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Weight and Volume of Plantation-Grown Choctawhatchee Sand Pine

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ABSTRACT

The aboveground green weight of the total tree and its major components, the main stem and crown, were determined in eight stands of planted Choctawhatchee sand pine ranging in age from 7 to 27 years. Eighty-three trees, ranging in d.b.h. from 0.7 to 11.1 inches and from 11 to 59 feet in total height, were sampled. After testing for significant differences, data were stratified to provide two sets of composite equations: one for the six stands with a closed canopy, i.e., ages 12 to 27 years, and one for the young stands where crown closure had not yet occurred. Equations for predicting individual tree green and dry weights and cubic volumes of wood, and of wood and bark, were developed for the main stem and crown of each canopy class. Ratio equations were developed to allow estimation of weights and volumes to specified top stem diameter. Tables for estimating green and dry weight and cubic volume are given for the total tree and its major components, based on d.b.h. and total height.

Keywords: Pinus clausa var. immuginata, biomass, prediction equations.

The Choctawhatchee variety of sand pine (Pinus clausa var. immuginata D. B. Ward) is the preferred commercial timber species for reforestation of xeric, deep sand sites in northwest Florida (Brendemuehl 1981). In addition to the area in Florida where it is endemic, Choctawhatchee sand pine has been planted with good success on similar deep sand sites in Georgia and South Carolina (Hebb 1982; McNab and Carter 1981; Outcalt and Brendemuehl 1985) (fig. 1). Choctawhatchee sand pine can be used for sawtimber and plywood and is suitable for production of both bleached and unbleached kraft papers of high strength (Taras 1973).

As with other pine species, commercial measurement of harvested Choctawhatchee sand pine is typically estimated by using scaling factors to convert truck-load weight totals to conventional units of volume. Applicable scaling factors for plantation-grown Choctawhatchee sand pine, however, are not available, and conversion factors for other pine species must be used. In addition, there are no satisfactory equations for estimating standing tree volumes in plantations. The purpose of this Paper is to present summary tables and equations for estimating the aboveground weight and volume of various ages of Choctawhatchee sand pine planted at typical stand densities. Similar information is available for natural stands of Choctawhatchee sand pine (Taras 1980) but may not be applicable to plantations because of differences in form class, crown characteristics, and wood physical properties.

Procedures

Field Procedures

Eight Choctawhatchee sand pine plantations, two each of ages 7, 18, and 27, and one 12 and one 13 years old, were selected for sampling during May 1981, after the major portion of the current year's growth had occurred. All plantations were growing on excessively drained, infertile, sandy soils of the

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[2] Now retired.

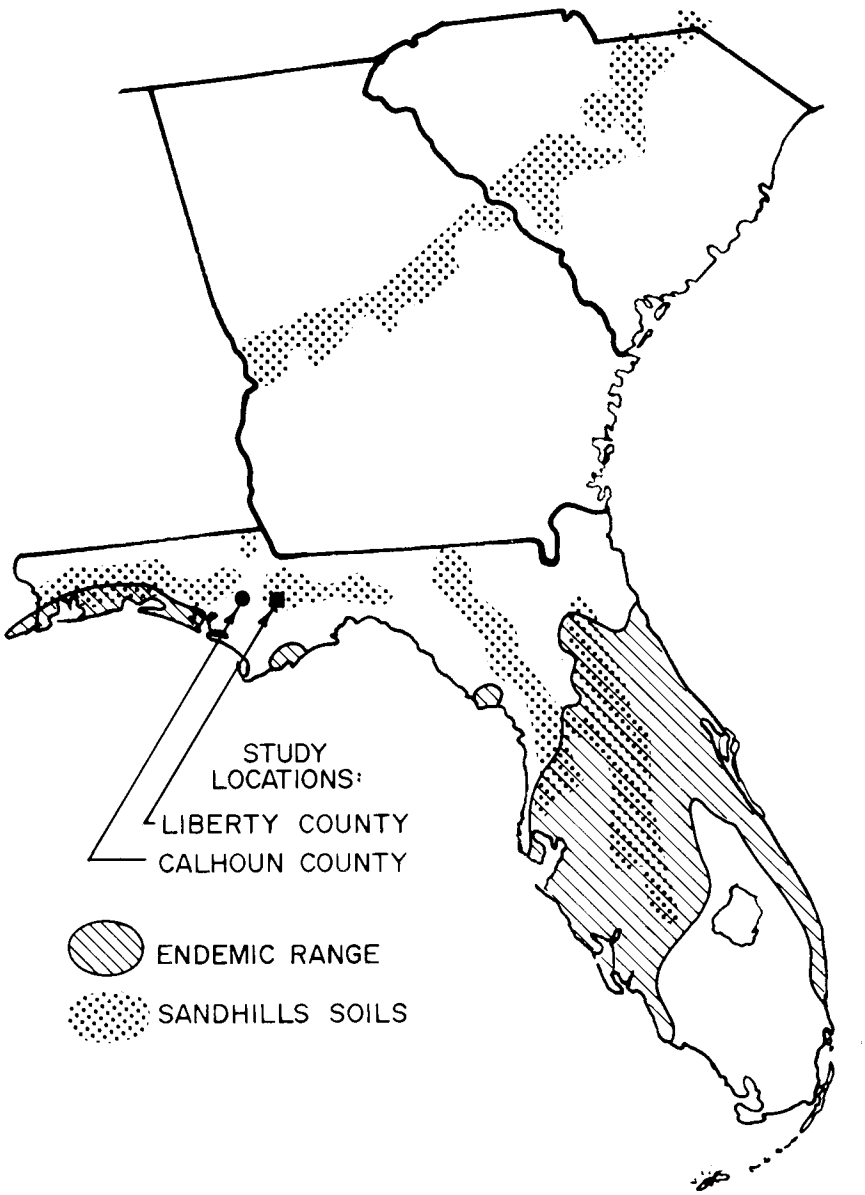

Figure 1.--The endemic range of sand pine (Pinus clausa) in Florida and sandhill soils in Georgia and South Carolina where the Choctawhatchee variety is also planted. The two study sites in Florida are shown.

Lakeland series, a thermic, coated Typic Quartzipsamment. These plantations had been established by similar site preparation and planting procedures. All seedlings originated from seed collected from natural stands of Choctawhatchee sand pine.

All plantations sampled were located in northwest Florida (fig. 1). The two 27-year-old plantations were in Liberty County, and the other six stands were in the Southeastern Forest Experiment Station's Chipola Experimental Forest, Calhoun County. Stocking and basal area of the sample stands were typical of other stands of similar age in northwest Florida (table 1). Site quality varied only slightly among the sample stands. At least 10 trees were selected for sampling in each of the eight stands to cover the range in d.b.h. and crown class. Table 2 gives means and ranges of sample-tree data by d.b.h. class for each age class. The two stands sampled in each of the two older age classes represented a low and high level of stocking.

After selection, sample trees were felled and measured. Each tree was separated into its two major components of main stem and crown. The main stem extended from the butt to 1-inch diameter outside bark (d.o.b.) and was marked at 7, 4, and 2 inches d.o.b. to simulate sizes of pine main stems typically harvested for merchantable products of sawtimber, pulpwood, and topwood, respectively. The length of each section was measured and then weighed on portable platform scales to the nearest 1/10 pound. The live crown was separated into lower, middle, and upper sections and each section was weighed. The main stem less than 1-inch d.o.b. was included in the upper crown section. Dead material was separated from all crown sections and combined for a single biomass component. Three sample whole branches were collected from each section to determine the ratio of needles to branch wood and bark.

Sample disks were collected from the stem and branches to determine physical properties of wood by laboratory analysis. Disks, each about 1.5 inches thick, were cut at the butt and at 5-foot intervals along the stem of each tree. Similar sample disks were cut from sample branches in each crown section and dead crown material. About 0.05 pound of current and previous year's needles were collected from each crown section and combined into a single sample. The disks and a needle sample were sealed in individual polyethylene bags and returned to the laboratory to determine specific gravity, moisture content, and bark content.

The diameter and weight of stem and branch disks were determined both with and without bark except for sample disks from dead branches, which were processed with bark attached. The proportion of bark was calculated on a green weight basis. After soaking for 2 to 3 days, specific gravity of wood and bark was determined from immersed green volume and dry weight (Heinrichs and Lassen 1970). The moisture content of wood, bark, and

Table 1.--Characteristics of planted Choctawhatchee sand pine stands sampled in northwest Florida

Age class (yr)	Stocking level	Basal area	Site quality[1]
	Trees/acre	Ft^2/acre	
27	225	94	53
27	630	135	50
18	400	96	52
18	801	114	49
13	560	65	52
12	647	57	49
7	831	15	52
7	955	45	54

[1]Total height at 25 years.

Table 2.--Diameters and heights of sample planted Choctawhatchee sand pine trees, by age and d.b.h. class

D.b.h. class	Sample trees	D.b.h.		Total Height	
		Mean	Range	Mean	Range
	No.	- - - - Inches - - - -		- - - - Feet - - - -	
		7 YEARS			
0	1	0.70	--	11.0	--
2	16	2.05	1.0- 2.9	15.5	11-18
4	3	3.40	3.1- 3.7	21.2	21-21
		12 YEARS			
2	3	2.47	2.3- 2.6	21.0	19-22
4	5	4.06	3.2- 4.5	26.6	25-28
6	2	5.40	5.3- 5.5	29.0	29-29
		13 YEARS			
2	1	2.90	--	22.9	--
4	5	4.22	3.6- 4.9	30.8	25-34
6	4	5.68	5.3- 5.9	34.4	33-37
		18 YEARS			
2	1	2.80	--	34.0	--
4	7	4.03	3.0- 4.9	38.0	33-43
6	7	6.10	5.3- 6.8	42.4	40-45
8	6	7.93	7.2- 8.6	47.8	46-50
10	1	9.10	--	50.0	--
		27 YEARS			
2	2	2.75	2.6- 2.9	35.0	31-39
4	3	4.33	3.9- 4.9	45.7	39-52
6	6	5.98	5.3- 6.7	54.5	49-57
8	5	8.00	7.3- 8.8	58.2	54-63
10	4	9.60	9.0-10.6	58.8	57-60
12	1	11.10	--	59.0	--

needles was determined on a dry weight basis after drying the individual samples of each component to a constant weight at 217 °F. The ratio of needle to branch wood plus bark in each crown section was determined by drying sample branches, separating out the needles, and weighing the needles and the woody components. This ratio was then applied to the total weight of each crown section to estimate total dry needle weight.

Mean values of specific gravity, moisture content, and bark content for the stem were estimated by weighting disk sample values by the volume[3] of the section they represented. The weighted specific gravity and moisture content was then used to determine the green weight per unit volume as follows:

Green weight per ft^3 =

$$[1+MC/100] \times SG \times C \qquad (1)$$

where: MC = weighted moisture content in percent
SG = weighted specific gravity
C = weight of water per cubic foot (62.43 pounds)

The weighted value of specific gravity for each section was used to calculate dry weight per cubic foot:

$$\text{Dry weight per } ft^3 = SG \times C \qquad (2)$$

The cubic volume of wood and bark in the stem were estimated by using dry weight and component weight per cubic foot:

Component volume (ft^3) =

component dry weight/component dry weight per ft^3

Mean physical properties of wood and bark for each crown section was estimated from simple averages of branch disk samples. Total crown properties were determined by combining the three sections for each tree, with dry weight as a weighting factor. Only results concerning the total crown will be presented and discussed in this report. Weight and volume of wood and bark components in the total crown were calculated in a manner similar to that used for the stem.

