

Predicting Biomass of Understory Stems in the Mississippi and Alabama Coastal Plains



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Understory forest biomass is becoming an important source of industrial fuelwood. Up to 40 tons per acre of above-ground biomass may be present in the understory of Southern pine stands. The above-ground portion is the only portion of the tree that can be harvested economically for fuel.

The authors recognized the need for better understory biomass estimators during a recent study. Conventional biomass estimators (for example, Reams, et al. 1982) are based on samples intentionally

biased toward merchantable stems. Such estimators behave erratically when used to estimate the weight of stems smaller than those occurring in the sample used to develop the predictors. Thus, estimators specifically developed for smaller stems are necessary for accurate prediction of above-ground understory biomass for energy stock.

The U.S. Forest Service Southeastern Forest Experiment Station has estimated understory biomass (Phillips 1981) using data collected from the mountains and Piedmont

of North Carolina and the Piedmont of South Carolina. The published predictors from this study were tested on data gathered near Brewton, Alabama and Lucedale, Mississippi. These preliminary tests indicated a statistically significant difference between the all-hardwood models in the Alabama-Mississippi study and the North Carolina-South Carolina study. Thus, the development of separate equations for the two geographic regions was warranted.

Sampling Procedure

During preharvest inventory of stands to be used in a harvest-site preparation study, 1/200 acre test plots were established to estimate the understory biomass in stands receiving different harvest treatments. The stands were situated in two test tracts near Brewton, Alabama and one tract near Lucedale, Mississippi. Ten 1/200-

acre plots were located in each of 12 stands under study. On each 1/200-acre plot, the above-ground portion of each stem under 3.5 inches in diameter was weighed. Diameter (DBH), total tree height (TTHT) and species also were recorded for a subsample of these stems. Additional understory stems with a diameter 3.5 inches and greater

subsequently were destructively sampled so that biomass regressions could be prepared. A subsample was collected and oven-dried for each destructively sampled stem, and the oven-dry weight of the biomass sample was recorded. Table 1 summarizes the data for the different species found on the three study tracts.

Regression Estimates

The dependent or predicted variables chosen for analysis were the green and dry weights for each individual tree. The independent or predicting variables chosen due to statistical significance (alpha equal to 0.01) were diameter at breast height squared (DBH²) or DBH² multiplied by total tree height (TTHT). The equations were transformed using log base 10 as follows:

$$\text{LOG } y = b_0 + b_1 \text{ LOG}(X_1) + e$$

where:

y = dry weight or green weight

b₀ = Y intercept

b₁ = species-dependent regression coefficient

X₁ = DBH² or DBH² x TTHT

e = sampling error

Dry weight was calculated using the ratio method as follows:

$$\text{DW} = (\text{GW} \times \text{SDW}) / \text{SGW}$$

where:

DW = dry weight of each tree

GW = green weight of each tree

DW = oven dry weight of biomass sample from each tree

SGW = green weight of biomass sample from each tree

The equations were developed using the regression package of the BMDP statistical software system. All equations are statistically significant at alpha equal to 0.01. Equations, standard errors of estimates and coefficients of determination

(R²) are given by species in Tables 2 and 3.

Tables of predicted dry and green weights are given by species and DBH in Tables 4 and 5. Predicted weights by species, DBH and total tree height are given in Tables 6 and 7.

Comparison with Other Biomass Equations

The equations presented here were compared with those derived by Phillips (1981). Table 8 summarizes the comparisons. No consistent trend in difference among the coefficients is obvious. From the 12 comparisons, the Alabama-Missis-

issippi intercept coefficients (b_0) were less than the North Carolina-South Carolina coefficients in five cases. The slope coefficients (b_1) for the Alabama-Mississippi data were less than the North Carolina-South Carolina coefficients in seven cases.

The conclusion is that there is no consistent ratio of weights between trees of the same height and diameter in the two regions. What must be concluded is that the form of the equation changes for a single species between the two regions.

References

Phillips, D. R. 1981. Predicted total tree biomass of understory hardwoods. USFS Southeastern For. Exp. Sta. Research Paper SE-223. 22 p.

Reams, G. A., A. D. Sullivan, T. G. Matney and R. R. Stevens. 1982. Estimating above-ground biomass of slash pine and sweetgum. MAFES Technical Bulletin 110. 11 p.

Table 1. Summary data for the various species sampled.

