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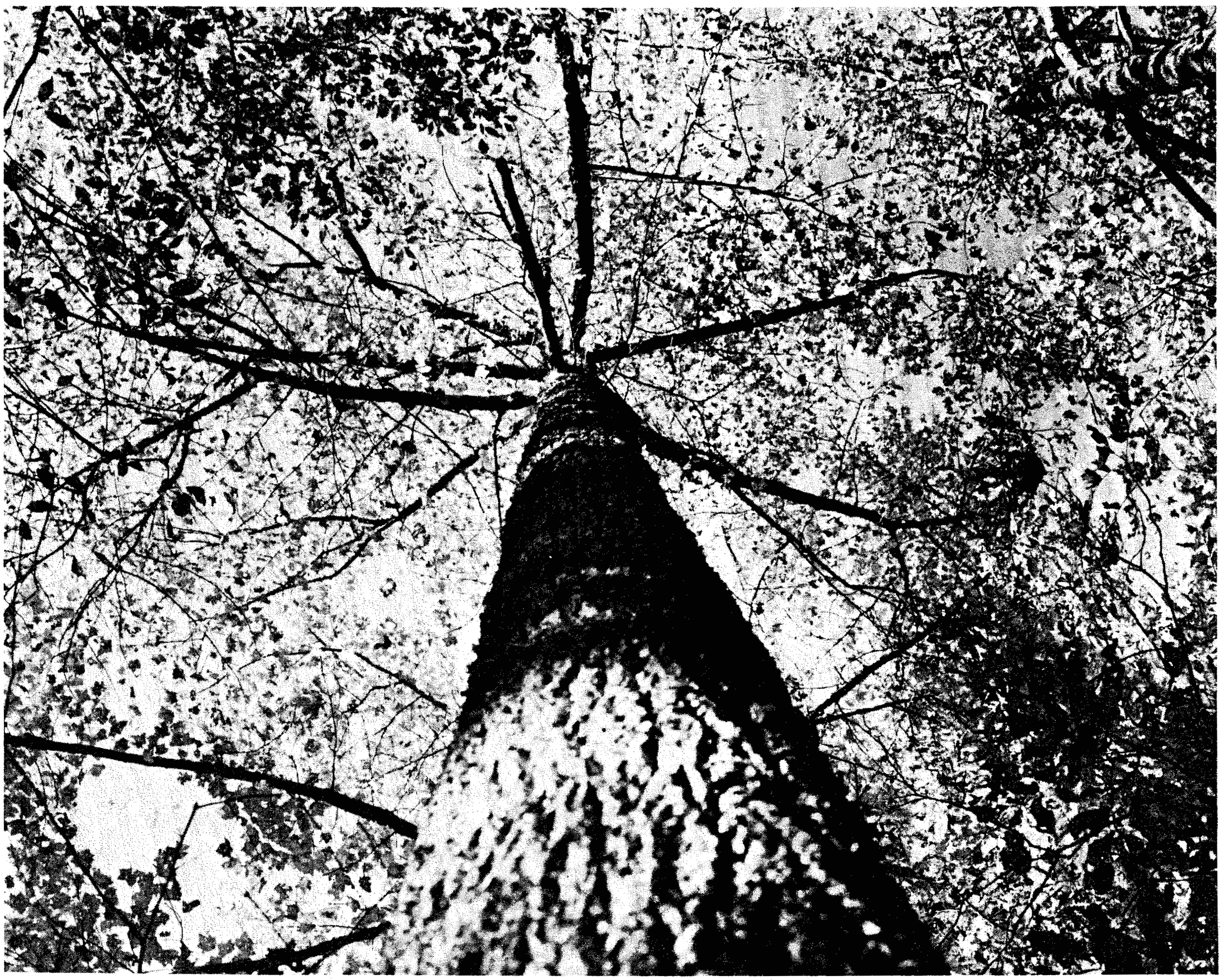

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Abstract

More than half of the commercial forest land in the Southeast Piedmont supports hardwood stands held by small nonindustrial private landowners. Total biomass production would increase 15 to 20 percent if these stands were fully stocked, and much of the present production could be shifted to more desirable species. Only 21 percent of all nonindustrial private forest (NIPF) stands are fully stocked with growing-stock trees.

Piedmont hardwood stands contain an average of 75.5 tons per acre of aboveground tree biomass. When these stands are harvested, 39.1 tons of living residues are left behind in the form of rough or rotten cull trees and noncommercial saplings. It is this practice which has caused the large number of poor-quality stands we have today. If the timber remaining after harvest is not marketable, it should be felled to encourage the natural regeneration of more desirable species.

Only 37 percent of all hardwood biomass harvested (standing and felled) is currently being utilized. The product output from the hardwood resource could at least be doubled with no threat to conventional hardwood supplies by improving utilization. Dramatic increases in hardwood production can be expected if NIPF owners can be persuaded to employ relatively inexpensive management techniques.

Keywords: Nonindustrial private forest land, forest trends, hardwood forest land, Piedmont forest land, forest biomass, hardwood timber volume, hardwood silviculture.

Introduction

Biological, economic, and social forces occurring between 1945 and 1965 led to the establishment of much of the vast southern pine resource we know today (Boyce and Knight 1979). Forest industry has provided the capital and technology needed to use the pine resource, and forest managers have devoted their efforts to its maintenance and improvement. Because of the numerous advantages associated with pines, hardwood management has been discouraged for decades. Long rotations, low stumpage values, expensive cultural treatments, and the absence of dependable hardwood markets have limited options available to those willing to improve the quality of their hardwood stands (Sosbe 1966). A common management approach has been to eradicate and convert hardwood stands to pine (Kellison 1971). Despite decades of such obstruction, hardwoods have been gaining ground on southern pines for at least 10 years and are likely to continue to do so. Current biological, social, and economic forces favoring hardwoods outweigh the cultural practices that favor pine (Boyce and Knight 1980).

The front line of this hardwood advance is on nonindustrial private forest (NIPF) land. For a variety of reasons, many NIPF owners have opted against the intensive cultural treatments required to regenerate pine after harvest. Many NIPF owners cannot profitably employ expensive industrial management techniques, or do not share the same management objectives as forest industry (Kingsley 1980). Oftentimes landowners are simply willing to accept whatever nature offers, and low-quality hardwood stands are permitted to develop by default. This passive or "custodial" approach to forest management is becoming increasingly costly to NIPF owners in terms of lost opportunities. Many can profitably improve their hardwood stands and still satisfy their nontimber needs.

The marginal productivity of NIPF hardwood stands is partially attributable to unfavorable market conditions but, as pine supplies decline, hardwoods can be used to supplement or replace pine in many products. Soft-textured hardwood species are being peeled into veneer for the inner plies of southern pine plywood. Hardwoods are also being substituted for pine in board products, in paper, and in some solid-wood products.

As opportunities to use low-quality hardwoods materialize, management options available to the NIPF owner will expand accordingly. Improved hardwood management guidelines are needed to help the small landowner grow more and better timber while meeting needs for firewood, good wildlife habitat, and esthetic values.

This paper describes the status of the NIPF hardwood resource in the Piedmont of the Southeast. It identifies areas with potential for major improvement, outlines a few inexpensive management practices the NIPF owner might adopt to make improvements, and provides a database for continuing hardwood research in the area.

