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TOTAL-TREE GREEN WEIGHTS OF SAPLING-SIZE PINES IN GEORGIA

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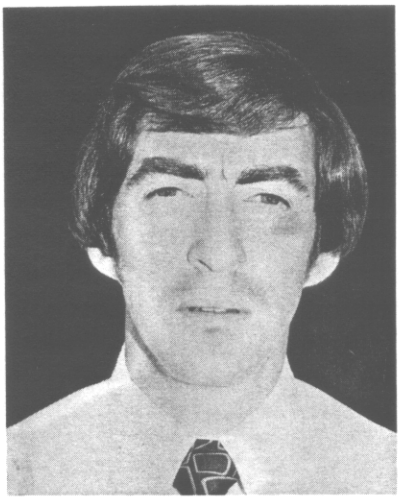

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INTRODUCTION

Total-tree chipping of entire stands, including trees as small as 1 inch in diameter, has been increasing throughout the South. Even though many stems below 5 inches dbh do not pay their way out of the woods in terms of product value, their harvest is important, because following removal, the site is clean and ready to be reforested. Wood from total-tree chipping operations is bought and sold on a weight basis. Thus, a complete stand inventory requires weight estimates for all trees including those 1-5 inches dbh. Total-tree green weight data are available for hardwood trees less than 5 inches dbh (Phillips 1977 and 1981, Wartluft 1977, Hitchcock 1978), but until now they have not been available for small pines. Edwards and McNab (1979) published dry-weight equations for loblolly, shortleaf, and Virginia pine seedlings in the Piedmont of Georgia, and Warner and Goebel (1963) published cubic volume equations for small pines in South Carolina, but the total-tree green weight equations for sapling-size pines provided here are the first to be published.

This report describes the total-tree biomass of sapling-size pines in the three broad physiographic regions of Georgia: Mountains, Piedmont, and Coastal Plain. Prediction equations and green weight tables are presented for open-grown and understory pines. Green weights of crown, foliage, and bark are also discussed.

PROCEDURES

Field and Laboratory

Five sample locations were chosen throughout Georgia: one in the Mountains, two in the Piedmont, and two in the Coastal Plain. Shortleaf, Virginia, and eastern white pines were sampled in the Mountains; loblolly, shortleaf, and Virginia pines in the Piedmont; and slash, longleaf, and loblolly pines in the Coastal Plain (Figure 1).

At each location, trees in two growing conditions were sampled: (1) open-grown, where saplings formed the first order canopy, and (2) understory, where saplings formed the understory of poletimber or sawtimber stands. Understory trees were selected from intermediate and suppressed crown classes of pine-hardwood stands that had at least 70 square feet of basal area per acre. Sample trees selected from open-grown stands were usually dominant or codominant and showed little or no indication of former competition.

At each location, 20 open-grown and 20 understory trees of the selected species were chosen for analysis. Statewide, 500 trees were sampled (100 in the Mountains, 200 in the Piedmont, and 200 in the Coastal Plain). At the Mountain location, 40 Virginia, 40 eastern white, and 20 shortleaf pines were selected. Only understory shortleaf pines were sampled in the Mountains. At the two Piedmont locations, 80 loblolly, 80 shortleaf, and 40 Virginia pines were selected. At the two Coastal Plain locations, 80 slash, 80 longleaf, and 40 loblolly pines were sampled. Trees 1.0 to 4.9 inches were selected from four diameter classes as follows: 1 inch (1.0 to 1.9 inches), 2 inch (2.0 to 2.9 inches), 3 inch (3.0 to 3.9 inches), and 4 inch (4.0 to 4.9 inches dbh).

Dbh and crown class were measured on standing trees. Trees were felled, and their total height, height to a 2-inch top, height to base of live crown, and d.o.b. (diameter outside bark) at base of live crown were measured. Stump d.i.b. (diameter inside bark) and tree age were also recorded. Stump height was considered to be zero since all trees were cut at or near ground line.

