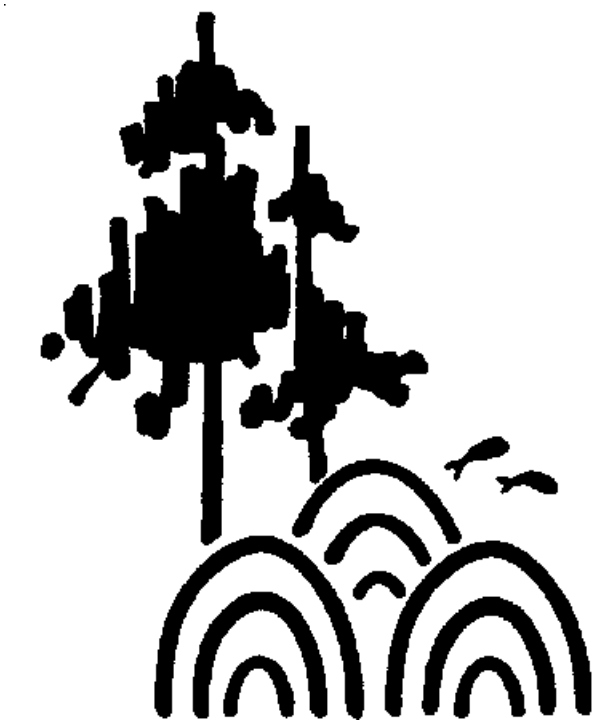
Diameter Distributions and Yields of Natural Stands of Loblolly Pine



Publication No. FWS-1-84
School of Forestry and Wildlife Resources
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061
1984

Revised July, 2001

DIAMETER DISTRIBUTIONS AND YIELDS OF NATURAL STANDS OF LOBLOLLY PINE

by

Thomas E. Burk

Harold E. Burkhart

Publication No. FWS-1-84
School of Forestry and Wildlife Resources
Virginia Polytechnic Institute
and State University
Blacksburg, Virginia 24061
1984

Revised July, 2001

PREFACE

This paper presents a diameter distribution growth and yield model, and Windows based software for implementing the model, for natural stands of loblolly pine. Those wishing to obtain copies of the software should contact:

Department of Forestry
Virginia Tech
Blacksburg, Virginia 24061

To defer the cost of development, a charge of $40.00 will be made for the Windows software. Checks should be made payable to *Treasurer, Virginia Tech*.

Although the software has been extensively tested and checked for accuracy and, to the best of our knowledge, contains no errors, neither Virginia Tech, the Department of Forestry, nor the authors claim any responsibility for any errors that do arise.

ABSTRACT

A diameter distribution yield model was developed based upon measurements of 117 0.1-acre temporary plots located in naturally regenerated loblolly pine stands in the Piedmont and Coastal Plain of Virginia and the Coastal Plain of North Carolina. Diameter distributions were derived using the Weibull density function by requiring that the distribution's arithmetic and quadratic means matched those predicted from stand-level attributes using regression equations. Stand and stock tables are presented for 30-year projections from age 20 for various combinations of site index and initial basal area.

AUTHORS

The authors are, respectively, Professor, Department of Forest Resources, University of Minnesota, St. Paul, MN, 55108, and University Distinguished Professor, Department of Forestry, Virginia Tech, Blacksburg, Virginia 24061.

TABLE OF CONTENTS

LIST OF TABLES

DIAMETER DISTRIBUTIONS AND YIELDS OF NATURAL STANDS OF LOBLOLLY PINE

Thomas E. Burk and Harold E. Burkhart

INTRODUCTION

An extensive acreage of naturally regenerated loblolly pine (*Pinus taeda* L.) exists in the southeastern United States. Reliable growth and yield information is needed if these stands are to be managed in a sound manner. Models predicting whole stand volume yields (Brender and Clutter 1970, Burkhart et al. 1972) and stand basal area and volume growth (Sullivan and Clutter 1972, Murphy and Sternitzke 1979) do exist for natural stands of loblolly pine in the Southeast. Forest managers, however, often desire growth and yield information at the size-class distribution level. Models providing this type of information are not presently available for natural stands of loblolly pine.

The objectives of this study were to: (1) develop a diameter distribution model for natural stands of loblolly pine, and (2) program this model and an existing stand basal area growth model to allow rapid prediction of current and future stand and stock tables.

DATA

Data for this study were previously used by Burkhart et al. (1972) to develop a whole stand yield model for natural stands of Loblolly pine. One-tenth acre temporary plots were randomly located in selected stands in the Piedmont and Coastal Plain of Virginia and the Coastal Plain of North Carolina. Measurements taken relevant to the present study were stand age and dominant and codominant height based on six to eight trees, dbh (nearest 0.1-inch) and product class (sawtimber, 8-inch dbh class or larger having at least one 16-foot sawlog to a 6-inch inside bark top diameter, or not) of each plot tree, and total height for a subsample of plot trees.

The yield model developed by Burkhart et al. (1972) included a variable describing the amount of hardwood competition in a stand. For the equations developed in the present study neither partial residual plots nor t-statistics indicated the need for such a term. Since the hardwood component is not accounted for in the final equations, a maximum level of 25 percent hardwood by basal area was set. Four of the original 121 plots had larger hardwood components than this and were deleted for the present study.

A number of the study plots appeared to have been tallied to a 4.6-inch dbh limit. In order to use these plots, the left tails of their diameter distributions needed to be filled in. A logit model relating percent of trees less than 4.6-inches dbh to stand attributes of trees greater than

4.6-inches dbh was fitted using plots where all trees, regardless of dbh, were tallied. Using this equation, number of trees below 4.6-inches dbh was predicted for the truncated plots. A three-parameter, left-censored Weibull distribution was then fitted to each of these plots (Zutter et al. 1982). Plot basal area and arithmetic mean dbh were then corrected using the first two noncentral moments of the fitted distribution. Subsequent comparisons of equations based upon both the adjusted and unadjusted data indicated only minor differences.

Statistics for variables relevant to this study are presented in Table 1. These statistics reflect the adjustments made to some plots as discussed above. The 117 plots used in this study are categorized by age, site index (base age 50, Schumacher and Coile 1960), and basal area in Table 2.

METHODS

Stand-level equations

Equations to predict current trees per acre, basal area, and arithmetic mean dbh were derived from the 117 study plots. The independent variables used were stand age, height of dominants and codominants, and basal area (trees per acre was used for the basal area equation). For each equation, various transformations of these independent variables were screened and the final equation form chosen based upon the PRESS statistic. The arithmetic mean dbh equation was conditioned to insure predicted values would be less than quadratic mean dbh. Transformations of the dependent variables were chosen using the Box-Cox procedure.

To predict future stand conditions, a basal area projection and/or a tree survival equation are (is) necessary. Since the available study data did not allow the derivation of such equations, the literature was consulted. No tree survival equation could be found for natural stands of loblolly pine. Although several basal area projection equations exist, Sullivan and Clutter's (1972) was thought to be most applicable to the present study area. This equation does, however, require an estimate of site index. The site curves used bv Sullivan and Clutter (1972) were published in chart form by Coile (1952). Study of several existing site index equations for natural stands of loblolly pine showed that Schumacher and Coile's (1960) equation most closely reproduced the curves of Coile (1952). Site index curves are also required to predict future values of dominant and codominant height.