Procedures

The Southeast Piedmont ranges from North Carolina to Georgia and encompasses 44 million acres.[1/] The Piedmont boundaries delineated in figure 1 follow Survey Unit boundaries used by the USDA Forest Service for statewide multiresource inventories. Data collected during the latest inventories of these six Units over a 5-year period were pooled for presentation in this report. Additional information and inventory procedures are outlined in the latest Resource Bulletins for the Piedmont Units of each State: Central and North Central Georgia (Cathey 1972; Knight 1972), the Piedmont of North Carolina (Welch 1975), the Southern and Northern Piedmont of Virginia (Sheffield 1976, 1977), and the Piedmont of South Carolina (Snyder 1978).

Initial estimates of forest and nonforest land area were based on the classification of 150,947 16-point sample clusters systematically spaced on the latest aerial photographs available. To adjust for changes since photos were taken and for errors in photo interpretation, 10,693 of these clusters were then examined on the ground.

Estimates of timber volumes and forest classifications were based on measurements recorded at 6,573 ground sample locations systematically distributed on commercial forest land. At each sample location, trees 5.0 inches d.b.h. and larger were selected for measurement at 3 to 10 points with a basal area factor of 37.5 square feet per acre. Trees less than 5.0 inches d.b.h. were tallied on fixed radius plots around the point centers.

Plot tallies were converted to volumes through a series of volume prediction equations derived from detailed measurements of over 35,000 trees throughout the Southeast (Cost 1978). Area statistics were then used to expand the per-acre volumes measured on the sample plots to volume estimates for the entire study area.

The utilization of hardwood removals was determined by merging information from several sources. Primary wood-using mills were canvassed to obtain information on wood receipts destined for industrial products. Timber volume removed for fuel, removed due to cultural operations and land clearing, and volume left standing in

[1/] Includes 389,000 acres of water according to Survey standards of area classification but defined by the Bureau of Census as land.

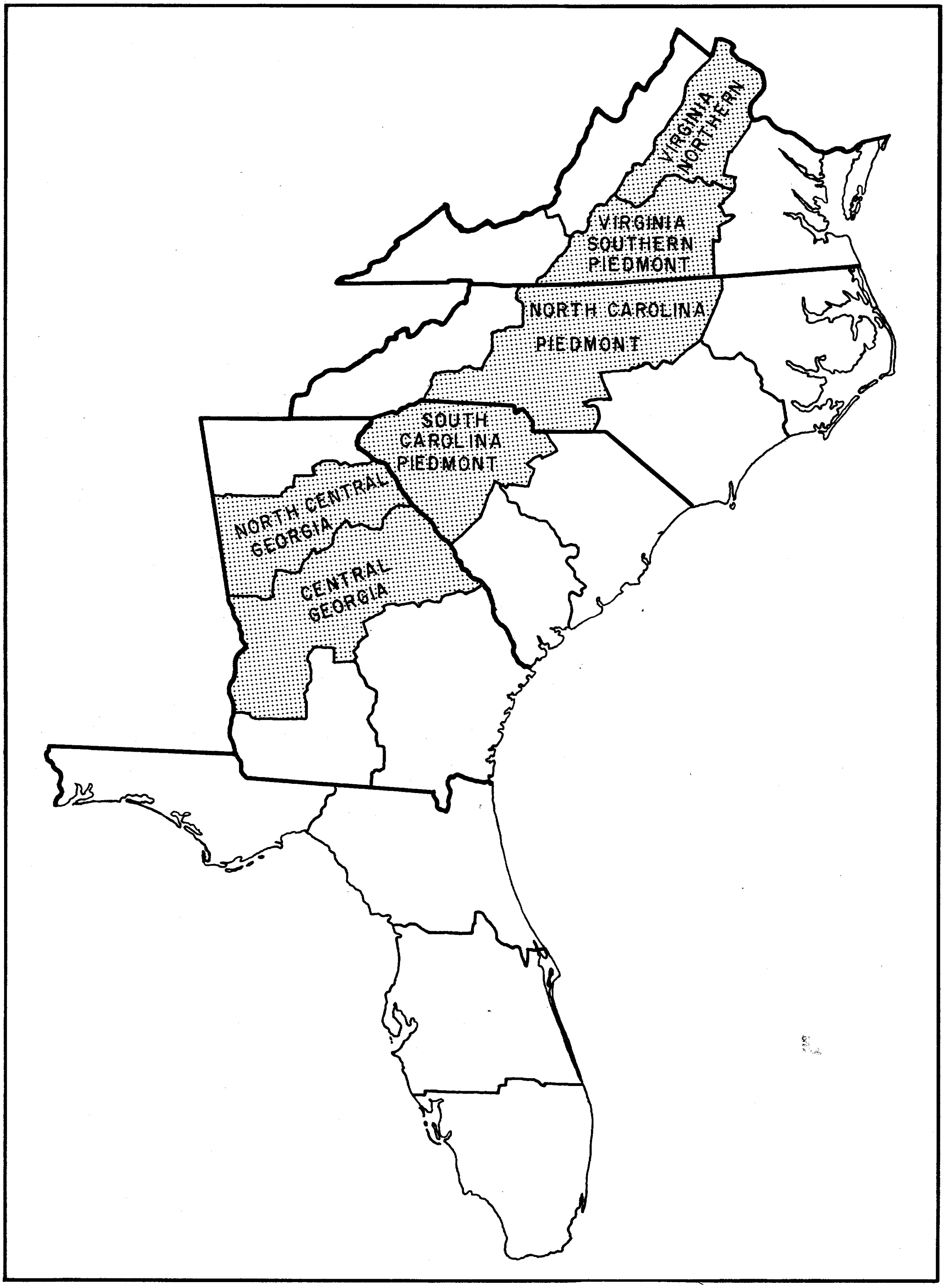

Figure 1.--Forest survey units in the Southeast Piedmont.

areas where classification changed from commercial forest to nonforest were estimated from the permanent remeasurement samples. Felled trees were measured at a sample of active harvesting operations to develop a measure of logging residues. Results of an earlier study, also based on the remeasurement of permanent samples and active cutting operations, were used to estimate volume in residual trees (living residues) left on commercial forest following harvest (Welch 1980).

Biomass, as used in this paper, is defined as the aboveground green weight of wood and bark in all live trees 1.0 inch d.b.h. and larger, including limbs greater than 0.5 inches at the base, but excluding all foliage. Tree volumes were converted to weight with equations developed by the Utilization of Southern Timber Research Unit of the Southeastern Forest Experiment Station in Athens, Georgia (Saucier 1979).

Included with the hardwood forest types referred to in this paper is the oak-pine type. This type generally results from harvesting pine stands and leaving a residual of nonmerchantable hardwoods and pines. In this class, pines make up at least 25 percent of the stocking, but not more than 50. Oak-pine figures for Georgia may be slightly distorted because sample plots were allowed to straddle two or more conditions. If one portion of the plot was in an oak-hickory stand and the other in a pine stand, the area was often typed as oak-pine. Since the last Georgia survey, straddling has been eliminated.

The NIPF Hardwood Perspective

More than 28 million acres, or some 64 percent of the total land area in the Southeast Piedmont, are classified as commercial forest. Of these 28 million acres, one-half support hardwood stands held by nonindustrial private owners. Although this assessment is largely confined to the forest biomass on these 14 million acres, it is important to understand the relationship of NIPF hardwood stands to all other stands in the Piedmont. Tables 1-3 provide the breakdown of the total Piedmont timberland acreage and associated biomass by State, ownership, and broad management class.