Trees were weighed in the field on platform scales. Fresh green weight was determined for the total tree, for the stem from the butt to the tip, and for branches with foliage. To determine tree foliage weight, three representative branches (one each from the lower, middle, and upper sections of the crown) were taken from each tree, sealed in a large plastic bag, and shipped to the laboratory where needle:branch ratios were determined.

Cross-sectional wood and bark samples were cut from the stem and crown of each tree, sealed in plastic bags, and returned to the laboratory where they were processed to determine tree bark content, tree age, and tree wood and bark moisture content and specific gravity.

Individual tree data were summarized by stand condition (open-grown and understory) within physiographic regions. Data were not summarized by species in this report but will be presented in a Southeastern Forest Experiment Station Research Paper to be published later.

Statistical

Through regression analyses, equations were developed for predicting tree weights by physiographic regions and stand condition. Equations were developed for use when only dbh is known, and for when dbh and total height are known. The forms of the equations are:

$$y = a\,(D^2)^b\,e$$

and

$$y = a\,(D^2Th)^b\,e$$

where:

y = total-tree green weight
a, b = regression coefficients
D^2 = diameter breast height squared
Th = total tree height
e = experimental error

The exponential form of the equation was selected because it best met the assumptions of regression and gave the best overall predictions.

RESULTS

Average Tree Characteristics

Dbh ranged from 1.0 to 4.9 inches for each species sampled and averaged 2.98 inches in the Mountains and Piedmont and 2.97 inches in the Coastal Plain. Open-grown trees were much shorter than understory trees of a given diameter, regardless of location. In the Mountains, open-grown trees were 5 feet shorter than understory trees. They were 9 feet shorter in the Piedmont and 4 feet shorter in the Coastal Plain (Table 1). Although open-grown trees were shorter than understory trees, their weights were not lower because their large crowns compensated for their lack of height. Average total-tree green weight ranged from 63.1 to 75.0 pounds; the highest average was for open-grown trees in the Mountains (Table 1). The high average tree weight for this group of trees was the result of having 40 percent Virginia pine and 40 percent white pine in the data base. When growing in the open, these two species produce unusually large crowns.

Crown weights varied considerably between open-grown and understory trees and to some extent between locations. Open-grown trees in the Mountains and Piedmont had crowns approximately twice as heavy as understory trees. In the Coastal Plain, open-grown trees had crowns about 60 percent heavier than understory trees (Table 1). The differences between locations are due primarily to species. Large-crowned Virginia and white pines dominated the Mountain sample while small-crowned slash and longleaf pines dominated the Coastal Plain sample.

Foliage weights ranged from 13.0 pounds for 3.0 inch open-grown pines in the Mountains to 5.0 pounds for the same size understory trees in the same region (Table 1). The foliage: branch weight ratio increased from the Mountains to the Coastal Plain because of a change from multibranch short-needled species (Virginia and shortleaf pines) to less branchy long-needled species (slash and longleaf pines).

Open-grown trees of a given size were 5 to 10 years younger than understory trees (Table 1). This difference was expected because open-grown trees are free to grow and can attain a given size much quicker than understory trees which receive less light and nutrients. Most understory pines in suppressed or intermediate crown classes are not much younger than overstory trees in the same stand.

Regression Equations

Equations for predicting total-tree green weights of sapling pines in open-grown, understory, and both growing conditions are given in Tables 2 and 3. Table 2 equations require measurement of both dbh and total height, while Table 3 equations are based on dbh alone. Standard errors of the estimate ($S_{y.x}$) are given as a relative measure of variability between equations. The lower the $S_{y.x}$, the more precise the prediction. Coefficients of determination (R^2), which ranged from 0.93 to 0.99, indicate that 93 to 99 percent of the variation in total-tree green weight was explained by the regression equations.

To determine a tree's weight based on its diameter and height, simply square the dbh in inches, multiply by total-tree height in feet, raise the result to the specified power, and multiply by the "a" coefficient. The result will be the tree's weight in pounds.

