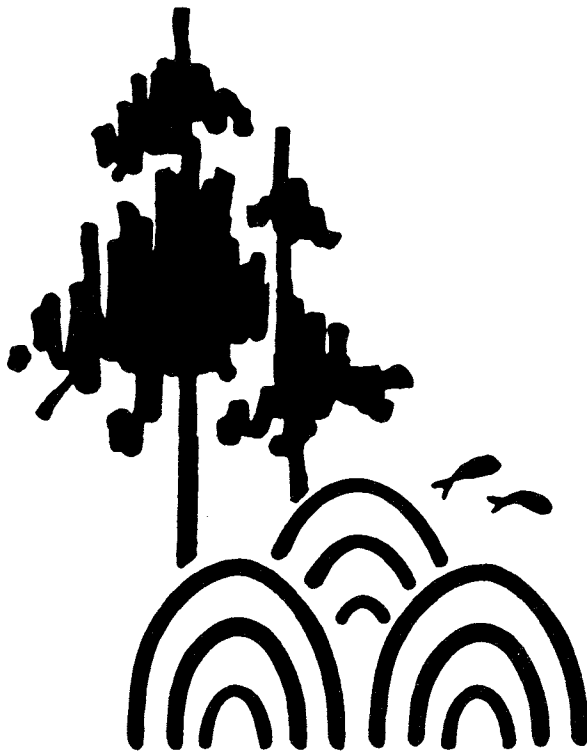


Diameter Distributions and Yields of Natural Stands of Loblolly Pine



Publication No. FWS-1-84

**School of Forestry and Wildlife Resources
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061**

1984

DIAMETER DISTRIBUTIONS AND YIELDS
OF NATURAL STANDS OF LOBLOLLY PINE

by

Thomas E. Burk

Harold E. Burkhart

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PREFACE

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

School of Forestry and Wildlife Resources
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061

To defer the cost of postage and handling, a charge of \$20.00 will be made for a card deck of the FORTRAN program or a diskette containing the BASIC program. Checks should be made payable to the Department of Forestry, VPI & SU.

Although the software presented has been extensively tested and checked for accuracy and, to the best of our knowledge, contains no errors, neither Virginia Polytechnic Institute and State University, 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. Software was written in FORTRAN and BASIC implementing the model and an existing basal area projection equation. 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, Assistant Professor and Thomas M. Brooks Professor in the Department of Forestry, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

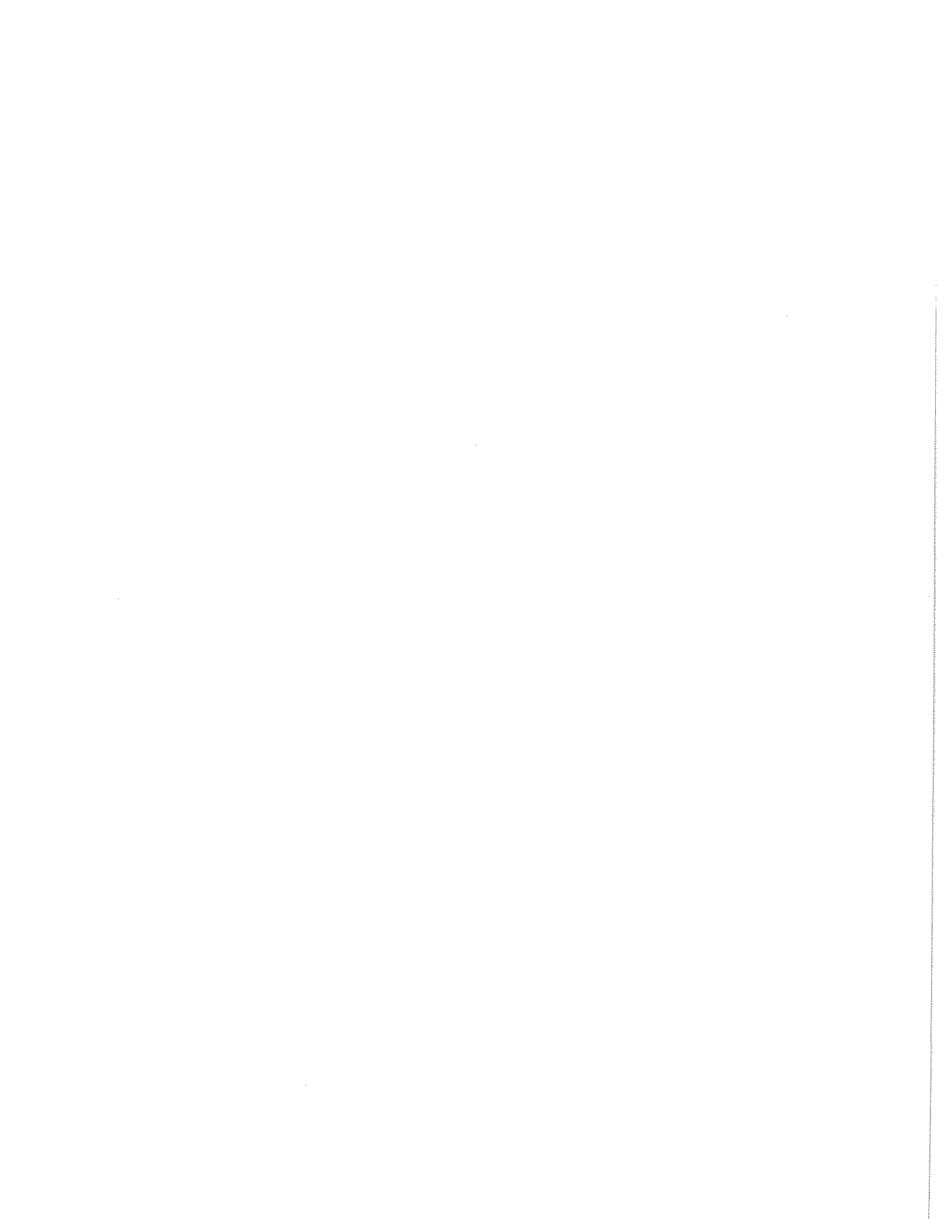
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DIAMETER DISTRIBUTIONS AND YIELDS
OF NATURAL STANDS OF LOBLOLLY PINE

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 study data

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)					Total
		60	100	140	180	220	
<15	90			1			1
	100			$\frac{1}{2}$			$\frac{1}{2}$
15-29	60	1	2				3
	70		4	8	2		14
	80	3	3	16	5		27
	90			10	5	3	18
	100		$\frac{1}{10}$	$\frac{1}{35}$	$\frac{4}{16}$	$\frac{1}{4}$	$\frac{7}{69}$
		$\frac{4}{1}$	$\frac{10}{10}$	$\frac{35}{35}$	$\frac{16}{16}$	$\frac{4}{4}$	$\frac{69}{69}$
30-44	70	1	2	5	4		12
	80			16	5	2	23
	90				$\frac{1}{10}$	$\frac{2}{2}$	$\frac{1}{36}$
		$\frac{1}{1}$	$\frac{2}{2}$	$\frac{21}{21}$	$\frac{10}{10}$	$\frac{2}{2}$	$\frac{36}{36}$
45-59	70		4	1			5
	80		$\frac{1}{5}$	$\frac{1}{1}$	$\frac{1}{1}$		$\frac{2}{7}$
			$\frac{5}{5}$	$\frac{1}{1}$	$\frac{1}{1}$		$\frac{7}{7}$
60-74	60		1				1
	80		$\frac{1}{2}$				$\frac{1}{2}$
			$\frac{2}{2}$				$\frac{2}{2}$
>74	70		$\frac{1}{1}$				$\frac{1}{1}$
			$\frac{1}{1}$				$\frac{1}{1}$
Total		5	20	59	27	6	117

available 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 by 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.