About 17 million acres, or 59 percent of the Piedmont commercial forest acreage, is allocated among the three hardwood types--oak-pine, upland hardwood, and lowland hardwood (table 1). The remaining acres are in pine forest types, 16 percent of which have been planted. Moving through the Piedmont from north to south, the proportion of total timberland acreage in hardwood types decreases from a high of 74 percent in Virginia to a low of 50 percent in South Carolina and Georgia.

NIPF owners possess over 23 million acres, or 82 percent of the Piedmont commercial forest. They own 94 percent of the Piedmont timberland in North Carolina, 83 percent in Virginia, 78 percent in Georgia, and 77 percent in South Carolina.

The distribution of biomass throughout the Piedmont is similar to the allocation of acreage (table 2). Nearly 1.3 billion tons, or 62 percent of the total Piedmont biomass, occurs in the hardwood classes. Planted pine accounts for only 4 percent of all Piedmont forest biomass. As with acreage, the relative amount of biomass in hardwood forest types decreases from north to south. NIPF landowners own 1.7 billion tons, or 83 percent of the total biomass in the Piedmont. Their portion ranges from 93 percent of the biomass in the North Carolina Piedmont to 77 percent in South Carolina and Georgia.

Nearly 53 percent of the total forest biomass in the Southeast Piedmont occurs within NIPF hardwood stands. NIPF upland hardwood stands by themselves contain over one-third of the total Piedmont biomass. NIPF oak-pine stands, which are very similar to upland hardwood stands, account for another 12 percent. Only 6 percent of the total Piedmont biomass is in NIPF lowland hardwood stands.

Tons of biomass per acre in NIPF stands are very close to State averages because these averages are heavily weighted by large numbers of NIPF acres (table 3). More biomass per acre is on public land because stands there are generally older than NIPF stands. Conversely, less biomass has accumulated on forest industry land because its stands are younger and on shorter rotations. The same logic holds when examining the broad forest types. Lowland hardwood stands have accumulated

Table 1.--Area of commercial forest land by State, year, ownership group, and broad forest type, Southeast Piedmont

State and year	Ownership group[a]	Broad forest type					
		All classes	Pine plantation	Natural pine	Oak-pine	Upland hardwood	Lowland hardwood
		Thousand acres					
Georgia 1972	Public	449.0	28.7	247.0	79.0	64.5	29.8
	Forest industry	1,995.6	352.2	741.8	308.5	390.4	202.7
	Other private	8,876.4	619.5	3,620.7	1,616.3	2,106.5	913.4
Total		11,321.0	1,000.4	4,609.5	2,003.8	2,561.4	1,145.9
South Carolina 1977	Public	428.8	20.0	235.8	50.9	107.9	14.2
	Forest industry	628.2	192.9	195.2	59.5	153.4	27.2
	Other private	3,471.1	193.1	1,419.0	563.2	1,208.7	87.1
Total		4,528.1	406.0	1,850.0	673.6	1,470.0	128.5
North Carolina 1975	Public	143.3	.5	40.6	27.1	41.9	33.2
	Forest industry	237.2	58.1	57.7	42.8	74.4	4.2
	Other private	5,647.5	111.7	1,827.3	757.5	2,572.3	378.7
Total		6,028.0	170.3	1,925.6	827.4	2,688.6	416.1
Virginia 1976	Public	306.4	.6	69.5	30.5	202.2	3.6
	Forest industry	781.7	158.7	168.5	107.3	317.5	29.7
	Other private	5,242.4	148.5	1,094.9	569.1	3,232.1	197.8
Total		6,330.5	307.8	1,332.9	706.9	3,751.8	231.1
All States	Public	1,327.5	49.8	592.9	187.5	416.5	80.8
	Forest industry	3,642.7	761.9	1,163.2	518.1	935.7	263.8
	Other private	23,237.4	1,072.8	7,961.9	3,506.1	9,119.6	1,577.0
Total		28,207.6	1,884.5	9,718.0	4,211.7	10,471.8	1,921.6

[a]Forest industry figures include 337.9 thousand acres of commercial forest land leased from NIPF owners.

Table 2.--Total green weight of aboveground biomass (excluding foliage) by State, year, ownership group, and broad forest type, Southeast Piedmont

State and year	Ownership group[a]	Broad forest type					
		All classes	Pine plantation	Natural pine	Oak-pine	Upland hardwood	Lowland hardwood
		Million tons					
Georgia 1972	Public	37.1	1.7	22.5	5.8	3.8	3.3
	Forest industry	124.5	12.8	50.4	17.2	22.7	21.4
	Other private	554.1	27.3	215.3	100.9	135.6	75.0
Total		715.7	41.8	288.2	123.9	162.1	99.7
South Carolina 1977	Public	45.7	.7	24.8	3.7	13.7	2.8
	Forest industry	33.9	7.7	14.3	2.2	6.5	3.2
	Other private	273.4	14.6	106.0	42.0	102.5	8.3
Total		353.0	23.0	145.1	47.9	122.7	14.3
North Carolina 1975	Public	14.4	--	5.2	3.1	3.3	2.8
	Forest industry	18.9	1.0	6.6	4.0	6.6	.7
	Other private	445.9	8.3	143.1	57.3	205.4	31.8
Total		479.2	9.3	154.9	64.4	215.3	35.3
Virginia 1976	Public	31.2	--	6.4	2.4	21.8	.6
	Forest industry	49.2	4.3	11.4	5.4	25.9	2.2
	Other private	402.6	4.7	84.4	39.8	260.2	13.5
Total		483.0	9.0	102.2	47.6	307.9	16.3
All States	Public	128.4	2.4	58.9	15.0	42.6	9.5
	Forest industry	226.5	25.8	82.7	28.8	61.7	27.5
	Other private	1,676.0	54.9	548.8	240.0	703.7	128.6
Total		2,030.9	83.1	690.4	283.8	808.0	165.6

[a]Forest industry figures include 14.4 million tons of biomass on commercial forest land leased from NIPF owners.

Table 3.--Average green weight of aboveground biomass (excluding foliage) per acre by State, year, ownership group, and broad forest type, Southeast Piedmont

State and year	Ownership group[a]	Broad forest type: All classes	Pine plantation	Natural pine	Oak-pine	Upland hardwood	Lowland hardwood
		Tons per acre					
Georgia 1972	Public	82.6	58.9	90.9	73.7	59.2	110.2
	Forest industry	62.4	36.4	67.9	55.8	58.0	105.7
	Other private	62.4	44.0	59.5	62.4	64.4	82.1
	All owners	63.2	41.8	62.5	61.9	63.3	87.0
South Carolina 1977	Public	106.7	37.4	105.0	72.0	127.5	197.5
	Forest industry	53.9	40.1	73.4	35.8	42.6	115.6
	Other private	78.8	75.9	74.6	74.5	84.8	95.1
	All owners	78.0	57.0	78.4	70.9	83.6	110.7
North Carolina 1975	Public	100.5	--	129.2	114.7	78.9	82.4
	Forest industry	79.6	16.7	113.9	94.1	88.0	180.1
	Other private	79.0	74.1	78.3	75.6	79.9	84.0
	All owners	79.5	54.3	80.5	77.8	80.1	84.9
Virginia 1976	Public	102.0	--	92.8	78.9	107.6	172.9
	Forest industry	63.0	26.9	67.8	50.1	81.7	74.5
	Other private	76.8	31.6	77.1	69.9	80.5	68.4
	All owners	76.3	29.1	76.7	67.3	82.1	70.8
All States	Public	96.8	49.0	99.4	80.0	102.4	116.9
	Forest industry	62.2	33.8	71.1	55.5	65.9	104.4
	Other private	72.1	51.2	68.9	68.4	77.2	81.6
	All owners	72.0	44.1	71.0	67.4	77.2	86.2

[a]Forest industry figures include lands leased from NIPF owners.

high average amounts of biomass due to long rotations, while pine plantations are younger and have accumulated significantly less biomass.

