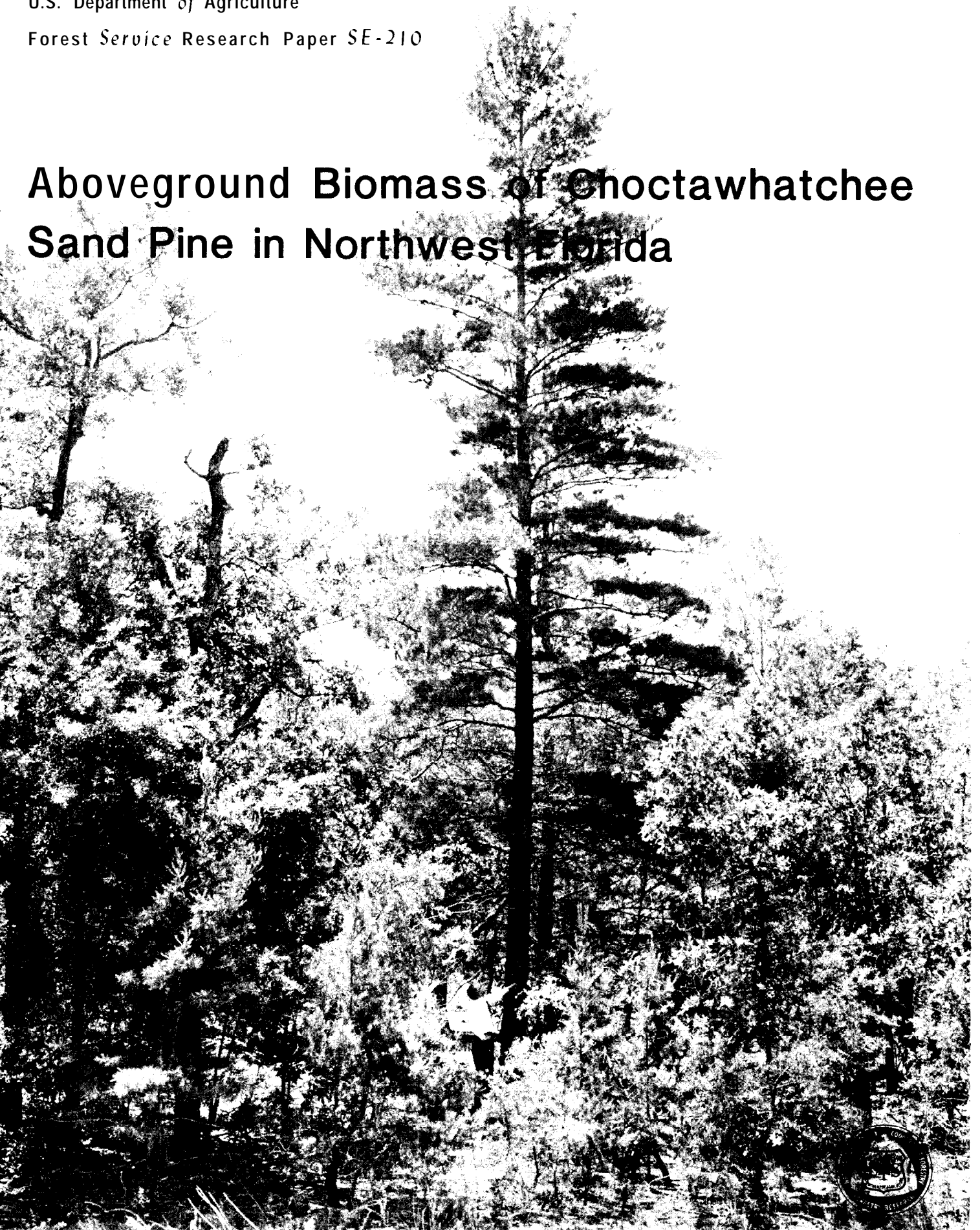


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Aboveground Biomass of Choctawhatchee Sand Pine in Northwest Florida



Conversion factors: English to metric

<i>Multiply</i>	<i>By</i>	<i>To obtain</i>
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.

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Asheville, North Carolina

Aboveground Biomass of Choctawhatchee Sand Pine in Northwest Florida¹

by
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ABSTRACT.-Choctawhatchee sand pine trees 4 to 14 inches d.b.h. were selected from a natural, uneven-aged stand in northwest Florida to determine the weight and volume of aboveground biomass. On the average, 85 percent of the green weight of the total tree was wood, 11 percent bark, and 4 percent needles. The average tree sampled had 82 percent of its wood in the stem and 18 percent in the crown. Specific gravity, moisture content, and green weight per cubic foot are presented for the total tree and its components. Tables developed from regression equations predict weight and cubic-foot volume of the total tree and its components by d.b.h. and total height classes.

Keywords: *Pinus clausa* var. *immuginata* Ward, weight, volume, equations, component proportions

This is the fifth in a series of reports on the aboveground biomass of southern pines. It contains information on Choctawhatchee sand pine (*Pinus clausa* var. *immuginata* Ward). The first four papers reported biomass for the four major southern pines (Taras and Clark 1975; Clark and Taras 1976; Taras and Clark 1977; and Taras and Phillips 1978).

This Paper reports weight and volume of various tree components (wood, bark, crown, branches, and foliage) as well as equations for predicting these values. The term "total tree" in this study refers only to the aboveground portion of the tree and does not include stump and roots.

PROCEDURE

Field

A stratified random sample of 36 trees was selected from a natural, uneven-aged Choctawhatchee sand pine stand on Eglin Air Force Base in northwest Florida. Site index (age 50) averaged about 50. Six trees in each even-inch d.b.h. class from 4 to 14 inches were randomly selected. Means and ranges in tree dimensions are shown in table 1.

¹This study was conducted in cooperation with the Forestry Division of Eglin Air Force Base, Fort Walton Beach, Fla.

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Sample trees were felled and limbed and the main stem of each tree was bucked into 3- to 5-foot segments and weighed to the nearest one-quarter pound on a portable balance. Separate weights were recorded for the saw-log portion of the main stem to a 6-inch d.i.b. top and for the pulpwood portion of the stem to a 3-inch d.o.b. top. Sample branches were selected from the lower, middle, and upper portions of the crown. These were weighed and stripped of their needles, and the needles were weighed to establish the foliage: branch ratio. The remainder of the crown (needles and branches) was weighed together. Needle weight for the whole tree was computed by applying the needle:branch ratio developed from the branch samples. Dead branches were weighed separately but were not included in calculations for the total tree in this report.

Moisture content and specific gravity of wood and bark were determined from disks removed at the butt of each tree, at d.b.h., and at quarter points in the stem to a 3-inch d.o.b. top. Disks were also taken from the branches randomly selected from the lower, middle, and upper portions of the crown. Each disk sample was sealed in a plastic bag for subsequent laboratory analysis. Samples of needles and dead branches were selected for determination of moisture contents of these components.

