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Research Report No. 5, Estimating the Cubic Foot Volume of Individual Loblolly Pine Trees Planted in East Texas

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REPORT NUMBER 5

TO

PARTICIPATING COMPANIES

IN THE

EAST TEXAS PINE PLANTATION RESEARCH PROJECT

A STUDY OF

LOBLOLLY AND SLASH PINE PLANTATIONS

IN

EAST TEXAS

CENTER FOR APPLIED STUDIES

SCHOOL OF FORESTRY

STEPHEN F. AUSTIN STATE UNIVERSITY

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This is the fifth in a continuing series of reports describing results from the East Texas Pine Plantation Research Project.

Subject and content of each ETPPRP report will be regional in scope and of particular interest to loblolly and slash pine plantation owners in East Texas.

Any suggestions, ideas or comments will always be welcomed.

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This report is based on work by:

1. Mr. Thomas J. Wiswell during the Spring '86 semester, as a doctoral student at SFASU on a T. L. L. Temple Fellowship.
2. Mr. Jock A. Blackard, as a Graduate Assistant.
3. Dr. J. David Lenhart.

J. David Lenhart
Project Director
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by

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__ABSTRACT__. Equations are presented to estimate the cubic foot content of the wood and bark in the stem and branches of individual loblolly pine trees planted on site-prepared land in East Texas. Taper functions are also developed.

INTRODUCTION

The estimation of the content of individual trees is a principal component in the measurement process to determine per acre yields. In particular, the content of individual trees is a value needed in the last stages of the diameter distribution yield prediction method. Also, tree information is useful in timber cruising.

In this report, we present equations to estimate the cubic foot content of individual planted loblolly pines in non-old-fields in East Texas as:

1. Complete Tree Cubic Feet Wood and Bark: CTCFWB.
2. Complete Tree Cubic Feet Wood only: CTCFW.
3. Total Stem Cubic Feet Wood and Bark: TSCFWB.
4. Partial Stem Cubic Feet Wood and Bark: PSCFWB
5. Total Stem Cubic Feet Wood only: TSCFW.
6. Partial Stem Cubic Feet Wood only: PSCFW.

By appropriate subtraction, the cubic feet of bark and the cubic feet of branches can be determined. Differences between total stem and partial stem values can be obtained for various multiple-product computations.

TREE MEASUREMENTS

A total of 68 loblolly pine sample trees located in the buffer zones of 34 of our 178 ETPPRP permanent plots in loblolly pine plantations were felled during January - March, 1986. Two trees were sampled per plantation. Three of the trees were eventually eliminated due to sampling errors. The distribution of the resulting 65 sample trees by county and by dbh and height classes is shown in Figure 1.

Prior to felling a tree, the dbh and crown class were determined. After felling, the branches were removed and weighed. A typical branch was weighed with and without needles. Eight branch segments (12" long) were cut and weighed with and without bark.

At 3-foot cut points along the stem, dob was recorded. Then the stem was bucked into 3-foot long bolts. Each bolt was weighed. At the bottom of each bolt, a 1- to 2-inch disk was cut. Each disk was weighed with and without bark. In addition, dib for each disk was noted. The top stem segment was also weighed and considered part of the stem.

The necessary field data was now available to compute observed cubic foot tree volume with and without bark as:

1. Partial stem to the top of each successive bolt.
2. Total stem.
3. Branches.

Branch volume was calculated using appropriate ratios of cubic feet to green weight. Complete tree cubic feet was determined by summing total stem and branch values.

COMPLETE TREE ESTIMATION

Plottings of CTCFWB and CTCFW over dbh (D) and total tree height (H) indicated a model originally suggested by Schumacher and Hall (1933) as

$$\text{Tree content} = b0D^{b1}H^{b2} \quad (1)$$

represented the relationships seen in the plottings.

Non-linear regression analysis of the data set produced the following prediction equations as

$$CTCFWB = 0.006389D^{2.242262}H^{0.668729} \quad (2)$$

and

$$CTCFW = 0.002196D^{2.263525}H^{0.872831}, \quad (3)$$

with $R^2 = 99\%$ for both equations*.

* All R^2 values in this report were calculated using non-linear regression results as:

$$R^2 = ((n-1)(\text{std dev dep var})^2 - \text{Residual SS})/((n-1)(\text{std dev dep var})^2)(100)$$

PARTIAL AND TOTAL STEM ESTIMATION

In a dissertation by McTague (1985), a new stem content estimation model was presented, that has several desirable properties:

1. Treats total stem content as a special case of partial stem content.
2. Predicts stem content between stump and any upper stem diameter limit.
3. Convertible to a well-behaved taper function.
4. Also, suitable for estimating green or dry weight of the total or partial stem.