NIPF Hardwood Stand Composition

Quality, species, and size distribution of the 1.1 billion tons of forest biomass in NIPF hardwood stands are given in tables 4 and 5. Totals shown include 147 million tons of biomass in softwood species in these hardwood stands. Not included are 120 million tons of hardwood biomass occurring in NIPF pine stands. In NIPF hardwood stands, total green weight of all forest biomass exceeds the weight of conventional growing stock by 66 percent. Only 60 percent of total biomass is in the bole portion of growing-stock trees; 14 percent is in the stumps and tops of growing-stock trees, 11 percent in rough or rotten trees, and 15 percent in saplings. These averages do not vary significantly by State.

On the average, oak-pine stands tend to have a lower proportion of biomass in rough and rotten timber than do pure hardwood stands. Since oak-pine stands have usually been more heavily cut, and thus more open than the two other hardwood types, they have a higher proportion of biomass in saplings. Lowland hardwood stands have the highest percentage of biomass in rough and rotten trees, because these stands are generally older and receive less treatment than upland stands.

Oaks account for more forest biomass than any other species group (table 5). At 126 million tons, more biomass has collected in white oak than any other single species. White oak, yellow-poplar, sweetgum, and hickory together account for more than one-third of the total tree biomass in NIPF Piedmont hardwood stands.

Nearly two-thirds of the biomass in these stands is concentrated in trees between 5 and 15 inches in diameter, and the greatest accumulation is in the 10-inch class. One-half of the total green weight of forest biomass is in sawtimber-size trees, 35 percent in poletimber, and the remainder in saplings.

Hardwood Stand Performance

Two variables important to the performance of all timber stands are stocking and site quality. In this analysis we demonstrate the effects that varying degrees of site and stocking have on the performance of NIPF hardwood stands. Oak-pine, upland hardwood, and lowland hardwood stands were grouped because no significant differences were observed when these stands were examined separately. Georgia data were omitted because stand age information collected during the fourth survey of Georgia was weakened by plots straddling more than one condition and the grouping of some stands into mixed age classes. We assume hardwood stands in Georgia perform similarly to those in the rest of the Piedmont.

Stocking levels are based on all live trees, and stocking standards are defined in table 6. Stands 100 percent or more stocked are fully stocked; stands 60 to 99 percent stocked are medium stocked; and stands less than 60 percent stocked are poorly stocked.

Site class is a measure of the inherent capacity of land to grow crops of industrial wood based in fully stocked natural stands. Sites capable of producing more than 85 cubic feet (roughly 3 tons) of wood per acre per year are good sites. Sites able to produce 50 to 85 cubic feet per acre annually are medium sites, and sites capable of producing only 20 to 50 cubic feet are poor sites.

Figures 2 and 3 isolate the effects of stocking on stand performance. These graphs represent the net results of all past treatments and disturbances, and therefore show how NIPF Piedmont hardwood stands are performing collectively. Care is advised in the interpretation of these figures, because a particular stand may not necessarily follow the delineated performance patterns throughout its entire lifespan. Depending on what treatments or disturbances a stand experiences, it could easily jump from one stocking level to another during its development. Indeed, there is a tendency for both fully stocked and poorly stocked stands to drift toward medium stocking as they get older.

Figure 2 shows how biomass accumulates over time. Stands are grouped into 10-year age classes, and the average biomass is plotted at each age-class midpoint. By age 30, stands at each stocking level have accumulated well over half of the biomass they are likely to accumulate if allowed to proceed to age 100. Across

Table 4.--Total green weight of aboveground biomass (excluding foliage) on NIPF hardwood stands in the Southeast Piedmont by State, year, hardwood broad forest type, and tree component[a]

State and year	Broad forest type	Aboveground biomass			Trees 5.0 inches d.b.h. and larger						Saplings total
					Growing stock			Rough and rotten			
		Total	Bole	Other[b]	Total	Bole	Other	Total	Bole	Other	
		Million tons									
Georgia 1972	Oak-pine	100.9	66.3	34.6	74.3	60.7	13.6	7.5	5.6	1.9	19.1
	Upland hardwood	135.6	89.1	46.5	95.6	77.0	18.6	16.3	12.1	4.2	23.7
	Lowland hardwood	75.0	52.8	22.2	55.8	45.7	10.1	9.4	7.1	2.3	9.8
Total		311.5	208.2	103.3	225.7	183.4	42.3	33.2	24.8	8.4	52.6
South Carolina 1977	Oak-pine	42.0	28.3	13.7	30.4	24.8	5.6	4.7	3.5	1.2	6.9
	Upland hardwood	102.5	71.7	30.8	77.5	62.4	15.1	12.4	9.3	3.1	12.6
	Lowland hardwood	8.3	6.5	1.8	6.4	5.3	1.1	1.4	1.2	.2	.5
Total		152.8	106.5	46.3	114.3	92.5	21.8	18.5	14.0	4.5	20.0
North Carolina 1975	Oak-pine	57.3	37.8	19.5	42.9	35.0	7.9	3.7	2.8	.9	10.7
	Upland hardwood	205.4	140.5	64.9	155.7	126.0	29.7	19.1	14.5	4.6	30.6
	Lowland hardwood	31.8	23.3	8.5	23.7	19.8	3.9	4.6	3.5	1.1	3.5
Total		294.5	201.6	92.9	222.3	180.8	41.5	27.4	20.8	6.6	44.8
Virginia 1976	Oak-pine	39.8	25.1	14.7	27.5	22.3	5.2	3.8	2.8	1.0	8.5
	Upland hardwood	260.2	181.5	78.7	195.2	158.2	37.0	30.9	23.3	7.6	34.1
	Lowland hardwood	13.5	10.1	3.4	9.8	8.1	1.7	2.5	2.0	.5	1.2
Total		313.5	216.7	96.8	232.5	188.6	43.9	37.2	28.1	9.1	43.8
All States	Oak-pine	240.0	157.5	82.5	175.1	142.8	32.3	19.7	14.7	5.0	45.2
	Upland hardwood	703.7	482.8	220.9	524.0	423.6	100.4	78.7	59.2	19.5	101.0
	Lowland hardwood	128.6	92.7	35.9	95.7	78.9	16.8	17.9	13.8	4.1	15.0
Total		1,072.3	733.0	339.3	794.8	645.3	149.5	116.3	87.7	28.6	161.2

[a]Does not include biomass on NIPF lands leased to forest industry.
[b]Includes all stumps, tops, and limbs, plus total sapling weight.