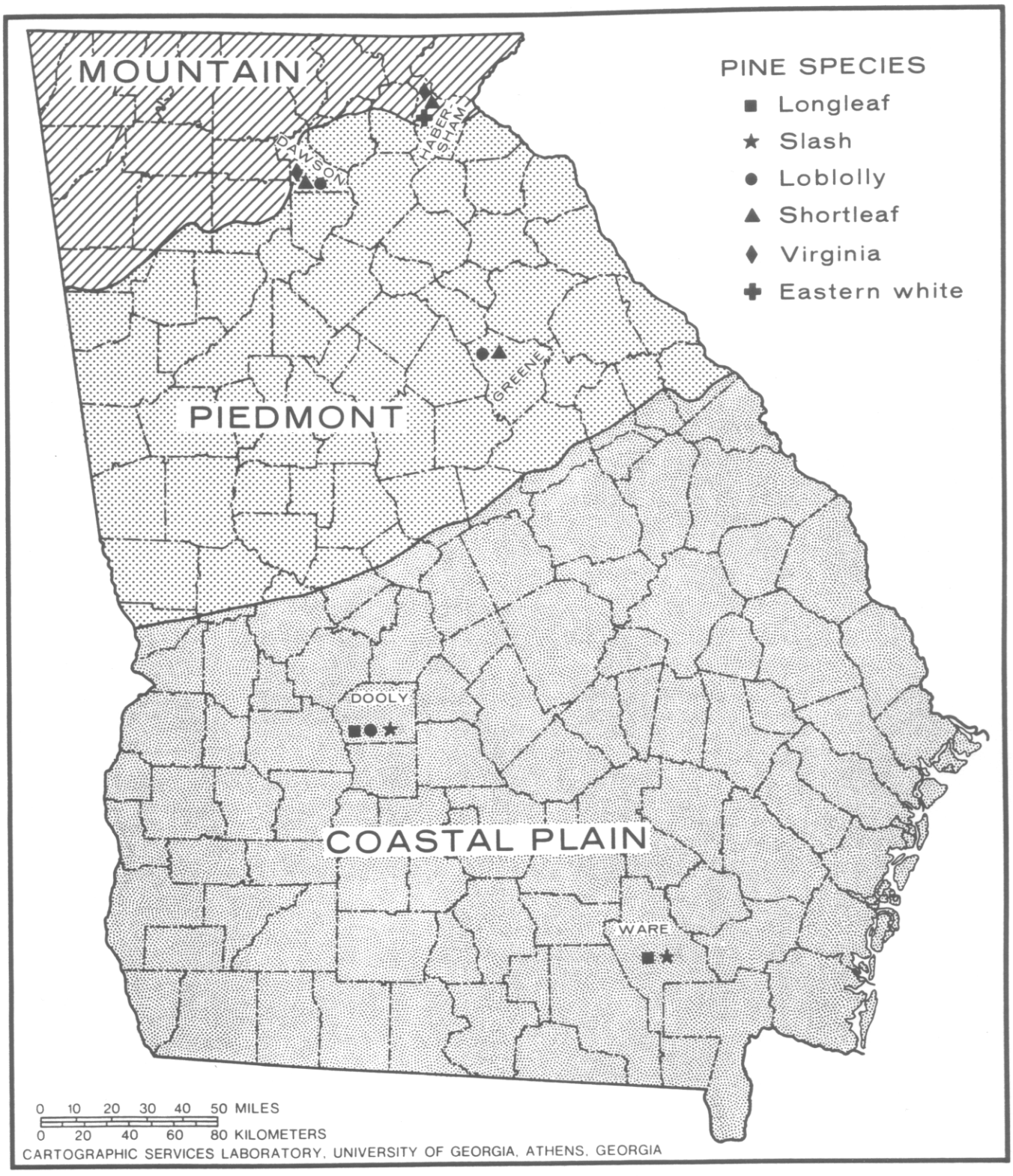

Figure 1.--Sample plot locations by physiographic regions in Georgia.

Table 1. Average green weight of the total tree and components, and bark content and age of sapling pines by physiographic regions in Georgia.