Table 1. Statistical summary of the 117 study plots.

Variable	Statistic		
	Minimum	Average	Maximum
Age (years)	13	29	77
Dominant and codominant height (feet)	40	61	81
Site index[a] (feet)	58	80	102
Trees per acre (number)	90	521	1220
Basal area (sq. ft. per acre)	42	144	217
Arithmetic mean dbh (inches)	4.5	7.7	14.4

[a]Based on a base age 50 site index equation from Schumacher and Coile (1960).

Table 2. Study plots categorized by age, site index (base age 50, Schumacher and Coile 1960), and basal area.

Age (years)	Site index (feet)	Basal area (sq. ft./acre)					
		60	100	140	180	220	Total
<15	90			1			1
	100			1			1
				2			2
15-29	60	1	2				3
	70		4	8	2		14
	80	3	3	16	5		27
	90			10	5	3	18
	100		1	1	4	1	7
		4	10	35	16	4	69
30-44	70	1	2	5	4		12
	80			16	5	2	23
	90				1		1
		1	2	21	10	2	36
45-59	70		4	1			5
	80		1		1		2
			5	1	1		7
60-74	60	1					1
	80	1					1
		2					2
>74	70	1					1
		1					1
Total		5	20	59	27	6	117

Tree-level equations

Diameter distribution growth and yield models require some method of predicting individual tree height from tree dbh and stand attributes. In the present study the methods proposed by Lenhart and Clutter (1971) and Matney and Sullivan (1982) were evaluated. Based on bias and absolute prediction error criteria, Matney and Sullivan's (1982) method performed slightly better. In this method the equation

$$\ln(h) = \ln(a_0) + a_1/dbh \qquad (1)$$

where h = total tree height (feet)
$\ln$ = natural logarithm
a_0, a_1 = regression coefficients

is fitted to the total height-dbh pairs for each plot. Equations are then obtained to predict a_0 and a_1 from stand-level attributes. The equations that gave the best results for the present study were

$$a_0 = H(1.0 + b_1 B^{b_2} \exp(b_3 H)) \qquad (2)$$

$$\overline{H} = H \exp(-H^{c_1}/(\overline{D}_2 + c_2)^{c_3}) \qquad (3)$$

$$a_1 = \overline{D}_2(\ln(\overline{H}) - \ln(a_0)) \qquad (4)$$

where H = height of dominants and codominants (feet)
B = basal area (square feet per acre)
$\overline{H}$ = height of tree of dbh $\overline{D}_2$ (feet)
$\overline{D}_2$ = quadratic mean dbh (inches)
exp = inverse natural logarithm
b_i's, c_i's = regression coefficients

Note that with this method asymptotic height and height of the tree of mean basal area are conditioned to be greater and smaller, respectively, than the height of dominants and codominants. However, individual tree heights are not restricted to be greater than 4.5 feet.

The product class information collected for each tree in the study data set allowed development of an equation predicting the probability that a tree is of sawtimber quality. The logistic equation has several properties which make it appropriate for describing this

relationship. To make the data set of more manageable size, trees were assigned to one-half inch dbh classes. Weighted nonlinear regression was used to fit the logistic equation to the data. After finding the best transformation of dbh to include in the equation, the stand-level variables age, height of dominants and codominants, and basal area were added. Only basal area added significantly to the explanatory power of the equation. The final equation form used was

$$P = 1.0/(1.0 + \exp(b_0 + b_1/dbh + b_2 B)) \quad (5)$$

where P = probability that a tree is sawtimber quality
b_i's = regression coefficients

In using this equation the condition $P = 0$ if $dbh < 7.6$ would be imposed.

Diameter distribution growth and yield models require an individual tree volume (or taper) equation to obtain a stock table from the stand table. A number of individual tree volume equations are available for naturally regenerated loblolly pine. Burkhart et al. (1972) presented several standard volume equations derived from the same data source used in the present study. Burkhart (1977) provided volume ratio equations based on the same data.

Recovering the diameter distribution

Due to its successful application in related studies and plots of diameter frequency data, the Weibull distribution was chosen for generating the dbh distribution of natural stands of loblolly pine. The Weibull density function is

$$f_X(x) = (c/b)[(x-a)/b]^{c-1} \exp\left\{-[(x-a)/b]^c\right\}$$

$$= 0, \text{ elsewhere}$$

where x = random variable (dbh here)
a = location parameter
b = scale parameter
c = shape parameter

An equation was first sought for predicting the location parameter. The commonly used approach of first predicting the minimum observed dbh was not possible since this value was not available for all study plots. Location parameters were found for each plot using the complete or left-censored Weibull maximum likelihood equations. The equation form providing the most logical predictions of these values was

$$a = \max(0.0, b_0 + b_1 B + b_2 \overline{D}_2) \quad (6)$$

where b_i's = regression coefficients

Once the location parameter is "known," estimates of the scale and shape parameters can be obtained such that the first two noncentral moments of the predicted distribution match specified values of arithmetic mean dbh and (quadratic mean dbh)^2. The appropriate equations are

$$b = \left(\overline{D}_1 - a\right)/\Gamma_1 \tag{7}$$

$$\overline{D}_2^2 - a^2 - 2a\left(\overline{D}_1 - a\right) - \left(\overline{D}_1 - a\right)^2 \Gamma_2 / \Gamma_1^2 = 0 \tag{8}$$

where:

$\overline{D}$ = arithmetic mean dbh (inches)

Γ_k = $\Gamma (1 + k/c)$

Γ = the complete gamma function

Software was written to solve (8) using a combination of the bisection and secant methods for finding roots of nonlinear equations. With c and a known, b can be determined using (7).

RESULTS AND DISCUSSION

The equations developed in this study are presented in Table 3. The fit statistics for these equations are comparable to those reported by other researchers. Statistics for the probability of sawtimber equation are based on predictions for individual trees; that is, observed values were either 0 or 1. The software utilizes these equations to generate a stand table for a natural loblolly pine stand of specified age, dominant and codominant height, and basal area and/or trees per acre. Two volume estimates by dbh class, are also provided using the individual tree volume equations of Burkhart et al. (1972) and Burkhart (1977). Further, the software allows projection of the stand table based upon Sullivan and Clutter's (1972) basal area projection equation and Schumacher and Coile's (1960) site index equation.

Stand and stock tables for ten-year projections from age 20 to age 50 are provided for nine combinations of initial basal area and site index in Tables 4 through 12. Midpoint dbhs were used to compute class basal area, total tree height, and volumes so that tabled values can be reproduced by hand (within rounding error). For this same reason (and rounding), total basal

area may not match exactly the value on which the recovery was conditioned. Table totals also may not add exactly due to rounding. The board foot volumes in these tables were computed using the equation in Burkhart et al. (1972). The cubic foot volumes were computed using the equations in Burkhart (1977).

Table 3. Stand and tree attribute equations for natural stands of loblolly pine.