Table 5.--Total green weight of aboveground biomass (excluding foliage) on NIPF hardwood stands in the Southeast Piedmont, by species and diameter class[a]

Species	All diameter classes	Diameter class											
		2	4	6	8	10	12	14	16	18	20	22-28	30+
	Million tons												
Southern yellow pines:													
Loblolly pine	57.0	.6	2.5	5.4	6.8	8.7	10.0	8.6	5.9	3.7	2.1	2.5	.2
Shortleaf pine	43.8	.7	2.2	6.3	10.2	10.1	7.4	3.7	1.8	1.0	.3	.1	--
Virginia pine	28.0	1.1	3.8	5.6	6.7	5.7	3.2	1.3	.5	.1	--	--	--
Other yellow pines	6.2	.1	.5	.6	.8	1.0	1.3	.9	.5	.2	.1	.2	--
Total yellow pines	135.0	2.5	9.0	17.9	24.5	25.5	21.9	14.5	8.7	5.0	2.5	2.8	.2
Other softwoods	12.3	1.2	1.7	1.9	1.5	1.3	1.0	1.0	.8	.9	.5	.4	.1
Total softwoods	147.3	3.7	10.7	19.8	26.0	26.8	22.9	15.5	9.5	5.9	3.0	3.2	.3
Soft hardwoods:													
Sweetgum	92.3	6.3	9.8	12.3	13.3	14.0	12.5	8.5	6.4	3.6	2.3	2.9	.4
Yellow poplar	101.8	2.8	5.2	7.6	9.3	12.8	15.8	14.7	11.6	8.0	5.7	6.8	1.5
Tupelo and blackgum	28.3	2.8	2.7	2.9	3.8	4.5	4.3	2.7	2.1	.9	.5	.9	.2
Bay and magnolia	3.9	.3	.4	.5	.6	.5	.4	.6	.2	.1	.1	.1	.1
Soft maples	67.6	6.5	8.9	9.4	9.0	9.4	6.8	5.5	4.1	2.7	1.9	2.8	.6
Other soft hardwoods	32.4	2.5	3.6	3.8	4.2	3.6	4.0	3.1	2.4	1.5	1.0	2.2	.5
Total soft hardwoods	326.3	21.2	30.6	36.5	40.2	44.8	43.8	35.1	26.8	16.8	11.5	15.7	3.3
Oaks:													
Black	35.2	.9	1.7	3.5	3.9	5.2	5.3	4.4	3.5	2.2	1.6	2.6	.4
Chestnut	41.4	.6	2.5	3.3	4.7	6.0	6.0	5.7	4.7	3.3	1.9	2.2	.5
Laurel	10.4	.8	1.1	1.1	1.0	1.2	.8	.7	.5	.5	.7	1.4	.6
Northern red	33.4	1.0	1.2	2.9	3.0	4.4	4.6	4.3	3.4	3.0	1.8	3.0	.8
Scarlet	38.3	.7	1.8	3.5	5.8	5.6	6.3	5.3	3.9	2.5	1.3	1.5	.1
Southern red	39.3	2.0	3.0	4.4	4.6	5.1	5.6	4.5	3.3	2.3	1.5	2.3	.7
Water	25.4	1.6	2.5	3.5	3.2	3.2	3.4	2.1	2.0	1.6	.6	1.5	.2
White	126.2	3.1	6.7	12.0	14.1	18.1	17.3	17.1	13.8	7.8	5.5	8.5	2.2
Other oaks	43.2	1.4	2.8	5.0	5.5	5.6	5.9	4.9	3.3	2.4	1.7	3.7	1.0
Scrub oaks	10.1	1.3	2.0	2.2	2.0	1.2	.9	.3	.1	.1	--	--	--
Total Oaks	402.9	13.4	25.3	41.4	47.8	55.6	56.1	49.3	38.5	25.7	16.6	26.7	6.5
Other hardwoods:													
Ash	17.6	1.2	1.8	2.6	2.6	2.4	2.2	1.8	1.1	.8	.4	.6	.1
Hickory	78.6	4.6	6.5	7.9	9.1	10.5	10.8	9.5	7.9	5.0	2.5	3.8	.5
Other hard hardwoods	70.8	12.5	13.5	5.6	5.8	6.4	7.5	5.7	3.9	3.4	2.0	4.0	.5
Miscellaneous spp.	28.8	6.7	9.7	6.2	2.9	1.8	.7	.4	.2	--	.1	.1	--
Total other hardwoods	195.8	25.0	31.5	22.3	20.4	21.1	21.2	17.4	13.1	9.2	5.0	8.5	1.1
Total hardwoods	925.0	59.6	87.4	100.2	108.4	121.5	121.1	101.8	78.4	51.7	33.1	50.9	10.9
All species	1,072.3	63.3	98.1	120.0	134.4	148.3	144.0	117.3	87.9	57.6	36.1	54.1	11.2

[a]Does not include biomass on NIPF lands leased to forest industry nor stands classified as primarily pine.

Table 6.--Minimum stocking standards by diameter class, numbers of trees, and basal area for fully and medium stocked stands

D.b.h. class	Minimum number of trees per acre for--		Minimum basal area per acre for--	
	Full stocking	Medium stocking	Full stocking	Medium stocking
Seedlings	600	360	--	--
2	560	336	--	--
4	460	276	--	--
6	340	204	67	40
8	240	144	84	50
10	155	93	85	51
12	115	69	90	54
14	90	54	96	58
16	72	43	101	61
18	60	36	106	64
20	51	31	111	67

all age classes, fully stocked hardwood stands in the Piedmont are accumulating 15 percent more biomass per acre than medium stocked stands and over three times more biomass than poorly stocked stands.

These graphs originate at age 15 because many hardwood stands begin with some biomass in residual trees left when the previous stand was harvested. Data from stands younger than age 15 are heavily influenced by these residuals and were not included.

About 63 percent of all NIPF hardwood stands in the Piedmont are fully stocked, 33 percent medium stocked, and 4 pecent poorly stocked with all live trees. These percentages and the biomass production values associated with them suggest that biomass production could be increased by 15 to 20 percent if all stands were fully stocked. In reality, opportunities are much greater if growing-stock stocking is considered. Only 21 percent of NIPF hardwood stands are fully stocked with growing-stock trees, while 56 percent are medium stocked and 23 percent are poorly stocked. Obviously, there is much opportunity not only to increase total growth but also to shift this growth to more desirable trees.

Dividing accumulated tons of biomass per acre in each age class by the age-class midpoint yields a measure of annual biomass production (fig. 3). In both medium and fully stocked stands, annual biomass production peaks before age 15 and begins to fall sharply as tree crowns close and overall growth slows. Poorly stocked stands, disadvantaged from the start by lack of trees available to fix light energy, never experience this early surge of growth. These stands start out slowly and reach the apex of biomass production at about age 30.

Unlike percent stocking, site quality is expensive to improve. Nevertheless, it is important to know the full impact of site quality on timber growth. The majority of Piedmont stands occur on medium sites. Figures 4 and 5 depict the influence of site class on biomass accumulation and production. Performance of a particular stand will vary as a result of the treatment it receives, but there is much less shifting among site classes than among stocking levels.

As expected, site class also has a significant bearing on biomass accumulation (fig. 4). On the average, good sites accrue about 26 percent more biomass than medium sites and 48 percent more than poor sites across all ages. Stands on poor sites are not nearly as disadvantaged as stands that are poorly stocked. Figure 5 shows that stands on poor sites experience an early surge of growth, whereas poorly stocked stands do not (fig. 3).

