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Weight and Volume Determination for Planted Loblolly Pine in North Louisiana

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Abstract

The objective of this study was to assess the variability in weight-to-volume relationships in loblolly pine (*Pinus taeda* L.) plantations and to determine predictability based on stand age, site quality, and/or tree size. Tree ages ranged from 11 to 40 years, with diameters to 21 inches and heights to 9 I feet. Measured site indices ranged from 4.5 to 72 at base age 25. A total of 75 planted loblolly pine trees were felled and processed to assess the variability in bole weight to volume relationships. Cubic volume, green weight, and dry weight relationships were investigated; and the predictability of these variables with respect to age, site index, and tree size was determined.

Keywords: Loblolly pine, *Pinus taeda*, plantation, volume, weight.

Introduction

Arguably, loblolly pine (*Pinus taeda* L.) is the most important commercial softwood species in the South and the most widely planted southern pine. The volume of wood coming from plantations is increasing, and the age at which plantations first support a commercial thinning continues to decline. Much of the commerce in purchasing roundwood is based on green weight, while initial manufacturing output is measured by dry weight, e.g., paper, or volume, e.g., lumber. The weight-to-volume relationship then becomes an important consideration for forest industry. A number of studies have been done on biomass estimates, which indicate that there are several interacting factors that influence green weight and dry weight per volume unit. The USDA Forest Service now markets timber sales on a cubic-volume basis, as opposed to a board-foot-volume basis that uses log scales such as Doyle, Scriber, or International 1/4-inch rule. Weight-to-volume relationships that change with age, tree size, or site quality carry important economic implications.

A review of previous publications on this topic reveals that equations based on project data frequently carry coefficients of determination ranging from 0.94 to 0.99, although weight and volume equations among studies often yield varying results. Based on a Mississippi study (Nelson and Switzer 1975), a 12-inch (in.) diameter at breast height (d.b.h.) tree 70 feet (ft) tall would have a green weight of 1,362 pounds (lb) on a poor site and 1,400 lb on a good site. Based on a Texas study (Wiswell and others 1986), the same tree would weigh 1,502 lb. Baldwin (1987) would predict 1,430 lb at age 27. Another study in Mississippi (Shelton and others 1984) determined that the green weight of a 20-year-old tree could exceed that of the same size lo-year-old tree by 15 percent. With weights of loblolly pine varying from Mississippi to Texas and sensitive to both site quality and age, justification exists for developing local tables for more specific regions of application. In this paper equations are developed for north Louisiana, where there is a substantial concentration of loblolly pine production and numerous product-manufacturing organizations that use this species. Comparisons are made with Baldwin's (1987) table, which is based on central Louisiana data. Our study assesses the variability in weight-to-volume relationships in loblolly pine plantations and determines predictability based on stand age, site quality, and/or tree size.

Methods

A cross section of loblolly pine plantations was selected from lands of Willamette Industries, Inc., through data base queries. Stands selected were located across six Louisiana parishes: Bienville, Claiborne, Jackson, Lincoln, Union, and Winn. To sample the influence of diameter on weight, two trees from the dominant, codominant, or intermediate crown classes were selected. One tree had a relatively large diameter and the other had a relatively small diameter. In some stands, a tree of a diameter between the other two was also sampled. The selected trees were a distance of at least 1.5 times their height from the stand boundary and were proximate (usually within 50 ft) to each other. This removed edge effect on tree growth and kept the site quality constant. Difference in tree size was, therefore, due to growth rates and not age or site quality.

Seventy-five trees were felled from 33 stands, 20 of which were age 25 or older. Sampling was carried out over a period of about 1 year. Twenty-three age classes ranging from 11 to 40 years were sampled. Tree d.b.h. ranged from 5 to 2 1 in., and height ranged from 50 to 9 1 ft (fig. 1). Site quality (25 years) ranged from 4.5 to 72 ft.

Each tree was cut at or near ground level. The felled stem was then limbed and bucked into 3-ft bolts to a 3-in. merchantable top. The large end of each bolt was numbered to identify the tree number and bolt number. A 13-in. heavy-duty commercial hanging scale (600 lbs by 8 ounces) set up on a tripod was used to weigh each bolt. Weights for each

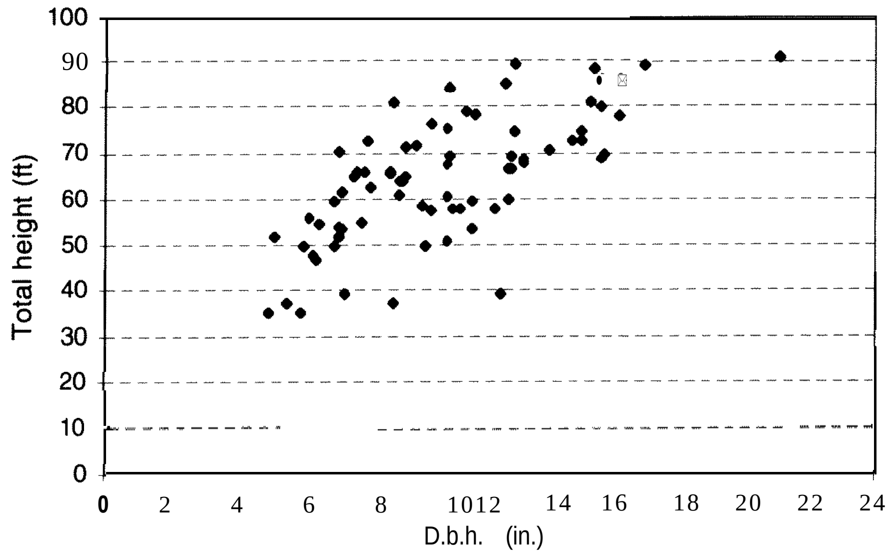

Figure I-Data distribution of sample trees by d.b.h. and total height.

bolt were recorded to the nearest 0.25 lbs along with the stand number code, d.b.h., and total tree height. Diameters outside bark for both ends of each bolt were measured to the nearest 0.1 in. using a diameter tape. Disks were then sawn from the end of each bolt (with tree and bolt numbers) and placed in plastic bags. These samples were taken to the laboratory where they were either processed or stored in a cooler prior to processing.

