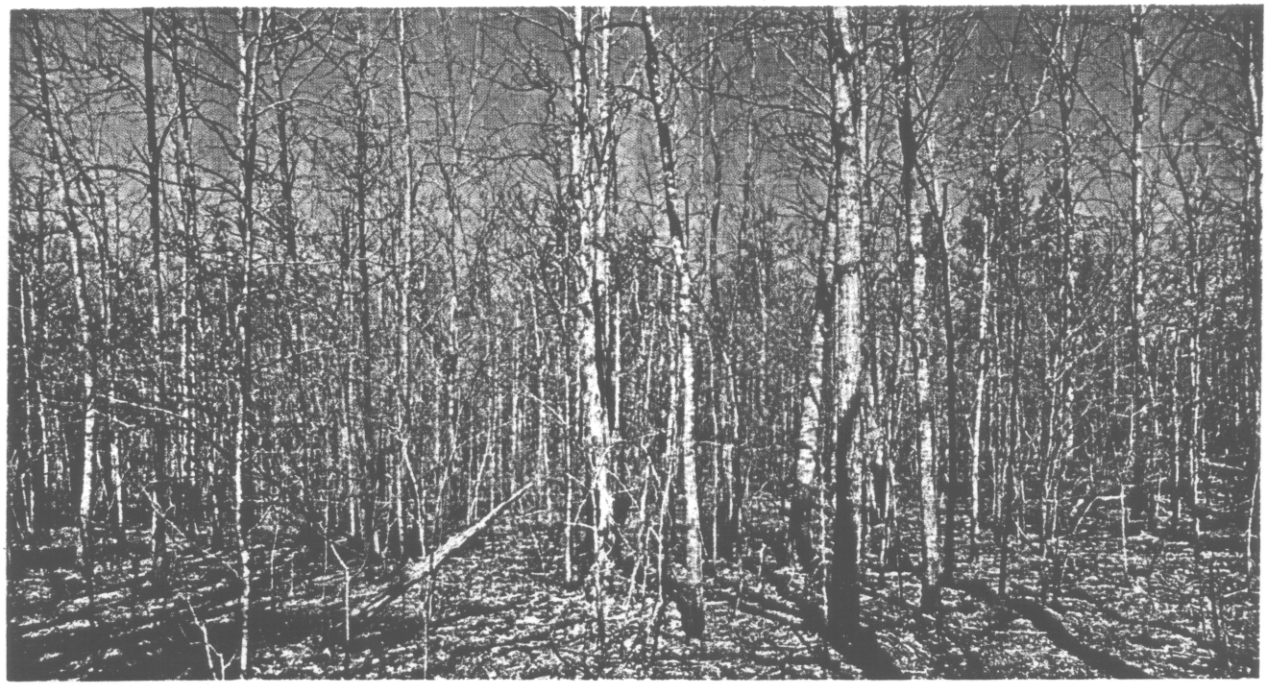
GEORGIA FOREST RESEARCH PAPER

7

AUGUST, 1979



A TEST OF PREDICTION EQUATIONS FOR ESTIMATING HARDWOOD UNDERSTORY AND TOTAL STAND BIOMASS

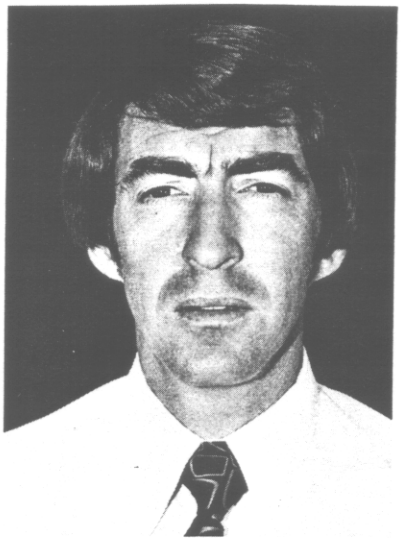
BY

DOUGLAS R. PHILLIPS AND JOSEPH R. SAUCIER

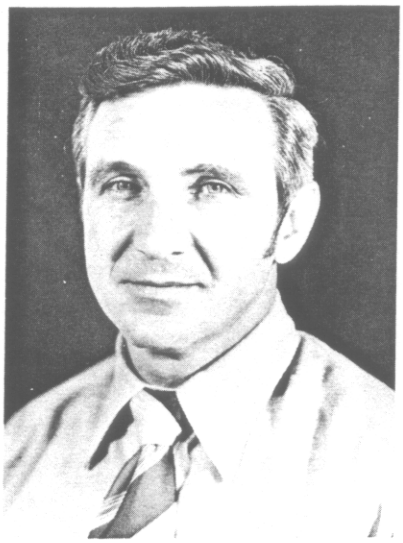
RESEARCH DIVISION

GEORGIA FORESTRY COMMISSION

THE AUTHORS



Douglas R. Phillips is Mensurationist with the Southeastern Forest Experiment Station at Athens, Georgia. He received BS and MF degrees in Forestry from North Carolina State University. He is currently a member of the Utilization of Southern Timber Project.