Green weight of forest biomass on all NIPF commercial forest land supporting hardwood stands in the Piedmont averages 79.5 tons per acre. The weighted average age of these same stands is 43.1 years. By dividing average age into average weight we can determine that the average Piedmont hardwood stand is manufacturing over 1.8 tons, or nearly 3,700 pounds, of biomass per acre annually. Remember that these figures do not include any foliage, shrubs, vines, forbs, etc.

NIPF Hardwood Past Treatment

At each sample location, field crews recorded the primary past treatment or disturbance that had occurred during the latest remeasurement period. Results were separated by broad forest type and summed for all six Piedmont Survey Units. Since the remeasurement periods for the Piedmont averaged 10.9 years, one can assume that values reported represent conditions approximately 5.5 years after treatment. Also, they indicate the forest type at the time of the new inventory rather than at time of treatment.

Over the remeasurement period nearly 2.3 million acres of NIPF land in the Piedmont experienced a final harvest, were retained in commercial forest, and are now classed as hardwood types (table 7). Thus, the rate of final harvest (including clear-cutting, seed-tree cutting, salvage, and high-grading) averaged more than 207,000 acres annually, excluding commercial thinnings, other intermediate cutting, and land clearing. The residual green weight of forest biomass on these acres averaged 39.1 tons per acre (table 8). Much of the biomass left in the woods after final harvest is in rough, rotten, and small trees. The high proportion of residual biomass left in these hardwood stands indicates that many acres are still being high-graded. This practice must be curtailed if we are to stem the proliferation of low-grade hardwood stands. The poor-

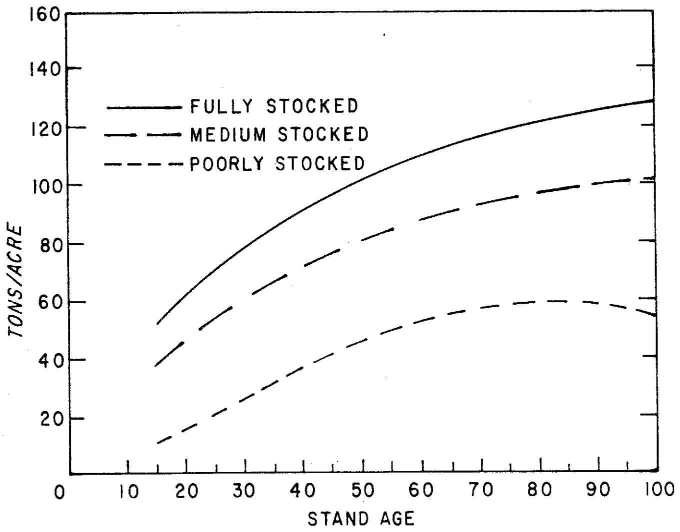

Figure 2.--Accumulation of biomass per acre, by stand age and stocking, on all NIPF hardwood stands, Southeast Piedmont (excluding Georgia).

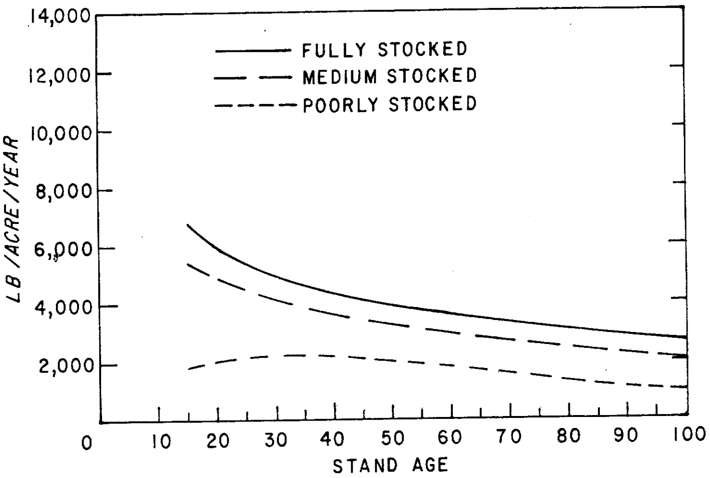

Figure 3.--Mean annual production of biomass per acre, by stand age and stocking, on all NIPF hardwood stands, Southeast Piedmont (excluding Georgia).

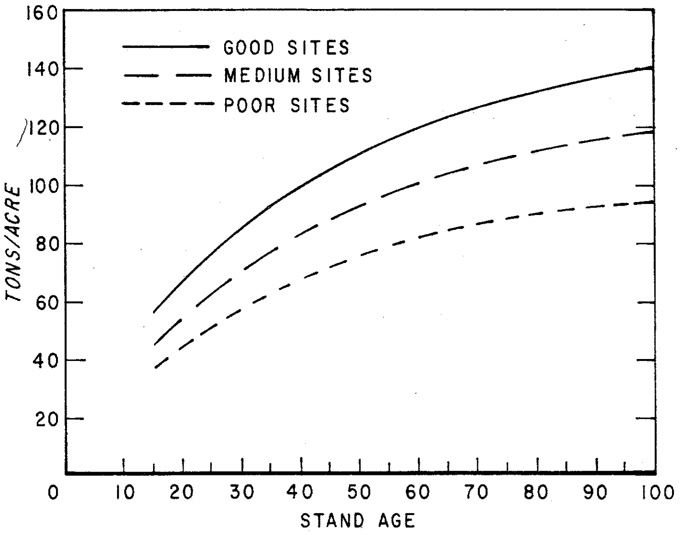

Figure 4.--Accumulation of biomass per acre, by stand age and site class, on all NIPF hardwood stands, Southeast Piedmont (excluding Georgia).

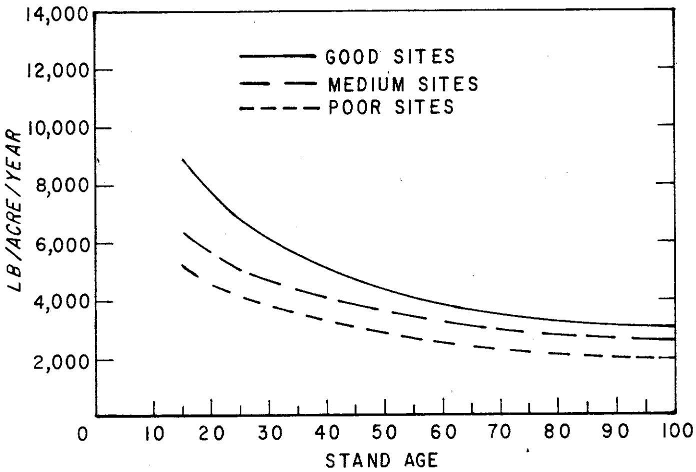

Figure 5.--Mean annual production of biomass per acre, by stand age and site class, on all NIPF hardwood stands, Southeast Piedmont (excluding Georgia).

Table 7.--Area of NIPF hardwood stands, by recent past treatment or disturbance and broad forest type, Southeast Piedmont

Recent past treatment or disturbance[a]	All types	Broad forest type		
		Oak-pine	Upland hardwood	Lowland hardwood
	- - - - - - - - - Thousand acres - - - - - - - - -			
Harvesting	2,257.0	533.6	1,532.5	190.9
Commercial thinning	296.6	112.0	145.3	39.3
Artificial planting	18.0	13.3	4.7	--
Natural disturbance	424.2	119.0	208.5	96.7
Other[b]	2,463.4	630.6	1,618.9	213.9
None	8,743.5	2,097.5	5,609.9	1,036.1
All stands	14,202.7	3,506.0	9,119.8	1,576.9

[a]Primary treatment or disturbance of the stand during latest survey interval in each State.