Laboratory weighing was done using a 3,000-gram (g) electronic balance. Weights for each disk were recorded to the nearest 0.1 g. Processing involved first weighing the green disks with the bark attached. The disk was then debarked and using calipers, two perpendicular inside bark diameters were then averaged to get the diameter of the disk to the nearest 0.1 in. Green weight without bark was recorded, and the disks were placed in a forced air oven at 105 °C. The first sample of disks was weighed three times daily during drying to monitor weight loss. After 48 hours, the dry weight had stabilized. All subsequent samples were dried for approximately 48 hours. The oven dry weight of each disk was then recorded. Afterwards, the disks were sanded, and growth rings were counted. The data collected to this point provided the basis for determining cubic-foot volumes, green weight per cubic foot, moisture contents (MC), dry weight per cubic foot, and height growth as a measure of site quality.

Results and Discussion

Effects of Site Quality and Age

The hypothesis that bole green weight is influenced by site quality and age was tested. Site quality (SQ_{25}) was defined as total tree height at age 25. This was determined by first counting growth rings on the cross-section disks; then, using only dominant and codominant trees at least 25 years of age (n = 24), the point on the stem at which the ring count was 25 rings less than the total ring count was assumed to be the height achieved in 25 years and was considered the actual site index. Both age and site index variables proved to be nonsignificant at the 0.05 probability level (F = 0.32, P = 0.58 and F = 1.29, P = 0.27, respectively) when tested against bole green weight outside bark using the model

$$LnWT = b_o + b_1 LnDBH + b_2 LnHT + b_3 LnAGE + b_4 LnSI \quad (1)$$

where

WT = bole green weight (lbs) outside bark,
DBH = tree diameter outside bark at 4.5 ft,
AGE = tree age in years,
SI = total tree height of dominant/codominant trees at age 25,
HT = total tree height,
Ln = natural logarithm, and
b_o, b_1, b_2, b_3, and b_4 = equation coefficients to be estimated.

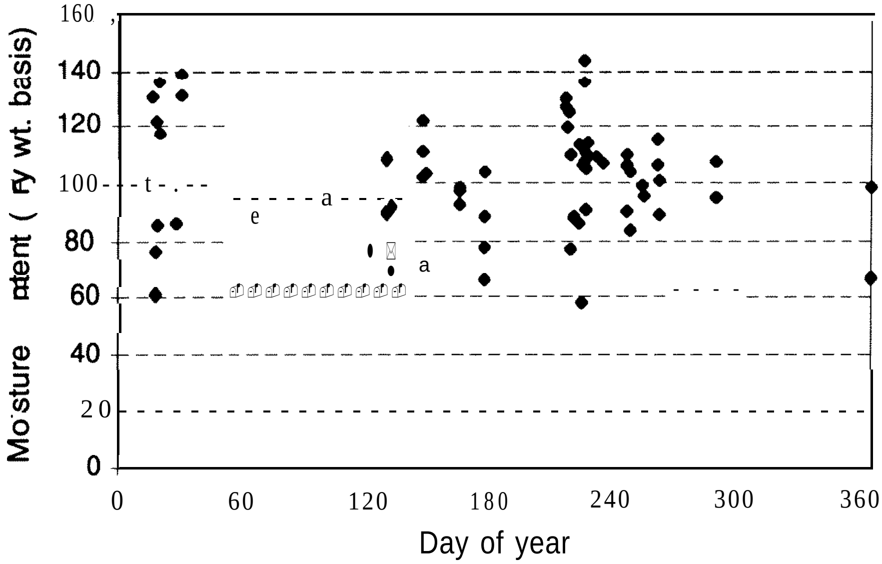

Figure 2-Moisture content of sample trees by sampling date.

Green and Dry Wood Density

Wood MC was calculated on a dry weight basis as

$$MC = (\text{green weight} - \text{dry weight}) / (\text{dry weight}) \times 100 \quad (2)$$

Tree age influenced MC and, therefore, dry weight. The data showed a wide variation in MC, but seasonal variations were not significant (fig. 2). The larger diameter sample trees had higher MC; but in intermediate-to-large d.b.h. trees, it was inconsistently so. Because there were only seven sample trees in this data class, these observations were removed. Age was broken into six 5-year age classes to test for a critical age of MC change using the model

$$MC = b_0 + b_1(\text{size}) + b_2(\text{age class}) + b_3(\text{size X age class}) \quad (3)$$

where

MC = moisture content,
size = small or large,
b_0, b_1, b_2, and b_3 = equation coefficients to be estimated, and
age class = 11 to 15, 16 to 20, 21 to 25, 26 to 30, 31 to 35, or 36 to 40 years.