Physio-graphic region	Stand condition	Sample trees	Average dbh	Total height	Average green weight of			Green bark content	Age
					Total tree	Crown	Foliage		
		Number	Inches	Feet	Pounds			Percent	Years
Mountains	Open grown	40	2.99	21	75.0	27.2	13.0	23.9	17
	Understory	60	2.98	26	64.0	12.3	5.0	22.7	24
	Combined	100	2.98	24	68.4	18.3	8.2	23.2	21
Piedmont	Open grown	100	2.98	21	63.1	23.1	11.7	26.0	11
	Understory	100	2.98	30	66.2	12.4	5.8	24.1	21
	Combined	200	2.98	25	64.6	17.8	8.7	25.1	16
Coastal Plain	Open grown	100	2.97	26	64.7	14.5	9.2	28.9	12
	Understory	100	2.97	30	67.6	9.2	5.7	27.9	17
	Combined	200	2.97	28	66.2	11.8	7.4	28.4	14
State Averages	Open grown	240	2.98	23	65.8	20.2	10.8	26.9	12
	Understory	260	2.98	29	66.2	11.2	5.6	25.3	20
	Combined	500	2.98	26	66.0	15.2	7.9	26.0	16

Table 2. Regression equations and associated statistics for predicting total tree green weight including foliage of sapling-size pines by physiographic regions in Georgia based on diameter squared times total height (D^2Th).

Physiographic region	Number of trees sampled (N)	Regression equation	Standard error of estimate[1] ($S_{y.x}$)	Coefficient of determination (R^2)
		OPEN GROWN		
Mountains	40	$Y = 0.95824(D^2Th)^{0.79639}$	0.0818	0.96
Piedmont	100	$Y = 0.65900(D^2Th)^{0.83469}$	0.1193	0.93
Coastal Plain	100	$Y = 0.35824(D^2Th)^{0.91084}$	0.0997	0.96
All locations	240	$Y = 0.57384(D^2Th)^{0.85266}$	0.1255	0.93
		UNDERSTORY		
Mountains	60	$Y = 0.28773(D^2Th)^{0.94546}$	0.0681	0.98
Piedmont	100	$Y = 0.25533(D^2Th)^{0.94684}$	0.0826	0.97
Coastal Plain	100	$Y = 0.35147(D^2Th)^{0.89240}$	0.0834	0.97
All locations	260/	$Y = 0.30230(D^2Th)^{0.92230}$	0.0827	0.97
		COMBINED		
Mountains	100	$Y = 0.54022(D^2Th)^{0.86372}$	0.1244	0.93
Piedmont	200	$Y = 0.47411(D^2Th)^{0.86800}$	0.1297	0.92
Coastal Plain	200	$Y = 0.36137(D^2Th)^{0.89825}$	0.0945	0.96
All locations	500	$Y = 0.44230(D^2Th)^{0.87741}$	0.1201	0.93

[1] In Log_{10} form.

Table 3. Regression equations and associated statistics for predicting total tree green weight including foliage of sapling-size pines by physiographic regions in Georgia based on diameter squared (D^2).

Physiographic region	Number of trees sampled (N)	Regression equation	Standard error of estimate[1/] ($S_{y.x}$)	Coefficient of determination (R^2)
		OPEN GROWN		
Mountains	40	$Y = 5.96407(D^2)^{1.07396}$	0.0715	0.97
Piedmont	100	$Y = 4.57039(D^2)^{1.11324}$	0.1095	0.94
Coastal Plain	100	$Y = 3.10789(D^2)^{1.27630}$	0.1137	0.95
All locations	240	$Y = 4.12566(D^2)^{1.17104}$	0.1173	0.93
		UNDERSTORY		
Mountains	60	$Y = 3.15154(D^2)^{1.26924}$	0.0826	0.97
Piedmont	100	$Y = 3.31164(D^2)^{1.25739}$	0.1122	0.95
Coastal Plain	100	$Y = 3.21457(D^2)^{1.27811}$	0.1030	0.96
All locations	260	$Y = 3.23668(D^2)^{1.26794}$	0.1019	0.96
		COMBINED		
Mountains	100	$Y = 4.17637(D^2)^{1.18379}$	0.1012	0.95
Piedmont	200	$Y = 3.90832(D^2)^{1.18400}$	0.1138	0.94
Coastal Plain	200	$Y = 3.16043(D^2)^{1.27724}$	0.1084	0.95
All locations	500	$Y = 3.64754(D^2)^{1.22050}$	0.1112	0.94

[1/] In Log_{10} form.