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

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

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 which gave the best results for the present study were

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

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

$$a_1 = \bar{D}_2 (\ln(\bar{H}) - \ln(a_0)) \quad (4)$$

where H = height of dominants and codominants (feet)
 \bar{B} = basal area (square feet per acre)
 \bar{H} = height of tree of dbh D_2 (feet)
 \bar{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. Burkhardt *et al.* (1972) presented several standard volume equations derived from the same data source used in the present study. Burkhardt (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

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

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

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

$$a = \text{maximum} (0.0, b_0 + b_1 B + b_2 \bar{D}_2) \quad (6)$$

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

$$b = (\bar{D}_1 - a) / \Gamma_1 \quad (7)$$

$$\bar{D}_2^2 - a^2 - 2a(\bar{D}_1 - a) - (\bar{D}_1 - a)^2 \Gamma_2 / \Gamma_1^2 = 0 \quad (8)$$

where \bar{D}_1 = 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

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

Attribute	Equation ^{a/}
Trees per acre	$\ln(N) = 8.3931 + 1.8360 \ln(B) - .01968 A$ $- 2.4754 \ln(H) - .1112 B/A$ $R^2(N) = .77 \text{ bias}(N) = -10 \text{ MAD}(N) = 86$
Basal area	$\ln(B) = 2.8078 + .5027 \ln(N) + .009135 A$ $+ 12.4668/A - 100.6073/H$ $R^2(B) = .71 \text{ bias}(B) = -1 \text{ MAD}(B) = 15$
Arithmetic mean dbh	$\ln(\bar{D}_2 - \bar{D}_1) = 32.9856 - 4.7745 \ln(H)$ $- 326.1481/H - 1.7136 \ln(B)$ $- 109.5631/B$ $R^2(\bar{D}_1) = .99 \text{ bias}(\bar{D}_1) = .01 \text{ MAD}(\bar{D}_1) = .06$
Probability of sawtimber tree	$P = 1.0 / (1.0 + \exp(-10.8908 + 122.6106/\text{dbh} - .0224 B))$ $R^2(P) = .53 \text{ bias}(P) = 0 \text{ MAD}(P) = .24$ $\bar{P} = .48 \quad n = 2052$
Total tree height	$\ln(h) = \ln(a_0) + a_1/\text{dbh}$ $a_0 = H (1.0 + 3.4831B^{-.6504} \exp(.01088 H))$ $\bar{H} = H \exp(-H^{.9053} / (\bar{D}_2 + 4.2566)^{2.4606})$ $a_1 = \bar{D}_2 (\ln(\bar{H}) - \ln(a_0))$ $R^2(h) = .86 \text{ bias}(h) = .2 \text{ MAD}(h) = 3.3$ $\bar{h} = 55.7 \quad n = 1651$
Weibull location parameter	$a = \text{maximum} (0.0, -3.6732 + .01111 B + .6876 \bar{D}_2)$ $R^2(a) = .54 \text{ bias}(a) = 0 \text{ MAD}(a) = .9$ $\bar{a} = 3.1$

a/ Notation

N = trees per acre (number)
 B = basal area (square feet per acre)
 A = stand age (years)
 \bar{H} = dominant and codominant height (feet)
 \bar{D}_1 = arithmetic mean dbh (inches)
 \bar{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)
 a_0 = asymptote in total height-dbh regression (feet)
 a_1 = slope coefficient in total height-dbh regression
 \underline{a} = Weibull location parameter
 \bar{H} = total height of tree of dbh \bar{D}_2 (feet)
 n = number of observations fit statistics are based upon
 ln = natural logarithm
 \ln^{exp} = inverse natural logarithm
 $R^2(\cdot)$ = square of simple correlation between observed and predicted
 bias(\cdot) = average difference between predicted and observed
 MAD(\cdot) = average absolute difference between observed and predicted

are based on predictions for individual trees; that is, observed values were either 0 or 1. Computer programs were written in FORTRAN and BASIC that utilize 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 Burkhardt *et al.* (1972) and Burkhardt (1977). Further, the programs allow 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. The programs were written to run interactively with minimal prompts. Users can easily alter either program to utilize other individual tree volume equations, another basal area projection equation, or other site index curves. Listings and program documentation are provided in the appendix of this report. A numerical example that illustrates the use of the model is also included in the Appendix.

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 Burkhardt *et al.* (1972). The cubic foot volumes were computed using the equations in Burkhardt (1977).

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 programs set future trees per acre equal to current trees per acre if predictions exceed current number. A warning message is also given. A tree survival equation can be easily incorporated into the model if one is available.

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

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	10.4	35	37	0
5	134.7	18.4	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	30.4	17.4	56	181	495
10	23.1	12.6	58	58	720
11	11.9	7.9	59	14	601
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 7.2 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	13.1	1.1	41	5	0
5	38.2	5.2	48	59	0
6	56.6	11.1	52	174	0
7	64.0	17.1	56	314	0
8	60.6	21.2	59	345	212
9	49.7	21.9	61	204	880
10	35.8	19.6	63	72	1383
11	23.0	15.2	65	21	1358
12	13.2	10.3	66	6	1047
13	6.8	6.2	67	2	681
14	3.1	3.3	69	0	385
15	1.3	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 9.7 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	42.5	23.2	66	72	1824
11	32.0	21.1	68	24	2049
12	21.4	16.8	70	8	1830
13	12.8	11.8	71	3	1386
14	6.9	7.4	72	1	911
15	3.3	4.1	73	0	526
16	1.4	2.0	74	0	269
17	0.6	0.9	75	0	122
18	0.2	0.3	76	0	49
19	0.1	0.1	77	0	18
TOTAL	304.3	146.2	---	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	34
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	368	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	100	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	MERCHANTABLE	INTERNATIONAL 1/4
			HEIGHT (FEET)	CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	BOARD FOOT VOLUME 6.0-INCH I.B. TOP
1	0.9	0.0	9	0	0
2	29.6	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	354	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	MERCHANTABLE	INTERNATIONAL 1/4
			HEIGHT (FEET)	CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	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	165	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	---	1488	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	MERCHANTABLE	INTERNATIONAL 1/4
			HEIGHT (FEET)	CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	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	MERCHANTABLE	INTERNATIONAL 1/4
			HEIGHT (FEET)	CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	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	348
9	58.0	25.6	64	179	1356
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	10816