Total-tree weight, volume, and physical properties were obtained by combining appropriate components and weighting by cubic volume.

Analysis

Linear regression equations with independent variables of d.b.h. squared times total height (D^2Th) were developed to predict green and dry weights and green volumes of wood and bark in the total tree and its components. Grouping the data into D^2Th classes and plotting the variance of Y over D^2Th indicated that the variance of predicted weights and volumes increased with increasing D^2Th. A logarithmic transformation (to the base 10) was used to obtain a relatively homogeneous variance that is assumed in regression analysis. Thus, regression coefficients for tree and component weights and volumes are calculated by using the equation:

$$\log Y = b_0 + b_1 \times \log(D^2Th) + e \qquad (3)$$

where: Y = weight or volume of component
e = sampling error
b_0, b_1 = regression coefficients

When a logarithmic estimate is converted back into original units it is biased downward because the antilogarithm of the estimated mean gives the geometric rather than the arithmetic mean (Cunia 1964). To account for this bias, a correction factor was computed by a procedure described by Baskerville (1972) and applied to each equation. The form of the equation, including the correction factor, is:

$$Y = 10(b_0+b_1 \times \log(D^2Th) + [S^2(y.x) \times \log_e(10)]/2+e) \qquad (4)$$

where: $S^2(y.x)$ = error mean square from regression analysis

[3] Computed by Smalian's formula.

Equation (4) was simplified to:

$$Y = a(D^2Th)^{b_1} \quad (5)$$

where: $a = 10^{(b_0+[S^2(y.x) \times \log_e(10)]/2)}$

Analysis of sample plot green weight and volume data revealed significant differences in slope and intercept for trees in young stands with open canopies compared with older trees on plots with closed canopies. No significant difference, however, was found between plots within a canopy class. Therefore, sample weight and volume data were pooled into two groups for analysis and presentation of results: (1) trees in young stands that had not reached crown closure, and (2) trees in closed-canopy stands.

In sampling over the range of diameters present in each stand, only single trees were measured in the 0-inch class[4] of open-canopy stands and the 12-inch d.b.h. class of trees in closed-canopy stands (table 1). Since inferences concerning a single tree could be misleading, these trees were included with the 2-inch and 10-inch d.b.h. classes, respectively, for presentation of results. The analysis of data was unaffected since measured d.b.h. of each sample tree was used as the independent variable.

Results

Main Stem Heights

Main stem lengths within a diameter class to the 4-inch and 2-inch d.o.b. points were about two times greater for trees growing in stands with a closed canopy compared with the young open-canopy plots (table 3). This is primarily due to the difference in ages of the trees. In the closed-canopy stands, height to a 4-inch top averaged about 6.2 feet in the 4-inch diameter class and increased to more than 40 feet for trees in the 10-inch d.b.h. class. Trees in the 8-inch d.b.h. class averaged 11.4 feet in height to a 7-inch d.o.b. top, hence most were too short for harvesting as a merchantable sawtimber product. All trees sampled in the 10-inch class, however, had at least one 16.3-foot saw log to a 7-inch d.o.b. top. None of the trees of sawtimber size had any defects, and d.o.b. at merchantable height was 7.0 inches. Girard form class[5] averaged 76 and ranged from 72 to 83 for the six sawtimber-size trees greater than 9.0 inches d.b.h.

Total-Tree Weights

Total-tree green weights above stump ranged from 37.1 pounds for 2-inch d.b.h trees to 1,059.9 pounds for 10-inch d.b.h. class trees. The proportion of total-tree weight in wood, bark, and needles varied with tree size. The proportion of total-tree weight in wood increased and the proportion of bark and needles decreased as tree size increased for Choctawhatchee sand pines sampled in stands with closed canopies (table 4). The average tree sampled in closed-canopy stands was 5.7 inches d.b.h. and contained 79 percent wood, 13 percent bark, and 8 percent needles on a green-weight basis. The proportion of needles was greater and the proportion of wood was less for young trees in open stands compared with older trees in closed-canopy stands. The proportion of tree dry weight by component differed only slightly from green-weight proportions primarily because of differences in moisture content.

Table 5 shows the breakdown of sampled trees into stem, branches, and needles. As tree size increased, the proportion of green weight in the stem generally increased, whereas the proportion in branches remained relatively constant. The proportion in needles decreased from 10 percent in 2-inch trees to about 5 percent in 10-inch trees. The average tree in a stand with closed canopy contained 75 percent of its green weight in the main stem, 17 percent in branches, and 8 percent in needles. By comparison, young trees in open-canopy stands contained about a third of their green weight in each component. Thus, a higher proportion of their green weight was in branches and needles, with less in the main stem.

[4] D.b.h. range, 0.1 to 0.9 inches.

[5] D.i.b. at 17 feet/d.b.h.

Table 3.--Mean and range of d.b.h. and height to various d.o.b. top diameters for planted Choctawhatchee sand pine sampled in open- and closed-canopy stands

D.b.h. class (in.)	Sample trees	Mean d.b.h.	Stem height to d.o.b. of: 7 inches Mean	7 inches Range	4 inches Mean	4 inches Range	2 inches Mean	2 inches Range	1 inch Mean	1 inch Range	Total height Mean	Total height Range
	No.	Inch	Feet									
			OPEN									
2	17	1.97	--	--	0.6	--	5.1	1-8	9.1	1-13	15.4	11-19
4	3	3.40	--	--	2.2	2-3	10.5	9-12	15.0	14-16	21.0	21-21
			CLOSED									
2	7	2.66	--	--	--	--	11.8	7-22	20.4	13-33	26.7	19-39
4	20	4.13	--	--	6.2	1-15	22.4	13-40	28.6	19-46	34.5	25-52
6	19	5.90	2.1	1-4	21.5	10-37	33.0	20-48	37.6	24-52	43.2	29-57
8	11	7.96	11.4	4-24	33.8	25-47	42.8	35-55	47.1	40-59	52.5	46-63
10	6	9.50	21.4	17-29	40.8	35-45	48.4	41-51	52.6	45-56	57.0	50-60

Table 4.--Average green and dry weight of total tree and proportion of tree in wood, bark, and needles for planted Choctawhatchee sand pine sampled in open- and closed-canopy stands

D.b.h. class (in.)	Total green weight	Tree component proportions (green)			Total dry weight	Tree component proportions (dry)		
		Wood	Bark	Needles		Wood	Bark	Needles
	Lb	- - - - Percent - - - -			Lb	- - - - Percent - - - -		
				OPEN				
2	29.0	53.6	14.6	31.8	11.7	53.2	13.7	33.1
4	91.6	64.2	13.5	22.2	36.1	65.0	14.1	20.9
Mean	38.4	55.2	14.4	30.4	15.4	55.0	13.7	31.3
				CLOSED				
2	37.1	72.7	17.1	10.2	17.1	73.9	16.5	9.6
4	130.4	77.2	14.0	8.7	59.5	78.5	13.4	8.1
6	326.4	79.4	12.3	8.3	146.4	80.6	11.6	7.8
8	645.5	83.2	10.8	6.0	277.5	83.9	10.0	6.1
10	1059.9	84.7	10.1	5.2	479.8	85.6	9.2	5.2
Mean	357.6	79.2	12.9	7.9	159.1	80.2	12.2	7.6

Table 5.--Average green and dry weight of total tree and proportion of tree in the main stem[1] and crown (branches and needles) for planted Choctawhatchee sand pine sampled in open- and closed-canopy stands

D.b.h. class (in.)	Total green weight	Tree component proportions (green)			Total dry weight	Tree component proportions (dry)		
		Stem	Branches	Needles		Wood	Branches	Needles
	Lb	- - - - Percent - - - -			Lb	- - - - Percent - - - -		
				OPEN				
2	29.0	38.3	29.9	31.8	11.7	37.7	29.2	33.2
4	91.6	46.1	31.7	22.2	36.1	46.6	32.5	20.9
Mean	38.4	39.5	30.1	30.3	15.4	39.0	29.7	31.3
				CLOSED				
2	37.1	72.9	16.9	10.2	17.1	73.8	16.6	9.6
4	130.4	73.9	17.4	8.7	59.5	75.0	16.9	8.1
6	326.4	73.3	18.3	8.3	146.4	74.4	17.8	7.8
8	645.5	79.0	15.0	6.0	277.5	79.5	14.4	6.1
10	1059.9	77.6	17.2	5.2	479.8	78.7	16.1	5.2
Mean	357.6	74.9	17.1	8.0	159.1	75.8	16.6	7.6

[1]Butt to 1-inch d.o.b. top.

The average green and dry weight and distribution of all wood in Choctawhatchee sand pines are given in table 6. A pulpwood-size tree in the 6-inch d.b.h. class would have about 61 percent of its green wood weight in the pulpwood portion of the stem, 15 percent in topwood, and 19 percent in branches. Small sawtimber-size trees in the 10-inch d.b.h. class had, on average, 56 percent of their green wood weight in saw-log material, 24 percent in pulpwood, 3 percent in topwood, and 17 percent in branches. The distribution of wood in the tree on a dry-weight basis was about the same as found on a green-weight basis.

Choctawhatchee sand pines growing in the young, open-canopy stands tended to have a larger portion of their green wood weight in branch components. For trees of the same d.b.h. class, trees in older, closed stands contained a 20 to 25 percent greater proportion of wood in the stem portion, compared with trees in open-canopy stands.

The distribution of bark among various tree components is shown in table 7. On the average, a pulpwood-size tree in the 6-inch d.b.h. class had 59 percent of the green bark weight in the pulpwood portion of the main stem, 13 percent in topwood, and 27 percent in branches. The average tree in the 10-inch d.b.h., small sawtimber size class, had 50 percent of its total green bark weight in the saw-log stem, 19 percent in pulpwood, 3 percent in topwood, and 28 percent in branches. On a dry-weight basis, the proportion of bark tended to be less for branches compared with the same components on a green-weight basis, and greater for the butt to 7-inch stem section.

Table 8 shows the distribution of wood and bark in the stem to a 1-inch d.o.b. top. The proportion of stem weight in wood increased and the proportion in bark decreased with increasing tree size. On the average, 87 percent of the green stem weight was wood and 13 percent was bark. For an average pulpwood-size tree in the 8-inch d.o.b. class, the percentage of wood in the green stem was about 90 percent. The distribution of biomass between wood and bark in the stem was about the same for both the green- and dry-weight basis.

Crown Biomass

Average proportion of the green and dry weight of wood, bark, and needles in the crown is given in table 9. For both open- and closed-canopy stands, the proportion of green crown weight in wood increased as tree d.b.h. increased and needle proportion decreased. On the average, 56 percent of crown green weight was wood, 13 percent was bark, and 31 percent was needles.

Mean green and dry crown weights were greater for trees in open-canopy stands than for similar-size trees in closed stands. In stands with an open canopy, the proportion of crown dry weight in needles averaged 19 percent greater than for trees in closed stands.

Dead Branch Material

Field and dry weights of dead branches by d.b.h. class are shown below for stands with a closed canopy:

D.b.h. class	Field weight	Dry weight
	- - - Pounds	- - -
2	1.0	0.8
4	4.2	3.4
6	11.0	9.2
8	20.3	17.0
10	39.8	33.7
Weighted average	12.1	10.1

Weight increased as d.b.h. class increased. The average field moisture content for dead branches equaled 19.8, whereas specific gravity ranged from 0.392 to 0.487 and averaged 0.441. Almost no dead crown material was found in the 7-year-old trees in the two stands with an open overstory canopy.