Species Group	Species Sampled	Sample Size	Diameter (in. DBH)		Dry Weight (lbs)		Green Weight (lbs)	
			Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Pine	Loblolly pine (<i>Pinus taeda</i>)	35	1.1	8.5	1.8	358.5	3.6	737.5
	Longleaf pine (<i>Pinus palustris</i>)							
	Slash pine (<i>Pinus elliottii</i>)							
Oak	Southern Red Oak (<i>Quercus falcata</i>)	29	1.1	6.8	4.6	404.5	7.2	632.2
	Water Oak (<i>Quercus nigra</i>)							
	Laurel Oak (<i>Quercus laurifolia</i>)							
	Willow Oak (<i>Quercus phellos</i>)							
	White Oak (<i>Quercus alba</i>)							
	Post Oak (<i>Quercus stellata</i>)							
	Blackjack Oak (<i>Quercus marilandica</i>)							
Dogwood	(<i>Cornus florida</i>)	24	1.0	4.8	0.6	103.8	1.0	165.0
Other Hardwoods	Sweetgum (<i>Liquidambar styraciflua</i>)	35	1.0	3.5	3.2	52.7	6.0	90.3
	Sparkleberry (<i>Vaccinium arboreum</i>)							
	Black Cherry (<i>Prunus serotina</i>)							
	Sweetbay (<i>Magnolia virginiana</i>)							
	Red Maple (<i>Acer rubrum</i>)							
	Blackgum (<i>Nyssa sylvatica</i>)							
	Hawthorn (<i>Crataegus sp.</i>)							
	Persimmon (<i>Diospyros virginiana</i>)							
	Titi (<i>Cliftonia monophylla</i>)							
	Holly (<i>Ilex opaca</i>)							
Yaupon (<i>Ilex vomitoria</i>)								

Table 2. Dry-weight prediction equations for above-ground understory biomass.

Species	R ²	Std. Error of Est.	Equation
Pine	.9805	.0975	LOG(Y) = 1.21031LOG(D ²) + .2582
Oak	.9105	.1620	LOG(Y) = 1.0901LOG(D ²) + .5554
Dogwood	.7814	.2998	LOG(Y) = 1.10352LOG(D ²) + .43251
Other Hardwoods	.8720	.1045	LOG(Y) = 1.05328LOG(D ²) + .58117
All Hardwoods	.8623	.1955	LOG(Y) = 1.06799LOG(D ²) + .54376
All Species	.8984	.1856	LOG(Y) = 1.08765LOG(D ²) + .49481

Pine	.9921	.0621	LOG(Y) = .92270LOG(D ² TTHT) - .80864
Oak	.8966	.1742	LOG(Y) = .82892LOG(D ² TTHT) - .39790
Dogwood	.7655	.3106	LOG(Y) = .92809LOG(D ² TTHT) - .69574
Other Hardwood	.8491	.1135	LOG(Y) = .78527LOG(D ² TTHT) - .34560
All Hardwood	.8518	.2028	LOG(Y) = .85240LOG(D ² TTHT) - .47831
All Species	.8943	.1893	LOG(Y) = .84664LOG(D ² TTHT) - .50924

where:

Y - Dry weight (pounds)
D - DBH (inches)
TTHT - total tree height (feet)

Table 3. Green-weight prediction equations for above-ground understory biomass.

Species	R ²	Std. Error of Est.	Equation
Pine	.9835	.0906	LOG(Y) = 1.22342LOG(D ²) + .5285
Oak	.9286	.1453	LOG(Y) = 1.10556LOG(D ²) + .76772
Dogwood	.8634	.2351	LOG(Y) = 1.15012LOG(D ²) + .65905
Other Hardwood	.8692	.1075	LOG(Y) = 1.070LOG(D ²) + .81410
All Hardwood	.9015	.1649	LOG(Y) = 1.08877LOG(D ²) + .77140
All Species	.9249	.1602	LOG(Y) = 1.10780LOG(D ²) + .72526

Pine	.9925	.0609	LOG(Y) = .93147LOG(D ² TTHT) - .56912
Oak	.9184	.1553	LOG(Y) = .84244LOG(D ² TTHT) - .20336
Dogwood	.8498	.2464	LOG(Y) = .96956LOG(D ² TTHT) - .52175
Other Hardwood	.8415	.2465	LOG(Y) = .79543LOG(D ² TTHT) - .12347
All Hardwood	.8903	.1740	LOG(Y) = .86882LOG(D ² TTHT) - .27021
All Species	.9196	.1657	LOG(Y) = .86183LOG(D ² TTHT) - .29693

where:

Y - Green weight (pounds)
D - DBH (inches)
TTHT - total tree height (feet)

Table 4. Predicted dry-weight for the above-ground portion of the stem, by species and dbh.