[b]Includes cleaning, release, draining, prescribed burning, site preparation, and other miscellaneous treatments.

Table 8.--Average green weight of forest biomass on NIPF hardwood stands, by recent past treatment or disturbance and hardwood broad forest type, Southeast Piedmont

Recent past treatment or disturbance[a]	All types	Broad forest type		
		Oak-pine	Upland hardwood	Lowland hardwood
	- - - - - - - - - Tons per acre - - - - - - - - -			
Harvesting	39.1	38.5	37.8	51.1
Commercial thinning	70.1	69.9	70.5	69.3
Artificial planting	21.6	29.2	0	--
Natural disturbance	75.2	78.7	73.4	74.9
Other[b]	76.2	70.5	78.4	75.9
None	85.0	75.0	87.9	89.4
All stands	75.5	68.4	77.2	81.6

[a]Primary treatment or disturbance of the stand during latest survey interval in each State.

[b]Includes cleaning, release, draining, prescribed burning, site preparation, and other miscellaneous treatments.

quality hardwood stands we observe today are not so much the result of poor sites or inherently poor tree form, but rather of the inferior trees left on the site after one or more harvest cuts. We cannot expect to produce fully stocked, high-quality hardwood stands when an average of 39.1 tons per acre of biomass remain on site after harvest in the form of rough and rotten cull trees and noncommercial understory saplings. Landowners should attempt to sell all trees when they make a timber sale, but where fuelwood markets are poor and firewood is too expensive to remove, sale may not be possible. In such cases, the residuals should be felled and left in the woods. Although this practice appears wasteful, the long-range benefits of establishing more valuable hardwoods far exceed the loss of underutilized biomass at the time of harvest.

Only 2 percent of all NIPF hardwood stands experienced a commercial thinning over the remeasurement period. On the average, these stands had about 15 tons per acre, or 18 percent of the biomass, removed from them. Relatively few hardwoods have been planted on NIPF land. The figures listed in tables 7 and 8 are most likely unsuccessful pine plantations which resulted in an oak-pine forest type. Natural disturbances and miscellaneous treatments occurred on 2.9 million acres of NIPF Piedmont timberland. These events reduced the average per acre forest biomass by about 10 tons.

Hardwood Utilization

Some people have expressed concern that harvesting forest biomass for energy or increased fiber production might aggravate hardwood procurement problems in the Piedmont. Estimates of Piedmont hardwood removals show that only 54 percent of all felled hardwood biomass (22.9 million tons) is used for roundwood products (table 9). Since it was not possible to isolate removals from only NIPF timberland for every item, the figures in table 9 include estimates of hardwood removals from all ownerships in the Piedmont. However, the NIPF ownership group holds such a high proportion of hardwood acreage in the Piedmont that ratios developed from table 9 are heavily influenced by harvesting practices on NIPF land. Also, a fraction of the hardwood biomass shown here came from pine stands.

Industrial products, along with the weight of hardwood biomass harvested for fuelwood, constitute the estimate of all roundwood products. Traditionally, the merchantable volume of a tree has been defined as that portion between a 1.0-foot stump and a 4.0-inch d.o.b. top, including all forks greater than 4.0 inches d.o.b in trees 5.0 inches and larger. Logging residues are the merchantable portions of felled trees remaining in the woods after harvest. Logging slash is the weight of wood and bark in felled-tree stumps less than 1.0 foot above ground, in felled-tree tops between 4.0 inches and 0.5 inches d.o.b., and in all felled saplings not used for timber products. Other removals include the unused total-tree biomass of all hardwoods destroyed in land clearing and cultural operations. Between 1971 and 1976, an average of 12 percent of the total annual felled weight of hardwood biomass in the Piedmont remained in the woods as logging residues; 17 percent remained as logging slash, and 17 percent as unused other removals.

During most harvest operations, some trees are judged worthless by the logger and bypassed because of size, species, or quality (Welch 1980). On NIPF land in the Piedmont, some 39 tons per acre of these living residues were left in the woods following final harvest. Generally these living remnants, although counted as part of the timber resource, inhibit the development of new stands. At least 7.4 million tons of hardwood biomass accumulated annually as obstructive living residues on commercial forest land in the Piedmont between 1971 and 1977 (table 9).

Other standing residues are those trees which were once part of the commercial forest but, because of land clearing for agricultural, urban, or some other land use, now stand in a nonforest condition. In many instances, these trees are beneficial because they encourage wildlife, have esthetic value, provide shade, or reduce erosion and siltation. In any case, they do not inhibit the establishment of new stands on existing timberland. About 2.9

Table 9.--Total green weight of annual removals of all hardwood live timber on all ownerships by item, State, and year, Southeast Piedmont

Item	All States	Georgia 1971	North Carolina 1973	South Carolina 1977	Virginia 1976
		State and year			
		Million tons			
All roundwood products[a]	12.3	3.2	3.3	1.6	4.2
Logging residues[b]	2.7	.7	.8	.3	.9
Logging slash[c]	3.9	1.2	1.0	.5	1.2
Other removals[d]	4.0	1.1	1.3	.6	1.0
Total felled weight	22.9	6.2	6.4	3.0	7.3
Commercial forest living residues[e]	7.4	2.6	1.8	1.3	1.7
Removed from commercial forest[f]	2.9	.8	1.0	.3	.8
Total standing residues	10.3	3.4	2.8	1.6	2.5
Total all	33.2	9.6	9.2	4.6	9.8

[a]Green weight of merchantable and unmerchantable portions of all live hardwoods 5.0 inches d.b.h. and larger, plus all hardwood saplings used to produce all roundwood products.

[b]Green weight of merchantable portions of all live hardwoods 5.0 inches d.b.h. and larger destroyed and not utilized during harvest operations.

[c]Green weight of unmerchantable portions of all live hardwoods 5.0 inches d.b.h. and larger, plus all hardwood saplings destroyed and not utilized during harvest operations.

[d]Total green weight of all live hardwoods 5.0 inches d.b.h. and larger, plus all hardwood saplings destroyed and not utilized during cultural operations and land clearing.

[e]Total green weight of all live hardwoods 5.0 inches d.b.h. and larger, plus all hardwood saplings still standing in commercial forest on acres which experienced a final harvest.

[f]Total green weight of all live hardwoods 5.0 inches d.b.h. and larger, plus all hardwood saplings still standing but no longer in a forest condition.

million tons of hardwood biomass were added to this category annually (table 9).

When both standing and felled residues are considered, only 37 percent of the hardwood biomass in harvested stands is being utilized. The remaining 63 percent is left in the woods because, to date, loggers have not been able to make these residues pay their way out of the woods. This situation may be changing. Currently, hardwood whole-tree chips bring an average delivered pulpwood price of $12 per green ton in the Piedmont (Timber Mart-South 1982). Based on cost comparisons with No. 2 fuel oil, the Office of Technology Assessment has estimated that economic conditions in the foreseeable future suggest that wood energy users could afford to pay up to $90 per dry ton of wood delivered, or about $45 per green ton (U.S. Congress 1980). Even if the value of this wood waste does not quadruple, the potential for increased value along with the magnitude of the resource clearly indicates substantial economic opportunity. In addition to the potential delivered value of logging waste and living residues, the removal of these materials from the forest would substantially reduce the landowner's cost of site preparation and replanting.