Table 6.--Average green and dry weight of wood in total tree and distribution of wood in main stem[1] and branches for planted Choctawhatchee sand pine sampled in open- and closed-canopy stands

D.b.h. class (in.)	Total wood weight	Proportion of wood in:					
		Main stem components (d.o.b.)				Total stem	Branches
		Butt-7	7-4	4-2	2-1		
	Lb	- - - - - - - - - - - - - - - - Percent - - - - - - - - - - - - - - - -					
				OPEN-GREEN			
2	16.8	--	0.1	37.5	19.2	56.8	43.2
4	59.0	--	12.2	45.8	2.2	60.2	39.8
Mean	23.2	--	2.0	38.7	16.6	57.3	42.7
				CLOSED-GREEN			
2	27.1	--	--	70.5	10.8	81.3	18.7
4	101.3	--	26.3	53.0	2.4	81.7	18.3
6	260.9	4.2	60.8	15.2	0.5	80.7	19.3
8	538.5	34.4	44.2	6.1	0.2	84.9	15.0
10	897.6	56.5	23.8	2.6	0.1	83.0	17.0
Mean	293.4	6.4	42.8	30.6	2.2	82.0	18.0
				OPEN-DRY			
2	6.7	--	0.1	37.7	17.8	55.6	44.4
4	23.5	--	12.5	43.7	1.9	58.1	41.9
Mean	9.2	--	2.0	38.6	15.4	56.0	44.0
				CLOSED-DRY			
2	12.9	--	--	72.0	8.9	80.9	19.1
4	47.2	--	27.6	52.2	1.8	81.6	18.4
6	118.7	4.6	61.9	13.9	0.3	80.7	19.3
8	233.4	37.6	42.2	5.3	0.1	85.2	14.8
10	410.6	60.1	21.5	2.1	(2)	83.8	16.2
Mean	132.1	7.6	43.0	29.9	1.6	82.1	17.9

[1]Butt to 1-inch d.o.b. top.

[2]Less then 0.1 percent.

Table 7.--Average green and dry weight of bark in total tree and distribution of bark in main stem[1] and branches for planted Choctawhatchee sand pine sampled in open- and closed-canopy stands

D.b.h. class (in.)	Total bark weight	Proportion of bark in:					
		Main stem component (d.o.b.)				Total stem	Branches
		Butt-7	7-4	4-2	2-1		
	Lb	- - - - - - - - - - - - - - - - Percent - - - - - - - - - - - - - - - -					
				OPEN-GREEN			
2	4.9	--	0.1	34.7	16.2	51.0	49.0
4	12.5	--	12.0	40.6	1.7	54.3	45.6
Mean	5.5	--	1.9	35.6	14.0	51.5	48.5
				CLOSED-GREEN			
2	6.4	--	--	69.5	7.8	77.4	22.6
4	17.8	--	27.0	45.8	2.0	74.8	25.2
6	39.8	5.0	54.5	12.9	0.6	73.0	27.0
8	69.5	34.4	36.0	5.9	0.3	76.6	23.4
10	106.1	49.9	19.4	3.0	0.2	72.5	27.5
Mean	40.6	6.7	38.6	27.5	1.8	74.6	25.4
				OPEN-DRY			
2	1.7	--	0.2	40.5	14.3	55.0	45.0
4	5.1	--	15.5	47.1	(2)	62.6	37.4
Mean	2.1	--	2.5	41.5	12.1	56.1	43.9
				CLOSED-DRY			
2	2.8	--	--	76.9	3.7	80.6	19.4
4	7.7	--	35.2	43.4	0.4	79.0	21.0
6	17.0	7.7	60.8	9.1	(2)	77.6	22.4
8	27.6	45.3	30.0	3.8	(2)	79.2	20.8
10	44.1	61.3	13.2	1.4	(2)	76.0	24.0
Mean	16.9	10.1	42.0	25.9	0.5	78.5	21.5

[1]Butt to 1-inch d.o.b. top.

[2]Less then 0.1 percent.

Table 8.--Average green and dry weight of stem[1] and proportion of stem in wood and bark for planted Choctawhatchee sand pine sampled in open- and closed-canopy stands

D.b.h. class	Green weight	Stem proportion (green)		Dry weight	Stem proportion (dry)	
		Wood	Bark		Wood	Bark
	Lb	- - - Percent - - -		Lb	- - - Percent - - -	
			OPEN			
2	12.1	79.9	20.1	4.8	79.5	20.5
4	42.2	84.0	16.0	16.8	81.1	18.9
Mean	16.6	80.6	19.4	6.6	79.8	20.2
			CLOSED			
2	27.6	81.6	18.4	13.1	81.3	18.6
4	93.3	85.8	14.2	44.9	85.7	14.3
6	243.1	87.8	12.2	10.9	87.7	12.3
8	511.4	89.5	10.5	221.5	90.0	10.0
10	822.0	90.6	9.4	377.5	91.1	8.9
Mean	274.5	87.0	13.0	123.8	87.1	12.9

[1]Butt to 1-inch d.o.b. top.

Table 9.--Average green and dry weight of crown and proportion of crown in wood, bark, and needles for planted Choctawhatchee sand pine sampled in open- and closed-canopy stands

D.b.h. class (in.)	Crown weight (green)	Crown proportion (green)			Crown weight (dry)	Crown proportion (dry)		
		Branch wood	Branch bark	Needles		Branch wood	Branch bark	Needles
	Lb	-----	Percent	-----	Lb	-----	Percent	-----
				OPEN				
2	17.0	37.7	11.6	50.7	6.9	38.1	9.7	52.2
4	49.4	47.2	11.5	41.3	19.3	50.8	9.8	39.4
Mean	21.8	39.1	11.6	49.3	8.8	39.9	9.8	50.3
				CLOSED				
2	9.5	48.4	15.1	36.5	4.0	51.3	13.3	35.6
4	34.2	52.6	13.5	33.9	14.6	55.5	11.4	33.1
6	83.3	56.0	12.6	31.4	35.5	58.1	10.5	31.4
8	134.1	59.6	12.1	28.3	55.9	60.1	10.2	29.6
10	237.9	64.1	12.6	23.2	102.3	65.0	10.7	24.2
Mean	83.1	55.5	13.1	31.4	35.3	57.5	11.1	31.4

Wood and Bark Physical Properties

Average specific gravity, moisture content, and green weight per cubic foot are shown in table 10 for the major components of trees growing in open-canopy stands. Similar statistics for trees in closed-canopy stands are given in table 11. Total-tree wood specific gravity averaged 0.443 for trees growing in closed-canopy stands. Wood specific gravity averaged 0.480 in the saw-log stem, 0.461 in the pulpwood portion, and 0.426 in branches. Compared with the specific gravity of the four major southern pines (*P. taeda*, *P. echinata*, *P. palustris*, *P. elliottii*), Choctawhatchee sand pine specific gravity was, on the average, higher in the main stem but lower in branch wood (Clark and Taras 1976; Taras and Clark 1975, 1977; Taras and Phillips 1978). Bark specific gravity averaged 0.377 for the total tree, 0.398 for the main stem, and 0.294 for branches.

Moisture content of wood averaged 120 percent for the total tree, 103 percent in the saw-log stem, and 114 percent in the pulpwood portion of the main stem compared with branch wood, which had an average moisture content of 128 percent. Compared with Virginia pine (*P. virginiana*) (Saucier and Boyd 1982), main stem wood moisture content was about 25 percent greater for sand pine. Bark moisture content was higher than wood moisture content for the total tree and branches. Within the main stem, bark moisture content was lower for the saw-log and pulpwood components than for the topwood portions. For the total-tree bark, moisture content averaged 135 percent, 79 percent for the saw-log stem, and 103 percent for the pulpwood portion. Moisture content of the branch bark averaged 181 percent, more than 50 percent higher than branch wood on a dry basis.

The green weight of wood per cubic foot of wood varied only slightly for tree components, and ranged from 60 pounds for branches to 61 pounds for stem wood from a 2- to 1-inch top. The green weight of wood and bark per cubic foot of wood and bark averaged about 58 pounds for branches, and was lowest among the various tree components.

The weight per cubic foot of wood for branches, in relation to other tree components in planted Choctawhatchee sand pine, is opposite to the trend reported for natural Choctawhatchee sand pine (Taras 1980) and natural Virginia pine (Saucier and Boyd 1982). Natural stands tend to have variable spacing which results in poorer pruning and large, older live branches in lower crowns that have denser wood. In contrast, close spacing in planted stands increases natural pruning and results in small branches that have lower wood density. The trend in green bark weight per cubic foot of bark for the components was similar to the other species.

The weight of wood and bark per unit volume of wood is a useful factor for estimating the volume of wood in a tree or its components when weight with bark is known; for example, in weight-scaling truckloads of tree-length logs. For trees in closed-canopy stands, the average green weight of wood and bark per cubic foot of wood was 71 pounds for the total tree, 70 pounds for the stem to a 2-inch d.o.b. top, and 69 pounds for the stem to a 7-inch top. For branch material, the green weight of wood and bark per cubic foot of wood averaged 75 pounds.

Prediction Equations

Tables 12 and 13 contain equations for predicting total-tree and component green and dry weights based on D^2Th, and tables 14 and 15 give equations for estimating cubic volume of wood and bark, with D^2Th also used as the independent variable. Each prediction equation is shown with statistics including the coefficient of determination (R^2) and standard error of estimate ($S_{y.x}$). The corrected sum of squares and mean value of D^2Th and the independent variable are also shown for use in calculating confidence intervals (Appendix, tables 12, 13).

Prediction equations that use tree d.b.h. alone were not developed because the equations might not be applicable to trees in stands on other sites with different diameter:height relationships. However, since local weight and volume

Table 10.--Average wood and bark specific gravity, moisture content, and green weight per cubic foot for planted Choctawhatchee sand pine sampled in open-canopy stands, by tree component

Tree component	Specific gravity	Moisture content	Green weight per cubic foot
		Percent	Pounds
	WOOD		
Total tree	0.408 ± 0.018	149 ± 12	63.4 ± 1.2
Butt to 4-inch d.o.b.	.437 ± .041	141 ± 14	65.6 ± 2.3
4-inch to 2-inch d.o.b.	.409 ± .029	152 ± 16	64.0 ± 1.5
2-inch to 1-inch d.o.b.	.388 ± .028	153 ± 15	63.9 ± 1.5
Main stem	.396 ± .021	150 ± 15	64.1 ± 1.5
Branches	.337 ± .025	142 ± 16	62.9 ± 2.7
	BARK		
Total tree	.337 ± .025	159 ± 25	54.1 ± 3.0
Butt to 4-inch d.o.b.	.444 ± .036	91 ± 13	52.9 ± 2.1
4-inch to 2-inch d.o.b.	.367 ± .029	125 ± 28	51.1 ± 3.8
2-inch to 1-inch d.o.b.	.348 ± .028	119 ± 27	50.8 ± 3.8
Main stem	.354 ± .033	123 ± 28	51.2 ± 3.8
Branches	.394 ± .015	197 ± 20	54.9 ± 4.7
	WOOD AND BARK		
Total tree	.394 ± .015	151 ± 10	61.1 ± 1.5
Butt to 4-inch d.o.b.	.439 ± .032	131 ± 10	63.0 ± 2.1
4-inch to 2-inch d.o.b.	.391 ± .031	154 ± 16	61.8 ± 1.3
2-inch to 1-inch d.o.b.	.371 ± .029	155 ± 15	61.2 ± 1.4
Main stem	.387 ± .017	144 ± 12	62.0 ± 1.6
Branches	.386 ± .016	156 ± 15	60.8 ± 2.7

Mean ± standard deviation.