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		INTERNATIONAL 1/4
				CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	BOARD FOOT VOLUME 6.0-INCH I.B. TOP	
2	7.9	0.2	21	0		0
3	41.1	2.0	31	0		0
4	74.3	6.5	37	25		0
5	92.5	12.6	42	126		0
6	90.6	17.8	45	240		0
7	72.8	19.5	48	304		0
8	48.8	17.0	50	262	56	21
9	27.5	12.1	51	137	231	72
10	13.0	7.1	53	40	316	21
11	5.2	3.4	54	8	220	7
12	1.7	1.4	55	1	105	2
13	0.5	0.5	56	0	38	1
14	0.1	0.1	56	0	11	0
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		INTERNATIONAL 1/4
				CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	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	22.8	60	371	250	0
9	51.4	22.7	62	205	963	0
10	35.6	19.4	64	68	1416	0
11	21.8	14.4	66	19	1314	0
12	11.8	9.3	67	5	958	0
13	5.7	5.3	68	1	588	0
14	2.5	2.7	69	0	312	0
15	1.0	1.2	70	0	145	0
16	0.3	0.5	71	0	59	0
17	0.1	0.2	72	0	21	0
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 74 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		INTERNATIONAL 1/4
				CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	BOARD FOOT VOLUME 6.0-INCH I.B. TOP	
5	8.4	1.1	51	14		0
6	30.4	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	56	2578
12	23.5	18.4	74	7	11	2163
13	13.1	12.1	75	2	15	1519
14	6.4	6.9	77	1	22	910
15	2.8	3.4	78	0	105	469
16	1.1	1.5	79	0	38	209
17	0.4	0.6	80	0	11	81
18	0.1	0.2	80	0	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		INTERNATIONAL 1/4
				CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	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		3537
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	9.2	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	9
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	53	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	110.2	---	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	43	7	0
5	51.1	7.0	49	82	0
6	73.4	14.4	54	230	0
7	80.2	21.4	57	401	0
8	72.5	25.3	60	395	327
9	56.1	24.8	62	197	1138
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	114
16	0.2	0.3	71	0	42
17	0.1	0.1	71	0	14
TOTAL	432.5	147.4	---	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	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	838
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	6.0	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 505
 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	6.7	0.1	22	0	0
3	49.0	2.4	32	0	0
4	96.8	8.5	38	33	0
5	124.0	16.9	42	171	0
6	120.5	23.7	45	320	0
7	93.0	24.9	48	389	0
8	58.1	20.3	50	295	97
9	29.5	13.0	51	121	316
10	12.2	6.7	52	26	327
11	4.1	2.7	53	4	179
12	1.1	0.9	54	1	67
13	0.2	0.2	55	0	19
TOTAL	595.4	120.2	---	1360	1005

AGE 30 YEARS
 SITE INDEX(BASE 50) 80 FEET
 BASAL AREA 156 SQ.FT.
 TREES PER ACRE 466
 DOM./CODOM. HEIGHT 66 FEET
 ARITHMETIC MEAN DBH 7.6 INCHES
 QUADRATIC MEAN DBH 7.8 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
4	19.0	1.7	43	7	0
5	55.3	7.5	49	89	0
6	81.1	15.9	54	255	0
7	88.9	23.8	57	446	0
8	79.8	27.9	60	413	417
9	60.7	26.8	62	187	1317
10	39.7	21.7	64	53	1661
11	22.5	14.9	65	13	1380
12	11.1	8.7	67	3	903
13	4.8	4.4	68	1	491
14	1.8	1.9	69	0	226
15	0.6	0.7	70	0	89
16	0.2	0.2	71	0	30
TOTAL	465.6	156.2	---	1469	6514

AGE 40 YEARS
 SITE INDEX(BASE 50) 80 FEET
 BASAL AREA 178 SQ.FT.
 TREES PER ACRE 388
 DOM./CODOM. HEIGHT 74 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
5	8.5	1.2	52	14	0
6	35.1	6.9	58	119	0
7	59.4	15.9	62	322	0
8	72.2	25.2	65	345	628
9	70.5	31.1	68	166	2028
10	57.7	31.5	70	54	2885
11	40.1	26.5	72	16	2841
12	24.0	18.8	74	5	2216
13	12.3	11.4	75	1	1426
14	5.5	5.8	76	0	769
15	2.1	2.6	77	0	350
16	0.7	1.0	78	0	135
17	0.2	0.3	79	0	44
TOTAL	388.2	178.0	---	1043	13325

AGE 50 YEARS
 SITE INDEX(BASE 50) 80 FEET
 BASAL AREA 193 SQ.FT.
 TREES PER ACRE 327
 DOM./CODOM. HEIGHT 80 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	4.9	1.0	59	17	0
7	23.5	6.3	64	132	0
8	44.0	15.3	68	190	500
9	58.0	25.6	71	110	1909
10	60.7	33.1	74	44	3316
11	52.7	34.8	76	16	4015
12	38.5	30.3	78	6	3813
13	23.8	21.9	79	2	2946
14	12.5	13.3	81	1	1877
15	5.5	6.8	82	0	931
16	2.1	2.9	83	0	435
17	0.6	1.0	84	0	158
18	0.2	0.3	85	0	48
TOTAL	327.0	192.6	---	517	20007

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	MERCHANTABLE	INTERNATIONAL 1/4
			HEIGHT (FEET)	CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	BOARD FOOT VOLUME 6.0-INCH I.B. TOP
2	0.1	0.0	20	0	0
3	16.4	0.8	32	0	0
4	45.1	3.9	39	16	0
5	65.4	8.9	45	95	0
6	72.5	14.2	49	206	0
7	67.0	17.9	52	303	0
8	53.3	18.6	54	304	94
9	37.1	16.4	56	184	424
10	22.8	12.4	58	65	681
11	12.4	8.2	59	17	616
12	6.0	4.7	60	4	414
13	2.6	2.4	61	1	230
14	1.0	1.1	62	0	109
15	0.3	0.4	63	0	45
16	0.1	0.1	64	0	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	MERCHANTABLE	INTERNATIONAL 1/4
			HEIGHT (FEET)	CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	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	65.4	22.8	65	355	437
9	61.4	27.1	68	191	1586
10	49.3	26.9	70	66	2375
11	34.3	22.6	72	20	2391
12	20.9	16.4	74	6	1913
13	11.1	10.2	75	2	1281
14	5.2	5.6	76	1	731
15	2.1	2.6	77	0	359
16	0.8	1.1	78	0	152
17	0.2	0.4	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	MERCHANTABLE	INTERNATIONAL 1/4
			HEIGHT (FEET)	CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	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	76	45	3577
11	54.6	36.0	79	17	4371
12	40.0	31.4	81	6	4156
13	24.5	22.6	83	2	3182
14	12.6	13.5	84	1	1986
15	5.4	6.6	85	0	1014
16	1.9	2.7	87	0	424
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	MERCHANTABLE	INTERNATIONAL 1/4
			HEIGHT (FEET)	CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	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	47.2	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	14.4	2.0	52	24	0
6	41.8	8.2	57	141	0
7	63.5	17.0	62	343	0
8	72.4	25.3	65	367	562
9	67.7	29.9	68	181	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 346
 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 11.5 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	31.8	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	26.4	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 489
 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	53.2	4.6	40	19	0
5	82.9	11.3	45	122	0
6	94.2	18.5	49	270	0
7	86.6	23.2	52	393	0
8	67.0	23.4	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	488.9	130.1	---	1402	2900