Attribute	Equation[a]
Trees per acre	$\ln(N) = 8.3931 + 1.8360\ \ln(B) - .01968\ A - 2.4754\ \ln(H) - 0.1112\ B/A$ $R^2(N) = .77$ bias $(N) = -10$ $MAD(N) = 86$
Basal area	$\ln(B) = 2.8078 + .5027\ \ln(N) + .009135\ A + 12.4668/A - 100.6073/H$ $R^2(B) = .71$ bias$(B) = -1$ $MAD(B) = 15$
Arithmetic mean dbh	$\ln(\overline{D}_2 - \overline{D}_1) = 32.9856 - 4.7745\ln(H) - 326.148/H - 1.7136\ln(B) - 109.5631/B$ $R^2(\overline{D}_1) = .99$ bias $(\overline{D}_1) = .01$ $MAD(\overline{D}_1) = .06$
Probability of sawtimber tree	$P = 1.0/(1.0 + \exp(-10.8908 + 122.6106/\text{dbh} - .0224\ B))$ $R^2(P) = .53$ bias$(P) = 0$ $MAD(P) = .24$ $P = .48$ $n = 2052$
Total tree height	$\ln(h) = \ln(a_0) + a_1/\text{dbh}$ $a_0 = H\ (1.0 + 3.4831B^{-.6504} \exp(.01088\ H))$ $\overline{H} = H\exp(-H^{.9053}/(\overline{D}_2 + 4.2566)^{2.4606})$ $a_1 = \overline{D}_2(\ln\overline{H} - \ln(a_0))$ $R^2(h) = .86$ bias$(h) = .2$ $MAD(h) = 3.3$ $\overline{h} = 55.7$ $n = 1651$
Weibull location parameter	$a = \max(0.0, -3.6732 + .01111B + .6876\overline{D}_2)$ $R^2(a) = .54$ bias$(a) = 0$ $MAD(a) = .9$ $\overline{a} = 3.1$

[a]Notation

N	=	trees per acre (number)
B	=	basal area (square feet per acre)
A	=	stand age (years)
H	=	dominant and codominant height (feet)
$\overline{D}_1$	=	arithmetic mean dbh (inches)
$\overline{D}_2$	=	quadratic mean dbh (inches)
dbh	=	diameter at breast height (inches)
P	=	probability that a tree is sawtimber quality
h	=	individual tree total height (feet)
a0	=	asymptote in total height-dbh regression (feet)
a1	=	slope coefficient in total height-dbh regression
a	=	Weibull location parameter
$\overline{H}$	=	total height of tree of dbh $\overline{D}_2$ (feet)
n	=	number of observations fit statistics are based upon
1n	=	natural logarithm
exp	=	inverse natural logarithm
R^2()	=	square of simple correlation between observed and predicted
bias()	=	average difference between predicted and observed
MAD()	=	average absolute difference between observed and predicted

The one component missing from the model presented for natural stands of loblolly pine is a tree survival equation. Trees per acre for a projected stand are estimated using projected basal area and the current trees per acre equation. In most instances this procedure will result in reasonable predictions. However, near the extremes of the data inconsistencies can occur. Since the current number of trees per acre is predicted using height of dominants and codominants, the prevalence of the problem also depends on the site index equation used. Currently the computer program sets future trees per acre equal to current trees per acre if predictions exceed current number.

The model presented should provide an adequate representation of a natural stand of loblolly pine for a wide range of stand conditions. Model components were developed with the most current techniques, and care was taken to insure each component incorporated as much theoretical knowledge as possible. Still, caution should be exercised in situations near the extremes of the data. Further, it should be remembered that stands with greater than 25 percent hardwood, by basal area, were excluded from the study. As is always the case with a growth and yield model, users must understand the nature of the values predicted by the model. Further, the applicability of the basal area projection equation suggested for use with the model must be evaluated for each user's circumstances.

Table 4. Natural stand loblolly pine stand and stock tables for ten-year projections from age 20 to age 50 for an initial basal area of 90 square feet per acre and a site index (base age 50, Schumacher and Coile 1960) of 70 feet.

AGE 20 YEARS
SITE INDEX(BASE 50) 70 FEET
BASAL AREA 90 SQ.FT.
TREES PER ACRE 578
DOM./CODOM. HEIGHT 45 FEET
ARITHMETIC MEAN DBH 5.1 INCHES
QUADRATIC MEAN DBH 5.3 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
1	1.3	0.0	7	0	0
2	24.9	0.5	21	0	0
3	73.0	3.6	29	0	0
4	118.7	10.8	35	37	0
5	134.7	18.8	39	170	0
6	112.4	22.1	41	272	0
7	69.2	18.5	43	263	0
8	31.2	10.9	45	155	20
9	10.1	4.4	46	49	58
10	2.3	1.2	47	7	43
11	0.4	0.2	48	1	12
TOTAL	578.1	90.2	---	953	134

AGE 30 YEARS
SITE INDEX(BASE 50) 70 FEET
BASAL AREA 118 SQ.FT.
TREES PER ACRE 446
DOM./CODOM. HEIGHT 57 FEET
ARITHMETIC MEAN DBH 6.6 INCHES
QUADRATIC MEAN DBH 7.0 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
2	0.1	0.0	21	0	0
3	18.6	0.9	32	0	0
4	51.9	4.5	40	18	0
5	75.4	10.3	45	111	0
6	83.0	16.3	49	238	0
7	75.5	20.2	52	343	0
8	58.5	20.4	54	327	121
9	39.4	17.4	56	181	495
10	23.1	12.6	58	58	720
11	11.9	7.9	59	14	603
12	5.4	4.3	60	3	375
13	2.2	2.0	61	1	192
14	0.8	0.8	62	0	84
15	0.2	0.3	63	0	31
16	0.1	0.1	63	0	10
TOTAL	446.2	118.0	---	1293	2630

AGE 40 YEARS
SITE INDEX(BASE 50) 70 FEET
BASAL AREA 135 SQ.FT.
TREES PER ACRE 366
DOM./CODOM. HEIGHT 65 FEET
ARITHMETIC MEAN DBH 7.9 INCHES
QUADRATIC MEAN DBH 8.2 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
4	13.3	1.1	41	5	0
5	38.2	5.2	48	58	0
6	56.6	11.1	52	174	0
7	64.0	17.1	56	344	0
8	60.6	21.2	59	385	232
9	49.7	23.9	61	284	880
10	35.8	19.6	63	78	1383
11	23.0	15.2	65	21	1558
12	13.2	10.1	66	6	1047
13	6.8	6.2	67	2	681
14	3.1	3.3	69	0	385
15	1.1	1.6	69	0	191
16	0.5	0.7	70	0	84
17	0.2	0.3	71	0	33
TOTAL	366.0	134.8	---	1203	6253

AGE 50 YEARS
SITE INDEX(BASE 50) 70 FEET
BASAL AREA 146 SQ.FT.
TREES PER ACRE 304
DOM./CODOM. HEIGHT 70 FEET
ARITHMETIC MEAN DBH 9.1 INCHES
QUADRATIC MEAN DBH 9.4 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
4	0.1	0.0	42	0	0
5	10.1	1.4	49	16	0
6	28.7	5.6	54	91	0
7	43.5	11.6	58	221	0
8	50.8	17.7	61	285	237
9	49.8	22.0	64	184	1054
10	42.9	25.2	66	72	1824
11	32.0	27.1	68	24	2449
12	21.4	26.8	70	8	1890
13	12.8	21.8	71	3	1386
14	6.9	15.4	72	1	911
15	3.3	9.1	73	0	526
16	1.4	4.9	74	0	269
17	0.6	2.0	75	0	122
18	0.2	0.8	76	0	49
19	0.1	0.3	77	0	18
TOTAL	304.3	186.2	---	904	10275

Table 5. Natural stand loblolly pine stand and stock tables for ten-year projections from age 20 to age 50 for an initial basal area of 100 square feet per acre and a site index (base age 50, Schumacher and Coile 1960) of 70 feet.