Table 11.--Average wood and bark specific gravity, moisture content, and green weight per cubic foot for planted Choctawhatchee sand pine sampled in closed-canopy stands, by tree component

Tree component	Specific gravity	Moisture content	Green weight per cubic foot
		Percent	Pounds
	WOOD		
Total tree	0.443 ± 0.028	120 ± 15	60.6 ± 2.4
Butt to 7-inch d.o.b.	.480 ± .048	103 ± 18	60.5 ± 2.3
7-inch to 4-inch d.o.b.	.461 ± .039	114 ± 18	61.2 ± 2.6
4-inch to 2-inch d.o.b.	.415 ± .038	139 ± 25	61.4 ± 3.0
2-inch to 1-inch d.o.b.	.395 ± .036	146 ± 26	61.5 ± 3.0
Main stem	.443 ± .031	121 ± 17	60.9 ± 2.7
Branches	.426 ± .024	128 ± 16	60.4 ± 3.5
	BARK		
Total tree	.337 ± .027	135 ± 20	55.1 ± 3.8
Butt to 7-inch d.o.b.	.453 ± .041	79 ± 25	50.2 ± 4.5
7-inch to 4-inch d.o.b.	.422 ± .034	103 ± 27	53.1 ± 4.9
4-inch to 2-inch d.o.b.	.327 ± .046	198 ± 63	59.2 ± 6.6
2-inch to 1-inch d.o.b.	.311 ± .044	208 ± 66	59.5 ± 6.7
Main stem	.398 ± .030	126 ± 21	55.0 ± 4.7
Branches	.294 ± .027	181 ± 22	51.4 ± 4.9
	WOOD AND BARK		
Total tree	.435 ± .026	121 ± 15	59.6 ± 2.2
Butt to 7-inch d.o.b.	.476 ± .044	99 ± 19	58.8 ± 2.0
7-inch to 4-inch d.o.b.	.455 ± .035	112 ± 18	59.8 ± 2.1
4-inch to 2-inch d.o.b.	.400 ± .035	150 ± 26	61.0 ± 2.7
2-inch to 1-inch d.o.b.	.380 ± .033	157 ± 24	61.3 ± 2.9
Main stem	.436 ± .029	122 ± 18	59.8 ± 2.5
Branches	.396 ± .022	139 ± 14	58.3 ± 3.1

Mean ± standard deviation.

tables are commonly used in timber stand cruising, an appropriate table can be easily developed by the user. First, the mean height of trees in each d.b.h. class of the stand must be determined. These heights are then used to solve the appropriate weight or volume prediction equation at the midpoint of each d.b.h. class.

For most tree components, with the exception of the crown, the high correlation coefficient indicates a close correlation between the independent variable (D^2Th) and component weights and volumes. The crown weight and volume data were more variable than stem data, due to greater variation in crown morphology. Sample trees were selected from all crown classes, from suppressed to dominant, and included a wide variation in branch and needle characteristics, and hence prediction equations had a lower coefficient of determination.

Specific equations were not developed to predict weight or volume of the stem pulpwood to various top diameters because of the wide range of pulpwood merchantability limits, and because of possible changes in utilization standards. Instead, a separate nonlinear relationship was developed to enable the user to obtain estimated stem weight or volume to any main stem top diameter larger than 1-inch outside bark. Based on a nonlinear model presented by Burkhart (1977), and a modified exponential form presented by Van Deusen and others (1981), Clark and Thomas (1984) developed a model for estimating the proportion of weight or volume to various top diameters of the main stem for hardwood and pine species in the Southeast:

$$R = e^{(b_1[(d.o.b.\ ^{b_2})(d.b.h.\ ^{b_3})])} \quad (6)$$

where: R = ratio of weight or volume
e = natural base logarithm
d.o.b. = diameter outside bark at specified point
d.b.h. = diameter outside bark at 4.5 feet
b_1, b_2, b_3 = regression coefficients

Prediction equations were derived to estimate the ratio of stem weight or volume to a specified diameter to stem weight or volume to a 1-inch top.

Tables 16-18 (Appendix) contain values of these weight and volume ratios for various commonly used combinations of d.b.h. and top d.o.b. limits. Examination of ratio values for green weight of wood and bark of a 10-inch d.b.h. tree reveals that proportions range from about 100 percent of total stem weight contained in the stem to a 1-inch d.o.b. top, to 12 percent for the stem to a 10-inch top, or to a height of 4.5 feet in this example.

Yield Tables

Appendix tables 19-34 were developed from the equations given in tables 12-15 to show total tree and tree component weight and volume by d.b.h. and total height classes. Additional tables may be constructed to show the weight or volume of stem material to various top diameters by applying the ratio values in table 16 to weights and volumes to a 1-inch d.o.b. stem top shown in table 24. For example, to estimate the green weight of wood and bark to an 8-inch d.o.b. top contained in a 10-inch d.b.h. tree 60 feet in height, multiply 933 pounds by 0.518 = 483 pounds. Similar values of weights to a 4- and 7-inch d.o.b. top are shown in tables 26-29.

Similar-size trees may vary in weight and volume because of differences in crown size, stem taper, and weight per cubic foot. Therefore, the equations and tables should be applied only to trees growing in planted, fully stocked stands of Choctawhatchee sand pine that have weights per cubic foot and physical characteristics similar to the trees sampled.

Computation of Confidence Limits

Approximate confidence limits in conventional units of measure can be calculated for lognormal means by using a modification of Cox's formula (Land 1972). By using the statistics of standard errors of the estimate, the sample mean of D^2Th, and the corrected sums of squares for D^2Th of each equation in

$\log_{10}$ form (tables 12-15), confidence intervals in pounds or cubic feet may be obtained by the equation:

$$Y_{U,L} = 10^{\log Y \pm Z \sqrt{S^2_{y \cdot x}\left[\frac{1}{n} + \frac{(x-\bar{x})^2}{\Sigma(x-\bar{x})^2}\right] + \frac{S^4_{y \cdot x}}{2(n+1)}}} \quad (7)$$

where:

$Y_{U,L}$ = upper and lower limits for Y
Y = predicted weight or volume of component from equation (5)
Z = value from the standard normal table appropriate confidence level
$S_{y.x}$ = standard error of estimate for prediction equations
n = number of observations used to develop equation
$\bar{x}$ = sample mean of log x -- (from table of equations)
$(x-\bar{x})^2$ = corrected sums of squares for log x -- (from table of equations)
x = value of independent variable in $\log_{10}$ form

Cox's method of approximation sufficiently estimates actual confidence limits when applied to samples with small variances as occur in the total-tree and stem weight and volume data sets. Thus, equation (7) should be used to approximate confidence limits for the single variable equations presented in this Paper.

Literature Cited

Baskerville, G.L. Use of logarithmic regression in the estimation of planted biomass. Canadian Journal of Forest Research 2:49-53; 1972.

Brendemuehl, R.H. Options for management of sandhill forest land. Southern Journal of Applied Forestry 5(4):216-222; 1981.

Burkhart, Harold E. Cubic-foot volume of loblolly pine to any merchantable top limit. Southern Journal of Applied Forestry 1(2):7-9; 1977.

Clark, Alexander, III; Taras, Michael A. Comparison of aboveground biomasses of the four major southern pines. Forest Products Journal 26(10):25-29; 1976.

Clark, Alexander, III; Thomas, Charles E. Weight equations for southern tree species--where we are and what is needed. In: Daniels, R.F.; Dunham, P.H.,eds. Proceedings of the 1983 southern forest biomass workshop. Fifth annual meeting of the Southern Forest Biomass Working Group; 1983 June 15-17; Charleston, SC. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station; 1984:100-106.

Cunia, T. Weighted least squares method and construction of volume tables. Forest Science 10:180-191; 1964.

Hebb, Edwin A. Sand pine performs well in the Georgia-Carolina Sandhills. Southern Journal of Applied Forestry 6(3):144-147; 1982.

Heinrichs, J. Frank; Lassen, L.E. Improved technique for determining the volume of irregularly shaped wood blocks. Forest Products Journal 20(4):24; 1970.

Land, C.E. An evaluation of approximate confidence interval estimation methods for lognormal means. Technometrics 14(1):145-158; 1972.

McNab, W. Henry; Carter, Allen R. Sand pine performance on South Carolina Sandhills. Southern Journal of Applied Forestry 5(4):84-88; 1981.

Outcalt, Kenneth W.; Brendemuehl, Raymond H. Growth of Choctawhatchee sand pine plantations in Georgia. Southern Journal of Applied Forestry 9(1):62-64; 1985.

Saucier, Joseph R.; Boyd, John A. Aboveground biomass of Virginia pine in north Georgia. Res. Pap. SE-232. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1982. 32 pp.

Taras, Michael A. Aboveground biomass of Choctawhatchee sand pine in Northwest Florida. Res. Pap. SE-210. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1980. 23 pp.

Taras, Michael A. Properties, uses, and potential market of sand pine. In: Proceedings, sand pine symposium. 1972 December 5-7; Panama City, FL. Gen. Tech. Rep. SE-2. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1973; 28-54.

Taras, Michael A.; Clark, Alexander, III. Aboveground biomass of loblolly pine in a natural, uneven-aged sawtimber stand in central Alabama. TAPPI 58(2):103-105; 1975.

Taras, Michael A.; Clark, Alexander, III. Aboveground biomass of longleaf pine in a natural sawtimber stand in southern Alabama. Res. Pap. SE-162. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1977. 32 pp.

Taras, Michael A.; Phillips, Douglas R. Aboveground biomass of slash pine in a natural sawtimber stand in southern Alabama. Res. Pap. SE-188. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1978. 31 pp.

Van Deusen, Paul C.; Sullivan, Alfred D.; Matney, Thomas G. A prediction system for cubic foot volume of loblolly pine applicable through much of its range. Southern Journal of Applied Forestry 5(4):186-191; 1981.

APPENDIX

Conversion factors: English to Metric

Multiply	By	To obtain
Inches	2.540	centimeters
Feet	.3048	meters
Pounds	.4536	kilograms
Cubic feet	.02832	cubic meters
Pounds per cubic foot	16.02	kilograms per cubic meter

All English units of measure in this report can be converted to metric units by multiplying the appropriate conversion factor listed above.

Table 12.--Regression equations for estimating green and dry weight and weight ratios of aboveground biomass of planted Choctawhatchee sand pine trees and tree components in open-canopy stands, with d.b.h. and total height used as independent variables

Weight (Y)	Regression equation[1]	Coefficient of determination (R^2)	Standard error[2] ($S_{y.x}$)
Total tree (including needles):			
Green	$Y = 0.63010(D^2Th)^{0.90101}$	0.97	0.07956
Dry	$Y = 0.26422(D^2Th)^{0.89173}$	.96	.08432
Total tree (excluding needles):			
Green	$Y = 0.24419(D^2Th)^{1.03789}$	.98	.07382
Dry	$Y = 0.09922(D^2Th)^{1.03184}$	.98	.07014
Total tree wood:			
Green	$Y = 0.17028(D^2Th)^{1.06786}$	.98	.07975
Dry	$Y = 0.07293(D^2Th)^{1.05184}$	.98	.07523
Wood and bark in total stem from stump to a 1-inch top d.o.b.:			
Green	$Y = 0.09924(D^2Th)^{1.11259}$	.98	.06878
Dry	$Y = 0.03745(D^2Th)^{1.12328}$	.98	.06588
Wood in total stem from stump to a 1-inch top d.o.b.:			
Green	$Y = 0.07154(D^2Th)^{1.13961}$	.98	.07500
Dry	$Y = 0.02912(D^2Th)^{1.12971}$	.98	.07169
Crown weight (including branch wood, branch bark, and needles):			
Green	$Y = 0.57116(D^2Th)^{0.80488}$	.93	.10526
Dry	$Y = 0.24750(D^2Th)^{0.79025}$	.92	.11541
Needles:			
Green	$Y = 0.49455(D^2Th)^{0.66638}$	.88	.11559
Dry	$Y = 0.22327(D^2Th)^{0.64879}$	.83	.13957
Wood and bark in crown material:			
Green	$Y = 0.14383(D^2Th)^{0.96956}$	.94	.11645
Dry	$Y = 0.05988(D^2Th)^{0.95759}$	.94	.11709
Wood in crown material:			
Green	$Y = 0.09739(D^2Th)^{1.00028}$	.94	.12657
Dry	$Y = 0.04248(D^2Th)^{0.98739}$	.94	.12586

N = 20; Corrected SS for D^2Th = 4.18715; Mean D^2Th = 1.80830.