The statistical difference between MC for the large trees and the small trees was then highly significant (F = 18.51, P = 0.0001). Average MC for large (faster growing) trees versus small (slower growing) trees in the stand was 108.3 percent and 94.7 percent, respectively. Age class was also a highly significant variable (F = 10.02, P = 0.0001). The MC for trees aged 11 to 20 years versus 21 to 40 years averaged 122.7 percent and 96.0 percent, respectively (table 1). Interaction between size and age proved to be nonsignificant (F = 1.43, P = 0.2280).

Density (pounds per cubic foot) was also tested against the relative size of the tree in the stand. Tree size was not a significant variable for green weight per cubic foot, either inside bark (F = 0.89, P = 0.41) or outside bark (F = 0.19, P = 0.12). Across the entire data set, the inside bark green weight was 62.6 lbs per cubic foot, and the outside bark green weight was 55.5 lbs per cubic foot. Tbe dry weight

Table 1-Effect of age on bole moisture content

Age class	Observations	MC[a]
	Number	Percent
11-15	8	124.4 a
16-20	6	120.5 a
21-25	14	99.5 b
26-30	12	98.2 b
31-35	12	93.7 b
36-40	16	93.0 b

MC = moisture content.
[a]Means followed by the same letter are not significantly different (Duncan's Multiple Range Test, P < 0.05).

did, however, vary significantly with tree size (faster versus slower growing trees) in concert with MC ($F = 9.64$, $P = 0.0002$). Small tree (slow growth) dry weight averaged 32.1 lbs per cubic foot and large tree (fast growth) dry weight averaged 30.1 lbs per cubic foot.

Considering the characteristics of the sample trees from both an age and size perspective, it was concluded that green weight per cubic foot is not affected by either of these variables. But in the faster growing, young plantations up to age 20, it was determined the weight was made up of more water and less wood fiber. Adjusting weight conversions as a wood procurement practice would be awkward, but correction of price based on expected dry fiber yield would be appropriate in wood procurement activity. This is the practice in agricultural grain markets where MC is measured at the delivery scales.

Volume and Green Weight Prediction

Weight and volume predictions in this analysis were to a 3-m top diameter (merchantable bole). For weights by log height, the weights were to an 8-in. top. Therefore, whether estimated from the total tree height or the merchantable height, weights are for the merchantable portion of the bole.

Figure 3 is a plot of actual tree weights from this study, which suggests that weight is a predictable variable. A set of equations based on these plantation data was developed. Table 2 displays the resulting coefficients of the regression analysis using the following model

$$LnY = b_0 + b_1 LnDBH + b_2 LnHT \qquad (4)$$

where

Ln = natural logarithm,
Y = variables for cubic-foot volume outside bark, cubic-foot volume inside bark, and green weight outside bark in pounds,
b_0, b_1, and b_2 = equation coefficients to be estimated
DBH = tree diameter outside bark at 4.5 ft, and
HT = total tree height or merchantable height to a 3-in. top diameter for all trees except those expressed in log heights that are to an 8-in. top (table 2).

The equations are for cubic-foot volume outside bark, cubic-foot volume inside bark, and green weight outside bark, both by total tree height and merchantable height to a 3-m top diameter for all trees except those expressed in log heights that are to an 8-in. top. Tree d.b.h. measurements are

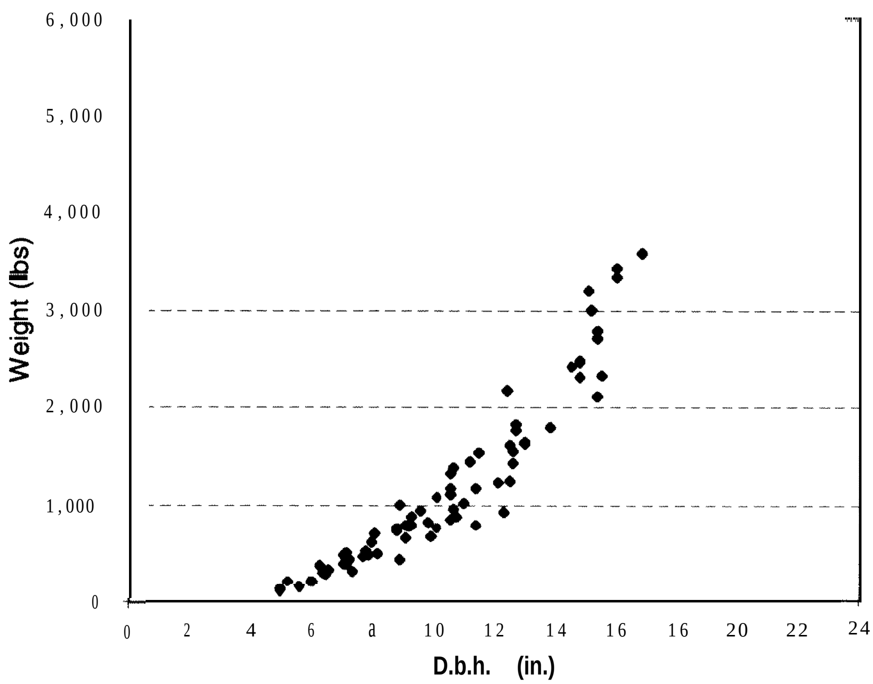

Figure 3—Data distribution of tree weights by d.b.h.