Subsequently, Pienaar and others (1985) developed variations of the original McTague model as

$$\text{Volume wood \& Bark in the stem} = b_0 D^{b1} H^{b2} - b_3 (d^{b4} / D^{b4-2})(H - 4.5), \qquad (4)$$

where d = upper stem diameter o. b. and

$$b_3 = 0.00545415(1-2/b_4),$$

and

$$\text{Volume wood only in the stem} = c_0 D^{c1} H^{c2} - c_3 (d^{c4} / D^{c4-2})(h - 4.5), \qquad (5)$$

Equation (4) was used in non-linear regression analysis with a data set comprised of 745 cases of cubic feet wood and bark . The resulting equation is

$$PSCFWB = 0.002103D^{1.958489}H^{1.062348}$$

$$- 0.0020323d^{3.187878}D^{-1.187878}(H - 4.5) \qquad (6)$$

with $R^2 = 98\%$.

If the value for the variable d (upper stem diameter o. b.)in Eq. 6 is set to zero (or the top of the stem), the latter part of Eq. 6 disappears, and we now have an equation to estimate

$$TSCFWB = 0.002103D^{1.958489}H^{1.062348}. \qquad (7)$$

Equation (5) was used in non-linear regression analysis with a data set comprised of 745 cases of cubic feet wood only . The resulting equation is

$$PSCFW = 0.000928D^{1.973735}H^{1.213909}$$

$$- 0.0017751d^{2.903589}D^{-0.903589}(H - 4.5) \qquad (8)$$

with $R^2 = 98\%$

and

$$TSCFW = 0.000928D^{1.973735}H^{1.213909} \qquad (9)$$

Tables 1 and 2 show predicted cubic foot volumes for various combinations of D, H and d based on Eqs. 6 and 8, respectively.

TABLE 1. ESTIMATED CUBIC FEET OF WOOD AND BARK IN THE STEM TO SPECIFIED UPPER DIAMETER LIMITS FOR INDIVIDUAL LOBLOLLY PINE TREES ON NON-OLD-FIELD PLANTATIONS IN EAST TEXAS.

DBH (IN)	UPPER STEM DIAMETER LIMIT (IN)	TOTAL TREE HEIGHT (FEET) 20	30	40	50	60	70	80
2	0	0						
4	0	1	1					
	2	1	1					
6	0		3	4	4			
	2		3	3	4			
	4		2	3	4			
8	0			6	8	10		
	2			6	8	9		
	4			6	7	9		
	6			4	6	7		
10	0				12	15	17	
	2				12	15	17	
	4				12	14	17	
	6				10	13	15	
12	0					21	25	29
	2					21	25	29
	4					21	24	28
	6					19	23	26
	8					17	20	23
14	0					29	34	39
	2					29	34	39
	4					28	33	38
	6					27	32	37
	8					25	29	34

TABLE 2. ESTIMATED CUBIC FEET OF WOOD ONLY IN THE STEM TO SPECIFIED UPPER DIAMETER LIMITS FOR INDIVIDUAL LOBLOLLY PINE TREES ON NON-OLD-FIELD PLANTATIONS IN EAST TEXAS.

DBH (IN)	UPPER STEM DIAMETER LIMIT (IN)	TOTAL TREE HEIGHT (FEET) 20	30	40	50	60	70	80
2	0	0						
4	0	1	1					
	2	0	1					
6	0		2	3	4			
	2		2	3	4			
	4		1	2	3			
8	0			5	6	8		
	2			5	6	8		
	4			4	6	7		
	6			3	4	5		
10	0				10	13	15	
	2				10	12	15	
	4				10	12	14	
	6				8	10	13	
12	0					18	22	26
	2					18	22	25
	4					17	21	25
	6					16	20	23
	8					14	17	20
14	0					24	29	35
	2					24	29	35
	4					24	29	34
	6					23	28	32
	8					21	25	30

TAPER FUNCTIONS

Based on a procedure outlined by Clutter (1980) and Pienaar et al. (1985), Eq. 6 was converted into the following taper equations as

$$\text{Upper stem dob} = D((H - L)/(H - 4.5))^{0.841837}, \quad (10)$$

Where L = Position on upper stem where dob occurs,

and

$$L = H - (H - 4.5)(dob/D)^{1.187878}. \quad (11)$$

Eq. 8 was converted into the following taper equations as

$$\text{Upper stem dib} = 0.885852D((H - L)/(H - 4.5))^{0.722175}, \quad (12)$$

and

$$L = H - 1.182741(H - 4.5)(dib/D)^{1.384706}. \quad (13)$$

where L = Position on upper stem where dib occurs,

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