Laboratory

Each sample disk was weighed and diameters were measured with and without bark, and spe-

Table I.-Means and ranges in dimensions of sample Choctawhatchee sand pines, by d.b.h. class

D.b.h. class (inches)	Sample trees	D.b.h.		Total height		Age	
		Average	Range	Average	Range	Average	Range
	Number	.....Inches.....		.....Feet.....		.....Years.....	
4	6	4.2	3.9- 4.4	33	24-44	46	37-52
6	6	6.1	5.7- 6.4	47	41-56	54	46-59
8	6	8.1	7.8- 8.4	50	45-56	53	37-59
10	6	10.0	9.6-10.3	57	53-61	59	53-66
12	6	12.1	11.6-12.5	60	53-63	58	54-61
14	6	14.1	13.6-14.7	64	56-67	73	60-88
All classes	36	9.1	3.9-14.7	52	24-67	57	37-88

cific gravity was determined for each component on a green-volume and oven-dry-weight basis. Moisture content samples were dried to a constant weight at 103° C, and moisture content was computed on an oven-dry basis. Percentage of bark was determined from the disk samples on a green-weight basis. Values for moisture content (MC), specific gravity (SG), and percentage of bark in the stem, branches, and total tree were calculated by weighting disk values in proportion to the volume of the component each represented. Weighted moisture content values were used to convert component green weights to oven-dry weights.

Green weights per cubic foot of wood and bark were computed from the weighted values for specific gravity and moisture content with the equation:

$$\text{Green wt/ft}^3 = \left[1 + \frac{\text{weighted MC in \%}}{100} \right] (\text{weighted SG})(62.4) \tag{1}$$

The green cubic-foot volumes of wood and bark were computed by dividing a component's weight by its green weight per cubic foot. Green cubic-foot volume of wood and bark combined was computed by adding the green volume of wood to the green volume of bark.

Analysis

Regression equations for predicting green and dry weights of wood, bark, and needles in the total tree and its components were developed with d.b.h. and total height as independent vari-

ables. Equations were also developed to predict green cubic-foot volumes of wood and bark separately and combined. Total-tree and tree component weights and volumes were estimated with the equation:

$$Y = b_0 + b_1 D^2 Th + e \tag{2}$$

where:

- Y = predicted weight or volume of component
- D = d.b.h. in inches
- Th = total tree height in feet
- e = experimental error

and

b_0, b_1 = coefficients.

Grouping of the data into D^2Th classes indicated that the variance of Y increased with increasing D^2Th . Therefore, a logarithmic transformation was used to make the variance more nearly homogeneous and meet this basic assumption of regression analysis. The final form of the equation used to predict weight and volume of the total tree and each component sampled was:

$$\text{Log}_{10} Y = b_0 + b_1 \text{Log}_{10}(D^2Th) \tag{3}$$

SAMPLE TREE CHARACTERISTICS

Total-Tree Biomass

Green weight of the total tree ranged from 126 pounds for 4-inch trees to 2,372 pounds for 14-inch trees. On the average, the trees sampled had 85 percent of their green weight in wood, 11 percent in bark, and 4 percent in needles. This distribution of wood, bark, and needles is similar

to those reported for the major southern pines. The proportion of tree weight in wood increased and the proportion in bark decreased sharply between the 4-inch and the 6-inch d.b.h. class, then remained relatively constant to the 14-inch class. The proportion of needles was highest (7 percent) in the 4-inch class and was consistently between 3 and 4 percent for all other diameter classes. Proportions of the various tree components computed on a dry basis varied slightly from those computed on a green basis because of differences in component moisture content (table 2).

When the trees are viewed as being composed of stem and crown, proportion of tree weight in the stem increases and that in branches decreases from the 4-inch d.b.h. class to the 6-inch class and then increases with tree size (table 3). The stem contained an average of 76 percent of

the tree green weight, and the crown 24 percent. The proportion of biomass in the stems of Choctawhatchee sand pines is 5 to 8 percent lower than that reported for the four major species of southern pine. Since the needle proportion was the same as reported for other southern pines (about 4 percent), the primary cause for the difference in crown biomass is the greater weight of branch material in sand pine.

The green and dry weights of all wood in the tree and the distribution of wood throughout the tree are presented in table 4. On the average, 82 percent of green weight was in the main stem (to a 3-inch d.o.b. top), and 18 percent was in the branches. The proportion of wood increased in the main stem from the 4-inch d.b.h. class to the 6-inch class and then decreased as tree size increased. Branchwood proportions decreased be-

Table 2.-Average green and dry weights of the total tree and proportions of the tree in wood, bark, and needles for Choctawhatchee sand pines 4 to 14 inches d.b.h.

D.b.h. class (inches)	Average total height	Sample trees	Total-tree green weight	Tree component proportions (green)			Total-tree dry weight	Tree component proportions (dry)		
				Wood	Bark	Needles		Wood	Bark	Needles
	<i>Feet</i>	<i>Number</i>	<i>Pounds</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Pounds</i>	<i>Percent</i>	<i>Percent</i>	
4	33	6	126	75	18	7	63	80	15	5
6	47	6	353	85	12	3	178	88	10	2
8	50	6	610	84	12	4	298	86	10	4
10	57	6	1,167	85	11	4	580	88	9	3
12	60	6	1,661	85	12	3	874	88	9	3
14	64	6	2,372	87	10	3	1,257	90	7	3
Average	—	—	1,048	85	11	4	542	88	9	3

Table 3.-Average green and dry weights of the total tree and proportions of the tree in the main stem and crown (branches and needles) for Choctawhatchee sand pines 4 to 14 inches d.b.h.

D.b.h. class (inches)	Average total height	Sample trees	Total-tree green weight	Tree component proportions (green)			Total-tree dry weight	Tree component proportions (dry)		
				Stem	Crown			Stem	Crown	
					Branches	Needles			Branches	Needles
	<i>Feet</i>	<i>Number</i>	<i>Pounds</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Pounds</i>	<i>Percent</i>	<i>Percent</i>	
4	33	6	126	61	32	7	63	68	27	5
6	47	6	353	80	17	3	178	84	14	2
8	50	6	610	79	17	4	298	83	13	4
10	57	6	1,167	79	17	4	580	82	15	3
12	60	6	1,661	76	21	3	874	79	18	3
14	64	6	2,372	76	21	3	1,257	80	17	3
Average	—	—	1,048	76	20	4	542	80	17	3

*Stem material to 3-inch d.o.b. top.

Table 4.—Average green and dry weights of wood in the total tree and distribution of wood in the main stem¹ and branches for Choctawhatchee sand pines 4 to 14 inches d.b.h.