Table 2-Coefficients for various bole volume and green weight equations

Dependent variable	b_0	DBH b_1	TOTHT b_2	MCHT b_2	LOGHT b_2	FI	SE
CFOB	-6.08947	1.93996	1.06747	—	—	0.983	2.34
CFIB	-6.70 152	1.97460	1.14332	—	—	.977	2.31
WT	- 1.90705	2.00230	.99208	—	—	.980	142.86
CFOB	-5.37 160	1.82063	—	1.0020 1	—	.987	2.07
CFIB	-5.90076	1.85502	—	1.06042	—	.981	2.08
WT	-1.20192	1.90120	—	.91601	—	.983	133.04
CFOB (16.5 ft logs)	- 1.63258	1.54659	—	—	1.05228	.989	1.97
CFIB (16.5 ft logs)	-2.28907	1.75195	—	—	.97262	.981	2.20
WT (16.5 ft logs)	2.14989	1.66811	—	—	.95809	.980	147.74
CFOB (17.5 ft logs)	-1.57067	1.54659	—	—	1.05228	.989	1.97
CFIB (17.5 ft logs)	-2.23 184	1.75195	—	—	.97262	.981	2.20
WT (17.5 ft logs)	2.20626	1.66811	—	—	.95809	.980	147.74

— = Not applicable.
Equation form: $LnY = b_0 + b_1 LnDBH + b_2 LnHT$
CFOB = cubic foot volume outside bark, CFIB = cubic foot volume inside bark; WT = weight in pounds; DBH = diameter at breast height (4.5 in.); TOTHT = total tree height; MCHT = merchantable tree height (3-in. top diameter outside bark); LOGHT = number of logs to an 8-in. top diameter outside bark; FI = fit index; SE = standard error of the estimate.

in inches and heights are in feet. Logs are either 16.5 or 17.5 ft to allow for trim on either saw log or ply log bolts, respectively.

Figure 4 reveals that on an individual tree basis, the predictions from the equations developed in this study can be somewhat variable as a percent of bole weight, ranging from - 17 percent to +26 percent. Compared to the actual measured weight, more than 75 percent of the 75 predicted weights were within 10 percent of the actual tree weight using total tree height (equation 3 in table 2). A similar outcome was found using merchantable height (equation 6 in table 2). Percent bark in this study varied by tree volume and weight, but averaged 19.4 percent of volume and 9.1 percent of weight (fig. 5).

As previously noted, different equations developed for the same species have produced different results. It is difficult to determine the reasons for these differences because comparisons must involve at least comparable data and the same model form. Most of these requirements were met with the Baldwin (1987) equations and the data and equations developed in this study. The same model form was used and the tree sizes and ages were fairly close, but Baldwin (1987) did not actually make measurements to a 3-in. top for the trees in his study. In this study, there was no differentiation between trees that came from thinned or unthinned stands, but suspected differences between these classes of trees was a main testing point in the Baldwin (1987) study.

Nevertheless, because Baldwin (1987) data were available, the following manipulations were accomplished in order to test for similarity or differences between the green weight and cubic-foot volume equations. The measured upper-stem diameter-height measurements from the Baldwin (1987) data were used to estimate height to a 3-inch top for each tree within those data, and all trees from thinned and unthinned stands were combined so comparable data were available for testing. Each test was done for both green weight and cubic-foot volume using model (4). The first test used was an F-test to determine if one equation was adequate for both data sets, or if separate equations would be better. This test revealed that there were significant differences between the two populations in both the green

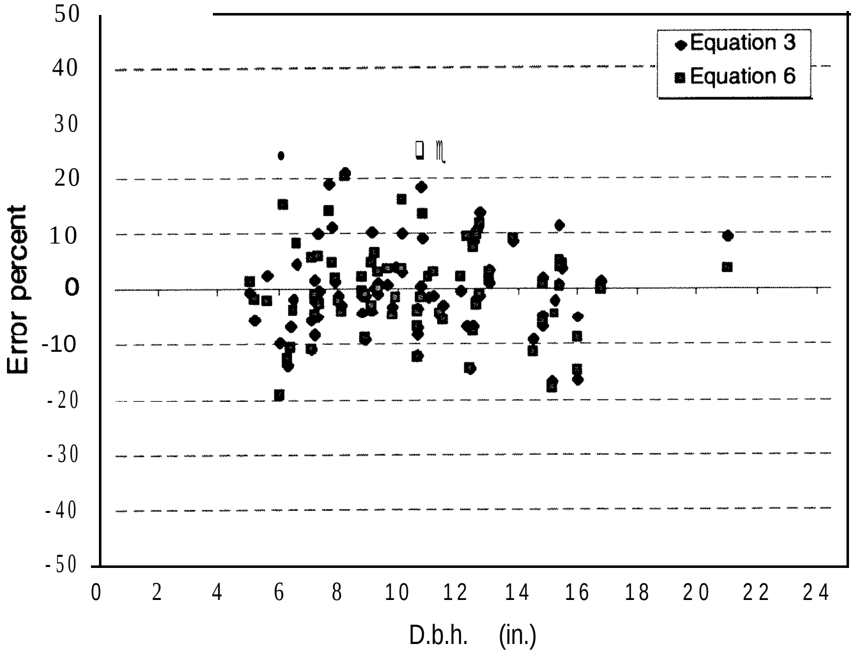

Figure 4—Predicted green weight as a percent of actual weight.