Joseph R. Saucier is Principal Wood Scientist with the Southeastern Forest Experiment Station at Athens, Georgia. He received a BS degree in Forestry from Louisiana State University and a MS degree in Wood Technology from the University of Georgia. He is presently a member of the Utilization of Southern Timber Project.

ACKNOWLEDGMENT:

The authors greatfully acknowledge the support and assistance given by the Georgia Forestry Commission for this research. A special note of thanks to Fred Allen, Tommy Loggins, and Winston West for their assistance in collecting the field data.

A TEST OF PREDICTION EQUATIONS FOR ESTIMATING HARDWOOD UNDERSTORY AND TOTAL STAND BIOMASS

By
Douglas R. Phillips, Mensurationist
and
Joseph R. Saucier, Principal Wood Specialist

INTRODUCTION

Recently, foresters have begun to look at entire stands, including tops, understory trees, and cull trees as sources of fiber for fuel. Chipping of these formerly unused trees and tree parts yields large amounts of fiber, and foresters must be able to estimate the quantities involved. In response to this need for information, forest products researchers have developed equations for predicting green weight (biomass) of total trees and portions thereof (1-10). Because the need was urgent, most of these equations were not field tested before publication. In this report are the results of a field test of equations for predicting weights of understory and overstory hardwoods. Most of the equations tested were developed in our Utilization of Southern Timber Project in Athens, Georgia. The results of the tests, conducted in a hardwood stand in northern Georgia, are quite encouraging.

PROCEDURES

Ten 1/20-acre plots were established on a 3.19 acre tract of hardwoods in Dawson County, Georgia. The stand had an average basal area of 60.3 square feet per acre. All live trees 1.0 inches dbh and larger on each plot (radius = 26.3 feet) were tallied by species, dbh, and crown class. Each tree was felled, measured for total length, and weighed to the nearest pound. Understory trees 4.9 inches dbh and smaller were cut and weighed on the plot. Pulpwood trees and the tops of sawtimber trees from a 9-inch stem dob (diameter outside bark) to the tip, plus branches, were field chipped in a commercial total tree chipharvester. All chips from a plot were weighed in a truck with portable scales that were checked against commercial scales at a local pulpwood yard. Individual stem sections of sawtimber trees from the butt to a 9-inch dob top were weighed to the nearest pound on electronically operated platform scales. Separate totals were determined for understory and overstory trees on each plot.

REGRESSION EQUATIONS USED

Regression equations available in the literature and some unpublished equations from our project were used to predict individual total tree weights. These equations are listed in Table 1. Some of the equations were used for two or three species even though they were developed for a single species. This was necessary since equations for all species are not available. The equations used had coefficients of determination (R^2) of 0.95 to 0.99 (Table 1), which indicates the equations fit the data on which they were based very well. Other information about the equations can be obtained from the original references.

UNDERSTORY TREE WEIGHT PREDICTIONS

Plot Means

Predicted green weight of understory trees on the 10 sample plots totaled 19,837 pounds or 720 pounds more than the actual weight of 19,117 pounds (Table 2). On individual plots, predicted total tree weight ranged from 1,096 to 3,343 pounds and averaged 1,984 pounds. On all but three plots the equations overestimated actual plot weights. Deviations of predictions from actual weights for plots ranged from -1.8 to +11.7 percent and averaged +3.8 percent. The largest error (+11.7 percent) occurred on plot 4, which contained 36 percent dogwood. The equation used to predict the weight of dogwood consistently overestimated tree weight.

Species Means

Understory equations overestimated the weights of chestnut oak, dogwood, red oak, and other species, but underestimated the weight of yellow-poplar, hickory, white oak, and sourwood (Table 3). The largest underestimate was for yellow-poplar (-9.7 percent), and the largest overestimate was for dogwood (+17.2 percent). We do not know why the overestimate for dogwood was so large. We do know that the size and shape of the crown on this extremely shade tolerant species varies considerably with the amount of light it receives.

Most of the 486 understory trees were dogwood, red oak, hickory, or sourwood. Average tree dbh was 2.2 inches and average height was 25 feet.

OVERSTORY TREE WEIGHT PREDICTIONS

Predicted total tree weight for the overstory trees on the 10 sample plots was 60,218 pounds, or 1,894 pounds below the actual weight of 62,112 pounds (Table 4). Deviations of predictions from actual weights on plots ranged from -22.0 to + 14.5 percent and averaged -3.0 percent (Table 4). Overstory trees were not weighed individually, so it was not possible to determine how accurately the equations predicted total tree weight by species.

