silverbell)	0	0	0	0	18
<i>Tilia americana</i> (basswood)	15	20	0	0	33
<i>Betula alleghaniensis</i> (yellow birch)	40	0	0	0	26
<i>Magnolia acuminata</i> (cucumber tree)	10	5	0	0	19
<i>Platanus occidentalis</i> (sycamore)	0	18	0	20	32
<i>Juglans nigra</i> (black walnut)	19	10	0	0	35
<i>Populus deltoides</i> (cottonwood)	0	8	0	0	28
<i>Quercus virginiana</i> (live oak)	10	0	0	0	0

^a Average volume of cull based on incidence for whole state.

Table 4. Incidence of heart rot and volume of cull in affected ring-porous and diffuse-porous hardwood 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	
Diffuse-porous						
Branch stubs	2.0	2.1	2.8	2.3	2.3	14
Top breaks	7.1	7.5	4.1	1.9	5.2	25
Fire scars	0.4	0.1	0.05	0.2	0.2	2
Logging wounds	1.5	1.7	1.3	0.1	1.2	8
Other basal defects	15.2	12.0	6.5	14.7	12.1	27
Total ^a	26.1	23.0	13.0	19.0	16.9	
Ring-porous						
Branch stubs	2.2	1.0	2.9	2.2	2.1	16
Top breaks	2.9	3.7	2.1	1.7	2.6	20
Fire scars	0.2	0.02	0.8	0.2	0.3	4
Logging scars	1.6	1.8	0.8	0.2	1.0	8
Other basal defects	7.6	7.0	5.4	10.1	7.5	24
Total ^a	14.1	13.4	12.2	14.5	13.6	

^a Different from individual sums because of averaging.

Table 5. Percentage of hardwoods affected by cankers in North Carolina, 1973–1974

Species	Southern Coastal Plain		Northern Coastal Plain		Piedmont		Mountains	
	Pole ^a	Sawtimber ^b	Pole	Sawtimber	Pole	Sawtimber	Pole	Sawtimber
<i>Acer rubrum</i> (red maple)	0.4	0.9	0.2	1.0	1.2	1.7	1.0	2.2
<i>Liquidambar styraciflua</i> (sweetgum)	0.2	0.5	0.2	0.4	0.4	0.4	...	...
<i>Cornus florida</i> (dogwood)	...	...	...	...	0.7	4.7	0.0	...
<i>Nyssa sylvatica</i> (lowland black gum)	2.1	2.7	0.9	0.0	0.0	0.0	...	...
<i>Liriodendron tulipifera</i> (yellow poplar)	0.0	1.0	0.0	0.0	0.4	0.2	0.7	0.2
<i>Quercus nigra</i> (water oak)	0.4	3.0	0.8	0.6	...	...	...	...
<i>Quercus alba</i> (white oak)	0.2	0.0	0.0	0.2	0.3	0.1	0.0	0.5
<i>Nyssa sylvatica</i> (upland black gum)	0.0	2.6	3.2	...	1.4	0.0	0.0	1.7
<i>Magnolia virginiana</i> (sweetbay)	2.0	0.0	0.2	0.0	...	0.0	...	...
<i>Carya</i> spp. (hickory)	0.8	1.4	0.0	1.2	0.1	0.5	0.8	1.2
<i>Fraxinus</i> spp. (ash)	0.4	1.0	0.3	1.4	1.5	0.5	0.0	0.0
<i>Quercus</i> sp. (scrub oak)	0.0	...	...	...	0.0	...	...	...
<i>Quercus falcata</i> (southern red oak)	0.6	2.0	0.6	0.0	0.0	0.9	0.0	0.0
<i>Ilex opaca</i> (holly)	...	...	0.0	0.0	...	...	...	...
<i>Quercus stellata</i> (post oak)	1.4	0.0	1.3	0.0	0.7	2.0	...	...
<i>Quercus prinus</i> (chestnut oak)	...	...	...	...	0.0	0.6	0.0	0.7
<i>Quercus coccinea</i> (scarlet oak)	0.0	...	0.0	0.0	1.4	0.2	0.0	0.4
<i>Ulmus</i> spp. (elm)	0.0	0.0	0.0	...	0.0	1.4	0.0	0.0
<i>Quercus velutina</i> (black oak)	0.0	0.0	0.0	0.0	0.7	0.6	0.0	0.8
<i>Prunus serotina</i> (black cherry)	0.0	...	0.0	...	0.0	...	0.0	...
<i>Betula</i> spp. (birch)	...	1.1	...	...	0.0	0.0	0.0	0.0
<i>Quercus rubra</i> (northern red oak)	...	...	...	...	0.4	0.2	0.0	1.2
<i>Fagus grandifolia</i> (beech)	...	0.0	3.2	0.9	0.0	0.8	0.0	0.0
<i>Salix</i> spp. (willow)	...	...	0.0	1.2	...	0.0	...	...
<i>Robinia pseudoacacia</i> (black locust)	...	...	...	...	13.4	14.6	6.0	6.6
<i>Quercus phellos</i> (willow oak)	...	...	...	...	0.3	0.0	...	...
<i>Acer saccharum</i> (sugar maple)	...	...	...	...	...	0.0	0.9	0.0
<i>Quercus michauxii</i> (swamp chestnut oak)	0.0	0.0	4.4	1.2	...	...	...	...
<i>Quercus falcata</i> var. <i>pagodaefolia</i> (cherry bark oak)	...	...	0.0	1.2	...	...	...	...

^a 12.7–28 cm (5–11 in.) in diameter at breast height (dbh).

^b > 28 cm (11 in.) in dbh.

^c Insufficient sample for reliable interpretation of data.

hardwoods and give indications as to the relative importance of certain diseases among the major tree species in the state. The information in Table 2 illustrates the practical value of the disease-incidence data provided by the survey. Some species of hardwood, such as sweetbay and red maple, are best suited for short-rotation products because of their relative susceptibility to heart rot. Other species, such as oaks and yellow poplar, are less prone to heart rot and thus can be managed for longer rotation products, including sawlogs, dimension stock, and veneer bolts.

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