Species	DBH Class (inches)			
	1	2	3	4
	-----lbs-----			
Pine	1.93	10.32	27.55	55.28
Oak	3.59	16.28	39.42	73.81
Dogwood	2.71	12.50	30.59	57.71
Other Hardwood	3.81	16.42	38.57	70.70
All Hardwood	3.50	15.37	36.55	67.57
All Species	3.12	14.11	34.10	63.75

Table 5. Predicted green-weights for the above-ground portion of the stem, by species and dbh.

Species	DBH Class (inches)			
	1	2	3	4
	-----lbs-----			
Pine	3.37	18.41	49.65	100.38
Oak	5.86	27.12	66.49	125.60
Dogwood	4.56	22.64	57.09	110.65
Other Hardwood	6.51	28.73	68.41	126.62
All Hardwood	5.91	26.72	64.62	120.90
All Species	5.31	24.67	60.59	114.60

Table 6. Predicted green-weights of above-ground portion of the stem, by species, dbh, and height.

Species	DBH Class (inches)			
	1	2	3	4
-----lbs-----				
Pine: (TTHT)				
10	2.30	8.37		
20	4.39	15.98	34.01	58.12
30		23.31	49.61	84.79
40			54.86	110.85
Oak: (TTHT)				
10	4.36	14.00		
20	7.81	25.11	49.72	80.74
30		35.37	69.97	113.61
40			89.16	144.77
Dogwood: (TTHT)				
10	4.70	14.15		
20	5.49	21.05	46.22	80.75
30		31.19	68.48	119.64
40			90.51	158.12
Other Hardwoods: (TTHT)				
10	4.69	14.15		
20	8.15	29.56	46.82	73.99
30		33.91	64.64	102.15
40			81.26	128.42
All Hardwoods: (TTHT)				
10	3.97	13.23		
20	7.25	24.17	48.89	80.60
30		34.37	69.53	114.63
40			87.28	147.18
All Species: (TTHT)				
10	3.67	12.13		
20	6.67	22.04	44.33	72.79
30		31.26	62.87	103.24
40			80.57	132.29

Table 7. Predicted dry-weight of above-ground portion of the stem, by species, dbh, and height.

Species	DBH Class (inches)			
	1	2	3	4
-----lbs-----				
Pine: (TTHT)				
10	1.30	4.67		
20	2.47	8.86	18.72	31.83
30		12.88	27.21	46.27
40			35.49	61.34
Oak: (TTHT)				
10	2.70	8.51		
20	4.79	15.12	29.62	47.72
30		21.16	41.45	66.78
40			52.61	84.76
Dogwood: (TTHT)				
10	1.71	6.18		
20	3.25	11.76	24.97	42.59
30		17.14	36.37	62.04
40			47.50	81.03
Other Hardwoods: (TTHT)				
10	2.75	8.17		
20	4.74	14.09	26.63	41.84
30		19.37	36.62	57.53
40			45.90	72.11
All Hardwoods: (TTHT)				
10	2.37	7.71		
20	4.27	13.93	27.80	45.40
30		19.68	39.28	64.15
40			50.20	81.97
All Species: (TTHT)				
10	2.17	7.03		
20	3.91	12.65	25.13	40.90
30		17.83	35.42	57.65
40			45.19	73.55

Table 8. Comparison of understory biomass estimators for Alabama-Mississippi with those for North Carolina-South Carolina.

Equation	Species	Alabama-Mississippi		North Carolina-South Carolina ^{1/}	
		b ₀	b ₁	b ₀	b ₁
$\log_{10}(\text{DW}) = b_0 + b_1 \log_{10}(D^2)$	Oak	0.5554	1.0901	.47152	1.17059
	Dogwood	0.43251	1.10352	.48905	1.14915
	All Hardwoods	0.54376	1.06799	.39794	1.19572
$\log_{10}(\text{DW}) = b_0 + b_1 \log_{10}(D^{2\text{TTHT}})$	Oak	-0.39790	0.82892	-.45832	.83893
	Dogwood	-0.69574	0.92809	-.57626	.90479
	All Hardwoods	-0.47831	0.85240	-.62864	.87762
$\log_{10}(\text{GW}) = b_0 + b_1 \log_{10}(D^2)$	Oak	.76772	1.10556	.68232	1.18368
	Dogwood	.65905	1.15012	.74223	1.14681
	All Hardwood	.77140	1.08877	.66548	1.18950
$\log_{10}(\text{GW}) = b_0 + b_1 \log_{10}(D^{2\text{TTHT}})$	Oak	-0.20336	0.84244	-.25832	0.84140
	Dogwood	-0.52175	0.96956	-.31867	0.90174
	All Hardwood	-0.27021	0.86882	-.36404	0.87655

^{1/}Coefficients from Phillips (1981).

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