AGE 30 YEARS
 SITE INDEX(BASE 50) 90 FEET
 BASAL AREA 180 SQ.FT.
 TREES PER ACRE 415
 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	44.2	8.7	58	149	0
7	69.1	18.5	62	374	0
8	79.4	27.7	65	373	705
9	73.9	32.7	68	168	2135
10	57.6	31.4	70	52	2873
11	38.1	25.1	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	94
17	0.1	0.2	79	0	28
TOTAL	414.5	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	22.8	83	1	3209
14	11.6	12.4	84	0	1820
15	4.4	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

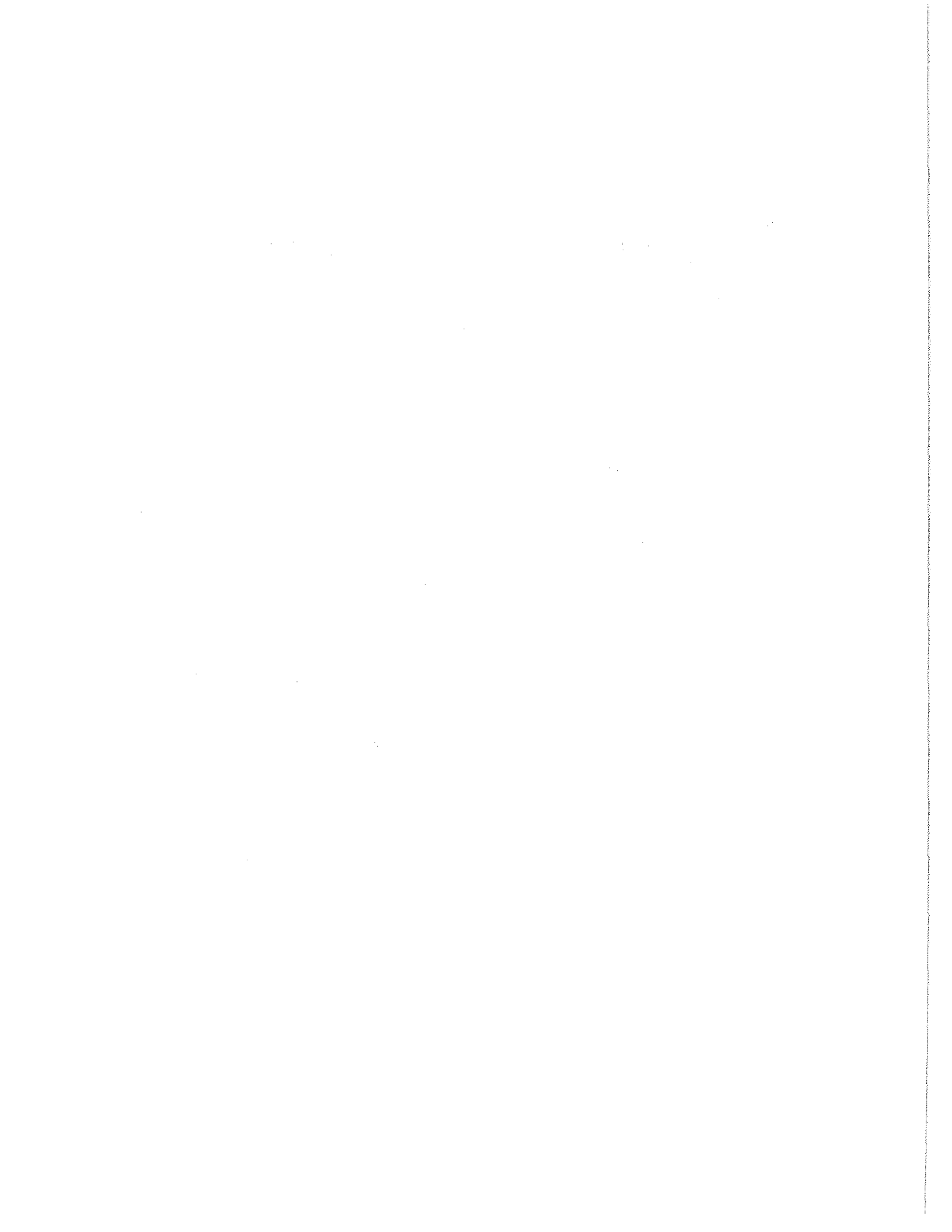
STAND/STOCK TABLE

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	247
9	33.9	15.0	77	31	1417
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	14.7	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

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.

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APPENDIX

Listings of the FORTRAN and BASIC programs implementing the diameter distribution growth and yield model for natural stands of loblolly pine can be found at the end of this appendix. The BASIC program was written to run on an IBM PC. Documentation for the programs follows in the form of an annotated example and information on substituting alternative equations for the various model components. Although both versions of the model flow similarly, differences do exist and will be pointed out in what follows.

Example

The example run shown in Figure A1 will serve to explain the use and document the computations of the programs listed at the end of this appendix. This example was generated by compiling the FORTRAN program under FORTRAN-G using the CMS operating system on an IBM 4341 computer. The numbers below refer to those found circled in Figure A1.

1. This title is printed at the start of every run. For the FORTRAN program this and all output are written to unit 6. The user's operating system can be used to assign unit 6 to the appropriate media. In the BASIC program output is written using the PRINT and PRINT USING statements. To direct output to the printer these statements must be changed to LPRINT and LPRINT USING (DOS 2.0 users can utilize Ctrl/PrtSc).
2. The first time this prompt is given the only appropriate response is -1 allowing generation of initial stand and stock tables. This and all responses must be followed by a carriage return. In the BASIC program the line feed and question marks are suppressed.
3. To obtain initial stand and stock tables requires specification of stand age, dominant and codominant height, and basal area and/or trees per acre. Either of the last two (but not both) may be entered as zero in which case the value is predicted. Values entered are for loblolly pine only (i.e. don't include competing hardwoods). Again, the question marks are suppressed by the BASIC program.