D.b.h. class (inches)	Average total height	Sample trees	Total-tree wood weight	Proportion of wood in—			
				Main stem			Branches
				saw log	Pulpwood	Total stem	
	<i>Feet</i>	<i>Number</i>	<i>Pounds</i>	<i>..... Percent</i>			
GREEN							
4	33	6	95	—	70	70	30
6	47	6	299	—	85	85	15
8	50	6	509	42	43	85	15
10	57	6	995	68	16	84	16
12	60	6	1,408	74	7	81	19
14	64	6	2,069	75	6	81	19
Average	—	—	896	70	12	82	18
DRY							
4	33	6	52	—	73	73	27
6	47	6	156	—	88	88	12
8	50	6	257	45	42	87	13
10	57	6	510	71	15	86	14
12	60	6	768	76	7	83	17
14	64	6	1,138	79	5	84	16
Average	—	—	480	73	12	85	15

¹Stem material to 3-inch d.o.b. top.

tween the 4- and 6-inch d.b.h. classes and then increased as tree size increased. The proportion of wood in the pulpwood section of a tree decreased, and proportion in the saw-log section increased as tree size increased. On the average, the trees contained 70 percent of their green wood in saw logs and 12 percent in pulpwood. The proportion of branches in Choctawhatchee sand pine is 5 to 7 percent greater than that found in the major species of southern pine because sand pines have a heavier branching habit.

The weight and distribution of bark in the tree are presented in table 5. On the average, 44 percent of all green bark in the tree was in the saw logs, 16 percent in the pulpwood, and 40 percent in the branches. In comparing the bark proportions with similar computations made from the major southern pine species, we find bark proportion of the crown to be 7 to 11 percent greater in sand pine. This difference is due to the greater proportion of branches in the crown of this species.

Crown Biomass

When the crown was analyzed as a separate entity composed of branchwood, branchbark, and needles, the proportion of crown weight in wood increased, the proportion of crown bark decreased, and the proportion of needles decreased as tree size increased (table 6). On the average, 66 percent of the green weight of the crown was wood, 19 percent was bark, and 15 percent was needles. Compared to the crowns of the major southern pine species, Choctawhatchee sand pine has a higher percentage of wood in the crown, about the same amount of bark, and fewer needles.

The dead branch components of these trees were not included in the total-tree weight or the weight of the crown even though the weight data on this component were collected. The reason it was not included was that it was felt that a high proportion of this material would be lost in felling and skidding and not recoverable. Equations

were developed, however, for predicting this component (see tables 9 and 10).

Main Stem Biomass

When the main stem was analyzed separately, the proportion of stem weight in wood

increased and the proportion of bark decreased as tree size increased (table 7). On the average, 91 percent of the green weight of the main stem was wood, and 9 percent was bark. Similar proportions of wood and bark in the main stem have been reported for the four major species of southern pine.

Table 5.—Average green and dry weights of bark in the total tree and distribution of bark in the main stem¹ and branches for Choctawhatchee sand pines 4 to 14 inches d.b.h.

D.b.h. class (inches)	Average total height	Sample trees	Total-tree bark weight	Proportion of bark in—			
				Main stem			Branches
				Saw log	Pulpwood	Total stem	
	<i>Feet</i>	<i>Number</i>	<i>Pounds</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
GREEN							
4	33	6	22	—	48	48	52
6	47	6	43	—	67	67	33
8	50	6	74	34	36	70	30
10	57	6	126	50	14	64	36
12	60	6	197	53	6	59	41
14	64	6	225	50	5	55	45
Average	—	—	115	44	16	60	40
DRY							
4	33	6	9	—	59	59	41
6	47	6	18	—	74	74	26
8	50	6	30	41	34	75	25
10	57	6	52	57	12	69	31
12	60	6	83	61	5	66	34
14	64	6	87	54	5	59	41
Average	—	—	44	50	16	66	34

¹Stem material to 3-inch d.o.b. top.

Table 6.—Average green and dry weights of the crown and proportion of the crown in wood, bark, and needles for Choctawhatchee sand pines 4 to 14 inches d.b.h.

D.b.h. class (inches)	Average total height	Sample trees	Crown weight (green)	Crown proportion (green)—			Crown weight (dry)	Crown proportion (dry)—		
				Branch-wood	Branch-bark	Needles		Branch-wood	Branch-bark	Needles
	<i>Feet</i>	<i>Number</i>	<i>Pounds</i>	<i>Percent</i>			<i>Pounds</i>	<i>Percent</i>		
4	33	6	49	59	14	17	21	65	19	16
6	47	6	71	64	20	16	28	68	16	16
8	50	6	126	61	18	21	51	64	15	21
10	57	6	248	63	19	19	103	67	15	18
12	60	6	407	66	30	14	182	72	15	13
14	64	6	571	68	19	14	248	73	14	13
Average			245	66	19	15	106	70	15	15

Table 7.—Average green and dry weights of the stem¹ and proportion of the stem in wood and bark for Choctawhatchee sand pines 4 to 14 inches d.b.h.

D.b.h. class (inches)	Average total height	Sample trees	Main stem weight (green)	Stem proportion in green—		Main stem weight (dry)	Stem proportion in dry—	
				Wood	Bark		Wood	Bark
	<i>Feet</i>	<i>Number</i>	<i>Pounds</i>	<i>.....Percent</i>		<i>Pounds</i>	<i>Percent</i>	
4	33	6	77	86	14	42	87	13
6	47	6	283	90	10	150	91	9
8	50	6	484	89	11	248	91	9
10	57	6	919	91	9	477	93	7
12	60	6	1,254	91	9	691	92	8
14	64	6	1,802	93	7	1,009	95	5
Average		—	803	91	9	436	93	7

¹Stem material to 3-inch d.o.b. top.

Physical Properties

Wood and bark specific gravity, moisture content, and green weight per cubic foot in the total tree and its components are presented in table 8. Wood specific gravity for the total tree averaged 0.475. Wood specific gravity of the saw-

log portion of the tree and the main stem as a whole averaged 0.485, which is the average reported in a wood density survey of the species (Clark and Taras 1969). Specific gravity of the pulpwood portion of the tree averaged 0.455, which is slightly lower than the saw-log portion of the tree but slightly higher than that for the

Table 8.—Average wood and bark specific gravity, moisture content, and green weight per cubic foot for Choctawhatchee sand pine trees and tree components