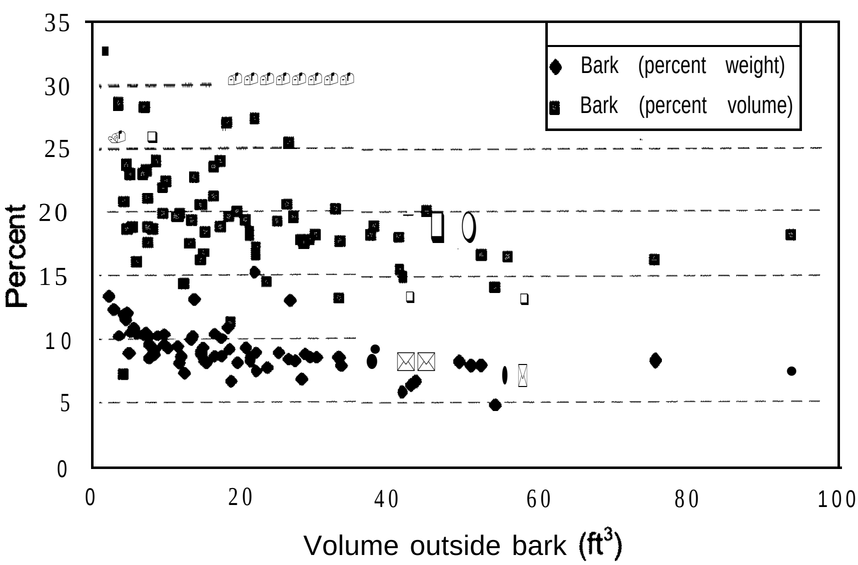

Figure 5-Percent of bole weight and bole volume in bark.

weight (F = 15.24, P = 0.0001) and volume (F = 12.01, P = 0.000 1).

An opportunity was taken to validate the Baldwin (1987) system using these new data. Comparisons of mean predicted and observed values, and mean percent differences, using a t-test, showed no significant differences between the Baldwin (1987) predictions and these data (for merchantable weight outside bark, t = 0.64, P = 0.52; and for mean volume outside bark, t = 1.605, P = 0.11). These apparently conflicting results led to some more exhaustive analyses. The most revealing was the test for normality of the two data sets using both measured and logarithmically transformed values. These analyses revealed that the logarithmically transformed values for the new data set were normally distributed; but for the Baldwin (1987) data set, they were not. For both data sets, the untransformed values were not normally distributed. From this we can conclude that the F- and t-tests performed were probably indicative of the actual situation, but not strictly valid.

Thus, we can reasonably conclude the following-the new data equations are somewhat different from Baldwin's (1987) and are more likely to be applicable for the north Louisiana region; although, the differences are minor and have much to do with the range of observations, different experimental goals, and methodology used. Where merchantable green weight and cubic-foot volume to a 3-m top diameter are desired in north Louisiana, these new equations can be used with confidence. Some tables generated by the equations are found in the Appendix.

Weight Adjustment for Top Diameter Limits

Burkhart (1977) published volume ratio equations to estimate tree volumes to various top diameters as a proportion of the total tree volume. The data collected in this study provided an opportunity to do similar calculations for weight ratios. A regression equation for topwood green weight (outside bark) from top diameters 10 in., 8 in., 6 in., and 4 in., to a 3-in. top was fitted using a variation of Burkhart's technique. For changing top diameters, topwood weight was subtracted from total merchantable bole weight (3-in. top) and the result expressed as a proportion of the total. The model was solved (fit index = 0.803, SE = 0.008)

$$LnTOP = b_o + b_1 Ln(d) + b_2 LnDBH \qquad (5)$$

where

Ln = natural logarithm,
TOP = the proportion of the total merchantable stem weight above the specified (d) to a 3-in. top,
b_o, b_1, and b_2 = equation coefficients to be estimated,
DBH = tree diameter outside bark at 4.5 ft, and
d = top diameter.

The following rearrangement of terms expresses the relationship as the ratio of the bole accounted for to a specified top diameter

$$R_{bole} = 1 - (2.0576 \times d^{2.56449}/DBH^{3.10283}) \qquad (6)$$

where

R_{bole} = the ratio (proportion) of the bole weight to a top diameter (d), and
DBH = tree diameter outside bark at 4.5 ft.

Table 3 shows the results of these partial stem weights as a proportion of total merchantable weight for use with weight estimates in loblolly pine plantations. For example, a 17-in. d.b.h. tree with a total height of 82 ft would weigh 3,421 lbs (by equation 3 in table 2). The proportion of that green weight to a 6-in. top is 0.969 (equation 6 or table 3); therefore, the estimated bole weight to a 6-in. top is 3,3 15 lbs (3,421 by 0.969). Similarly, bole weight to a 10-in. top is 3,029 lbs (3,421 by 0.885).

Table 3-Ratio of partial bole weight to a top diameter as a proportion of total weight (to a 3-inch top)

D.b.h.	Top diameter 10	8	6	4
	Inches			
11	0.557	0.750	0.880	0.958
12	.662	.809	.909	.968
13	.736	.851	.929	.975
14	.790	.882	.943	.980
15	.831	.904	.954	.984
16	.861	.922	.963	.987
17	.885	.935	.969	.989
18	.904	.946	.974	.991
19	.919	.954	.978	.992
20	.931	.961	.981	.993
21	.940	.966	.984	.994

Conclusions

The data in this study do not support the hypothesis that weight per cubic-foot volume varies significantly with site quality and tree age. There was weight variation according to growth rates; but it was apparently a combination of influences including stand density, site quality, tree age, and perhaps genetics. Differences in merchantable green weight and volume of planted loblolly pine for north and south Louisiana were also tested. Unfortunately, those tests were inconclusive. We conclude, however, that the new equations are valid and can be used with confidence in the north Louisiana region. The Baldwin (1987) equations can be used for other plantation management and merchantability situations. Further validation of these weight and volume estimates should be made in the field and under market conditions to determine the equations' robustness.