DIAMETER DISTRIBUTION MODEL FOR UNTHINNED, NATURAL LOBLOLLY PINE STANDS (1)

SELECT OPTION -1(INITIALIZE),0(STOP), OR 1(PROJECT)

?
?-1 (2)

INPUT LOBLOLLY PINE AGE, DOM./CODOM. HEIGHT, BASAL AREA, TREES PER ACRE

? 30, 65, 100, 0 (3)

INITIAL CONDITIONS

AGE 30 YEARS
 SITE INDEX(BASE 50) 79 FEET (4)
 BASAL AREA 100 SQ.FT.
 TREES PER ACRE 258
 DOM./CODOM. HEIGHT 65 FEET
 ARITHMETIC MEAN DBH 8.0 INCHES
 QUADRATIC MEAN DBH 8.4 INCHES

STAND/STOCK TABLE (5)

DBH (6) (INCHES)	TREES PER ACRE	BASAL AREA (7) (SQ.FT./ACRE)	TOTAL (8) HEIGHT (FEET)	MERCHANTABLE (9) CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 (10) BOARD FOOT VOLUME 6.0-INCH I.B. TOP
3	0.6	0.0	30	0	0
4	13.3	1.2	39	5	0
5	27.8	3.8	46	42	0
6	37.2	7.3	51	111	0
7	40.5	10.8	55	196	0
8	38.3	13.4	59	242	68
9	32.5	14.3	61	193	381
10	25.0	13.6	63	92	814
11	17.6	11.6	65	33	981
12	11.4	8.9	67	11	893
13	6.8	6.3	68	4	690
14	3.8	4.0	70	1	473
15	1.9	2.4	71	0	293
16	0.9	1.3	72	0	165
17	0.4	0.7	73	0	85
18	0.2	0.3	73	0	41
19	0.1	0.1	74	0	18
TOTAL	258.2	100.0	---	930	4903 (11)

Figure A1. Sample run of natural stand loblolly pine diameter distribution model.

SELECT OPTION -1(INITIALIZE),0(STOP), OR 1(PROJECT)

?

?1

(12)

INPUT PROJECTION AGE

?

?40

(13)

PROJECTED CONDITIONS

AGE 40 YEARS

SITE INDEX(BASE 50) 79 FEET

BASAL AREA 127 SQ.FT.

TREES PER ACRE 245

DOM./CODOM. HEIGHT 74 FEET

ARITHMETIC MEAN DBH 9.4 INCHES

QUADRATIC MEAN DBH 9.7 INCHES

(14)

STAND/STOCK TABLE

DBH (INCHES)	TREES PER ACRE	BASAL AREA (SQ.FT./ACRE)	TOTAL HEIGHT (FEET)	MERCHANTABLE		INTERNATIONAL 1/4
				CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	VOLUME	BOARD FOOT VOLUME 6.0-INCH I.B. TOP
5	7.2	1.0	49	11		0
6	20.7	4.1	55	66		0
7	31.6	8.4	59	164		0
8	37.6	13.1	63	237		133
9	38.1	16.8	66	187		716
10	34.1	18.6	69	86		1453
11	27.3	18.0	71	33		1812
12	19.8	15.5	73	12		1776
13	13.0	12.0	75	4		1488
14	7.8	8.4	76	2		1097
15	4.3	5.3	78	1		722
16	2.2	3.0	79	0		428
17	1.0	1.6	80	0		229
18	0.4	0.7	81	0		111
19	0.2	0.3	82	0		49
20	0.1	0.1	82	0		20
TOTAL	245.3	127.0	---	804		10033

SELECT OPTION -1(INITIALIZE),0(STOP), OR 1(PROJECT)

?

?0

Figure A1. Sample run of natural stand loblolly pine diameter distribution model (continued).

4. Site index is computed by function SITE. If not specified, basal area is computed by function BAA. If not specified, trees per acre is computed by function TREES. Arithmetic mean dbh is computed by function DAVG. Quadratic mean dbh is computed using basal area and trees per acre. All functions appear at the end of the FORTRAN listing and at the beginning of the BASIC listing.
5. The main computation done by the programs is the recovery of the diameter distribution using arithmetic and quadratic mean dbh. This is done by subroutine WEIBM2 in FORTRAN or the subroutine beginning at line 1150 in BASIC. In BASIC this requires an extra routine to evaluate the complete gamma function (line 1390). In BASIC on the IBM PC, parameter recovery causes an approximate 5 second pause during runs. In both FORTRAN and BASIC the Weibull location parameter is calculated in function APARM. Computations and printing of the stand and stock tables is done in FORTRAN subroutine TABOUT or the BASIC subroutine beginning at line 780.
6. The smallest dbh class is defined by the interval from the location parameter to the upper bound of the 1-inch class containing the location parameter. However, the midpoint of the 1-inch class is used to compute basal area, height, and volume leading to a slight negative bias. All other dbh classes are one inch in width (e.g. the three inch class is from 2.5 to 3.5 inches).
7. Basal area in a class is basal area of one tree of the class midpoint dbh times number of trees in the class.
8. This is the total height of one tree with dbh equal to the class midpoint. In FORTRAN the height equation coefficients are computed by subroutine HTCDEF and tree heights are computed by function HT. In BASIC these are done by the subroutine starting at line 150 and function HT, respectively.
9. Cubic foot volumes are computed for the proportion of trees in the class that are not sawtimber using class midpoint dbh and total height. The proportion of sawtimber trees is calculated in function PSAW in both FORTRAN and BASIC. The volumes are calculated in function CUFT in FORTRAN and in the subroutine beginning at line 210 in BASIC.

10. Board foot volumes are computed for the proportion of trees in the class that are sawtimber using class midpoint dbh and total height. These volumes are calculated in function BDFT in both FORTRAN and BASIC.
11. Values in the table may not add to the totals given due to rounding.
12. Any of the options could logically be selected here.
13. This is the age at the end of the growth period.
14. Projected basal area is computed in function PROJBA in FORTRAN and in the subroutine beginning at line 260 in BASIC. Projected dominant and codominant height is calculated in function HTDOM in both FORTRAN and BASIC.

Altering program code

Situations will arise where it is desirable to substitute different equations for some model components. The most common changes will be to the basal area projection equation, the site index equation, and the volume equations. A tree survival equation should also be incorporated if one is available. A concerted effort was made to write the programs so that these changes would require minimal re-programming.

The basal area projection equation appears in FORTRAN function PROJBA. The variables involved are: AGE-age at the beginning of the projection period, PACE-age at the end of the projection period, BA-basal area at the beginning of the projection period, and SI-site index. In BASIC basal area is projected in the subroutine beginning at line 260. The variables are the same as above.

The site index equation appears in functions SITE and HTDOM in both FORTRAN and BASIC. The variables involved are: AGE-present age, HD-present height of dominants and codominants, and SI-site index.

Cubic foot volumes are computed in function CUFT in FORTRAN and the subroutine beginning at line 210 in BASIC. In FORTRAN the variables involved are: H-total tree height, D-tree dbh, and TD-top diameter limit (need not be used--see variable CFI below). The corresponding variables in BASIC are H, XK, and CFI. If cubic foot volumes are to be computed for all trees, rather than just non-sawtimber, PTR must be

changed to CTR in FORTRAN line 1860 or BASIC line 1060. The labels in the stock table can also be changed by altering the BLOCK DATA subroutine in FORTRAN or the DATA statements in BASIC lines 340 and 350. CF1 is the top diameter limit value which is inside or outside bark according to variable CF2. CF1 can also be used when cubic foot volume is computed using a volume ratio equation. Board foot volumes are computed in function BDFE in both FORTRAN and BASIC. In FORTRAN the variables are the same as in the cubic foot computation. In BASIC the variables are: X-total tree height and Y-tree dbh. In the DATA and BLOCK DATA segments the relevant variables are: BF1-log rule name (20 characters), BF2- top limit for the board foot volume, and BF3-whether the top limit is inside or outside bark.