AGE 20 YEARS
SITE INDEX(BASE 50) 70 FEET
BASAL AREA 100 SQ.FT.
TREES PER ACRE 664
DOM./CODOM. HEIGHT 45 FEET
ARITHMETIC MEAN DBH 5.0 INCHES
QUADRATIC MEAN DBH 5.3 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
1	1.2	0.0	8	0	0
2	28.0	0.6	22	0	0
3	86.3	4.2	30	0	0
4	142.3	12.4	35	45	0
5	159.9	21.8	39	202	0
6	129.0	25.3	41	313	0
7	75.0	20.1	43	285	0
8	31.0	10.8	45	150	25
9	8.9	3.9	46	40	59
10	1.7	0.9	47	5	31
11	0.2	0.1	48	0	8
TOTAL	663.6	100.3	---	1039	126

AGE 30 YEARS
SITE INDEX(BASE 50) 70 FEET
BASAL AREA 126 SQ.FT.
TREES PER ACRE 492
DOM./CODOM. HEIGHT 57 FEET
ARITHMETIC MEAN DBH 6.6 INCHES
QUADRATIC MEAN DBH 6.9 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
3	19.8	1.0	33	0	0
4	58.3	5.1	40	21	0
5	85.9	11.7	45	127	0
6	94.5	18.6	49	272	0
7	84.8	22.7	52	386	0
8	64.3	22.4	54	349	157
9	41.8	18.5	56	174	578
10	23.5	12.8	58	50	758
11	11.4	7.6	59	11	583
12	4.9	3.8	60	2	337
13	1.8	1.7	61	1	159
14	0.6	0.6	62	0	63
15	0.2	0.2	62	0	21
TOTAL	491.7	126.5	---	1393	2657

AGE 40 YEARS
SITE INDEX(BASE 50) 70 FEET
BASAL AREA 142 SQ.FT.
TREES PER ACRE 395
DOM./CODOM. HEIGHT 65 FEET
ARITHMETIC MEAN DBH 7.8 INCHES
QUADRATIC MEAN DBH 8.1 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
4	14.0	1.2	42	5	0
5	42.2	5.8	48	66	0
6	63.0	12.4	53	194	0
7	71.1	19.0	56	350	0
8	66.6	23.3	59	468	266
9	53.6	23.7	61	200	1019
10	37.7	20.6	63	66	1494
11	23.4	15.4	65	19	1396
12	12.9	10.1	66	5	1026
13	6.3	5.8	67	1	634
14	2.7	2.9	68	0	337
15	1.1	1.3	69	0	156
16	0.4	0.5	70	0	64
17	0.1	0.2	71	0	23
TOTAL	395.1	142.1	---	1276	6414

AGE 50 YEARS
SITE INDEX(BASE 50) 70 FEET
BASAL AREA 152 SQ.FT.
TREES PER ACRE 324
DOM./CODOM. HEIGHT 70 FEET
ARITHMETIC MEAN DBH 9.0 INCHES
QUADRATIC MEAN DBH 9.3 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
4	0.1	0.0	42	0	0
5	11.0	1.5	49	18	0
6	31.4	6.2	54	108	0
7	47.8	12.8	58	244	0
8	55.6	19.4	62	302	290
9	54.0	23.9	64	182	1205
10	45.3	24.7	66	68	1985
11	33.4	22.0	68	22	2155
12	21.7	17.1	70	7	1863
13	12.6	11.6	71	2	1360
14	6.5	6.9	72	1	857
15	3.0	3.7	73	0	471
16	1.2	1.7	74	0	227
17	0.4	0.7	75	0	97
18	0.1	0.3	76	0	36
TOTAL	324.1	152.4	---	946	10546

Table 6. Natural stand loblolly pine stand and stock tables for ten-year projections from age 20 to age 50 for an initial basal area of 110 square feet per acre and a site index (base age 50, Schumacher and Coile 1960) of 70 feet.

AGE 20 YEARS
SITE INDEX(BASE 50) 70 FEET
BASAL AREA 110 SQ.FT.
TREES PER ACRE 748
DOM./CODOM. HEIGHT 45 FEET
ARITHMETIC MEAN DBH 5.0 INCHES
QUADRATIC MEAN DBH 5.2 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
1	0.9	0.0	9	0	0
2	99.6	0.6	22	0	0
3	98.6	4.8	30	0	0
4	166.4	14.5	35	53	0
5	186.3	25.4	39	236	0
6	146.2	28.7	41	359	0
7	80.3	21.5	43	304	0
8	30.3	10.6	45	143	29
9	7.7	3.4	46	31	57
10	1.3	0.7	47	3	26
11	0.1	0.1	48	0	5
TOTAL	747.7	110.3	---	1125	117

AGE 30 YEARS
SITE INDEX(BASE 50) 70 FEET
BASAL AREA 135 SQ.FT.
TREES PER ACRE 536
DOM./CODOM. HEIGHT 57 FEET
ARITHMETIC MEAN DBH 6.5 INCHES
QUADRATIC MEAN DBH 6.8 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
3	20.4	1.0	33	0	0
4	64.3	5.6	41	23	0
5	96.5	13.2	46	143	0
6	106.1	20.8	49	306	0
7	94.2	25.2	52	430	0
8	69.8	24.4	54	366	199
9	43.9	19.4	56	185	660
10	23.6	12.9	58	43	785
11	10.9	7.2	59	9	559
12	4.3	3.4	60	2	299
13	1.5	1.4	61	0	130
14	0.4	0.5	62	0	47
15	0.1	0.1	62	0	14
TOTAL	535.8	134.8	---	1486	2692

AGE 40 YEARS
SITE INDEX(BASE 50) 70 FEET
BASAL AREA 149 SQ.FT.
TREES PER ACRE 423
DOM./CODOM. HEIGHT 65 FEET
ARITHMETIC MEAN DBH 7.8 INCHES
QUADRATIC MEAN DBH 8.0 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
4	14.6	1.3	42	6	0
5	46.0	6.3	48	73	0
6	69.3	13.6	53	215	0
7	78.2	20.9	56	386	0
8	72.5	25.3	59	387	328
9	57.4	25.4	61	195	1157
10	39.4	21.5	63	60	1592
11	23.7	15.6	65	16	1420
12	12.5	9.8	66	4	997
13	5.8	5.4	67	1	586
14	2.4	2.6	68	0	294
15	0.9	1.1	69	0	128
16	0.3	0.4	70	0	48
17	0.1	0.1	71	0	16
TOTAL	423.1	149.1	---	1343	6565