Total-tree Green Weight Tables

Predicted total-tree green weights of sapling pines, by dbh classes from 1 to 6 inches and by total-tree height classes from 15 to 60 feet, are presented in Tables 4 through 7. These tables were generated from the equations in Table 2. Tables 4 through 6 present weights of trees in open-grown, understory, and both stand conditions for the Mountains, Piedmont, and Coastal Plain. Table 7 groups all the pine species and locations studied; it can be used for broad general weight estimates.

Predicted total-tree green weights based on dbh alone (D^2) are given in Table 8. Weights are given by 1-inch diameter classes from 1 to 6 inches. Differences between regions and stand conditions are reduced when the height variable is removed.

Table 4. Predicted total tree green weight including foliage of sapling-size pines in the Mountains of Georgia.[1]

Dbh (inches)	Total tree height (feet)									
	15	20	25	30	35	40	45	50	55	60
	Pounds									
	OPEN GROWN[2]									
1	8	10	12	14	16					
2	24	31	37	43	49	54				
3	47	59	71	82	93	104	114	124		
4	75	94	113	130	147	164	180	196	212	227
5	107	135	161	186	211	234	257	280	302	324
6	143	180	215	249	282	313	344	374	404	433
	UNDERSTORY[3]									
1	3	4	6	7	8					
2	13	18	22	26	30	34	39			
3	29	39	48	57	66	75	83	92		
4	51	67	83	98	114	129	144	159	174	189
5	78	102	126	150	173	197	220	243	266	289
6	110	144	178	212	245	278	311	344	376	408
	COMBINED[4]									
1	5	7	8	10	11					
2	18	23	28	33	38	43	47			
3	37	47	58	68	77	87	96	105	114	123
4	61	78	95	111	127	143	158	173	188	203
5	90	115	140	164	187	210	233	255	277	299
6	123	158	192	225	257	288	319	350	380	409

[1] Blocked in area indicates range of data.

[2] Based on the equation: $Y = 0.95824(D^2Th)^{0.79639}$

[3] Based on the equation: $Y = 0.28773(D^2Th)^{0.94546}$

[4] Based on the equation: $Y = 0.54022(D^2Th)^{0.86372}$

Table 5. Predicted total tree green weight including foliage of sapling-size pines in the Piedmont of Georgia.[1]

Dbh (inches)	Total tree height (feet)									
	15	20	25	30	35	40	45	50	55	60
	Pounds									
	OPEN GROWN[2]									
1	6	8	9	11	12					
2	20	25	30	35	40	45				
3	39	50	60	70	80	89	98	108		
4	63	81	97	113	129	144	159	174	189	203
5	92	117	142	165	188	210	232	253	274	295
6	125	159	192	224	255	285	314	343	372	400
	UNDERSTORY[3]									
1	3	4	5	6	7	8				
2	12	16	19	23	27	31	34	38		
3	26	34	43	51	59	67	75	8^	90	
4	45	60	74	88	102	115	129	143	156	170
5	69	91	113	134	155	176	197	218	239	259
6	98	129	160	190	220	249	279	308	337	366
	COMBINED[4]									
1	4	6	7	9	10	11				
2	16	21	25	30	34	38	42	47		
3	33	42	52	61	69	78	86	95	103	
4	55	70	85	100	115	129	143	156	170	183
5	81	104	126	148	169	190	210	231	251	270
6	111	143	173	203	232	261	289	317	344	371

[1] Blocked in area indicates range of data.