Tree component	Average and standard deviation		
	Specific gravity	Moisture content	Green weight per cubic foot
		<i>Percent</i>	<i>Pounds</i>
	WOOD		
Total tree	0.475 ± 0.025	91 ± 14	56.4 ± 3.4
Saw log	.485 ± .030	81 ± 11	54.7 ± 3.9
Pulpwood	.455 ± .041	101 ± 21	56.8 ± 3.7
Main stem	.485 ± .029	84 ± 13	55.7 ± 3.5
Branches	.433 ± .028	123 ± 21	59.9 ± 3.9
	BARK		
Total tree	0.349 ± 0.022	151 ± 15	53.3 ± 2.3
Saw log	.398 ± .037	117 ± 26	53.4 ± 3.2
Pulpwood	.316 ± .066	183 ± 57	53.5 ± 2.7
Main stem	.390 ± .035	121 ± 26	53.4 ± 3.3
Branches	.288 ± .016	195 ± 18	52.9 ± 1.8
	WOOD AND BARK		
Total tree	0.457 ± 0.020	96 ± 16	55.8 ± 2.9
Saw log	.478 ± .027	84 ± 10	54.5 ± 3.5
Pulpwood	.440 ± .041	110 ± 23	56.4 ± 3.3
Main stem	.475 ± .026	88 ± 12	55.3 ± 3.2
Branches	.398 ± .023	140 ± 17	58.3 ± 3.1

branches (0.433). Bark specific gravity was consistently lower than wood specific gravity, averaging 0.349 for the total tree, 0.390 for the main stem, and 0.288 for the branches. The specific gravity of the main stem bark approached that reported for longleaf pine (0.409) and was higher than that reported for loblolly, shortleaf, and slash pine. The branchbark specific gravity (0.288) was lower than that found for the four major species of southern pine.

Wood moisture content averaged 91 percent for the total tree, 84 percent for the main stem, and 123 percent for the branches (table 8). Wood moisture content was considerably higher for pulpwood (101 percent) than for saw logs (81 percent).

On a total-tree basis, bark moisture content averaged 151 percent, which was 60 percent higher than the corresponding value for wood (table 8). Bark moisture content was lower for saw logs (117 percent) than for pulpwood (183 percent) or branches (195 percent). The bark moisture contents reported here are all considerably higher (up to 100 percent higher) than those reported for other species of southern pine. These large differences are probably due to sand pine's considerably thinner bark and higher ratio of inner bark (which has an extremely high moisture content) to outer bark.

Green wood weight per cubic foot ranged from 54.7 pounds in saw logs to 59.9 pounds in branches and averaged 56.4 pounds in the total tree. Bark green weight per cubic foot was consistently lower than that of the wood (table 8), averaging about 53.4 pounds per cubic foot. Green weight of wood and bark per cubic foot of wood and bark averaged 55.8 pounds for the total tree, 55.3 pounds for the main stem, and 58.3 pounds for the branches.

PREDICTION EQUATIONS

Equations were developed to predict weights and volumes of the total tree and its components. Those used for predicting dry weight (Y) and green:dry weight ratio (Y_r) to 6- and 4-inch d.i.b. tops are presented in table 9. Similar equations for

predicting cubic-foot volume (Y) and cubic-foot volume ratio (Y_r) are given in table 10. A ratio technique developed by Burkhart (1977) was used to avoid crossovers in which predicted values to a 6-inch top exceed values to a 4-inch top in the same tree. In this procedure, two equations are used to predict the weight or volume at any given top diameter: (1) a total stem volume or weight equation, and (2) an equation for estimating the ratio of merchantable stem volume or weight to total stem volume or weight for the specified top diameter. With these two equations, volume or weight can be obtained to any top diameter limit or between any two specific points on the stem simply by subtraction. In this study, we developed equations to predict the weight and volume ratios to a 6-inch d.i.b. top and a 4-inch d.i.b. top.

The equations presented in tables 9 and 10 for predicting wood, bark, and wood and bark to a 6- or 4-inch d.i.b. top predict only the volume or weight ratios of the merchantable stem and not the actual weight or volume. To find the weight or volume to these merchantable limits, the predicted ratio (Y_r) must be subtracted from the value 1 and then multiplied by the predicted total stem weight or volume. An example of application of this ratio technique is presented in the Appendix.

YIELD TABLES

For convenience to the users, the equations for total tree, stem to a 3-inch d.o.b. top, and crown in tables 9 and 10 were used to develop weight and volume tables; they are presented in the Appendix (tables 11-21). Other equations in tables 9 and 10 can be used to construct tables as needed, or they can be requested from the author.

Trees with the same d.b.h. and total height can vary considerably in weight and volume because of differences in crown size, moisture content, specific gravity, and taper. The yield tables presented in the Appendix should not be used indiscriminately over the range of sand pine without testing. Rather, they should be applied only to trees in natural stands which are similar in age, taper rate, and wood properties.

Table 9.—Regression equations for estimating green and dry weights and weight ratios of the aboveground biomass of Choctawhatchee sand pine trees and tree components with d.b.h. and total height as independent variables