AGE 50 YEARS
SITE INDEX(BASE 50) 70 FEET
BASAL AREA 158 SQ.FT.
TREES PER ACRE 343
DOM./CODOM. HEIGHT 70 FEET
ARITHMETIC MEAN DBH 8.9 INCHES
QUADRATIC MEAN DBH 9.2 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
4	0.1	0.0	43	0	0
5	11.7	1.6	49	19	0
6	34.1	6.7	55	109	0
7	52.0	13.9	59	266	0
8	60.3	21.0	62	317	148
9	58.0	25.6	64	179	1156
10	48.0	26.2	66	64	2136
11	34.6	22.8	68	20	2248
12	21.9	17.2	70	6	1883
13	12.3	11.3	71	2	1327
14	6.1	6.5	72	1	802
15	2.7	3.3	73	0	420
16	1.0	1.4	74	0	192
17	0.4	0.6	75	0	77
18	0.1	0.2	76	0	27
TOTAL	343.1	158.4	---	983	10516

Table 7. Natural stand loblolly pine stand and stock tables for ten-year projections from age 20 to age 50 for an initial basal area of 100 square feet per acre and a site index (base age 50, Schumacher and Coile 1960) of 80 feet.

AGE 20 YEARS
SITE INDEX(BASE 50) 80 FEET
BASAL AREA 100 SQ.FT.
TREES PER ACRE 476
DOM./CODOM. HEIGHT 51 FEET
ARITHMETIC MEAN DBH 5.9 INCHES
QUADRATIC MEAN DBH 6.2 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
2	7.9	0.2	21	0	0
4	41.1	2.0	31	0	0
6	78.3	6.5	37	29	0
8	92.5	12.6	42	126	0
10	90.6	17.8	45	240	0
12	72.8	19.5	48	304	0
14	48.8	17.0	50	262	56
16	27.5	12.1	51	137	231
18	13.0	7.1	53	40	316
20	5.2	3.4	54	8	220
22	1.7	1.4	55	1	105
24	0.5	0.5	56	0	38
26	0.1	0.1	56	0	11
TOTAL	476.1	100.2	---	1144	976

AGE 30 YEARS
SITE INDEX(BASE 50) 80 FEET
BASAL AREA 138 SQ.FT.
TREES PER ACRE 398
DOM./CODOM. HEIGHT 66 FEET
ARITHMETIC MEAN DBH 7.7 INCHES
QUADRATIC MEAN DBH 8.0 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
3	0.3	0.0	34	0	0
4	18.6	1.6	42	7	0
5	46.6	6.3	49	74	0
6	65.6	12.9	53	205	0
7	71.5	19.1	57	356	0
8	65.2	22.6	60	371	250
9	51.4	22.7	62	205	963
10	35.6	19.9	64	68	1416
11	21.8	14.4	66	19	1314
12	11.8	9.3	67	5	958
13	5.7	5.1	68	1	588
14	2.5	2.7	69	0	312
15	1.0	1.2	70	0	145
16	0.3	0.5	71	0	59
17	0.1	0.2	72	0	21
TOTAL	398.0	138.3	---	1311	6027

AGE 40 YEARS
SITE INDEX(BASE 50) 80 FEET
BASAL AREA 162 SQ.FT.
TREES PER ACRE 343
DOM./CODOM. HEIGHT 78 FEET
ARITHMETIC MEAN DBH 9.1 INCHES
QUADRATIC MEAN DBH 9.3 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
5	8.9	1.1	51	14	0
6	30.9	6.0	57	101	0
7	49.8	13.3	61	267	0
8	60.2	21.0	65	323	413
9	59.7	26.4	68	182	1562
10	50.4	27.5	70	65	2444
11	36.8	24.3	72	21	2578
12	23.5	18.4	74	7	2163
13	13.1	12.1	75	2	1519
14	6.4	6.9	77	1	910
15	2.8	3.4	78	0	469
16	1.1	1.5	79	0	209
17	0.4	0.6	80	0	81
18	0.1	0.2	80	0	27
TOTAL	342.8	162.6	---	983	12374

AGE 50 YEARS
SITE INDEX(BASE 50) 80 FEET
BASAL AREA 179 SQ.FT.
TREES PER ACRE 295
DOM./CODOM. HEIGHT 80 FEET
ARITHMETIC MEAN DBH 10.3 INCHES
QUADRATIC MEAN DBH 10.6 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
6	4.6	0.9	59	16	0
7	20.4	5.5	63	114	0
8	37.5	13.1	67	183	353
9	49.4	21.8	71	119	1520
10	52.5	28.6	73	50	2802
11	47.0	31.0	76	20	3543
12	35.9	28.2	78	7	3937
13	23.6	21.7	79	3	2912
14	13.3	14.3	81	1	2009
15	6.5	8.0	82	0	1170
16	2.7	3.8	83	0	577
17	1.0	1.6	84	0	241
18	0.3	0.5	85	0	85
19	0.1	0.2	86	0	26
TOTAL	294.7	179.1	---	513	18777

Table 8. Natural stand loblolly pine stand and stock tables for ten-year projections from age 20 to age 50 for an initial basal area of 110 square feet per acre and a site index (base age 50, Schumacher and Coile 1960) of 80 feet.

AGE 20 YEARS
SITE INDEX(BASE 50) 80 FEET
BASAL AREA 110 SQ.FT.
TREES PER ACRE 537
DOM./CODOM. HEIGHT 51 FEET
ARITHMETIC MEAN DBH 5.8 INCHES
QUADRATIC MEAN DBH 6.1 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
2	7.6	0.2	22	0	0
3	45.7	2.2	31	0	0
4	85.8	7.5	38	29	0
5	108.1	14.7	42	148	0
6	105.2	20.7	45	279	0
7	82.8	22.1	48	346	0
8	53.5	18.7	50	280	74
9	28.6	12.6	51	130	273
10	12.7	6.9	51	33	325
11	4.6	3.1	54	6	200
12	1.4	1.1	54	1	85
13	0.4	0.3	55	0	27
14	0.1	0.1	56	0	7
TOTAL	536.5	130.2	---	1252	991

AGE 30 YEARS
SITE INDEX(BASE 50) 80 FEET
BASAL AREA 147 SQ.FT.
TREES PER ACRE 433
DOM./CODOM. HEIGHT 66 FEET
ARITHMETIC MEAN DBH 7.6 INCHES
QUADRATIC MEAN DBH 7.9 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
3	0.1	0.0	34	0	0
4	19.0	1.7	53	7	0
5	51.1	7.0	59	82	0
6	73.4	14.4	64	230	0
7	80.2	21.6	67	401	0
8	72.5	25.3	69	395	327
9	56.1	24.8	62	197	1138
10	37.8	20.6	69	60	1545
11	22.2	14.7	66	16	1350
12	11.5	9.1	67	4	934
13	5.3	4.9	68	1	539
14	2.3	2.3	69	0	266
15	0.8	0.9	70	0	110
16	0.2	0.3	71	0	42
17	0.1	0.1	71	0	14
TOTAL	432.5	147.9	---	1393	6273