[1] $Y = b_0(D^2Th)^{b_1}$

where: Y = weight of tree or component in pounds
D = d.b.h. in inches
Th = total height in feet
b_1, b_0 = regression coefficients

[2] Standard error in $\log_{10}$ form.

Table 13.--Regression equations for estimating green and dry weight and weight ratios of aboveground biomass of planted Choctawhatchee sand pine trees and tree components in closed-canopy stands, with d.b.h. and total height used as independent variables

Weight (Y)	Regression equation[1]	Coefficient of determination (R^2)	Standard error[2] ($S_{y.x}$)
Total tree (including needles):			
Green	$Y = 0.28927(D^2Th)^{0.95482}$	0.97	0.08204
Dry	$Y = 0.13420(D^2Th)^{0.94927}$	.97	.07260
Total tree (excluding needles):			
Green	$Y = 0.22798(D^2Th)^{0.97613}$	.98	.06993
Dry	$Y = 0.10806(D^2Th)^{0.96836}$	.98	.06372
Total tree wood:			
Green	$Y = 0.15928(D^2Th)^{1.00545}$	.98	.06903
Dry	$Y = 0.07544(D^2Th)^{0.99909}$	.98	.06343
Wood and bark in total stem from stump to a 1-inch top d.o.b.:			
Green	$Y = 0.14906(D^2Th)^{1.00482}$	.99	.04416
Dry	$Y = 0.07063(D^2Th)^{0.99871}$	.99	.04868
Wood in total stem from stump to a 1-inch top d.o.b.:			
Green	$Y = 0.10571(D^2Th)^{1.03394}$	.99	.04598
Dry	$Y = 0.04846(D^2Th)^{1.03267}$	.99	.05255
Crown weight (including branch wood, branch bark, and needles):			
Green	$Y = 0.15755(D^2Th)^{0.85428}$	.70	.25609
Dry	$Y = 0.06840(D^2Th)^{0.85137}$	.70	.25854
Needles:			
Green	$Y = 0.10836(D^2Th)^{0.73980}$	.64	.25762
Dry	$Y = 0.03832(D^2Th)^{0.76422}$	.66	.25028
Wood and bark in crown material:			
Green	$Y = 0.07629(D^2Th)^{0.90461}$	.72	.26343
Dry	$Y = 0.03617(D^2Th)^{0.89038}$	.70	.27150
Wood in crown material:			
Green	$Y = 0.05260(D^2Th)^{0.92800}$	.72	.26784
Dry	$Y = 0.02700(D^2Th)^{0.90822}$	.69	.27842
Fuelwood (branches, needles and stem > 4-inches d.o.b.):			
Green	$Y = 4.00910(D^2Th)^{0.47660}$	.81	.10621
Dry	$Y = 2.12189(D^2Th)^{0.44547}$	.78	.11009
Fuelwood (branches and stem > 4-inches d.o.b.):			
Green	$Y = 4.39949(D^2Th)^{0.43642}$	.80	.09899
Dry	$Y = 2.49000(D^2Th)^{0.39567}$	.74	.10964

Continued

Table 13.--Regression equations for estimating green and dry weight and weight ratios of aboveground biomass of planted Choctawhatchee sand pine trees and tree components in closed-canopy stands, with d.b.h. and total height used as independent variables--Continued

Weight (Y)	Regression equation[1]	Coefficient of determination (R^2)	Standard error[2] ($S_{y.x}$)
Wood and bark in dead crown material:			
Green	$Y = 0.00342(D^2Th)^{1.10260}$	.76	.28736
Dry	$Y = 0.00279(D^2Th)^{1.10580}$	.76	.28737

RATIO EQUATIONS[3]

Wood and bark in stem to any top d.o.b.:

Green	$Y_r = e^{-0.44474}(d_t^{5.28683})(D^{-4.60481})$
Dry	$Y_r = e^{-0.42872}(d_t^{5.54740})(D^{-4.89752})$

Wood in stem to any top d.o.b.:

Green	$Y_r = e^{-0.46227}(d_t^{5.31122})(D^{-4.62988})$
Dry	$Y_r = e^{-0.46019}(d_t^{5.52156})(D^{-4.88689})$

where: Y_r = ratio of stem weight or volume to any d.o.b. top
d_t = specificied stem top d.o.b. in inches
D = tree d.b.h. in inches
e = base of natural log

N = 63; Corrected SS for D^2Th = 13.00063; Mean D^2Th = 3.04845.

[1] $Y = b_0(D^2Th)^{b_1}$

where: Y = weight of tree or component in pounds
D = d.b.h. in inches
Th = total height in feet
b_0, b_1 = regression coefficients

[2]Standard error in $\log_{10}$ form.

[3] Y_r = Weight to any given top d.o.b. (d_t) by using ratio technique. Statistics (R^2) and ($S_{y.x}$) cannot be calculated.

Table 14.--Regression equations for estimating green cubic-foot and volume ratios of aboveground biomass of planted Choctawhatchee sand pine trees and tree components in open-canopy stands, with d.b.h. and total height used as independent variables

Cubic-foot volume (Y)	Regression equation[1]	Coefficient of determination (R^2)	Standard error[2] ($S_{y.x}$)
Total tree:			
Wood α bark	$Y = 0.0092588(D^2Th)^{0.88462}$	0.98	0.06116
Wood	$Y = 0.0063652(D^2Th)^{0.90945}$	.98	.06309
Total stem to a 1-inch top d.o.b.:			
Wood α bark	$Y = 0.0016357(D^2Th)^{1.11081}$	.98	.06943
Wood	$Y = 0.0011852(D^2Th)^{1.12889}$	.98	.07570
Live branch material:			
Wood α bark	$Y = 0.0025967(D^2Th)^{0.94853}$	.94	.11841
Wood	$Y = 0.0015654(D^2Th)^{0.99756}$	.94	.12538

N = 20; Corrected SS for D^2Th = 4.18715; Mean D^2Th = 1.80830.

[1] $Y = b_0(D^2Th)^{b_1}$

where: Y = volume of tree or component in cubic feet
D = d.b.h. in inches
Th = total height in feet
b_0, b_1 = regression coefficients

[2] Standard error in $\log_{10}$ form.

Table 15.--Regression equations for estimating green cubic-foot and volume ratios of planted Choctawhatchee sand pine trees and tree components in closed-canopy stands, with d.b.h. and total height used as independent variables

Cubic-foot volume (Y)	Regression equation[1]	Coefficient of determination (R^2)	Standard error[2] ($S_{y.x}$)
Total tree:			
Wood α bark	$Y = 0.006084(D^2Th)^{0.91556}$	0.98	0.05319
Wood	$Y = 0.003882(D^2Th)^{0.95518}$	.99	.05269
Total stem to a 1-inch top d.o.b.:			
Wood α bark	$Y = 0.002686(D^2Th)^{0.99374}$	.99	.04210
Wood	$Y = 0.001757(D^2Th)^{1.03218}$	.99	.04464
Live branch material:			
Wood α bark	$Y = 0.001542(D^2Th)^{0.88200}$	.70	.26478
Wood	$Y = 0.000969(D^2Th)^{0.91515}$	.70	.27714
Fuelwood (branches and stem > 4-inches d.o.b.):			
Wood α bark	$Y = 0.00000(D^2Th)^{0.41750}$	.78	.10113
Wood	$Y = 0.00000(D^2Th)^{0.43246}$	.79	.10397
Dead branch material:			
Wood α bark	$Y = 0.000100015(D^2Th)^{1.10731}$	.76	.28487

RATIO EQUATIONS[3]

Stem volume to any top d.o.b:

Wood α bark $\quad Y_r = e^{-0.44534}(d_t^{5.38627})(D^{-4.71582})$

Wood $\quad Y_r = e^{-0.48022}(d_t^{5.37425})(D^{-4.72508})$

where: Y_r = ratio of stem weight or volume to any top d.o.b.
d_t = specificied stem top d.o.b. in inches
D = tree d.b.h. in inches
e = base of natural log

N = 63; Corrected SS for D^2Th = 13.00063; Mean D^2Th = 3.04845.

[1] $Y = b_0(D^2Th)^{b_1}$

where: Y = volume of tree or component in cubic feet
D = d.b.h. in inches
Th = total height in feet
b_1, b_0 = regression coefficients

[2] Standard error in $\log_{10}$ form.

[3] Y_r = Volume to any given top d.o.b. (d_t) by using ratio technique. Statistics (R^2) and ($S_{y.x}$) cannot be calculated.

Table 16.--Ratio of green weight of wood and bark in main stem to a 1-inch top d.o.b. based on d.b.h. class and desired top d.o.b. for planted Choctawhatchee sand pine trees growing in closed-canopy stands in northwest Florida

D.b.h. (in.)	Top diameters outside bark (inches)									
	1	2	3	4	5	6	7	8	9	10
					WOOD AND BARK[1]					
1	0.64099	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	.98189	.48991	.00227	.00000	.00000	.00000	.00000	.00000	.00000	.00000
3	.99718	.89557	.39030	.01349	.00000	.00000	.00000	.00000	.00000	.00000
4	.99925	.97110	.77869	.31829	.02412	.00006	.00000	.00000	.00000	.00000
5	.99973	.98956	.91437	.66385	.26370	.03035	.00037	.00000	.00000	.00000
6	.99988	.99548	.96207	.83782	.56231	.22103	.03304	.00100	.00000	.00000
7	.99994	.99777	.98117	.91667	.75345	.47605	.18697	.03348	.00178	.00002
8	.99997	.99880	.98977	.95404	.85807	.66943	.40388	.15935	.03260	.00254
9	.99998	.99930	.99404	.97302	.91486	.79190	.59032	.34377	.13665	.03099
10	.99999	.99957	.99633	.98330	.94669	.86621	.72290	.51824	.29369	.11782
11	.99999	.99972	.99763	.98920	.96530	.91155	.81123	.65455	.45386	.25187
12	.99999	.99981	.99841	.99275	.97662	.93985	.86923	.75284	.58909	.39706
					WOOD[2]					
1	.62985	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
2	.98163	.47894	.00176	.00000	.00000	.00000	.00000	.00000	.00000	.00000
3	.99718	.89388	.38041	.01163	.00000	.00000	.00000	.00000	.00000	.00000
4	.99926	.97090	.77539	.30962	.02160	.00004	.00000	.00000	.00000	.00000
5	.99974	.98957	.91363	.65947	.25618	.02769	.00029	.00000	.00000	.00000
6	.99989	.99551	.96197	.83639	.55741	.21455	.03049	.00083	.00000	.00000
7	.99994	.99780	.98122	.91633	.75138	.47105	.18140	.03114	.00153	.00001
8	.99997	.99882	.98985	.95406	.85742	.66689	.39904	.15457	.03049	.00223
9	.99998	.99931	.99411	.97314	.91479	.79092	.58749	.33925	.13255	.02912
10	.99999	.99958	.99638	.98344	.94684	.86601	.72164	.51529	.28956	.11431
11	.99999	.99973	.99767	.98933	.96551	.91170	.81088	.65308	.45093	.24815
12	.99999	.99982	.99845	.99286	.97683	.94013	.86936	.75237	.58750	.39425