Average dbh for the overstory trees was 8.9 inches, and average total height was 55.9 feet. Average dbh by plot ranged from 7.0 to 12.4 inches (Table 4). Most of the 62 overstory trees on the 10 plots were chestnut oaks, red oaks, yellow-poplar, and hickory.

Table 1. — Total tree green weight prediction equations used to estimate individual tree and total stand biomass.

SPECIES	EQUATION[1]	R^2	REFERENCE NO.
	UNDERSTORY SPECIES		
Yellow-poplar	$Log_{10}Y = -0.61138 + 0.93557\ Log_{10}(D^2Th)$	0.99	7
Sweetgum Loblolly pine Shortleaf pine	$Log_{10}Y = -0.43892 + 0.87880\ Log_{10}(D^2Th)$	.97	7
White oak	$Log_{10}Y = -0.33307 + 0.86574\ Log_{10}(D^2Th)$	.99	7
Chestnut oak	$Log_{10}Y = -0.25205 + 0.83728\ Log_{10}(D^2Th)$	.99	7
Post oak	$Y = 4.70542 + 0.18111\ (D^2Th)$	.99	8
N. red oak Black oak S. red oak	$Log_{10}Y = -0.09254 + 0.77793\ Log_{10}(D^2Th)$	.95	7
Dogwood	$Log_{10}Y = -0.15203 + 0.83686\ Log_{10}(D^2Th)$	.98	7
Hickory	$Log_{10}Y = -0.45800 + 0.90556\ Log_{10}(D^2Th)$	.99	7
Sourwood Persimmon Sassafras	$Y = 10.30660 + 0.17780\ (D^2Th)$	.99	8
Black cherry	$Log_{10}Y = -0.36125 + 0.88931\ Log_{10}(D^2Th)$	.99	8
	OVERSTORY SPECIES		
Yellow-poplar	$Log_{10}Y = -0.69614 + 0.96067\ Log_{10}(D^2Th)$	0.99	2
Blackgum Sweetgum	$Y = 0.03342\ (D^2)^{1.03144}\ (Th)^{1.31046}$	.98	1
Loblolly pine	$Log_{10}Y = -0.78974 + 1.00404\ Log_{10}(D^2Th)$	.99	9
Shortleaf pine	$Log_{10}Y = -1.20938 + 1.11931\ Log_{10}(D^2Th)$	.99	4
White oak Post oak	$Y = 0.14925\ (D^2Th)^{1.03696}$	.99	3
Chestnut oak	$Y = 0.11649\ (D^2Th)^{1.04876}$	.98	3
N. red oak Black oak	$Y = 0.18579\ (D^2Th)^{1.00655}$	.99	6
S. red oak Scarlet oak	$Y = 0.06632\ (D^2Th)^{1.11245}$	.98	5
Hickory	$Y = 0.15625\ (D^2Th)^{1.01813}$	.99	10
Black cherry	$Y = 0.27025\ (D^2Th)^{0.94754}$	.99	10

[1] Y = total tree green weight, D = Dbh, Th = total height

Table 2.—Actual and predicted total tree green weights of understory hardwoods by plot number.

Plot Number	Sample Trees	Average DBH	Average Total Height	Total Weight of Understory Trees		Difference
				Actual	Predicted	
	Number	Inches	Feet	- - - Pounds - - -		Percent
1	32	2.7	28	1,876	1,869	- 0.4
2	46	2.2	25	1,994	2,046	+ 2.6
3	66	2.4	27	3,084	3,343	+ 8.4
4	52	2.1	23	1,554	1,736	+ 11.7
5	42	2.2	23	1,608	1,738	+ 8.1
6	67	2.1	25	2,748	2,788	+ 1.4
7	33	2.1	22	1,132	1,155	+ 2.0
8	30	2.0	22	1,116	1,096	- 1.8
9	55	2.0	24	1,856	1,844	- 0.6
10	62	2.1	21	2,148	2,222	+ 3.4
Average or total	486	2.2	25	19,117	19,837	+ 3.8

Table 3.—Actual and predicted total tree green weights of understory hardwoods by species.

Species	Sample Trees	Average DBH	Average Total Height	Total Weight of Understory Trees		Difference
				Actual	Predicted	
	Number	Inches	Feet	- - - Pounds - - -		Percent
Yellow-poplar	38	2.8	33	2,664	2,406	- 9.7
Chestnut oak	19	2.9	32	1,323	1,449	+ 9.5
Dogwood	186	2.0	21	5,099	5,974	+ 17.2
Hickory	63	1.7	22	1,575	1,488	- 5.5
Sourwood	61	3.4	27	3,015	2,957	- 1.9
Red oaks	85	2.5	31	4,106	4,134	+ 0.7
White oaks	11	2.4	26	475	474	- 0.2
Other species	22	2.4	24	862	955	+ 10.8
Average or total	486	2.2	25	19,117	19,837	+ 3.8

Table 4.—Actual and predicted total tree green weight of overstory hardwoods by plot number.