AGE 40 YEARS
SITE INDEX(BASE 50) 80 FEET
BASAL AREA 170 SQ.FT.
TREES PER ACRE 366
DOM./CODOM. HEIGHT 74 FEET
ARITHMETIC MEAN DBH 9.0 INCHES
QUADRATIC MEAN DBH 9.2 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
5	8.5	1.2	52	14	0
6	32.8	6.4	57	110	0
7	54.6	14.6	62	295	0
8	66.2	23.1	65	336	515
9	65.1	28.8	68	174	1795
10	54.1	29.5	70	59	2870
11	38.6	25.2	72	18	2718
12	23.8	18.7	74	6	2197
13	12.8	11.8	75	2	1476
14	5.9	6.4	76	0	839
15	2.4	3.0	78	0	400
16	0.8	1.2	79	0	168
17	0.3	0.4	79	0	60
18	0.1	0.1	80	0	16
TOTAL	366.0	170.5	---	1016	12862

AGE 50 YEARS
SITE INDEX(BASE 50) 80 FEET
BASAL AREA 186 SQ.FT.
TREES PER ACRE 311
DOM./CODOM. HEIGHT 80 FEET
ARITHMETIC MEAN DBH 10.3 INCHES
QUADRATIC MEAN DBH 10.5 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
6	4.8	0.9	59	16	0
7	22.0	5.9	64	123	0
8	40.8	14.2	68	188	424
9	53.7	23.7	71	114	1715
10	56.7	30.9	74	47	3083
11	49.9	33.0	76	18	3786
12	37.3	29.3	78	7	3685
13	23.8	21.9	79	2	2937
14	12.9	13.8	81	1	1946
15	6.0	7.4	82	0	1079
16	2.4	3.3	83	0	501
17	0.8	1.3	84	0	195
18	0.2	0.4	85	0	64
19	0.1	0.1	86	0	17
TOTAL	311.3	186.1	---	516	19413

Table 9. Natural stand loblolly pine stand and stock tables for ten-year projections from age 20 to age 50 for an initial basal area of 120 square feet per acre and a site index (base age 50, Schumacher and Coile 1960) of 80 feet.

AGE 20 YEARS
SITE INDEX(BASE 50) 80 FEET
BASAL AREA 120 SQ.FT.
TREES PER ACRE 537
DOM./CODOM. HEIGHT 61 FEET
ARITHMETIC MEAN DBH 5.4 INCHES
QUADRATIC MEAN DBH 6.1 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
2	7.6	0.2	27	0	0
3	45.7	2.2	51	0	0
4	85.8	7.5	58	29	0
5	108.1	14.7	62	148	0
6	105.2	20.7	65	279	0
7	82.8	22.1	68	346	0
8	53.5	18.7	70	280	79
9	28.6	12.6	71	130	273
10	12.7	6.9	73	53	325
11	4.6	3.1	74	6	200
12	1.6	1.1	74	1	85
13	0.4	0.3	75	0	27
14	0.1	0.1	76	0	7
TOTAL	536.5	118.2	---	1252	991

AGE 30 YEARS
SITE INDEX(BASE 50) 80 FEET
BASAL AREA 147 SQ.FT.
TREES PER ACRE 433
DOM./CODOM. HEIGHT 66 FEET
ARITHMETIC MEAN DBH 7.6 INCHES
QUADRATIC MEAN DBH 7.9 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
3	0.1	0.0	36	0	0
4	19.0	1.7	43	7	0
5	51.1	7.0	49	82	0
6	73.4	14.4	54	239	0
7	80.2	21.8	57	401	0
8	72.5	25.3	60	395	327
9	56.1	24.8	62	342	1130
10	37.8	20.6	64	60	1545
11	22.2	14.7	66	16	1354
12	11.5	9.1	67	4	934
13	5.3	4.9	68	1	539
14	2.1	2.3	69	0	266
15	0.8	0.9	70	0	110
16	0.2	0.3	71	0	42
17	0.1	0.1	71	0	14
TOTAL	432.5	147.4	---	1393	6271

AGE 40 YEARS
SITE INDEX(BASE 50) 80 FEET
BASAL AREA 170 SQ.FT.
TREES PER ACRE 366
DOM./CODOM. HEIGHT 74 FEET
ARITHMETIC MEAN DBH 9.0 INCHES
QUADRATIC MEAN DBH 9.2 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
5	8.5	1.2	52	14	0
6	32.8	6.4	57	110	0
7	58.6	16.6	62	295	0
8	66.2	23.1	65	336	515
9	65.1	28.8	68	170	1795
10	54.1	29.5	70	59	2670
11	38.6	25.5	72	18	2718
12	23.8	18.7	74	6	2197
13	12.8	11.8	75	2	1476
14	5.9	6.4	76	0	830
15	2.4	3.0	78	0	406
16	0.8	1.2	79	0	168
17	0.3	0.4	79	0	60
18	0.1	0.1	80	0	18
TOTAL	366.0	170.5	---	1016	12862

AGE 50 YEARS
SITE INDEX(BASE 50) 80 FEET
BASAL AREA 186 SQ.FT.
TREES PER ACRE 311
DOM./CODOM. HEIGHT 80 FEET
ARITHMETIC MEAN DBH 10.3 INCHES
QUADRATIC MEAN DBH 10.5 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
6	4.8	0.9	59	16	0
7	22.0	5.9	64	123	0
8	40.8	14.2	68	188	424
9	53.7	23.7	71	114	1715
10	56.7	30.9	74	47	3063
11	49.9	33.0	76	18	3786
12	37.3	29.3	78	7	3685
13	23.8	21.9	79	2	2937
14	12.9	13.8	81	1	1946
15	6.4	7.4	82	0	1079
16	2.9	3.3	83	0	501
17	0.8	1.3	84	0	195
18	0.2	0.4	85	0	64
19	0.1	0.1	86	0	17
TOTAL	311.3	186.7	---	516	19413

Table 10. Natural stand loblolly pine stand and stock tables for ten-year projections from age 20 to age 50 for an initial basal area of 110 square feet per acre and a site index (base age 50, Schumacher and Coile 1960) of 90 feet.

AGE 20 YEARS
SITE INDEX(BASE 50) 90 FEET
BASAL AREA 110 SQ.FT.
TREES PER ACRE 402
DOM./CODOM. HEIGHT 57 FEET
ARITHMETIC MEAN DBH 6.7 INCHES
QUADRATIC MEAN DBH 7.1 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
2	0.1	0.0	20	0	0
3	16.0	0.6	32	0	0
4	45.1	3.9	39	16	0
5	65.4	8.9	47	95	0
6	72.5	16.2	52	206	0
7	67.0	27.9	54	303	0
8	53.3	38.6	56	388	94
9	37.1	46.0	58	434	424
10	22.8	50.4	59	419	681
11	12.4	52.2	59	417	616
12	6.0	51.7	60	414	414
13	2.6	50.4	61	411	230
14	1.0	49.1	62	409	109
15	0.3	48.0	63	408	45
16	0.1	47.1	64	407	16
TOTAL	402.1	110.1	---	1196	2630