[1] $Y_r = e^{-0.44474}(d_t^{5.28683})(D^{-4.60481})$

[2] $Y_r = e^{-0.46227}(d_t^{5.31122})(D^{-4.63988})$

where: Y_r = ratio of stem weight or volume to any top d.o.b.
d_t = specificied stem top d.o.b. in inches
D = tree d.b.h. in inches
e = base of natural log

Table 17.--Ratio of dry weight of wood and bark in main stem to a 1-inch top d.o.b. based on d.b.h. class and desired top d.o.b. for planted Choctawhatchee sand pine trees growing in closed-canopy stands in northwest Florida

D.b.h. (in.)	Top diameters outside bark (inches)									
	1	2	3	4	5	6	7	8	9	10
					WOOD AND BARK[1]					
1	0.65134	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	.98572	.51034	.00170	.00000	.00000	.00000	.00000	.00000	.00000	.00000
3	.99803	.91179	.41666	.01332	.00000	.00000	.00000	.00000	.00000	.00000
4	.99952	.97768	.80737	.34803	.02627	.00005	.00000	.00000	.00000	.00000
5	.99984	.99246	.93078	.70198	.29518	.03492	.00037	.00000	.00000	.00000
6	.99993	.99691	.97105	.86512	.60677	.25318	.03954	.00114	.00000	.00000
7	.99997	.99854	.98629	.93417	.79070	.52432	.21906	.04138	.00220	.00002
8	.99998	.99924	.99285	.96521	.88505	.71482	.45406	.19089	.04146	.00331
9	.99999	.99957	.99598	.98031	.93372	.82814	.64182	.39449	.16733	.04046
10	.99999	.99975	.99760	.98820	.95989	.89355	.76744	.57395	.34399	.14742
11	.99999	.99984	.99849	.99258	.97466	.93186	.84707	.70601	.51216	.30107
12	.99999	.99990	.99902	.99515	.98338	.95496	.89728	.79666	.64601	.45662
					WOOD[2]					
1	.63116	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
2	.98457	.48945	.00123	.00000	.00000	.00000	.00000	.00000	.00000	.00000
3	.99786	.90619	.39686	.01084	.00000	.00000	.00000.	.00000	.00000	.00000
4	.99947	.97614	.79727	.32979	.02230	.00003	.00000	.00000	.00000	.00000
5	.99982	.99192	.92669	.68881	.27858	.03027	.00028	.00000	.00000	.00000
6	.99993	.99668	.96925	.85819	.59195	.23815	.03470	.00089	.00000	.00000
7	.99997	.99843	.98540	.93053	.78125	.50889	.20550	.03661	.00177	.00001
8	.99998	.99918	.99237	.96320	.87938	.70345	.43870	.17866	.03687	.00273
9	.99999	.99954	.99570	.97914	.93026	.82052	.62917	.37963	.15630	.03613
10	.99999	.99973	.99743	.98748	.95772	.88851	.75814	.56058	.32987	.13748
11	.99999	.99983	.99839	.99212	.97325	.92849	.84047	.69540	.49852	.28781
12	.99999	.99989	.99894	.99484	.98243	.95266	.89262	.78864	.63445	.44305

$^{1}Y_r = e^{-0.42872}(d_t^{5.54740})(D^{-4.89752})$

$^{2}Y_r = e^{-0.46019}(d_t^{5.52156})(D^{-4.88689})$

where: Y_r = ratio of stem weight or volume to any top d.o.b.
d_t = specificied stem top d.o.b. in inches
D = tree d.b.h. in inches
e = base of natural log

Table 18.--Ratio of cubic volume of wood and bark contained in main stem to a 1-inch top d.o.b. based on d.b.h. class and desired top d.o.b. for planted Choctawhatchee sand pine trees growing in closed-canopy stands in northwest Florida

D.b.h. (in.)	Top diameters outside bark (inches)									
	1	2	3	4	5	6	7	8	9	10
					WOOD AND BARK[1]					
1	0.64061	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	.98320	.49224	.00185	.00000	.00000	.00000	.00000	.00000	.00000	.00000
3	.99750	.90056	.39447	.01252	.00000	.00000	.00000	.00000	.00000	.00000
4	.99936	.97339	.78698	.32365	.02346	.00004	.00000	.00000	.00000	.00000
5	.99977	.99063	.91977	.67445	.26978	.03026	.00033	.00000	.00000	.00000
6	.99990	.99602	.96522	.84646	.57435	.22753	.03350	.00094	.00000	.00000
7	.99995	.99808	.98304	.92258	.76488	.48888	.19365	.03438	.00174	.00001
8	.99998	.99897	.99093	.95798	.86693	.68300	.41703	.16606	.03384	.00255
9	.99999	.99941	.99478	.97567	.92133	.80351	.60540	.35692	.14328	.03248
10	.99999	.99964	.99682	.98512	.95137	.87537	.73687	.53428	.30661	.12429
11	.99999	.99977	.99797	.99048	.96869	.91859	.82300	.67038	.47039	.26440
12	.99999	.99985	.99865	.99368	.97912	.94522	.87876	.76697	.60632	.41373
					WOOD[2]					
1	.61865	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
2	.98201	.47090	.00129	.00000	.00000	.00000	.00000	.00000	.00000	.00000
3	.99733	.89506	.37536	.01007	.00000	.00000	.00000	.00000	.00000	.00000
4	.99931	.97193	.77750	.30695	.01987	.00003	.00000	.00000	.00000	.00000
5	.99976	.99013	.91605	.66265	.25533	.02633	.00024	.00000	.00000	.00000
6	.99990	.99582	.96363	.84040	.56167	.21509	.02964	.00074	.00000	.00000
7	.99995	.99798	.98228	.91950	.75697	.47627	.18297	.03077	.00142	.00001
8	.99997	.99892	.99053	.95633	.86230	.67389	.40506	.15688	.03055	.00214
9	.99999	.99938	.99456	.97473	.91859	.79754	.59571	.34587	.13541	.02953
10	.99999	.99963	.99669	.98456	.94969	.87152	.72989	.52448	.29661	.11754
11	.99999	.99976	.99789	.99013	.96763	.91608	.81816	.66276	.46086	.25547
12	.99999	.99984	.99860	.99345	.97843	.94355	.87543	.76134	.59838	.40469

[1] $Y_r = e^{-0.44534(d_t^{5.38627})(D^{-4.71582})}$

[2] $Y_r = e^{-0.48022(d_t^{5.37425})(D^{-4.72508})}$

where: Y_r = ratio of stem weight or volume to any top d.o.b.
d_t = specificied stem top d.o.b. in inches
D = tree d.b.h. in inches
e = base of natural log

Table 19.--Predicted weight of total tree (wood, bark, and needles) aboveground for planted Choctawhatchee sand pine trees growing in open-canopy stands in northwest Florida[1]

D.b.h. (in.)	Total-tree height[2] (feet)						
	10	12	14	16	18	20	22
	Pounds						
	GREEN[3]						
0.5	1.4	1.7	1.9	2.2			
1.0	5.0	5.9	6.8	7.7	8.5		
1.5	10.4	12.3	14.1	15.9	17.7	19.5	
2.0	17.5	20.6	23.7	26.7	29.7	32.7	
2.5		30.8	35.4	39.9	44.4	48.8	53.2
3.0		42.8	49.2	55.5	61.7	67.8	73.9
3.5			64.9	73.2	81.4	89.6	97.6
4.0			82.6	93.2	103.6	113.9	124.1
4.5				115.2	128.1	140.8	153.5
5.0				139.3	154.9	170.3	185.6
5.5						202.2	220.3
6.0						236.5	257.7
	DRY[4]						
0.5	0.6	0.7	0.8	0.9			
1.0	2.1	2.4	2.8	3.1	3.5		
1.5	4.2	5.0	5.7	6.5	7.2	7.9	
2.0	7.1	8.3	9.6	10.8	12.0	13.2	
2.5		12.4	14.2	16.0	17.8	19.6	21.3
3.0		17.2	19.7	22.2	24.7	27.1	29.5
3.5			26.0	29.2	32.5	35.7	38.9
4.0			32.9	37.1	41.2	45.3	49.3
4.5				45.8	50.9	55.9	60.8
5.0				55.3	61.4	67.4	73.4
5.5						79.9	87.0
6.0						93.3	101.6

[1]Blocked-in area indicates range of data.

[2]Includes 0.1-foot stump allowance.

[3]$Y = 0.63010(D^2Th)^{0.90101}$

[4]$Y = 0.26424(D^2Th)^{0.89173}$

where: Y = weight of total tree or component in pounds
D = d.b.h. in inches
Th = total height in feet

Table 20.--Predicted weight of total tree (wood, bark, and needles) aboveground for planted Choctawhatchee sand pine trees growing in closed-canopy stands in northwest Florida[1]

D.b.h. (in.)	Total-tree height[2] (feet)						
	10	20	30	40	50	60	70
	Pounds						
	GREEN[3]						
1	3	5	7				
2	10	19	28	37	46		
3	21	41	61	80	99	118	
4	37	71	105	138	171	204	
5	56	109	161	212	262	312	361
6		155	228	300	371	442	512
7		208	306	403	498	593	687
8			395	519	643	765	886
9				650	805	958	1110
10				795	984	1172	1357
11					1181	1405	1628
12					1394	1659	1923
	DRY[4]						
1	1	2	3				
2	4	9	13	17	21		
3	10	19	27	36	44	53	
4	17	32	47	62	76	91	
5	25	49	72	95	117	139	161
6		69	102	134	165	196	227
7		93	136	179	221	263	305
8			176	231	285	339	392
9				289	357	424	491
10				352	436	518	600
11					522	621	718
12					616	732	847

[1]Blocked-in area indicates range of data.

[2]Includes 0.1-foot stump allowance.

[3]$Y = 0.28927(D^2Th)^{0.95482}$

[4]$Y = 0.13420(D^2Th)^{0.94927}$

where: Y = weight of total tree or component in pounds
D = d.b.h. in inches
Th = total height in feet

Table 21.--Predicted weight of total tree (wood and bark) aboveground for planted Choctawhatchee sand pine trees growing in open-canopy stands in northwest Florida[1]

D.b.h. (in.)	Total-tree height[2] (feet)						
	10	12	14	16	18	20	22
	Pounds						
	GREEN[3]						
0.5	0.6	0.8	0.9	1.0			
1.0	2.7	3.2	3.8	4.3			
1.5	6.2	7.5	8.8	10.1	11.4	12.7	
2.0	11.2	13.6	15.9	18.3	20.7	23.1	
2.5		21.6	25.3	29.1	32.9	36.6	40.5
3.0		31.5	37.0	42.4	48.0	53.5	59.1
3.5			50.9	58.5	66.1	73.7	81.3
4.0			67.1	77.1	87.2	97.2	107.3
4.5				98.5	111.3	124.1	137.1
5.0				122.6	138.5	154.5	170.6
5.5						188.3	207.9
6.0						225.6	249.0
	DRY[4]						
0.5	0.3	0.3	0.4	0.4			
1.0	1.1	1.3	1.5	1.7	2.0		
1.5	2.5	3.0	3.5	4.0	4.5	5.0	
2.0	4.5	5.4	6.3	7.2	8.2	9.1	
2.5		8.5	10.0	11.5	13.0	14.5	16.0
3.0		12.4	14.6	16.7	18.9	21.1	23.2
3.5			20.0	23.0	26.0	29.0	32.0
4.0			26.4	30.3	34.2	38.2	42.1
4.5				38.6	43.6	48.6	53.7
5.0				48.0	54.2	60.5	66.7
5.5						73.6	81.2
6.0						88.1	97.2

[1]Blocked-in area indicates range of data.