Acknowledgments

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Appendix

Table Al-Cubic-foot volume (outside bark) by d.b.h. and total tree height

	Height							
D.b.h.	25	35	45	55	65	75	85	9.5
In.				*Feet*				
5	1.6	2.3	3.0	3.7	4.4	—	—	—
6	2.3	3.3	4.3	5.3	6.3	—	—	—
7	3.1	4.4	5.7	7.1	8.5	9.9	—	—
8	4.0	5.7	7.4	9.2	11.0	12.9	—	—
9	5.0	7.2	9.4	11.6	13.9	16.1	18.5	—
10	6.1	8.8	11.5	14.2	17.0	19.8	22.6	—
11	7.4	10.6	13.8	17.1	20.5	23.8	27.2	30.7
12	8.7	12.5	16.4	20.3	24.2	28.2	32.3	36.3
13	10.2	14.6	19.1	23.7	28.3	33.0	37.7	42.4
14	11.8	16.9	22.1	27.3	32.7	38.1	43.5	49.0
15	13.5	19.3	25.2	31.2	37.3	43.5	49.7	56.0
16	15.3	21.9	28.6	35.4	42.3	49.3	56.4	63.5
17	17.2	24.6	32.1	39.8	47.6	55.5	63.4	71.4
18	19.2	27.5	35.9	44.5	53.2	62.0	70.8	79.7
19	21.3	30.5	39.9	49.4	59.1	68.8	78.7	88.6
20	23.5	33.7	44.1	54.6	65.2	76.0	86.9	97.8

— = Not applicable.

Table AZ-Cubic-foot volume (inside bark) by d.b.h. and total tree height

	Height							
D.b.h.	25	35	45	55	65	7.5	85	95
In.				- *Feet* -				
5	1.2	1.7	2.3	2.9	3.5	—	—	—
6	1.7	2.5	3.3	4.1	5.0	—	—	—
7	2.3	3.3	4.4	5.6	6.8	8.0	—	—
8	3.0	4.3	5.8	7.3	8.8	10.4	—	—
9	3.7	5.5	7.3	9.2	11.1	13.1	15.1	—
10	4.6	6.8	9.0	11.3	13.7	16.1	18.6	—
11	5.5	8.1	10.9	13.7	16.5	19.5	22.5	25.5
12	6.6	9.7	12.9	16.2	19.6	23.1	26.7	30.3
13	7.7	11.3	15.1	19.0	23.0	27.1	31.3	35.5
14	8.9	13.1	17.5	22.0	26.6	31.4	36.2	41.1
15	10.2	15.0	20.0	25.2	30.5	35.9	41.5	47.1
16	11.6	17.1	22.8	28.6	34.7	40.8	47.1	53.5
17	13.1	19.2	25.7	32.3	39.1	46.0	53.1	60.3
18	14.7	21.5	28.7	36.1	43.7	51.5	59.4	67.5
19	16.3	24.0	32.0	40.2	48.7	57.3	66.1	75.1
20	18.1	26.5	35.4	44.5	53.8	63.4	73.2	83.1

— = Not applicable.

Table A3—Cubic-foot volume (outside bark) by d.b.h. and height to a 3-in. top

	Height							
D.b.h.	20	30	40	50	60	70	80	90
In.	*Feet*							
5	1.8	2.6	3.5	4.4	5.3	—	—	
6	2.4	3.7	4.9	6.1	7.3	—	—	—
7	3.2	4.9	6.5	8.1	9.7	11.3	—	—
8	4.1	6.2	8.3	10.3	12.4	14.5	—	—
9	5.1	7.7	10.2	12.8	15.4	17.9	20.5	—
10	6.2	9.3	12.4	15.5	18.6	21.7	24.8	—
11	7.4	11.0	14.7	18.4	22.1	25.8	29.5	33.2
12	8.6	12.9	17.3	21.6	25.9	30.3	34.6	38.9
13	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0
14	11.4	17.1	22.9	28.6	34.3	40.1	45.8	51.5
15	12.9	19.4	25.9	32.4	38.9	45.4	51.9	58.4
16	14.6	21.9	29.2	36.5	43.8	51.1	58.4	65.7
17	16.3	24.4	32.6	40.7	48.9	57.0	65.2	73.4
18	18.0	27.1	36.1	45.2	54.2	63.3	72.4	81.4
19	19.9	29.9	39.9	49.9	59.8	69.8	79.8	89.8
20	21.9	32.8	43.8	54.7	65.7	76.7	87.7	98.6

— = Not applicable.