[2] Based on the equation: $Y = 0.65900(D^2Th)^{0.83469}$

[3] Based on the equation: $Y = 0.25533(D^2Th)^{0.94684}$

[4] Based on the equation: $Y = 0.47411(D^2Th)^{0.86800}$

Table 6. Predicted total tree green weight including foliage of sapling-size pines in the Coastal Plain of Georgia.[1]

Dbh (inches)	Total tree height (feet)									
	15	20	25	30	35	40	45	50	55	60
	Pounds									
	OPEN GROWN[2]									
1	4	5	6	7	9	10				
2	14	19	23	28	32	36	40			
3	31	40	49	58	67	76	84	93	101	
4	52	68	83	99	114	128	143	157	172	186
5	79	102	126	148	171	193	215	237	258	279
6	110	143	175	207	238	269	300	330	360	390
	UNDERSTORY[3]									
1	3	5	6	7	8	9				
2	13	17	21	25	28	32	36	39		
3	27	36	44	51	59	67	74	81	89	
4	46	60	73	86	99	112	124	136	149	161
5	69	90	109	129	148	167	185	203	222	240
6	96	124	152	179	205	231	257	282	307	332
	COMBINED[4]									
1	4	5	6	7	8	9				
2	14	18	22	26	30	34	38	42		
3	29	38	46	55	63	71	79	87	95	
4	49	64	78	92	106	119	133	146	159	172
5	74	96	117	138	158	178	198	218	238	257
6	102	133	167	191	220	248	275	303	330	357

[1] Blocked in area indicates range of data.

[2] Based on the equation: $Y = 0.35824(D^2Th)^{0.91084}$

[3] Based on the eauation: $Y = 0.35147(D^2Th)^{0.89240}$

[4] Based on the equation: $Y = 0.36137(D^2Th)^{0.89825}$

Table 7. Predicted total tree green weight including foliage of sapling-size pines in Georgia (all locations).[1]

Dbh (inches)	Total tree height (feet)									
	15	20	25	30	35	40	45	50	55	60
	Pounds									
	OPEN GROWN[2]									
1	5	7	8	10	11	13				
2	18	24	29	34	38	43	48			
3	37	48	56	67	77	86	95	104	113	
4	61	78	94	110	126	141	156	171	185	200
5	89	114	138	162	185	207	229	250	272	293
6	122	156	189	221	252	283	312	342	371	399
	UNDERSTORY[3]									
1	3	4	5	6	8	9				
2	13	17	21	25	28	32	36	40		
3	27	36	44	52	60	68	76	84	92	
4	47	61	75	89	103	117	130	143	157	170
5	71	93	114	135	156	176	197	217	237	256
6	100	130	160	189	218	247	275	303	331	359
	COMBINED[4]									
1	4	6	7	8	10	11				
2	16	20	25	29	33	37	42	46		
3	32	42	51	60	68	77	85	94	102	
4	54	69	84	99	114	128	142	155	169	183
5	80	103	125	147	168	189	210	230	250	270
6	110	142	172	202	232	261	289	317	345	372

[1] Blocked in area indicates range of data.

[2] Based on the equation: $Y = 0.57384(D^2Th)^{0.85266}$

[3] Based on the equation: $Y = 0.30230(D^2Th)^{0.92230}$

[4] Based on the equation: $Y = 0.44230(D^2Th)^{0.87747}$

Table 8. Predicted total tree green weight including foliage of sapling-size pines based on dbh alone.[1/]

Physiographic region	Sample trees	Total tree green weight by dbh class					
		1-inch	2-inch	3-inch	4-inch	5-inch	6-inch
	Number	Pounds					
				OPEN GROWN			
Mountains	40	6	26	63	117	189	280
Piedmont	100	5	21	53	100	164	247
Coastal Plain	100	3	18	51	107	189	301
All locations	240	4	21	54	106	179	274
				UNDERSTORY			
Mountains	60	3	18	51	106	187	298
Piedmont	100	3	19	52	108	190	300
Coastal Plain	100	3	19	53	111	197	314
All locations	260	3	19	52	109	192	304
				COMBINED			
Mountains	100	4	22	56	111	189	290
Piedmont	200	4	20	53	104	177	272
Coastal Plain	200	3	19	52	109	193	307
All locations	500	4	20	53	108	185	289

[1/] Predicted values in this table are based on equations in Table 3.

Typical closed stand sapling pines that occur in the understory. From top to bottom : (1) loblolly pine, (2) Virginia pine.

Typical open-grown sapling-size pines. From top to bottom : (1) loblolly pine, (2) Virginia pine and (3) eastern white pine

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