[2]Includes 0.1-foot stump allowance.

[3]$Y = 0.24419(D^2Th)^{1.03789}$

[4]$Y = 0.09922(D^2Th)^{1.03184}$

where: Y = weight of total tree or component in pounds
D = d.b.h. in inches
Th = total height in feet

Table 22.--Predicted weight of total tree (wood and bark) aboveground for planted Choctawhatchee sand pine trees growing in closed-canopy stands in northwest Florida[1]

D.b.h. (in.)	Total-tree height[2] (feet)						
	10	20	30	40	50	60	70
	Pounds						
GREEN[3]							
1	2	4	6				
2	8	16	24	32	40		
3	18	36	54	71	89	106	
4	32	64	94	125	155	186	
5	50	98	146	193	240	287	334
6		140	208	276	343	410	477
7		190	282	373	464	554	644
8			365	484	602	719	836
9				609	757	905	1052
10				748	930	1111	1292
11					1120	1339	1556
12					1328	1586	1844
DRY[4]							
1	1	2	3				
2	4	8	11	15	18		
3	8	17	24	32	40	48	
4	15	29	43	56	70	83	
5	23	44	66	87	108	129	149
6		63	94	124	153	183	213
7		85	126	167	207	247	286
8			163	216	268	320	371
9				271	337	401	466
10				332	413	492	572
11					496	592	688
12					587	701	814

[1]Blocked-in area indicates range of data.

[2]Includes 0.1-foot stump allowance.

[3]$Y = 0.22798(D^2Th)^{0.97613}$

[4]$Y = 0.15928(D^2Th)^{0.96836}$

where: Y = weight of total tree or component in pounds
D = d.b.h. in inches
Th = total height in feet

Table 23.--Predicted weight of total-tree wood aboveground for planted Choctawhatchee sand pine trees growing in closed-canopy stands in northwest Florida[1]

D.b.h. (in.)	Total-tree height[2] (feet)						
	10	20	30	40	50	60	70
	Pounds						
GREEN[3]							
1	2	3	5				
2	7	13	20	26	33		
3	15	29	44	59	74	89	
4	26	53	79	106	132	159	
5	41	82	124	165	207	249	290
6		119	179	239	299	359	419
7		162	244	325	407	489	571
8			319	426	533	640	747
9				539	675	811	947
10				667	834	1002	1170
11					1010	1214	1417
12					1204	1446	1688
DRY[4]							
1	1	2	2				
2	3	6	9	12	15		
3	7	14	20	27	34	41	
4	12	24	36	48	60	72	
5	19	38	56	75	94	112	131
6		54	81	108	135	162	189
7		73	110	147	184	220	257
8			144	192	240	288	335
9				243	303	364	424
10				300	374	449	524
11					453	543	634
12					539	646	754

[1]Blocked-in area indicates range of data.

[2]Includes 0.1-foot stump allowance.

[3]$Y = 0.15928(D^2Th)^{1.00545}$

[4]$Y = 0.07544(D^2Th)^{0.99909}$

where: Y = weight of total tree or component in pounds
D = d.b.h. in inches
Th = total height in feet

Table 24.--Predicted weight of total-stem wood and bark for planted Choctawhatchee sand pine trees growing in closed-canopy stands in northwest Florida[1]

D.b.h. (in.)	Total-tree height[2] (feet)						
	10	20	30	40	50	60	70
	Pounds						
	GREEN[3]						
1	2	3	5				
2	6	12	18	24	31		
3	14	28	41	55	69	83	
4	24	49	74	98	123	148	
5	38	77	115	154	193	232	270
6		111	166	222	278	334	390
7		151	227	303	379	455	532
8			297	396	496	596	695
9				502	628	755	881
10				621	777	933	1089
11					940	1130	1319
12					1120	1345	1571
	DRY[4]						
1	1	1	2				
2	3	6	8	11	14		
3	6	13	19	25	32	38	
4	11	22	34	45	56	67	
5	18	35	53	70	87	105	122
6		50	76	101	126	151	176
7		69	103	137	171	206	240
8			134	179	224	268	313
9				226	283	340	396
10				280	349	419	489
11					423	507	591
12					503	603	704

[1]Blocked-in area indicates range of data.

[2]Includes 0.1-foot stump allowance.

[3]$Y = 0.14906(D^2Th)^{1.00482}$

[4]$Y = 0.07063(D^2Th)^{0.99871}$

where: Y = weight of total tree or component in pounds
D = d.b.h. in inches
Th = total height in feet

Table 25.--Predicted weight of total-stem wood (bark excluded) for planted Choctawhatchee sand pine trees growing in closed-canopy stands in northwest Florida[1]

D.b.h. (in.)	Total-tree height[2] (feet)						
	10	20	30	40	50	60	70
	Pounds						
	GREEN[3]						
1	1	2	4				
2	5	10	15	20	25		
3	11	23	35	46	59	71	
4	20	41	63	84	106	128	
5	32	65	99	134	168	203	238
6		95	145	195	245	296	347
7		131	199	268	338	408	478
8			262	353	445	537	630
9				451	568	685	804
10				560	706	852	999
11					859	1038	1217
12					1029	1242	1457
	DRY[4]						
1	1	1	2				
2	2	4	7	9	12		
3	5	10	16	21	27	32	
4	9	19	28	38	48	58	
5	15	30	45	61	76	92	108
6		43	66	89	111	135	158
7		59	90	122	153	185	217
8			119	160	202	244	286
9				204	257	311	364
10				254	320	386	453
11					390	470	552
12					466	563	660

[1]Blocked-in area indicates range of data.

[2]Includes 0.1-foot stump allowance.

[3]$Y = 0.10571(D^2Th)^{1.03394}$

[4]$Y = 0.04846(D^2Th)^{1.03267}$

where: Y = weight of total tree or component in pounds
D = d.b.h. in inches
Th = total height in feet

Table 26.--Predicted weight of wood and bark in stem to 4-inch top d.o.b. for planted Choctawhatchee sand pine trees growing in closed-canopy stands in northwest Florida[1]

D.b.h. (in.)	Total-tree height[2] (feet)						
	10	20	30	40	50	60	70
	Pounds						
	GREEN[3]						
4	8	16	23	31	39	47	
5	25	51	77	102	128	154	180
6		93	139	186	233	280	327
7		138	208	278	348	417	487
8			283	378	473	568	663
9				489	611	734	857
10				610	764	917	1071
11					930	1117	1305
12					1112	1336	1559
	DRY[4]						
4	4	8	12	16	19	23	
5	12	25	37	49	61	74	86
6		44	65	87	109	131	152
7		64	96	128	160	192	224
8			130	173	216	259	302
9				222	277	333	388
10				276	345	414	483
11					419	503	587
12					500	600	700

[1]Blocked-in area indicates range of data.

[2]Includes 0.1-foot stump allowance.

[3] $Y = 0.14906(D^2Th)^{1.00482}$

$R = e^{-0.44(d_t^{5.29})(D^{-4.60})}$

$Y_r = R(Y)$

[4] $Y = 0.07063(D^2Th)^{0.99871}$

$R = e^{-0.43(d_t^{5.55})(D^{-4.90})}$

$Y_r = R(Y)$

where: Y = total stem weight in pounds
d_t = specified stem top d.o.b. in inches
D = d.b.h. in inches
Th = total height in feet
R = ratio of weight to 4-inch top to total stem weight
Y_r = estimated stem weight to 4-inch top d.o.b.
e = base of natural log

Table 27.--Predicted weight of wood excluding bark in stem to 4-inch top d.o.b. for planted Choctawhatchee sand pine trees growing in closed-canopy stands in northwest Florida[1]

D.b.h. (in.)	Total-tree height[2] (feet)						
	10	20	30	40	50	60	70
	Pounds						
	GREEN[3]						
4	6	13	19	26	33	40	
5	21	43	65	88	111	134	157
6		80	121	163	205	248	291
7		120	182	246	309	373	438
8			250	337	424	512	601
9				439	552	667	782
10				551	694	838	983
11					850	1027	1204
12					1022	1233	1447
	DRY[4]						
4	3	6	9	13	16	19	
5	10	20	31	42	53	64	75
6		37	56	76	96	115	135
7		55	84	113	143	172	202
8			115	154	194	235	275
9				200	252	304	357
10				251	316	382	447
11					387	467	547
12					464	560	657

[1]Blocked-in area indicates range of data.

[2]Includes 0.1-foot stump allowance.

[3] $Y = 0.10571(D^2Th)^{1.03394}$

$R = e^{-0.46(d_t^{5.31})(D^{-4.64})}$

$Y_r = R(Y)$

[4] $Y = 0.04846(D^2Th)^{1.03267}$

$R = e^{-0.46(d_t^{5.52})(D^{-4.89})}$

$Y_r = R(Y)$

where: Y = total stem weight in pounds
d_t = specified stem top d.o.b. in inches
D = d.b.h. in inches
Th = total height in feet
R = ratio of weight to 4-inch top to total stem weight
Y_r = estimated stem weight to 4-inch top d.o.b.
e = base of natural log

Table 28.--Predicted weight of wood and bark in stem to 7-inch top d.o.b. for planted Choctawhatchee sand pine trees growing in closed-canopy stands in northwest Florida[1]

D.b.h. (in.)	Total-tree height[2] (feet)				
	30	40	50	60	70
	Pounds				
	GREEN[3]				
7	42	57	71	85	99
8	120	160	200	241	281
9		296	371	446	520
10		449	561	674	787
11			763	916	1070
12			974	1169	1365
	DRY[4]				
7	23	30	38	45	53
8	61	81	102	122	142
9		145	182	218	254
10		215	268	322	375
11			358	429	501
12			451	541	631

[1]Blocked-in area indicates range of data.

[2]Includes 0.1-foot stump allowance.

[3] $Y = 0.14906(D^2Th)^{1.00482}$

$R = e^{-0.44(d_t^{5.29})(D^{-4.60})}$

$Y_r = R(Y)$

[4] $Y = 0.07063(D^2Th)^{0.99871}$

$R = e^{-0.43(d_t^{5.55})(D^{-4.90})}$

$Y_r = R(Y)$

where: Y = total stem weight in pounds
d_t = specified stem top d.o.b. in inches
D = d.b.h. in inches
Th = total height in feet
R = ratio of weight to 7-inch top to total stem weight
Y_r = estimated stem weight to 7-inch top d.o.b.
e = base of natural log

Table 29.--Predicted weight of wood excluding bark in stem to 7-inch top d.o.b. for planted Choctawhatchee sand pine trees growing in closed-canopy stands in northwest Florida[1]

D.b.h. (in.)	Total-tree height[2] (feet)				
	30	40	50	60	70
	Pounds				
	GREEN[3]				
7	36	49	61	74	87
8	105	141	178	214	251
9		265	333	403	472
10		404	509	615	721
11			697	841	987
12			894	1080	1267
	DRY[4]				
7	19	25	31	38	45
8	52	70	89	107	125
9		129	162	196	229
10		193	243	293	343
11			328	395	464
12			416	503	589

[1]Blocked-in area indicates range of data.