It is not reasonable to expect that all harvested biomass can or should be utilized. The economic, ecological, and social impacts of total utilization are complex and differ greatly with local situations. If hardwood stands in the Piedmont were properly harvested, however, the product output from the hardwood resource could at least be doubled with no threat to conventional hardwood supplies. With proper regeneration and maintenance after harvest, increased yields of better quality hardwoods are certain.

Hardwood Treatment Opportunity

As long as vegetative cover is present, biomass will be produced. It is the task of the forest manager to maximize and channel this growth onto the most beneficial species that circumstances permit. On 14 million acres of NIPF in the Piedmont, hardwood management is a logical choice because it can produce good returns at much lower costs than pine management, and because it can provide the multiple benefits many small landowners desire. As the hardwood resource on NIPF land plays a role of increasing importance, it becomes critical that this resource be managed more productively.

In contrast to pine management, hardwood silviculture need be neither expensive nor intensive. Although research on hardwood management in the Piedmont has been rather limited, results applicable to the Piedmont are available from other regions of the country (Kellison, Frederick, and Gardner 1981; McGee, Beck, and Sims 1979; McGee and Hooper 1970). Several silvicultural options available to the hardwood manager at minimal cost are:

1. After final harvest, clearcut all residuals 1.0 inch d.b.h. and larger. Residuals need to be removed because they do not respond favorably to release after being in the understory so long; they shade out new sprouts and seedlings, and the stumps of these small stems prove to be the best sprouters. Salvage the residuals for firewood where possible but, even if the wood is not recoverable, fell the stems so a new vigorous even-aged stand can begin.

2. Strive to maintain full stocking. This condition is easily achieved at harvest by applying proper regeneration techniques; it is much more difficult to increase the stocking of established stands. Landowners should have their stands assessed for natural regeneration potential. Some of the better oak stands, with most of the stems larger than 15 inches d.b.h., will not regenerate naturally because the stems do not sprout. In these stands, enrichment plantings may be needed to obtain full stocking. Fortunately, most hardwood stands do not need enrichment plantings. Sprouts from small stumps, and seeds that remain viable in the soil litter for long periods of time, normally provide sufficient regeneration.

3. Deadening of undesirable species may be helpful on certain sites where strong competition from unwanted species will severely restrict or eliminate desirable species. Landowners should

weigh the cost of treatment against the probable improvement of species composition. They should be reminded that many undesirable species will drop out through natural mortality as the stand develops. Discretion should be used so that a tree is not killed where no other tree is available to occupy the site.

4. In fully stocked or overstocked stands, thinning and timber stand improvement (TSI) cuts are possibilities. At present, these operations are economical only where a heavy thinning is possible and markets are favorable. In the future, it is hoped the biomass removed in light thinnings and TSI operations will return enough revenue to offset operating costs. Landowners should be reminded that returns from management efforts are usually greatest on the best sites and that all stands do not need treatment. Some young stands just need time to develop on their own.

If NIPF owners would apply some of the treatments suggested here and put their land under management, several important benefits would logically follow. In the short run, the demand for energy wood and some other products would be met through the conversion of poor-quality stands to young, vigorous stands. In the long run, the hardwood resource would be improved in both quantity and quality; landowners would make more profit from timber sales; and some of the demand pressure now placed on southern pines could be relieved.

Literature Cited

Boyce, Stephen G.; Knight, Herbert A. Prospective ingrowth of southern pine beyond 1979. Res. Pap. SE-200. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1979. 48 p.

Boyce, Stephen G.; Knight, Herbert A. Prospective ingrowth of southern hardwoods beyond 1980. Res. Pap. SE-203. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1980. 33 p.

Cathey, Robert C. Forest statistics for Central Georgia, 1972. Resour. Bull. SE-22. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1972. 34 p.

Cost, Noel D. Multiresource inventories: a technique for measuring volumes in standing trees. Res. Pap. SE-196. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1978. 18 p.

Kellison, Robert C. Hardwood management philosophies and practices. In: Proceedings: Symposium on southeastern hardwoods; 1971 September 15-16; Dothan, AL; 1971: 8-16. Available from: Southeastern Area State and Private Forestry, Atlanta, GA.

Kellison, Robert C.; Frederick, Douglas J.; Gardner, William E. 1981. A guide for regenerating and managing natural stands of southern hardwoods. Bull. 463. Raleigh, NC: NC State University Agricultural Experiment Station; 1981. 24 p.

Kingsley, Neal P. The nonindustrial forest-land owner: Who? Where? Why? In: Proceedings: Eighth annual hardwood symposium of the Hardwood Research Council; 1980 April 23-26; Cashiers, NC: Hardwood Research Council Sponsored Publication; 1980: 13-31. Available from: Hardwood Research Council, Asheville, NC.

Knight, Herbert A. Forest statistics for North Central Georgia, 1972. Resour. Bull. SE-24. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1972. 34 p.

McGee, Charles E.; Beck, Donald E.; Sims, Daniel A. Natural regeneration of upland hardwoods in the South. (Unnumbered brochure.) Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1979.

McGee, Charles E.; Hooper, Ralph M. Regeneration after clearcutting in the Southern Appalachians. Res. Pap. SE-70. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1970. 12 p.

Saucier, Joseph R. Estimation of biomass production and removal. In: Proceedings: impact of intensive harvesting on forest nutrient cycling; 1979 August; Syracuse, NY; 1979: 172-189. Available from: Northeastern Forest Experiment Station, Broomall, PA.

Sheffield, Raymond M. Forest statistics for the Southern Piedmont of Virginia, 1976. Resour. Bull. SE-35. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1976. 33 p.

Sheffield, Raymond M. Forest statistics for the Northern Piedmont of Virginia, 1977. Resour. Bull. SE-39. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1977. 33 p.

Snyder, Nolan L. Forest statistics for the Piedmont of South Carolina, 1978. Resour. Bull. SE-45. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1978. 33 p.

Sosbe, E. H. The status of growing and marketing hardwoods on short rotations. In: Proceedings: 1966 Symposium on hardwoods of the Piedmont and Coastal Plain; 1966 October 26-27; Macon, GA: Georgia Forest Research Council Sponsored Publication; 1966: 56-58. Available from: Georgia Forestry Commission, Macon, GA.

Timber Mart-South, Inc. U.S. Forest Service timber sales report: In summary form - for Southeastern States. Timber Mart-South 7(5):var. pg.; 1982.

U.S. Congress, Office of Technology Assessment. Energy from biological processes. Washington, DC: U.S. Congress, Office of Technology Assessment; 1980. 196 p.

Welch, Richard L. Forest statistics for the Piedmont of North Carolina, 1975. Resour. Bull. SE-32. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1975. 33 p.

Welch, Richard L. Living residues in the South Atlantic States. For. Prod. J. 30(6):37-39; 1980.

Bechtold, William A.; Phillips, Douglas R.
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KEYWORDS: Nonindustrial private forest land, forest trends, hardwood forest land, Piedmont forest land, forest biomass, hardwood timber volume, hardwood silviculture.

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