Table A4—Cubic-foot volume (inside bark) by d.b.h. and height to a 3-in. top

	Height							
D.b.h.	20	30	40	50	60	70	80	90
In.				Feet				
5	1.3	2.0	2.7	3.4	4.2	—	—	—
6	1.8	2.8	3.8	4.8	5.8	—	—	—
7	2.4	3.7	5.1	6.4	7.8	9.2	—	—
8	3.1	4.8	6.5	8.2	10.0	11.7	—	—
9	3.9	5.9	8.1	10.2	12.4	14.6	16.8	—
10	4.7	7.2	9.8	12.4	15.1	17.7	20.4	—
11	5.6	8.6	11.7	14.8	18.0	21.2	24.4	27.6
12	6.6	10.1	13.7	17.4	21.1	24.9	28.7	32.5
13	7.6	11.8	15.9	20.2	24.5	28.9	33.3	37.7
14	8.8	13.5	18.3	23.2	28.1	33.1	38.2	43.2
15	10.0	15.3	20.8	26.3	32.0	37.6	43.4	49.1
16	11.2	17.3	23.4	29.7	36.0	42.4	48.9	55.4
17	12.6	19.3	26.2	33.2	40.3	47.5	54.7	62.0
18	14.0	21.5	29.2	36.9	44.8	52.8	60.8	68.9
19	15.5	23.8	32.2	40.8	49.5	58.3	67.2	76.2
20	17.0	26.1	35.5	44.9	54.5	64.2	73.9	83.8

— = Not applicable.

Table AS-Bole weight (pounds) by d.b.h. and total tree height

D.b.h.	Height 25	35	45	55	65	75	85	95
	Feet							
5	91	127	163	199	234	—	—	—
6	131	183	234	286	338	—	—	—
7	178	249	319	389	460	530	—	—
8	233	325	417	509	601	692	—	—
9	295	411	528	644	760	876	992	—
10	364	508	652	796	939	1,082	1,225	—
11	440	615	789	963	1,136	1,310	1,483	1,656
12	524	732	939	1,146	1,353	1,559	1,765	1,971
13	615	859	1,102	1,345	1,588	1,830	2,072	2,314
14	714	997	1,279	1,560	1,842	2,123	2,403	2,684
15	819	1,144	1,468	1,792	2,115	2,437	2,759	3,081
16	933	1,302	1,671	2,039	2,406	2,773	3,140	3,506
17	1,053	1,470	1,886	2,302	2,717	3,131	3,545	3,959
18	1,181	1,648	2,115	2,581	3,046	3,511	3,975	4,439
19	1,316	1,837	2,357	2,876	3,395	3,912	4,430	4,946
20	1,458	2,035	2,612	3,187	3,762	4,336	4,909	5,481

— = Not applicable.

Table A6—Bole weight (pounds) by d.b.h. and height to a 3-in. top

	Height							
D.b.h.	20	30	40	50	60	70	80	90
In.	Feet							
5	100	145	188	231	273	—	—	—
6	141	204	266	326	386	—	—	—
7	189	274	357	438	517	595	—	—
8	244	353	460	564	666	768	—	—
9	305	442	575	705	834	960	1,085	—
10	372	540	703	862	1,019	1,173	1,326	—
11	446	647	842	1,033	1,221	1,406	1,589	1,770
12	527	764	994	1,219	1,441	1,659	1,875	2,089
13	613	889	1,157	1,419	1,677	1,932	2,183	2,432
14	706	1,024	1,332	1,634	1,931	2,224	2,514	2,800
15	805	1,167	1,519	1,863	2,202	2,536	2,866	3,192
16	910	1,319	1,717	2,106	2,489	2,867	3,240	3,609
17	1,021	1,480	1,927	2,364	2,793	3,217	3,636	4,050
18	1,138	1,650	2,148	2,635	3,114	3,586	4,053	4,515
19	1,262	1,829	2,381	2,920	3,451	3,975	4,492	5,004
20	1,391	2,016	2,624	3,220	3,805	4,382	4,952	5,516

— = Not applicable.

Table A7—Cubic-foot volume (outside bark) by d.b.h. and 16.5ft logs

	Logs							
D.b.h.	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
In.				Feet				
10	6.9	10.5	14.3	18.0	21.9	—	—	—
11	8.0	12.2	16.5	20.9	25.3	29.8	—	—
12	9.1	14.0	18.9	23.9	29.0	34.1	39.2	—
13	10.3	15.8	21.4	27.1	32.8	38.6	44.4	50.3
14	11.6	17.7	24.0	30.4	36.8	43.3	49.8	56.4
15	12.9	19.7	26.7	33.8	40.9	48.1	55.4	62.7
16	14.2	21.8	29.5	37.3	45.2	53.2	61.2	69.3
17	15.6	23.9	32.4	41.0	49.7	58.4	67.2	76.1
18	17.1	26.2	35.4	44.8	54.3	63.8	73.4	83.1
19	18.6	28.4	38.5	48.7	59.0	69.4	79.8	90.4
20	20.1	30.8	41.7	52.7	63.9	75.1	86.4	97.8

— = Nor applicable.

Table AS-Cubic-foot volume (inside bark) by d.b.h. and 16.5-ft logs

	Logs							
D.b.h.	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
In.				*Feet*				
10	5.7	8.5	11.2	14.0	16.7	—	—	—
11	6.8	10.0	13.3	16.5	19.7	22.9	—	—
12	7.9	11.7	15.5	19.2	22.9	26.7	30.3	—
13	9.1	13.4	17.8	22.1	26.4	30.7	34.9	39.2
14	10.3	15.3	20.3	25.2	30.1	34.9	39.8	44.6
15	11.6	17.3	22.9	28.4	33.9	39.4	44.9	50.3
16	13.0	19.4	25.6	31.8	38.0	44.1	50.2	56.3
17	14.5	21.5	28.5	35.4	42.2	49.1	55.9	62.6
18	16.0	23.8	31.5	39.1	46.7	54.2	61.7	69.2
19	17.6	26.1	34.6	43.0	51.3	59.6	67.9	76.1
20	19.3	28.6	37.8	47.0	56.1	65.2	74.3	83.3

— = Not applicable.