AGE 30 YEARS
SITE INDEX(BASE 50) 90 FEET
BASAL AREA 161 SQ.FT.
TREES PER ACRE 362
DOM./CODOM. HEIGHT 74 FEET
ARITHMETIC MEAN DBH 8.8 INCHES
QUADRATIC MEAN DBH 9.0 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
4	0.3	0.0	44	0	0
5	14.7	2.0	52	25	0
6	39.0	7.7	57	130	0
7	57.7	15.4	61	310	0
8	65.6	27.8	65	355	437
9	61.4	37.1	68	191	1586
10	49.3	36.9	70	66	2375
11	34.3	32.6	72	20	2391
12	20.9	26.4	74	6	1913
13	11.1	18.2	75	2	1281
14	5.2	11.6	76	1	731
15	2.1	6.6	77	0	359
16	0.8	3.1	78	0	152
17	0.2	1.4	79	0	56
18	0.1	0.1	80	0	18
TOTAL	362.4	161.0	---	1106	11299

AGE 40 YEARS
SITE INDEX(BASE 50) 90 FEET
BASAL AREA 194 SQ.FT.
TREES PER ACRE 327
DOM./CODOM. HEIGHT 83 FEET
ARITHMETIC MEAN DBH 10.2 INCHES
QUADRATIC MEAN DBH 10.4 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
6	3.8	0.7	61	14	0
7	21.3	5.7	66	123	0
8	42.4	14.8	70	186	527
9	57.8	25.6	74	110	2032
10	62.1	33.8	78	45	3577
11	54.6	36.0	79	17	4371
12	40.8	37.4	81	6	4156
13	24.5	22.6	83	2	3182
14	12.6	13.9	84	1	1986
15	5.4	6.6	85	0	1014
16	1.9	2.7	87	0	428
17	0.6	0.9	88	0	145
18	0.1	0.2	89	0	40
TOTAL	327.1	194.6	---	503	21452

AGE 50 YEARS
SITE INDEX(BASE 50) 90 FEET
BASAL AREA 218 SQ.FT.
TREES PER ACRE 291
DOM./CODOM. HEIGHT 90 FEET
ARITHMETIC MEAN DBH 11.6 INCHES
QUADRATIC MEAN DBH 11.7 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
7	1.2	0.3	68	7	0
8	11.8	4.1	73	40	200
9	29.6	13.1	77	37	1191
10	43.2	25.8	80	21	2956
11	56.9	37.6	83	11	4880
12	54.6	42.9	85	5	6048
13	42.3	39.0	87	2	5839
14	26.4	28.3	89	1	4436
15	13.2	16.3	90	0	2650
16	5.3	7.4	92	0	1238
17	1.6	2.6	93	0	449
18	0.4	0.7	94	0	125
19	0.1	0.1	95	0	26
TOTAL	290.8	218.1	---	125	30039

Table 11. Natural stand loblolly pine stand and stock tables for ten-year projections from age 20 to age 50 for an initial basal area of 120 square feet per acre and a site index (base age 50, Schumacher and Coile 1960) of 90 feet.

AGE 20 YEARS
SITE INDEX(BASE 50) 90 FEET
BASAL AREA 120 SQ.FT.
TREES PER ACRE 446
DOM./CODOM. HEIGHT 57 FEET
ARITHMETIC MEAN DBH 6.7 INCHES
QUADRATIC MEAN DBH 7.0 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
3	16.2	0.8	32	0	0
4	49.6	4.3	40	18	0
5	74.3	10.1	45	109	0
6	83.2	16.3	49	238	0
7	76.6	20.5	52	347	0
8	60.0	20.9	54	332	129
9	40.7	18.0	56	182	523
10	24.1	13.1	58	57	755
11	12.5	8.2	59	14	629
12	5.7	4.5	60	3	393
13	2.3	2.1	61	1	202
14	0.8	0.9	62	0	88
15	0.3	0.3	63	0	33
16	0.1	0.1	63	0	11
TOTAL	446.3	120.2	---	1301	2762

AGE 30 YEARS
SITE INDEX(BASE 50) 90 FEET
BASAL AREA 170 SQ.FT.
TREES PER ACRE 389
DOM./CODOM. HEIGHT 74 FEET
ARITHMETIC MEAN DBH 8.7 INCHES
QUADRATIC MEAN DBH 9.0 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
4	0.1	0.0	45	0	0
5	10.9	2.0	52	24	0
6	41.8	8.2	57	141	0
7	63.5	17.0	62	343	0
8	72.9	25.3	65	567	562
9	67.7	29.9	68	781	1858
10	53.5	29.2	70	58	2627
11	36.3	23.9	72	17	2543
12	21.3	16.7	73	5	1952
13	10.8	10.0	75	1	1244
14	4.8	5.1	76	0	669
15	1.8	2.2	77	0	306
16	0.6	0.8	78	0	119
17	0.2	0.3	79	0	40
TOTAL	389.0	170.5	---	1138	11920

AGE 40 YEARS
SITE INDEX(BASE 50) 90 FEET
BASAL AREA 203 SQ.FT.
TREES PER ACRE 306
DOM./CODOM. HEIGHT 83 FEET
ARITHMETIC MEAN DBH 10.2 INCHES
QUADRATIC MEAN DBH 10.4 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
6	3.5	0.7	62	13	0
7	22.3	6.0	67	130	0
8	45.8	16.0	71	183	630
9	63.0	27.8	74	101	2287
10	67.3	36.7	77	40	3922
11	58.4	38.5	79	15	4693
12	41.7	32.8	81	5	4342
13	24.7	22.8	83	2	3203
14	12.1	12.9	84	1	1904
15	4.9	6.0	85	0	915
16	1.6	2.2	87	0	355
17	0.4	0.7	88	0	111
18	0.1	0.2	89	0	28
TOTAL	345.9	203.3	---	490	22389

AGE 50 YEARS
SITE INDEX(BASE 50) 90 FEET
BASAL AREA 226 SQ.FT.
TREES PER ACRE 305
DOM./CODOM. HEIGHT 90 FEET
ARITHMETIC MEAN DBH 11.9 INCHES
QUADRATIC MEAN DBH 11.7 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
7	1.1	0.3	69	7	0
8	12.3	4.3	73	38	224
9	31.0	14.1	77	34	1306
10	51.0	27.8	80	20	3219
11	61.3	40.4	83	10	5269
12	58.0	45.5	85	5	6428
13	43.8	40.4	87	2	6050
14	26.9	28.2	89	1	4430
15	12.6	15.5	90	0	2520
16	4.7	6.6	92	0	1106
17	1.4	2.1	93	0	370
18	0.3	0.5	94	0	94
TOTAL	304.7	225.7	---	116	31016

Table 12. Natural stand loblolly pine stand and stock tables for ten-year projections from age 20 to age 50 for an initial basal area of 130 square feet per acre and a site index (base age 50, Schumacher and Coile 1960) of 90 feet.