Weight (Y)	Regression equation ¹	Coefficient of determination (R ²)	Standard error (S _{y-x}) ²
Total tree (including needles):			
Green	Log ₁₀ Y = -0.55650 + 0.95706 Log ₁₀ D ² Th	.99	.045
Dry	Log ₁₀ Y = 0.91826 + 0.97593 Log ₁₀ D ² Th	.99	.043
Total tree (excluding needles):			
Green	Log ₁₀ Y = -0.62122 + 0.96994 Log ₁₀ D ² Th	.99	.039
Dry	Log ₁₀ Y = -0.97356 + 0.98720 Log ₁₀ D ² Th	.99	.047
Total tree-wood:			
Green	Log ₁₀ Y = -0.79639 + 1.00201 Log ₁₀ D ² Th	.99	.041
Dry	Log ₁₀ Y = -1.12844 + 1.01698 Log ₁₀ D ² Th	.99	.044
Total tree-bark:			
Green	Log ₁₀ Y = -0.84088 + 0.77934 Log ₁₀ D ² Th	.96	.073
Dry	Log ₁₀ Y = 1.16148 + 0.76005 Log ₁₀ D ² Th	.94	.099
Wood in total stem from stump to a 6-inch d.i.b. top:³			
Green	Log ₁₀ Y _r = 2.93777 - 3.62385 Log ₁₀ D	.85	.143
Dry	Log ₁₀ Y _r = 3.01711 - 3.73405 Log ₁₀ D	.84	.156
Bark in total stem from stump to a h-inch d.i.b. top:³			
Green	Log ₁₀ Y _r = 2.51837 - 1.15915 Log ₁₀ D	.87	.113
Dry	Log ₁₀ Y _r = 2.51422 - 3.23465 Log ₁₀ D	.81	.148
Wood and bark in total stem from stump to a h-inch d.i.b. top:³			
Green	Log ₁₀ Y _r = 2.90335 - 3.58539 Log ₁₀ D	.86	.139
Dry	Log ₁₀ Y _r = 2.98467 - 3.70246 Log ₁₀ D	.84	.154
Wood in total stem from stump to a 4-inch d.i.b. top:³			
Green	Log ₁₀ Y _r = 1.87940 - 3.58590 Log ₁₀ D	.94	.162
Dry	Log ₁₀ Y _r = 1.97120 - 3.78576 Log ₁₀ D	.92	.211
Bark in total stem from stump to a 4-inch d.i.b. top:³			
Green	Log ₁₀ Y _r = 1.52148 - 3.14421 Log ₁₀ D	.92	.169
Dry	Log ₁₀ Y _r = 1.05411 - 2.86826 Log ₁₀ D	.73	.320
Wood and bark in total stem from stump to a 4-inch d.i.b. top:³			
Green	Log ₁₀ Y _r = 1.84122 - 3.53864 Log ₁₀ D	.94	.158
Dry	Log ₁₀ Y _r = 1.91231 - 3.72593 Log ₁₀ D	.96	.208
Wood in total stem from stump to a 3-inch d.o.b. top:³			
Green	Log ₁₀ Y = 1.08343 + 1.05588 Log ₁₀ D ² Th	.98	.052
Dry	Log ₁₀ Y = 1.37915 + 1.06463 Log ₁₀ D ² Th	.98	.053
Bark in total stem from stump to a 3-inch d.o.b. top:³			
Green	Log ₁₀ Y = 1.20771 + 0.81960 Log ₁₀ D ² Th	.96	.090
Dry	Log ₁₀ Y = 1.33809 + 0.76003 Log ₁₀ D ² Th	.94	.090
Wood and bark in total stem from stump to a 3-inch d.o.b. top:³			
Green	Log ₁₀ Y = -0.94689 + 1.03056 Log ₁₀ D ² Th	.99	.046
Dry	Log ₁₀ Y = 1.23518 + 1.03557 Log ₁₀ D ² Th	.99	.046
Crown weight (including branchwood, branchbark, and needles):			
Green	Log ₁₀ Y = -0.69292 + 0.81995 Log ₁₀ D ² Th	.86	.157
Dry	Log ₁₀ Y = -1.13105 + 0.83740 Log ₁₀ D ² Th	.84	.165
Needles:			
Green	Log ₁₀ Y = 1.41056 + 0.79520 Log ₁₀ D ² Th	.72	.233
Dry	Log ₁₀ Y = 1.86151 + 0.80988 Log ₁₀ D ² Th	.72	.235
Wood in live branch material:			
Green	Log ₁₀ Y = 1.03397 + 0.86048 Log ₁₀ D ² Th	.87	.153
Dry	Log ₁₀ Y = 1.41556 + 0.87041 Log ₁₀ D ² Th	.86	.165
Bark in live branch material:			
Green	Log ₁₀ Y = 1.12593 + 0.74215 Log ₁₀ D ² Th	.81	.166
Dry	Log ₁₀ Y = 1.68595 + 0.76767 Log ₁₀ D ² Th	.82	.171
Wood and bark in live branch material:			
Green	Log ₁₀ Y = -0.81148 + 0.83105 Log ₁₀ D ² Th	.86	.154
Dry	Log ₁₀ Y = 1.25295 + 0.85039 Log ₁₀ D ² Th	.85	.164
Wood and bark in dead branch material:			
Green	Log ₁₀ Y = -3.26819 + 1.17798 Log ₁₀ D ² Th	.79	.282

¹Log₁₀ Y = b₀ + b₁ Log₁₀ D² Th

where:

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

Log₁₀ Y_r = b₀ + b₁ Log₁₀ D

where

$$Y_r = \frac{\text{Total stem weight} - \text{weight to specified d.i.b. top}}{\text{Total stem weight}}$$

D = d.b.h. in inches.

²Standard error of estimate in Log₁₀ form.

³Regression equations based on 24 trees 8 to 14 inches d.b.h.

⁴Weight to a specified d.i.b. top can be computed using ratio values (Y_r) developed by these equations as follows:

$$\text{Weight to specified d.i.b. top} = 1 - (Y_r) (\text{total stem weight to 3-inch d.o.b. top}).$$

Table IO.-Regression equations for estimating green cubic-foot and volume ratios of aboveground biomass of Choctawhatchee sand pine trees and tree components with d.b.h. and total height as independent variables

Cubic-foot volume (Y)	Regression equation ¹	Coefficient of determination (R ²)	Standard error (S _{y·x}) ²
Total tree:			
Wood	$\text{Log}_{10}Y = -2.63695 + 1.02742 \text{Log}_{10}D^2Th$	0.99	0.036
Bark	$\text{Log}_{10}Y = -2.52437 + 0.76732 \text{Log}_{10}D^2Th$	.96	.076
Wood & bark	$\text{Log}_{10}Y = -2.43029 + 0.98764 \text{Log}_{10}D^2Th$	.99	.032
Total stem to a 6-inch top: ³			
Wood	$\text{Log}_{10}Y_r = 3.00835 - 3.70252 \text{Log}_{10}D$	.86	.143
Bark	$\text{Log}_{10}Y_r = 2.52777 - 3.19292 \text{Log}_{10}D$	.86	.123
Wood & bark	$\text{Log}_{10}Y_r = 2.97064 - 3.66251 \text{Log}_{10}D$	.86	.140
Total stem to a 4-inch top: ³⁴			
Wood	$\text{Log}_{10}Y_r = 1.97174 - 3.72042 \text{Log}_{10}D$	.93	.191
Bark	$\text{Log}_{10}Y_r = 1.45182 - 3.11971 \text{Log}_{10}D$	.90	.185
Wood & bark	$\text{Log}_{10}Y_r = 1.91809 - 3.65827 \text{Log}_{10}D$	.93	.183
Total stem to a 3-inch top:			
Wood	$\text{Log}_{10}Y = -2.92462 + 1.08298 \text{Log}_{10}D^2Th$	.99	.052
Bark	$\text{Log}_{10}Y = -2.83818 + 0.79252 \text{Log}_{10}D^2Th$	.97	.066
Wood & bark	$\text{Log}_{10}Y = -2.75688 + 1.04968 \text{Log}_{10}D^2Th$	.99	.044
Live branch material:			
Wood	$\text{Log}_{10}Y = -2.83057 + 0.86608 \text{Log}_{10}D^2Th$	.88	.151
Bark	$\text{Log}_{10}Y = -2.86248 + 0.74598 \text{Log}_{10}D^2Th$	.81	.167
Wood & bark	$\text{Log}_{10}Y = -2.58501 + 0.83384 \text{Log}_{10}D^2Th$	.87	.154
Dead branch material:			
Wood & bark	$\text{Log}_{10}Y = -4.72271 + 1.18320 \text{Log}_{10}D^2Th$	.81	.271

$${}^1\text{Log}_{10}Y = b_0 + b_1\text{Log}_{10}D^2Th$$

where:

Y = cubic feet of tree or component,

D = d.b.h. in inches,

Th = total height in feet.

$$\text{Log}_{10}Y_r = b_0 + b_1\text{Log}_{10}D$$

where:

$$Y_r = \frac{\text{Total stem volume} - \text{volume to specified d.i.b. top}}{\text{Total stem volume}}$$

D = d.b.h. in inches.