Table A9—Bole weight (pounds) by d.b.h. aud 16.5ft logs

	Logs							
D.b.h.	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
In.	- - - - - - - - - -	- - - - - - - - - -	- - - - - - - - - -	- - - - - *Feet*	- - - - - - - - - -	- - - - - - - - - -	- - - - - - - - - -	- - - - - - - - - -
10	400	590	777	962	1,145	—	—	
11	469	691	910	1,127	1,343	1,556	—	
12	542	799	1,053	1,304	1,552	1,799	2,045	—
13	619	913	1,203	1,490	1,774	2,057	2,337	2,616
14	701	1,033	1,361	1,686	2,008	2,327	2,645	2,961
15	786	1,159	1,527	1,891	2,252	2,611	2,967	3,322
16	876	1,291	1,701	2,106	2,509	2,908	3,305	3,699
17	969	1,429	1,882	2,331	2,775	3,217	3,656	4,093
18	1,066	1,572	2,070	2,564	3,053	3,539	4,022	4,503
19	1,166	1,720	2,266	2,806	3,341	3,873	4,402	4,927
20	1,270	1,874	2,468	3,056	3,640	4,219	4,795	5,368

— = Not applicable.

Table AlO-Cubic-foot volume (outside bark) by d.b.h. and 17.5-ft logs

	Logs							
D.b.h.	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
In.	- - - - - - - - - -	- - - - - - - - - -	- - - - - - - - - -	- - - - - *Feet*	- - - - - - - - - -	- - - - - - - - - -	- - - - - - - - - -	- - - - - - - - - -
10	7.3	11.2	15.2	19.2	23.3	—	—	—
11	8.5	13.0	17.6	22.2	26.9	31.7		
12	9.7	14.9	20.1	25.4	30.8	36.3	41.7	—
13	11.0	16.8	22.8	28.8	34.9	41.0	47.2	53.5
14	12.3	18.9	25.5	32.3	39.1	46.0	53.0	60.0
15	13.7	21.0	28.4	35.9	43.5	51.2	58.9	66.7
16	15.1	23.2	31.4	39.7	48.1	56.6	65.1	73.7
17	16.6	25.5	34.5	43.6	52.8	62.1	71.5	81.0
18	18.2	27.8	37.7	47.6	57.7	67.9	78.1	88.4
19	19.8	30.3	41.0	51.8	62.8	73.8	84.9	96.1
20	21.4	32.8	44.3	56.1	67.9	79.9	92.0	104.1

— = Not applicable.

Table All-Cubic-foot volume (inside bark) by d.b.b. and 17.5ft logs

	Logs							
D.b.h.	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
In.	*Feet*							
10	6.1	9.0	11.9	14.8	17.6	—	—	—
11	7.2	10.6	14.1	17.5	20.9	24.2	—	—
12	8.3	12.4	16.4	20.3	24.3	28.2	32.1	—
13	9.6	14.2	18.8	23.4	27.9	32.5	37.0	41.5
14	10.9	16.2	21.5	26.7	31.8	37.0	42.1	47.2
15	12.3	18.3	24.2	30.1	35.9	41.7	47.5	53.3
16	13.8	20.5	27.1	33.7	40.2	46.7	53.2	59.6
17	15.4	22.8	30.1	37.5	44.7	51.9	59.2	66.3
18	17.0	25.2	33.3	41.4	49.4	57.4	65.4	73.3
19	18.7	27.7	36.6	45.5	54.3	63.1	71.9	80.6
20	20.4	30.3	40.1	49.8	59.4	69.1	78.6	88.2

— = Not applicable.

Table A12—Bole weight (pounds) by d.b.h. and 17.5ft logs

	Logs							
D.b.h.	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
In.	*Feet*							
10	423	624	822	1,018	1,212	—		—
11	496	731	963	1,193	1,421	1,647	—	—
12	573	845	1,114	1,379	1,642	1,904	2,164	
13	655	966	1,273	1,576	1,877	2,176	2,473	2,768
14	741	1,093	1,440	1,784	2,124	2,462	2,798	3,132
15	832	1,227	1,616	2,001	2,383	2,762	3,139	3,514
16	926	1,366	1,800	2,229	2,654	3,076	3,496	3,914
17	1,025	1,511	1,991	2,466	2,936	3,404	3,868	4,330
18	1,127	1,663	2,190	2,712	3,230	3,744	4,255	4,764
19	1,234	1,820	2,397	2,968	3,535	4,098	4,657	5,213
20	1,344	1,982	2,611	3,234	3,851	4,464	5,073	5,679

— = Not applicable.

Newbold, **Ray A.; Baldwin, V. Clark, Jr.;** Hill, **Gary.** 2001. Weight and volume determination for planted loblolly pine in North Louisiana. Research Paper SRS-26. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 19 p.

The objective of this study was to assess the variability in weight-to-volume relationships in loblolly pine (*Pinus taeda* L.) plantations and to determine predictability based on stand age, site quality, and/or tree size. Trees ages ranged from 11 to 40 years, with diameters to 2 1 inches and heights to 9 1 feet. Measured site indices ranged from 45 to 72 at base age 25. A total of 75 planted loblolly pine trees were felled and processed to assess the variability in bole weight to volume relationships. Cubic volume, green weight, and dry weight relationships were investigated; and the predictability of these variables with respect to age, site index, and tree size was determined.

Keywords: Loblolly pine, ***Pinus taeda***, plantation, volume, weight.

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