If available, a tree survival equation should be substituted into FORTRAN subroutine PROJ or the subroutine beginning at line 610 in BASIC. In FORTRAN a function similar to PROJBA should be added that evaluates the survival equation. This function should be called immediately after line 990. The relevant variables are: AGE-age at the beginning of the projection period, PAGE-age at the end of the projection period, and TR-trees per acre at the beginning of the projection period. Lines 1020 through 1080 should be deleted. The label (50) on line 1090 should also be deleted. In BASIC a subroutine similar to the one beginning at line 260 should be added that evaluates the survival function. A GOSUB calling this subroutine should be added after the GOSUB 260 in line 670. The variables are the same as above. Lines 680 and 690 should be deleted.

FORTRAN LISTING

```

C
C PROGRAM NATLOB--DIAMETER DISTRIBUTION MODEL FOR NATURAL STANDS OF
C          LOBLOLLY PINE. T.E. BURK VPI&SU NOVEMBER 1, 1983
C
C          COMMON/BLK1/AGE, SI, BA, TR, HD, D1, D2
C
C CONTROL PROGRAM
C
C          WRITE(6,1000)
10          WRITE(6,1001)
            READ(5,*)IOPT
            IF(10PT)20,40,30
20          SI=0.0
            CALL INIT
            GO TO 10
30          CALL PROJ
            GO TO 10
40          STOP
1000         FORMAT(//' DIAMETER DISTRIBUTION MODEL FOR UNTHINNED, NATURAL ',
+ 'LOBLOLLY PINE STANDS')
1001         FORMAT('/' SELECT OPTION -1(INITIALIZE),0(STOP), OR 1(PROJECT)')
            END
C
C
C          SUBROUTINE INIT
C
C INITIALIZE DISTRIBUTION
C
C          COMMON/BLK1/AGE, SI, BA, TR, HD, D1, D2
10          WRITE(6,1000)
C
C READ AND CHECK INPUTS
C
C          READ(5,*)AGE, HD, BA, TR
            IF(AGE.GE.10.0.AND.AGE.LE.80.0 .AND.
+ HD.GE.30.0.AND.HD.LE.120.0)GO TO 20
            WRITE(6,1001)AGE, HD
            GO TO 10
20          IF(BA.GT.0.0.OR.TR.GT.0.0)GO TO 30
            WRITE(6,1002)
            GO TO 10
30          IF(BA.LE.0.0)BA=BAA(TR, AGE, HD)
            IF(TR.LE.0.0)TR=TREES(BA, AGE, HD)
            IF(BA.GE.50.0.AND.BA.LE.225.0 .AND.
+ TR.GE.100.0.AND.TR.LE.1300.0)GO TO 40
            WRITE(6,1003)BA, TR
            GO TO 10
C
C COMPUTE STAND ATTRIBUTES AND RECOVER DISTRIBUTION
C
40          D2=SQRT(BA/TR/.005454)
            SI=SITE(HD, AGE)
            D1=DAVG(D2, HD, BA)
            A=APARM(D2, BA)

```

```

NAT00010
NAT00020
NAT00030
NAT00040
NAT00050
NAT00060
NAT00070
NAT00080
NAT00090
NAT00100
NAT00110
NAT00120
NAT00130
NAT00140
NAT00150
NAT00160
NAT00170
NAT00180
NAT00190
NAT00200
NAT00210
NAT00220
NAT00230
NAT00240
NAT00250
NAT00260
NAT00270
NAT00280
NAT00290
NAT00300
NAT00310
NAT00320
NAT00330
NAT00340
NAT00350
NAT00360
NAT00370
NAT00380
NAT00390
NAT00400
NAT00410
NAT00420
NAT00430
NAT00440
NAT00450
NAT00460
NAT00470
NAT00480
NAT00490
NAT00500
NAT00510
NAT00520
NAT00530
NAT00540
NAT00550

```

FORTRAN LISTING (continued)

```

IF(A.LT.0.0)A=0.0
D22=D2*D2
CALL WEIBM2(D1,D22,A,1.0,5.0,B,C,D1P,D2P,IER)
D1=D1P
IF( IER.EQ.0.OR.IER.EQ.2)GO TO 50
WRITE(6,1004)
RETURN
50  WRITE(6,1005)
    CALL TABOUT(A,B,C)
    RETURN
1000 FORMAT(/' INPUT LOBLOLLY PINE AGE,DOM./CODOM. HEIGHT,BASAL AREA,TRN
+ EES PER ACRE')
1001 FORMAT(' AGE AND/OR HEIGHT ARE OUTSIDE/' DATABASE BOUNDS--',
+ 'VALUES ARE ',2G12.6)
1002 FORMAT(' MUST SPECIFY EITHER BASAL AREA OR TREES PER ACRE OR BOTH'
+)
1003 FORMAT(' BASAL AREA AND/OR TREES PER ACRE ARE OUTSIDE/' DATABASE
+ ' BOUNDS--VALUES ARE ',2G12.6)
1004 FORMAT(' MOMENT SOLUTION NOT POSSIBLE FOR GIVEN STAND ATTRIBUTES')
1005 FORMAT(/' INITIAL CONDITIONS'/)
END
C
C
C
C   SUBROUTINE PROJ
C
C   PROJECT DISTRIBUTION
C
C   COMMON/BLK1/AGE,SI,BA,TR,HD,D1,D2
C   IF(SI)10,10,20
10  WRITE(6,1000)
C
C   READ AND CHECK INPUTS
C
C   RETURN
20  WRITE(6,1001)
    READ(5,*)PAGE
    IF(PAGE.GT.AGE.AND.PAGE.LE.80.0)GO TO 30
    WRITE(6,1002)
    RETURN
C
C   COMPUTE STAND ATTRIBUTES AND RECOVER DISTRIBUTION
C
30  BA=PROJBA(AGE,PAGE,BA,SI)
    AGE=PAGE
    HD=HTDOM(SI,AGE)
    PTR=TREES(BA,AGE,HD)
C   CHECK TO SEE THAT TREES DECREASE
C   (SURVIVAL EQUATION WILL GO HERE)
    IF(PTR.LE.TR)GO TO 40
    WRITE(6,1003)
    GO TO 50
40  TR=PTR
50  D2=SQRT(BA/TR/.005454)
    D1=DAVG(D2,HD,BA)

```

```

NAT00560
NAT00570
NAT00580
NAT00590
NAT00600
NAT00610
NAT00620
NAT00630
NAT00640
NAT00650
NAT00660
NAT00670
NAT00680
NAT00690
NAT00700
NAT00710
NAT00720
NAT00730
NAT00740
NAT00750
NAT00760
NAT00770
NAT00780
NAT00790
NAT00800
NAT00810
NAT00820
NAT00830
NAT00840
NAT00850
NAT00860
NAT00870
NAT00880
NAT00890
NAT00900
NAT00910
NAT00920
NAT00930
NAT00940
NAT00950
NAT00960
NAT00970
NAT00980
NAT00990
NAT01000
NAT01010
NAT01020
NAT01030
NAT01040
NAT01050
NAT01060
NAT01070
NAT01080
NAT01090
NAT01100