²Standard error of estimate in Log₁₀ form.

³Regression equations based on 24 trees 8 to 14 inches d.b.h.

⁴Cubic-foot volume to a specified d.i.b. top can be computed using ratio values (Y_r) as follows:

$$\text{Volume to specified d.i.b. top} = 1 - (Y_r) (\text{total stem volume to 3-inch d.o.b. top}).$$

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APPENDIX

ILLUSTRATION OF THE RATIO TECHNIQUE

Suppose you have a tree with a d.b.h. of 9.8 inches and a total height of 58 feet and you wish to compute the cubic-foot volume to a 4-inch top. First select the appropriate cubic-foot volume equation from table 10 for predicting total stem volume to a 3-inch top and substitute the tree dimensions:

$$\begin{aligned}\text{Log}_{10}(Y) &= -2.75688 + 1.04968 \text{Log}_{10}(D^2(Th)) \\ &= -2.75688 + 1.04968 \text{Log}_{10}(9.8^2(58)) \\ &= 14.97 \text{ ft}^3 \text{ in total stem.}\end{aligned}$$

Cubic-foot volume to a 4-inch top (d.i.b.) is computed by substituting into the appropriate volume ratio (Y_r) equation in table 10. In this case, since we wish to predict volume of wood and bark to a 4-inch top, we would use the following equation:

$$\begin{aligned}\text{Log}_{10}(Y_r) &= 1.91809 - 3.65877 \text{Log}_{10}(D) \\ &= 1.91809 - 3.65827 \text{Log}_{10}(9.8) \\ &= 0.01958.\end{aligned}$$

The ratio computed above is the proportion of wood in the main stem between the 4-inch (d.i.b.) and the 3-inch (d.o.b.) top. To compute the actual weight or volume to a 4-inch top, the above ratio must be subtracted from 1 and the resultant value multiplied by the previously computed total stem value as follows:

$$\begin{aligned}\text{Volume to a 4-inch top} &= (1 - Y_r) (\text{Total stem volume to 3-inch top}) \\ &= (1 - 0.01958) (14.97 \text{ ft}^3) \\ &= 14.68 \text{ ft}^3\end{aligned}$$

Table 1 I.-Predicted weight of total tree (wood, bark, and needles) above ground for Choctaw-hatchee sand pine trees 4 to 14 inches d.b.h.¹

D.b.h. (inches)	Total-tree height ² (feet)					
	20	30	40	50	60	70
..... Pounds						
GREEN: ³						
4	69	102	135	167	198	
5	106	157	206	256	304	
6	151	222	293	362	431	500
7	202	298	393	487	579	671
8	261	385	508	628	748	867
9	328	483	636	787	937	1,086
10		591	778	963	1,147	1,329
11		709	934	1,156	1,376	1,595
12		837	1,103	1,365	1,626	1,884
13			1,285	1,591	1,895	2,196
14			1,481	1,834	2,183	2,530
15					2,492	2,888
DRY: ⁴						
4	34	50	66	82	98	
5	52	77	102	127	152	
6	74	110	146	181	217	252
7	100	149	197	245	293	340
8	130	193	256	318	380	442
9	164	243	322	400	478	556
10		299	395	492	587	683
11		360	476	592	708	822
12		426	564	702	838	975
13			660	820	980	1,139
14			763	948	1,133	1,317
15					1,296	1,507

¹Blocked-in area indicates range of data.

²Includes 1-foot stump allowance.

³ $\text{Log}_{10}Y = -0.55650 + 0.95706 \text{Log}_{10}D^2Th.$

⁴ $\text{Log}_{10}Y = -0.91826 + 0.97593 \text{Log}_{10}D^2Th.$

Table 12.-Predicted weight of total tree (wood and bark) excluding needles for Choctawhatchee sand pine trees 4 to 14 inches d.b.h.¹

D.b.h. (inches)	Total-tree height ² (feet)					
	20	30	40	50	60	70
..... Pounds						
GREEN³						
4	64	95	126	156	186	
5	99	147	194	241	288	
6	141	209	276	344	410	476
7	191	282	373	464	553	642
8	246	366	484	601	717	832
9	310	460	608	754	901	1,046
10		564	746	926	1,105	1,283
11		678	897	1,114	1,329	1,544
12		803	1,062	1,318	1,574	1,828
13			1,241	1,540	1,838	2,134
14			1,432	1,778	2,122	2,464
15					2,426	2,818
DRY⁴						
4	32	47	63	78	93	
5	49	73	97	121	145	
6	70	105	139	174	208	242
7	95	142	189	236	282	328
8	124	185	246	307	367	428
9	157	234	310	387	463	540
10		288	382	477	570	664
11		347	461	575	689	802
12		412	548	683	818	952
13			642	800	958	1,115
14			743	926	1,109	1,291
15					1,270	1,479

¹Blocked-in area indicates range of data.

²Includes 1-foot stump allowance.

³ $\text{Log}_{10}Y = -0.62122 + 0.96994 \text{Log}_{10}D^2Th.$

⁴ $\text{Log}_{10}Y = -0.97356 + 0.98720 \text{Log}_{10}D^2Th.$

Table 13.—Predicted weight of all aboveground wood excluding bark for Choctawhatchee sand pine trees 4 to 14 inches d.b.h.¹

D.b.h. (inches)	Total-tree height ² (feet)					
	20	30	40	50	60	70
..... Pounds						
GREEN: ³						
4	52	78	104	130	156	
5	81	122	162	203	243	
6	117	175	234	292	351	409
7	159	238	318	398	477	557
8	208	312	416	520	624	728
9	263	394	526	658	790	922
10		487	650	813	976	1,139
11		590	787	984	1,181	1,378
12		702	937	1,171	1,406	1,641
13			1,100	1,375	1,651	1,927
14			1,276	1,595	1,915	2,235
15					2,199	2,566
DRY: ⁴						
4	26	40	53	67	80	
5	41	62	84	105	126	
6	60	90	121	152	183	214
7	82	124	166	208	250	293
8	108	162	218	273	329	384
9	137	206	277	347	418	489
10		256	343	430	517	605
11		310	416	522	628	735
12		370	496	623	750	877
13			584	733	882	1,032
14			679	852	1,026	1,200
15					1,180	1,381

¹Blocked-in area indicates range of data.
²Includes 1-foot stump allowance.
³Log₁₀Y = -0.79639 + 1.00201 Log₁₀D²Th.
⁴Log₁₀Y = -1.12844 + 1.01698 Log₁₀D²Th.