Plot Number	Sample Trees	Average DBH	Average Total Height	Total Weight of Overstory Trees		Difference
				Actual	Predicted	
	Number	Inches	Feet	- - - Pounds - - -		Percent
1	4	12.4	56.9	7,752	6,453	- 16.8
2	5	11.8	42.5	8,823	9,057	+ 2.6
3	8	8.5	52.2	3,877	4,439	+ 14.5
4	8	7.6	54.6	6,639	6,569	- 1.0
5	4	12.0	57.9	7,939	6,194	- 22.0
6	11	6.4	50.1	3,688	3,548	- 3.8
7	4	11.4	63.4	7,591	8,071	+ 6.3
8	5	9.7	57.6	5,810	6,188	+ 6.5
9	7	8.7	50.8	6,218	6,318	+ 1.6
10	6	7.0	43.2	3,775	3,382	- 10.4
Average or total	62	8.9	55.9	62,112	60,218	- 3.0

SUMMARY AND CONCLUSIONS

The actual total tree green weight of all trees (understory and overstory) on the ten 1/20-acre plots was 81,229 pounds; 24 percent or 19,117 pounds was in understory trees, and 76 percent or 62,112 pounds was in overstory trees. Using equations available in the literature plus some unpublished equations, we predicted a total weight on all plots of 80,155 pounds or 1.7 percent below the actual weight. Understory tree weights were overestimated by 3.8 percent and overstory tree weights were underestimated by 3.0 percent. These prediction errors are quite low and very acceptable for most practical applications. It appears from these results that in broad applications the equations work extremely well.

On individual plots, prediction error ran as high as 11.7 percent for understory trees and 22.0 percent for overstory trees. Since some deviations were positive and some negative, most of the error was cancelled out and indications are that with adequate sampling, these equations will provide accurate predictions. Even so, the best approach in applying any set of regression equations is to test them on a small sample of trees before they are applied.

REFERENCES CITED

1. Clark, A. III and D.R. Phillips. 1980. Yield tables for predicting abovestump total tree weight and volume of white oak, sweetgum, and yellow-poplar in the Georgia Piedmont. USDA For. Serv. Res. Pap. (In preparation.) Southeast. For. Exp. Stn., Asheville, N.C.
2. Clark, A. III and J. G. Schroeder. 1977. Biomass of yellow-poplar in natural stands in western North Carolina. USDA For. Serv. Res. Pap. SE-165. Southeast. For. Exp. Stn., Asheville, N.C. p. 41.
3. Clark, A. III and J. G. Schroeder. 1980. Yield tables for predicting abovestump total tree weight and volume of chestnut oak, white oak, and yellow-poplar in western North Carolina. USDA For. Serv. Res. Pap. (In preparation.) Southeast. For. Exp. Stn., Asheville, N.C.
4. Clark, A. III and M. A. Taras. 1976. Biomass of shortleaf pine in a natural sawtimber stand in northern Mississippi. USDA For. Serv. Res. Pap. SE-146. Southeast. For. Exp. Stn., Asheville, N.C. p. 32.
5. Clark, A. III, D. R. Phillips, and H. C. Hitchcock III. 1979. Predicted total tree biomass of southern red oak in central Tennessee. USDA For. Serv. Res. Pap. (In preparation.) Southeast. For. Exp. Stn., Asheville, N.C.
6. Clark, A. III, D. R. Phillips, and J. G. Schroeder. 1979. Predicted total tree biomass of northern red oak in western North Carolina. USDA For. Serv. Res. Pap. (In preparation.) Southeast. For. Exp. Stn., Asheville, N.C.
7. Phillips, D. R. 1977. Total tree weights and volumes for understory hardwoods. TAPPI 60(6): 68-71.
8. Phillips, D. R. 1980. Predicted total tree biomass of understory hardwoods. USDA For. Serv. Res. Pap. (In preparation.) Southeast. For. Exp. Stn., Asheville, N.C.
9. Taras, M. A. and A. Clark III. 1974. Aboveground biomass of loblolly pine in a natural uneven-aged sawtimber stand in central Alabama. TAPPI 58(2): 103-105.
10. Wiant, Harry V. Jr., Froylan Castaneda, Carter E. Sheetz, Andrew Colaninno, and James C. DeMoss. 1979. Equations for predicting weights of some Appalachian hardwoods. *In* West Virginia Forestry Notes No. 7, p. 21-26.

A. Ray Shirley, Director

John W. Mixon, Chief of Forest Research

Printed by:
DOAS
Printing Services

Cost $1309
Quantity
5M