```

FORTRAN LISTING (continued)

```

      A=APARM(D2,BA)
C  SINCE BA AND D2 MUST INCREASE SO MUST A
      IF(A.LI.0.0)A=0.0
      D22=D2*D2
      CALL WEIBM2(D1,D22,A,1.0,5.0,B,C,D1P,D2P,IER)
      D1=D1P
      IF(IER.EQ.0.OR.IER.EQ.2)GO TO 60
      WRITE(6,1004)
      RETURN
60  WRITE(6,1005)
      CALL TABOUT(A,B,C)
      RETURN
1000 FORMAT(' NO CURRENT STAND TABLE EXISTS')
1001 FORMAT('/' INPUT PROJECTION AGE')
1002 FORMAT('/' PROJECTION AGE MUST BE > CURRENT AGE AND < 80')
1003 FORMAT('/' ***WARNING*** PROJECTED NUMBER OF TREES SET EQUAL TO',
+ ' CURRENT NUMBER'/)
1004 FORMAT(' MOMENT SOLUTION NOT POSSIBLE FOR GIVEN STAND ATTRIBUTES')
1005 FORMAT('/' PROJECTED CONDITIONS'/)
      END
C
C
C
      SUBROUTINE TABOUT(A,B,C)
C  GENERATE STAND AND STOCK TABLE
C
      INTEGER CF2,BF1(5),BF3
      COMMON/BLK1/AGE,SI,BA,TR,HD,D1,D2
      COMMON/LABELS/CF1,CF2,BF1,BF2,BF3
      CDF(X)=1.0-EXP(-1.0*((X-A)/B)**C)
C  PRINT WHOLE STAND INFORMATION
C
      IAGE=AGE+.5
      ISI=SI+.5
      IBA=BA+.5
      ITR=TR+.5
      IHD=HD+.5
      WRITE(6,1001)IAGE,ISI,IBA,ITR,IHD,D1,D2
      WRITE(6,1002){BF1(J),J=1,5}
      WRITE(6,1003)CF1,CF2,BF2,BF3
      CALL HTCOEF(HD,D2,AGE,BA,A0,A1)
      IFLAG=0
      TCUFT=0.0
      TBDFT=0.0
      TTR=0.0
      TBA=0.0
      CLOW=0.0
      K=A+.5
C
C  COMPUTE AND PRINT ONE CLASS'S INFORMATION
C
10  XK=FLOAT(K)
      XUP=XK+.5

```

NATO1110
 NATO1120
 NATO1130
 NATO1140
 NATO1150
 NATO1160
 NATO1170
 NATO1180
 NATO1190
 NATO1200
 NATO1210
 NATO1220
 NATO1230
 NATO1240
 NATO1250
 NATO1260
 NATO1270
 NATO1280
 NATO1290
 NATO1300
 NATO1310
 NATO1320
 NATO1330
 NATO1340
 NATO1350
 NATO1360
 NATO1370
 NATO1380
 NATO1390
 NATO1400
 NATO1410
 NATO1420
 NATO1430
 NATO1440
 NATO1450
 NATO1460
 NATO1470
 NATO1480
 NATO1490
 NATO1500
 NATO1510
 NATO1520
 NATO1530
 NATO1540
 NATO1550
 NATO1560
 NATO1570
 NATO1580
 NATO1590
 NATO1600
 NATO1610
 NATO1620
 NATO1630
 NATO1640
 NATO1650

FORTRAN LISTING (continued)

```

C  NOTE 1ST CLASS'S VALUES ARE BIASED SLIGHTLY LOW AS 1-INCH CLASS
C  MIDPOINT DBH IS USED FOR COMPUTATIONS
      CUP=CDF(XUP)
      CTR=(CUP-CLOW)*TR
      IF(CTR.GT.0.05)GO TO 20
      IF(IFLAG.EQ.1)GO TO 30
      GO TO 25
20    IFLAG=1
      CBA=.005454*XX*XX*CTR
      TTR=TTR+CTR
      TBA=TBA+CBA
      H=HT(A0,A1,XP)
      CBDFT=0.0
      PTR=CTR
      IF(K.LT.8)GO TO 15
      STR=PSAW(XK,BA)*CIR
      PTR=CTR-STR
      CBDFT=BDFT(H,XK)*STR
      IF(CBDFT.LE.0.0)CBDFT=0.0
      TBDFT=TBDFT+CBDFT
15    CCUFT=CUFT(H,XK,CF1)*PTR
      IF(CCUFT.LE.0.0)CCUFT=0.0
      TCUFT=TCUFT+CCUFT
      ICCUFT=CCUFT+.5
      ICBDFT=CBDFT+.5
      IH=H+.5
      WRITE(6,1004)K,CTR,CBA,IH,ICCUFT,ICBDFT
25    K=K+1
      CLOW=CUP
      GO TO 10
30    ITCUFT=TCUFT+.5
      ITBDF=TBDF+.5
C
C  PRINT TABLE TOTALS
C
      WRITE(6,1005)TTR,TBA,ITCUFT,ITBDF
      RETURN
1001  FORMAT(' AGE ',13,' YEARS'/' SITE INDEX(BASE 50) ',13,' FEET'/
+ ' BASAL AREA ',13,' SQ.FT.'/' TREES PER ACRE ',14/
+ ' DOM./CODOM. HEIGHT ',13,' FEET'/' ARITHMETIC MEAN DBH ',F4.1,
+ ' INCHES'/' QUADRATIC MEAN DBH ',F4.1,' INCHES')
1002  FORMAT(/31X,'STAND/STOCK TABLE'/1X,78('-')/34X,'TOTAL',4X,
+ 'MERCHANTABLE',4X,5A4)
1003  FORMAT(4X,'DBH',5X,'TREES',4X,'BASAL AREA HEIGHT CUBIC FOOT VOLUM
+ME BOARD FOOT VOLUME'/2X'(INCHES) PER ACRE (SQ.FT./ACRE) (FEET) '
+ ,F3.1,'-INCH ',A4,' TOP ',F4.1,'-INCH ',A4,' TOP'/1X,78('-'))
1004  FORMAT(5X,12,5X,F5.1,7X,F5.1,6X,13,9X,14,16X,14)
1005  FORMAT(1X,78('-')/3X,'TOTAL',3X,F6.1,7X,F5.1,6X,'---',8X,15,15X,15
+//)
      END
C
C
C
C  REAL FUNCTION HTDOM(SI,AGE)
C