Table 14.—Predicted weight of wood and bark in main stem to a 3-inch d.o.b. top for Choctaw-hatchee sand pine trees 4 to 14 inches d.b.h.¹

D.b.h. (inches)	Total-tree height ² (feet)					
	20	30	40	50	60	70
.....Pounds						
GREEN ³						
4	43	66	88	111	134	
5	68	104	140	176	212	
6	100	151	203	256	309	362
7	137	208	279	351	424	497
8	180	273	368	463	558	655
9	229	348	469	590	712	834
10		433	582	733	885	1,037
11		527	709	892	1,077	1,262
12		63	1	848	1,067	1,288
13			1,000	1,259	1,519	1,781
14			1,165	1,467	1,770	2,074
15					2,040	2,391
DRY ⁴						
4	23	35	47	59	71	84
5	36	55	74	94	113	133
6	53	80	109	137	165	194
7	73	111	149	188	227	267
8	96	146	197	248	300	352
9	123	187	251	317	383	449
10		232	313	394	476	558
11		283	381	480	580	680
12		339	456	575	694	814
13			538	678	819	961
14			628	791	955	1,120
15					1,102	1,292

¹Blocked-in area indicates range of data.

²Includes 1-foot stump allowance.

³Log₁₀Y = -0.94689 + 1.03056 Log₁₀D²Th.

⁴Log₁₀Y = -1.23518 + 1.03557 Log₁₀D²Th.

Table 15.—Predicted weight of wood excluding bark in main stem to a 3-inch d.o.b. top for Choctawhatchee sand pine trees 4 to 14 inches d.b.h.¹

D.b.h. (inches)	Total-tree height ² (feet)					
	20	30	40	50	60	70
..... Pounds						
GREEN: ³						
4	36	56	76	96	116	
5	58	90	121	154	186	
6	86	132	178	226	274	322
7	119	182	247	313	379	446
8	158	242	328	415	503	591
9	202	310	420	532	645	758
10		387	525	664	805	947
11		474	642	812	985	1,159
12		569	771	976	1,183	1,392
13			913	1,156	1,401	1,649
14			1,068	1,352	1,638	1,928
15					1,895	2,230
DRY: ⁴						
4	19	30	41	52	62	
5	31	48	65	83	100	
6	46	71	96	122	148	175
7	64	98	134	170	206	242
8	85	131	178	225	273	322
9	109	168	228	289	351	414
10		210	286	362	440	518
11		258	350	444	539	635
12		310	421	534	648	764
13			499	633	769	906
14			585	741	900	1,061
15					1,043	1,229

¹Blocked-in area indicates range of data.

²Includes 1-foot stump allowance.

³ $\text{Log}_{10} Y = -1.08343 + 1.05588 \text{Log}_{10} D^2 Th.$

⁴ $\text{Log}_{10} Y = -1.37915 + 1.06463 \text{Log}_{10} D^2 Th.$

Table 16.—Predicted weight of crown material (branchwood, branchbark, and needles) in Choctaw-hatchee sand pine trees 4 to 14 inches d.b.h.¹

D.b.h. (inches)	Total-tree height ² (feet)					
	20	30	40	50	60	70
..... Pounds						
GREEN³						
4			41	49	57	
5	33	46	58	70	82	
6	43	62	79	95	110	125
7	58	80	102	122	142	161
8	72	100	126	152	176	200
9	87	121	153	184	214	243
10		144	182	219	254	288
11		168	213	256	297	337
12		194	246	295	343	389
13			280	336	391	443
14			316	380	441	501
15					494	561
DRY⁴						
4	9	13	17	20	23	
5	14	19	24	29	34	
6	18	26	33	39	46	52
7	24	33	42	51	59	68
8	30	42	53	64	74	84
9	36	51	64	78	90	103
10		60	77	93	108	123
11		71	90	109	126	144
12		82	104	126	146	167
13			119	144	167	190
14			135	163	189	216
15					213	242

¹Blocked-in area indicates range of data

²Includes 1-foot stump allowance.

³ $\text{Log}_{10} Y = -0.69292 + 0.81995 \text{Log}_{10} D^2 Th.$

⁴ $\text{Log}_{10} Y = -1.13105 + 0.83740 \text{Log}_{10} D^2 Th.$

Table 17.—Predicted weight of wood and bark in branches of Choctawhatchee sand pine trees 4 to 14 inches d.b.h.¹

D.b.h. (inches)	Total-tree height' (feet)					
	20	30	40	50	60	70
..... Pounds						
GREEN ²						
4	19	26	33	40	46	
5	27	38	48	58	67	
6	37	51	65	78	91	104
7	47	66	84	101	118	134
8	59	83	105	126	147	167
9	72	100	128	154	179	203
10		120	152	183	213	242
11		140	178	214	250	284
12		162	206	248	288	228
13			235	283	329	374
14			266	320	373	424
15					418	475
DRY ³						
4	6	11	14	16	19	
5	11	16	20	24	28	
6	15	21	27	33	38	44
7	20	28	35	43	50	57
8	24	35	44	53	62	71
9	30	42	54	65	76	87
10		51	65	78	91	104
11		60	76	92	107	122
12		69	88	106	124	142
13			101	122	142	162
14			114	138	161	184
15					182	207

¹Blocked-in area indicates range of data.

²Includes i-foot stump allowance.

³Log₁₀Y = -0.81 148 + 0.83105 Log₁₀D²Th.

⁴Log₁₀Y = -1.25295 + 0.85039 Log₁₀D²Th.

Table 18.—Predicted weight of branchwood in Choctawhatchee sand pine trees 4 to 14 inches d.b.h.¹

D. b. h. (inches)	Total-tree height ² (feet)					
	20	30	40	50	60	70
..... Pounds						
GREEN³						
4	13	19	24	29	34	
5	19	26	35	43	50	
6	27	38	48	58	68	78
7	35	49	63	76	89	102
8	44	62	79	96	112	128
9	53	76	97	117	138	157
10		91	116	141	165	188
11		107	137	166	194	222
12		124	159	193	226	258
13			183	221	259	296
14			206	251	294	336
15					331	378
DRY⁴						
4	6	8	11	13	15	
5	9	12	16	19	22	
6	12	17	22	26	31	35
7	15	22	28	34	40	46
8	19	28	36	43	51	58
9	24	34	44	53	62	71
10		41	52	64	75 75	85
11		48	62	75	88 88	101
12		56	72	88	103	117
13			83	101	118	135
14			94	114	134	153
15					151	173

¹Blocked-in area indicates range of data.

²Includes 1-foot stump allowance.