[2]Includes 0.1-foot stump allowance.

[3] $Y = 0.10571(D^2Th)^{1.03394}$

$R = e^{-0.46(d_t^{5.31})(D^{-4.64})}$

$Y_r = R(Y)$

[4] $Y = 0.04846(D^2Th)^{1.03267}$

$R = e^{-0.46(d_t^{5.52})(D^{-4.89})}$

$Y_r = R(Y)$

where: Y = total stem weight in pounds
d_t = specified stem top d.o.b. in inches
D = d.b.h. in inches
Th = total height in feet
R = ratio of weight to 7-inch top to total stem weight
Y_r = estimated stem weight to 7-inch top d.o.b.
e = base of natural log

Table 30.--Predicted volume of total tree (wood and bark) aboveground for planted Choctawhatchee sand pine trees growing in open-canopy stands in northwest Florida[1]

D.b.h. (in.)	Total-tree height[2] (feet)						
	10	12	14	16	18	20	22
	Cubic feet						
WOOD AND BARK[3]							
0.5	0.02	0.02	0.03	0.03			
1.0	.07	.08	.10	.11	0.12		
1.5	.15	.17	.20	.22	.24	0.27	
2.0	.24	.28	.33	.37	.41	.45	
2.5		.42	.48	.54	.60	.66	0.72
3.0		.58	.67	.75	.83	.92	1.00
3.5			.88	.99	1.10	1.20	1.31
4.0			1.11	1.25	1.39	1.52	1.66
4.5				1.54	1.71	1.88	2.04
5.0				1.86	2.06	2.26	2.46
5.5						2.68	2.91
6.0						3.12	3.39
WOOD[4]							
0.5	0.01	0.02	0.02	0.02			
1.0	.05	.06	.07	.08	.09		
1.5	.11	.13	.15	.17	.18	0.20	
2.0	.18	.22	.25	.28	.31	.34	
2.5		.32	.37	.42	.47	.51	0.56
3.0		.45	.52	.58	.65	.72	.78
3.5			.68	.77	.86	.95	1.03
4.0			.87	.99	1.10	1.21	1.32
4.5				1.22	1.36	1.50	1.63
5.0				1.48	1.65	1.81	1.98
5.5						2.16	2.35
6.0						2.53	2.75

[1]Blocked-in area indicates range of data.

[2]Includes 0.1-foot stump allowance.

[3]$Y = 0.0092588(D^2Th)^{0.88462}$

[4]$Y = 0.0063652(D^2Th)^{0.90945}$

where: Y = volume of total tree or component in cubic feet
D = d.b.h. in inches
Th = total height in feet

Table 31.--Predicted volume of total tree (wood and bark) aboveground for planted Choctawhatchee sand pine trees growing in closed-canopy stands in northwest Florida[1]

D.b.h. (in.)	Total-tree height[2] (feet)						
	10	20	30	40	50	60	70
	Cubic feet						
	WOOD AND BARK[3]						
1	0.05	0.09	0.14				
2	.18	.34	.49	.63	.78		
3	.37	.71	1.02	1.33	1.63	1.93	
4	.63	1.20	1.73	2.26	2.77	3.27	
5	.95	1.80	2.61	3.40	4.17	4.92	5.67
6		2.51	3.64	4.74	5.82	6.87	7.91
7		3.33	4.83	6.29	7.71	9.11	10.50
8			6.17	8.03	9.85	11.64	13.40
9				9.96	12.22	14.44	16.63
10				12.08	14.82	17.51	20.17
11					17.65	20.85	24.01
12					20.69	24.45	28.16
	WOOD[4]						
1	0.04	0.07	0.10				
2	.13	.26	.38	.49	.61		
3	.29	.55	.82	1.07	1.33	1.58	
4	.49	.96	1.41	1.86	2.30	2.74	
5	.76	1.47	2.16	2.85	3.53	4.20	4.86
6		2.08	3.07	4.04	4.99	5.94	6.89
7		2.79	4.12	5.42	6.70	7.98	9.25
8			5.31	6.99	8.65	10.30	11.93
9				8.76	10.84	12.90	14.94
10				10.71	13.25	15.77	18.28
11					15.90	18.92	21.93
12					18.77	22.35	25.89

[1]Blocked-in area indicates range of data.

[2]Includes 0.1-foot stump allowance.

[3]$Y = 0.006084(D^2Th)^{0.91556}$

[4]$Y = 0.003882(D^2Th)^{0.95518}$

where: Y = volume of total tree or component in cubic feet
D = d.b.h. in inches
Th = total height in feet

Table 32.--Predicted volume of total stem (wood and bark) for planted Choctawhatchee sand pine trees growing in closed-canopy stands in northwest Florida[1]

D.b.h. (in.)	Total-tree height[2] (feet)						
	10	20	30	40	50	60	70
	Cubic feet						
	WOOD AND BARK[3]						
1	0.03	0.05	0.08				
2	.10	.21	.31	0.42	0.52		
3	.24	.47	.70	.93	1.16	1.39	
4	.42	.83	1.24	1.65	2.06	2.47	
5	.65	1.29	1.93	2.57	3.21	3.85	4.49
6		1.86	2.78	3.70	4.61	5.53	6.44
7		2.52	3.77	5.02	6.27	7.51	8.76
8			4.92	6.55	8.17	9.79	11.42
9				8.27	10.33	12.38	14.43
10				10.20	12.73	15.26	17.79
11					15.39	18.44	21.50
12					18.29	21.93	25.56
	WOOD[4]						
1	0.02	0.04	0.06				
2	.08	.16	.25	0.33	0.42		
3	.18	.37	.57	.76	.96	1.16	
4	.33	.68	1.03	1.38	1.74	2.10	
5	.52	1.07	1.63	2.19	2.76	3.34	3.91
6		1.56	2.38	3.20	4.03	4.86	5.70
7		2.15	3.27	4.40	5.53	6.68	7.83
8			4.30	5.79	7.29	8.80	10.32
9				7.39	9.30	11.22	13.16
10				9.18	11.56	13.95	16.36
11					14.07	16.98	19.91
12					16.84	20.35	23.83

[1]Blocked-in area indicates range of data.

[2]Includes 0.1-foot stump allowance.

[3]$Y = 0.002686(D^2Th)^{0.99374}$

[4]$Y = 0.001757(D^2Th)^{1.03218}$

where: Y = volume of total tree or component in cubic feet
D = d.b.h. in inches
Th = total height in feet

Table 33.--Predicted volume of stem (wood and bark) to 4-inch top d.o.b. for planted Choctawhatchee sand pine trees growing in closed-canopy stands in northwest Florida[1]

D.b.h. (in.)	Total-tree height[2] (feet)						
	10	20	30	40	50	60	70
	Cubic feet						
	WOOD AND BARK[3]						
4	0.13	0.27	0.40	0.53	0.67	0.80	
5	.44	.87	1.30	1.73	2.17	2.60	3.03
6		1.57	2.35	3.13	3.90	4.68	5.46
7		2.33	3.48	4.63	5.78	6.93	8.08
8			4.71	6.27	7.83	9.38	10.94
9				8.07	10.08	12.08	14.08
10				10.05	12.54	15.03	17.52
11					15.24	18.27	21.29
12					18.18	21.79	25.39
	WOOD[4]						
4	0.10	0.21	0.32	0.42	0.54	0.65	
5	.35	.71	1.08	1.45	1.83	2.21	2.59
6		1.31	2.00	2.69	3.38	4.08	4.79
7		1.98	3.00	4.04	5.09	6.14	7.20
8			4.12	5.54	6.97	8.42	9.87
9				7.20	9.06	10.94	12.83
10				9.04	11.38	13.73	16.10
11					13.93	16.82	19.72
12					16.73	20.19	23.67

[1]Blocked-in area indicates range of data.

[2]Includes 0.1-foot stump allowance.

[3] $Y = 0.002686(D^2Th)^{0.99374}$

$R = e^{-0.44}(d_t^{5.39})(D^{-4.72})$

$Y_r = R(Y)$

[4] $Y = 0.001757(D^2Th)^{1.03218}$

$R = e^{-0.48}(dt^{5.37})(D^{-4.73})$

$Y_r = R(Y)$

where: Y = total stem volume in cubic feet
d_t = specified stem top d.o.b. in inches
D = d.b.h. in inches
Th = total volume in cubic feet
R = ratio of volume to 4-inch top to total stem volume
Y_r = estimated stem volume to 4-inch top d.o.b.
e = base of natural log

Table 34.--Predicted volume of stem (wood and bark) to 7-inch top d.o.b. for planted Choctawhatchee sand pine trees growing in closed-canopy stands in northwest Florida[1]

D.b.h. (in.)	Total-tree height[2] (feet)				
	30	40	50	60	70
	- - - - - Cubic feet - - - - -				
	WOOD AND BARK[3]				
7	0.73	0.97	1.21	1.45	1.70
8	2.05	2.73	3.41	4.08	4.76
9		5.01	6.25	7.49	8.73
10		7.52	9.38	11.25	13.11
11			12.66	15.18	17.69
12			16.08	19.27	22.46
	WOOD[4]				
7	0.60	0.80	1.01	1.22	1.43
8	1.74	2.35	2.95	3.56	4.18
9		4.40	5.54	6.69	7.84
10		6.70	8.44	10.18	11.94
11			11.51	13.90	16.29
12			14.74	17.79	20.86

[1]Blocked-in area indicates range of data.

[2]Includes 0.1-foot stump allowance.

[3] $Y = 0.002686(D^2Th)^{0.99374}$

$R = e^{-0.44(d_t^{5.39})(D^{-4.72})}$

$Y_r = R(Y)$

[4] $Y = 0.001757(D^2Th)^{1.03218}$

$R = e^{-0.48(d_t^{5.37})(D^{-4.73})}$

$Y_r = R(Y)$

where: Y = total stem volume in cubic feet
d_t = specified stem top d.o.b. in inches
D = d.b.h. in inches
Th = total volume in cubic feet
R = ratio of volume to 7-inch top to total stem volume
Y_r = estimated stem volume to 7-inch top d.o.b.
e = base of natural log

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McNab, W. Henry; Outcalt, Kenneth W.; Brendemuehl, Raymond H.
Weight and volume of plantation-grown Choctawhatchee sand pine.
Res. Pap. SE-252. Asheville, NC: U.S. Department of Agriculture,
Forest Service, Southeastern Forest Experiment Station; 1985. 44 pp.

The aboveground green weight of the total tree and its major components, the main stem and crown, were determined in eight stands of planted Choctawhatchee sand pine ranging in age from 7 to 27 years. Eighty-three trees, ranging in d.b.h. from 0.7 to 11.1 inches from 11 to 59 feet in total height, were sampled. After testing for significant differences, data were stratified to provide two sets of composite equations: one for the six stands with a closed canopy, i.e., ages 12 to 27 years, and one for the young stands where crown closure had not yet occurred. Equations for predicting individual tree green and dry weights and cubic volumes of wood, and of wood and bark, were developed for the main stem and crown of each canopy class. Ratio equations were developed to allow estimation of weights and volumes to specified top stem diameter. Tables for estimating green and dry weight and cubic volume are given for the total tree and its major components, based on d.b.h. and total height.

KEYWORDS: Pinus clausa var. immuginata, biomass, prediction equations.

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