AGE 20 YEARS
SITE INDEX(BASE 50) 90 FEET
BASAL AREA 130 SQ.FT.
TREES PER ACRE 889
DOM./CODOM. HEIGHT 57 FEET
ARITHMETIC MEAN DBH 6.7 INCHES
QUADRATIC MEAN DBH 7.0 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
3	14.9	0.7	33	0	0
4	50.2	4.6	41	19	0
5	82.9	11.3	45	122	0
6	94.2	18.5	49	240	0
7	86.6	23.2	52	393	0
8	67.0	23.6	54	357	173
9	44.3	19.6	56	176	633
10	25.2	13.8	57	50	823
11	12.4	8.2	59	12	635
12	5.3	4.2	60	2	369
13	2.0	1.8	61	1	175
14	0.6	0.7	62	0	69
15	0.2	0.2	62	0	23
TOTAL	888.9	130.1	---	1402	2900

AGE 30 YEARS
SITE INDEX(BASE 50) 90 FEET
BASAL AREA 180 SQ.FT.
TREES PER ACRE 419
DOM./CODOM. HEIGHT 74 FEET
ARITHMETIC MEAN DBH 8.7 INCHES
QUADRATIC MEAN DBH 8.9 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
5	13.7	1.9	53	23	0
6	46.2	8.7	58	149	0
7	69.1	18.5	62	374	0
8	79.4	27.7	65	573	705
9	73.9	32.7	68	668	2135
10	57.6	31.4	70	592	2873
11	38.3	25.3	72	15	2682
12	21.5	16.9	73	4	1980
13	10.5	9.6	75	1	1202
14	4.4	4.7	76	0	610
15	1.6	1.9	77	0	260
16	0.5	0.7	78	0	99
17	0.1	0.2	79	0	28
TOTAL	416.5	179.9	---	1160	12568

AGE 40 YEARS
SITE INDEX(BASE 50) 90 FEET
BASAL AREA 211 SQ.FT.
TREES PER ACRE 364
DOM./CODOM. HEIGHT 83 FEET
ARITHMETIC MEAN DBH 10.1 INCHES
QUADRATIC MEAN DBH 10.3 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
6	3.2	0.6	62	12	0
7	23.2	6.2	67	136	0
8	49.0	17.1	71	177	738
9	68.1	30.1	74	93	2539
10	72.5	39.5	77	36	4259
11	62.0	40.9	79	13	5001
12	43.3	34.0	81	4	4508
13	24.7	22.6	83	1	3209
14	11.6	12.4	84	0	1820
15	4.8	5.4	85	0	824
16	1.4	1.9	86	0	298
17	0.3	0.5	87	0	85
18	0.1	0.1	88	0	19
TOTAL	363.8	211.6	---	474	23300

AGE 50 YEARS
SITE INDEX(BASE 50) 90 FEET
BASAL AREA 233 SQ.FT.
TREES PER ACRE 318
DOM./CODOM. HEIGHT 90 FEET
ARITHMETIC MEAN DBH 11.4 INCHES
QUADRATIC MEAN DBH 11.6 INCHES

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 BOARD FOOT VOLUME 6.0-INCH I.B. TOP
7	1.0	0.3	69	6	0
8	12.7	4.4	74	35	267
9	33.9	15.0	77	31	1077
10	54.8	29.9	80	18	3475
11	65.5	43.2	83	9	5647
12	61.1	48.0	85	4	6787
13	45.1	41.6	87	2	6233
14	26.2	28.1	89	1	4406
15	12.0	15.7	90	0	2391
16	4.2	5.9	92	0	987
17	1.1	1.8	93	0	307
18	0.2	0.4	94	0	71
TOTAL	317.9	233.1	---	107	31968

LITERATURE CITED

Brender, E. V. and J. L. Clutter. 1970. Yield of even-aged natural stands of loblolly pine. Ga. For. Res. Counc., Rep. No. 23, 7 p.

Burkhart, H. E. 1977. Cubic foot volume of loblolly pine to any merchantable top limit. South. J. Appl. For. 1:7-9.

Burkhart, H. E., R. C. Parker, and R. G. Oderwald. 1972. Yields for natural stands of loblolly pine. Div. of Forestry and Wildlife Resources, Va. Polytech. Inst. and State Univ., FWS-2-72, 63 p.

Coile, T. S. 1952. Soil productivity for southern pines: Part I. Shortleaf and loblolly pines. For. Farmer 11:10-11, 13.

Lenhart, J. D. and J. L. Clutter. 1971. Cubic-foot yield tables for old-field loblolly pine plantations in the Georgia Piedmont. Ga. For. Res. Counc., Rep. No. 22, 12 p.

Matney, T. G. and A. D. Sullivan. 1982. Compatible stand and stock tables for thinned and unthinned loblolly pine stands. For. Sci. 28:161-171.

Murphy, P. A. and H. S. Sternitzke. 1979. Growth and yield estimation for loblolly pine in the West Gulf. U.S. Forest Service, Res. Pap. SO-154, 8 p.

Schumacher, F. X. and T. S. Coile. 1960. Growth and yield of natural stands of the southern pines. T. S. Coile, Inc., Durham, N.C., 115 p.

Sullivan, A. D. and J. L. Clutter. 1972. A simultaneous growth and yield model for loblolly pine. For. Sci. 18:76-86.

Zutter, B. R., R. G. Qderwald, R. M. Farrar, Jr., and P. A. Murphy. 1982. WEIBUL: A program to estimate parameters of forms of the Weibull distribution using complete, censored, and truncated data. School of Forestry and Wildlife Resources, Va. Polytech. Inst. and State Univ., FWS-3-82, 17 p.

NATLOB USER'S MANUAL

Preface

The equations that comprise NATLOB have been programmed into a Windows application for implementation with Windows 95, 98, NT or 2000 operating systems. The NATLOB software is available for $40 by contacting:

Department of Forestry
Virginia Tech
Blacksburg, VA 24061

Most of the functionality of the NATLOB software follows that of other Windows applications and experienced users of Windows software should have no trouble implementing NATLOB. There are, however, nuances peculiar to this application for which additional explanation may be helpful.

Purpose of NATLOB

NATLOB is a computer program which can be used to predict the growth and yield of natural loblolly pine stands. Predictions are obtained by choosing options from pop-up menus and responding to requests for stand level characteristics on a per acre basis. Results are displayed in terms of trees per acre, basal area and volumes per acre by one-inch diameter at breast height (dbh) classes. If a parallel printer is attached to the computer system, all output on the screen can be printed.

Initializing a stand

When the INITIALIZE toolbar button is selected NATLOB prompts for the current age of the stand, the average height of the dominant and codominant stand, the basal area and/or the number of trees surviving.

Output

The NATLOB stand table output displays two columns of volumes. The first volume column displays merchantable outside bark volume to a 4-inch top outside bark. The second column presents International ¼ sawtimber volume to a 6-inch top inside bark

Copying output

Stand and stock table output values can be highlighted with the arrow keys or by dragging the mouse and then copied to the Windows clipboard. From the clipboard they can be pasted into other Windows applications such as spreadsheets or graphics packages. This facilitates further analyses of NATLOB simulation results. Utilizing the "Select all" option in the Edit menu command highlights the entire output window for copying to the clipboard. Selecting the "View All Tables" option under the View menu command displays all output during a current session. Otherwise, only the current output stand and stock table is shown.

Program limits and error messages

The stand age must be between 10 and 80 years old. Dominant and codominant height must be between 30 and 120 feet. Basal area must be between 50 and 225 square feet/ac. Number of trees must be between 100 and1300. If data outside these limits are specified, an error message will appear. If an unrealistic combination of inputs is specified projections and predictions may be unrealistic.

Growing a plantation

To grow a plantation, click the Grow toolbar button and specify a future age. A plantation must be initialized before it can be grown. The projected age must be greater than the current age and less than 80 years.