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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 (DBH^2) or DBH^2 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
b_0 = Y intercept
b_1 = species-dependent regression coefficient
X_1 = DBH^2 or $DBH^2 \times TTHT$
e = sampling error

Dry weight was calculated using the ratio method as follows:

$$DW = (GW \times SDW)/SGW$$

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 (R^2) 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-Mississippi 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 conclused 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) Minimum	Diameter (in. DBH) Maximum	Dry Weight (lbs) Minimum	Dry Weight (lbs) Maximum	Green Weight (lbs) Minimum	Green Weight (lbs) Maximum
Pine	Loblolly pine (*Pinus taeda*) Longleaf pine (*Pinus palustris*) Slash pine (*Pinus elliottii*)	35	1.1	8.5	1.8	358.5	3.6	737.5
Oak	Southern Red Oak (*Quercus falcata*) Water Oak (*Quercus nigra*) Laurel Oak (*Quercus laurifolia*) Willow Oak (*Quercus phellos*) White Oak (*Quercus alba*) Post Oak (*Quercus stellata*) Blackjack Oak (*Quercus marilandica*)	29	1.1	6.8	4.6	404.5	7.2	632.2
Dogwood	(*Cornus florida*)	24	1.0	4.8	0.6	103.8	1.0	165.0
Other Hardwoods	Sweetgum (*Liquidambar styraciflua*) Sparkleberry (*Vaccinium arboreum*) Black Cherry (*Prunus serotina*) Sweetbay (*Magnolia virginiana*) Red Maple (*Acer rubrum*) Blackgum (*Nyssa sylvatica*) Hawthorn (*Crataegus sp.*) Persimmon (*Diospyros virginiana*) Titi (*Cliftonia monophylla*) Holly (*Ilex opaca*) Yaupon (*Ilex vomitoria*)	35	1.0	3.5	3.2	52.7	6.0	90.3

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

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

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 b_0	Alabama-Mississippi b_1	North Carolina-South Carolina[1] b_0	North Carolina-South Carolina[1] b_1
$\log_{10}(DW) = b_0 + b_1 \log_{10}(D^2)$	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
$\log_{10}(DW) = b_0 + b_1 \log_{10}(D^2TTHT)$	Oak	-0.39790	0.82892	-.45832	.83893
	Dogwood	-0.69574	0.92809	-.57626	.90479
	All Hardwoods	-0.47831	0.85240	-.62864	.87762
$\log_{10}(GW) = b_0 + b_1 \log_{10}(D^2)$	Oak	.76772	1.10556	.68232	1.18368
	Dogwood	.65905	1.15012	.74223	1.14681
	All Hardwood	.77140	1.08877	.66548	1.18950
$\log_{10}(GW) = b_0 + b_1 \log_{10}(D^2TTHT)$	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).