³ $\log_{10} Y = -1.03397 + 0.86048 \log_{10} D^2 Th.$

⁴ $\log_{10} Y = -1.41556 + 0.87041 \log_{10} D^2 Th.$

Table 19.—Predicted green volume of wood and bark of the total tree for Choctawhatchee sand pine trees 4 to 14 inches d.b.h.¹

D.b.h. (inches)	Total-tree height' (feet)					
	20	30	40	50	60	70
..... Cubic feet						
WOOD AND BARK ²						
4	1.1	1.6	2.2	2.7	3.3	
5	1.7	2.6	3.4	4.2	5.1	
6	2.5	3.7	4.9	6.1	7.3	8.5
7	3.3	5.0	6.6	8.3	9.9	11.5
8	4.4	6.5	8.6	10.8	12.9	15.0
9	5.5	8.2	10.9	13.6	16.2	18.9
10		10.1	13.4	16.7	20.0	23.3
11		12.2	16.2	20.2	24.2	28.1
12		14.5	19.2	24.0	28.7	33.4
13			22.5	28.1	33.6	39.1
14			26.1	32.5	38.9	45.3
15				37.2	44.6	51.9
WOOD ⁴						
4	0.9	1.3	1.8	2.2	2.7	
5	1.4	2.1	2.8	3.5	4.2	
6	2.0	3.0	4.1	5.1	6.2	7.2
7	2.7	4.1	5.6	7.0	8.4	9.9
8	3.6	5.4	7.3	9.2	11.1	13.0
9	4.6	6.9	9.3	11.7	14.2	16.6
10		8.6	11.6	14.6	17.6	20.6
11		10.5	14.1	17.7	21.4	25.0
12		12.5	16.9	21.2	25.6	29.9
13			19.9	25.0	30.1	35.3
14			23.1	29.1	35.1	41.1
15				33.5	40.4	47.4

¹Blocked-in area indicates range of data.

²Includes 1-foot stump allowance.

³ $\text{Log}_{10}Y = -2.43029 + 0.98764 \text{Log}_{10}D^2Th.$

⁴ $\text{Log}_{10}Y = -2.63695 + 1.02742 \text{Log}_{10}D^2Th.$

Table 20.-Predicted green volume of wood and bark in the main stem to a 3-inch d.o.b. top for Choctawhatchee sand pine trees 4 to 14 inches d.b.h.¹

D.b.h. (inches)	Total-tree height ² (feet)					
	20	30	40	50	60	70
..... <i>Cubic feet</i>						
WOOD AND BARK³						
4	0.8	1.1	1.5	2.0	2.4	
5	1.2	1.8	2.5	3.1	3.8	
6	1.8	2.7	3.6	4.6	5.5	6.5
7	2.4	3.7	5.0	6.3	7.6	9.0
8	3.2	4.9	6.6	8.4	10.1	11.9
9	4.1	6.3	8.5	10.7	13.0	15.2
10		7.8	10.6	13.4	16.2	19.0
11		9.6	12.9	16.3	19.8	23.2
12		11.5	15.5	19.6	23.7	27.9
13			18.3	23.2	28.1	33.0
14			21.4	27.1	32.6	38.6
15				31.3	37.1	43.6
WOOD⁴						
4	0.6	1.0	1.3	1.7	18.1	21.3
5	1.0	1.6	2.1	2.7	21.8	25.8
6	1.5	2.3	3.1	4.0	25.9	30.6
7	2.1	3.2	4.4	5.6	30.4	36.0
8	2.8	4.3	5.9	7.4	35.4	41.8
9	3.6	5.5	7.5	9.6	11.7	13.8
10		6.9	9.5	12.1	14.7	17.4
11		8.5	11.6	14.8	18.1	21.3
12		10.3	14.1	17.9	21.8	25.8
13			16.7	21.3	25.9	30.6
14			19.6	25.0	30.4	36.0
15				29.0	35.4	41.8

¹Blocked-in area indicates range of data.

²Includes i-foot stump allowance.

³ $\text{Log}_{10}Y = -2.75688 + 1.04968 \text{Log}_{10}D^2Th.$

⁴ $\text{Log}_{10}Y = -2.92462 + 1.08298 \text{Log}_{10}D^2Th.$

Table 21.—Predicted green volume of wood and bark in branches for Choctawhatchee sand pine trees 4 to 14 inches d.b.h.¹

D.b.h. (inches)	Total-tree height ² (feet)					
	20	30	40	50	60	70
..... Cubic feet						
WOOD AND BARK ³						
4	0.3	0.4	0.6	0.7	0.8	
5	0.5	0.6	0.8	1.0	1.2	
6	0.6	0.9	1.1	1.4	1.6	1.8
7	0.8	1.1	1.4	1.7	2.0	2.3
8	1.1	1.4	1.8	2.2	2.5	2.9
9	1.2	1.7	2.2	2.6	3.1	3.5
10		2.1	2.6	3.2	3.7	4.2
11		2.4	3.1	3.7	4.3	4.9
12		2.8	3.6	4.3	5.0	5.7
13			4.1	4.9	5.7	6.5
14			4.6	5.5	6.4	7.3
15				6.2	7.2	8.2
WOOD ⁴						
4	0.2	0.3	0.4	0.5	0.6	
5	0.3	0.5	0.6	0.7	0.8	
6	0.4	0.6	0.8	1.0	1.1	1.3
7	0.6	0.8	1.0	1.3	1.5	1.7
8	0.7	1.0	1.3	1.6	1.9	2.2
9	0.9	1.3	1.6	2.0	2.3	2.6
10		1.5	2.0	2.4	2.8	3.2
11		1.8	2.3	2.8	3.3	3.7
12		2.1	2.7	3.2	3.8	4.3
13			3.1	3.8	4.4	5.0
14			3.5	4.2	5.0	5.7
15				4.8	5.6	6.4

¹Blocked-in area indicates range of data.

²Includes 1-foot stump allowance.

³ $\text{Log}_{10}Y = -2.58501 + 0.83384 \text{Log}_{10}D^2Th.$

⁴ $\text{Log}_{10}Y = -2.83057 + 0.86608 \text{Log}_{10}D^2Th.$



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Taras, Michael A.

1980. Aboveground biomass of Choctawhatchee sand pine in northwest Florida. USDA For. Serv., Res. Pap. SE-2 10, 00 p. Southeast. For. Exp. Stn., Asheville, N.C.

Choctawhatchee sand pine trees 4 to 14 inches d.b.h. were selected from a natural, uneven-aged stand in northwest Florida to determine the weight and volume of aboveground biomass. On the average, 85 percent of the green weight of the total tree was wood, 11 percent bark, and 4 percent needles. The average tree sampled had 82 percent of its wood in the stem and 18 percent in the crown. Specific gravity, moisture content, and green weight per cubic foot are presented for the total tree and its components. Tables developed from regression equations predict weight and cubic-foot volume of the total tree and its components by d.b.h. and total height classes.

KEYWORDS: *Pinus clausa* var. *immuginata* Ward, weight, volume, equations, component proportions.

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