```

```

NAT01660
NAT01670
NAT01680
NAT01690
NAT01700
NAT01710
NAT01720
NAT01730
NAT01740
NAT01750
NAT01760
NAT01770
NAT01780
NAT01790
NAT01800
NAT01810
NAT01820
NAT01830
NAT01840
NAT01850
NAT01860
NAT01870
NAT01880
NAT01890
NAT01900
NAT01910
NAT01920
NAT01930
NAT01940
NAT01950
NAT01960
NAT01970
NAT01980
NAT01990
NAT02000
NAT02010
NAT02020
NAT02030
NAT02040
NAT02050
NAT02060
NAT02070
NAT02080
NAT02090
NAT02100
NAT02110
NAT02120
NAT02130
NAT02140
NAT02150
NAT02160
NAT02170
NAT02180
NAT02190
NAT02200

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FORTRAN LISTING (continued)

```

C HEIGHT OF DOMINANTS AND CODOMINANTS--SCHUMACHER, F.X., AND T.S. COILE NAT02210
C 1960. GROWTH AND YIELD OF NATURAL STANDS OF THE SOUTHERN PINES. NAT02220
C T.S. COILE, INC., 115PP. NAT02230
C NAT02240
C HTDOM=ALOG10(S1)-6.528*(1.0/AGE-.02) NAT02250
C HTDOM=10**HTDOM NAT02260
C RETURN NAT02270
C END NAT02280
C NAT02290
C NAT02300
C REAL FUNCTION TREES(BA,AGE,HD) NAT02310
C NAT02320
C CURRENT TREES PER ACRE NAT02330
C NAT02340
C TREES=8.3931+1.8360*ALOG(BA)-.01968*AGE-2.4754*ALOG(HD)-.1112*BA/ NAT02350
C +AGE NAT02360
C TREES=EXP(TREES) NAT02370
C RETURN NAT02380
C END NAT02390
C NAT02400
C NAT02410
C REAL FUNCTION BAA(TR,AGE,HD) NAT02420
C NAT02430
C CURRENT BASAL AREA NAT02440
C NAT02450
C BAA=2.8078+.5027*ALOG(TR)+.009135*AGE+12.4668/AGE-100.6073/HD NAT02460
C BAA=EXP(BAA) NAT02470
C RETURN NAT02480
C END NAT02490
C NAT02500
C NAT02510
C NAT02520
C REAL FUNCTION DAVG(D2,HD,BA) NAT02530
C NAT02540
C ARITHMETIC MEAN DBH NAT02550
C NAT02560
C DAVG=32.9856-4.7745*ALOG(HD)-326.1481/HD-1.7136*ALOG(BA)-109.5631/ NAT02570
C +BA NAT02580
C DAVG=D2-EXP(DAVG) NAT02590
C RETURN NAT02600
C END NAT02610
C NAT02620
C NAT02630
C NAT02640
C REAL FUNCTION APARM(D2,BA) NAT02650
C NAT02660
C WEIBULL LOCATION PARAMETER NAT02670
C NAT02680
C APARM=-3.6732+.01111*BA+.6876*D2 NAT02690
C RETURN NAT02700
C END NAT02710
C NAT02720
C NAT02730
C NAT02740
C NAT02750

```

FORTRAN LISTING (continued)

C		NAT02760
	REAL FUNCTION PSAW(D,BA)	NAT02770
C		NAT02780
C	PROBABILITY (PROPORTION) OF SAWTIMBER TREES	NAT02790
C		NAT02800
	PSAW=EXP(-10.8908+122.6106/D-.0224*BA)	NAT02810
	PSAW=1.0/(1.0+PSAW)	NAT02820
	RETURN	NAT02830
	END	NAT02840
C		NAT02850
C		NAT02860
C		NAT02870
	SUBROUTINE HTCDEF(HD,D2,AGE,BA,A0,A1)	NAT02880
C		NAT02890
C	COEFFICIENTS OF TOTAL HEIGHT-DBH EQUATION	NAT02900
C		NAT02910
	HD2=HD*EXP(-1.0*HD**.9053/(D2+4.2566)**2.4606)	NAT02920
	A0=HD*(1.0+3.4831/BA**.6504*EXP(.01088*HD))	NAT02930
	A0=ALOG(A0)	NAT02940
	A1=D2*(ALOG(HD2)-A0)	NAT02950
	RETURN	NAT02960
	END	NAT02970
C		NAT02980
C		NAT02990
C		NAT03000
	REAL FUNCTION HT(A0,A1,D)	NAT03010
C		NAT03020
C	INDIVIDUAL TREE TOTAL HEIGHT	NAT03030
C		NAT03040
	HT=EXP(A0+A1/D)	NAT03050
	IF(HT.LT.5.0)HT=5.0	NAT03060
	RETURN	NAT03070
	END	NAT03080
C		NAT03090
C		NAT03100
C		NAT03110
	REAL FUNCTION BDFT(H,D)	NAT03120
C		NAT03130
C	BOARD FOOT VOLUME OF ONE TREE--BURKHART, H.E., R.C. PARKER, AND R.G.	NAT03140
C	ODERWALD. 1972. YIELDS FOR NATURAL STANDS OF LOBLOLLY PINE. DIV.	NAT03150
C	OF FORESTRY AND WILDLIFE RESOURCES, VA. POLYTECH. INST. AND STATE	NAT03160
C	UNIV., FWS-2-72, 63PP.	NAT03170
C		NAT03180
	BDFT=-23.67532+.01102*D*D*H	NAT03190
	RETURN	NAT03200
	END	NAT03210
C		NAT03220
C		NAT03230
C		NAT03240
	REAL FUNCTION CUFT(H,D,TD)	NAT03250
C		NAT03260
C	CUBIC FOOT VOLUME OF ONE TREE--BURKHART, H.E. 1977. CUBIC FOOT VOLUME	NAT03270
C	OF LOBLOLLY PINE TO ANY MERCHANTABLE TOP LIMIT. SO. J. APPL.	NAT03280
C	FORESTRY. 2:7-9.	NAT03290
C		NAT03300

· FORTRAN LISTING (continued)

```

C      TO RECOVER THE SHAPE AND SCALE PARAMETERS OF THE WEIBULL      NAT03860
C      USING THE FIRST AND SECOND NONCENTRAL MOMENTS OF DBH.        NAT03870
C                                                                    NAT03880
C      T.E. BURK VPI&SU APRIL 1, 1983                               NAT03890
C                                                                    NAT03900
C      VARIABLES                                                    NAT03910
C      X1-FIRST NONCENTRAL MOMENT OF DBH(INPUT)                    NAT03920
C      X2-SECOND NONCENTRAL MOMENT OF DBH(BA/TR/.005454)(INPUT)   NAT03930
C      LOCA-WEIBULL LOCATION PARAM. ESTIMATED INDEPENDENTLY(INPUT) NAT03940
C      SHAPEL-LOWER BOUND FOR SHAPE PARAMETER(INPUT)              NAT03950
C      SHAPEU-UPPER BOUND FOR SHAPE PARAMETER(INPUT)              NAT03960
C      SCALE-WEIBULL SCALE PARAMETER(OUTPUT)                      NAT03970
C      SHAPE-WEIBULL SHAPE PARAMETER(OUTPUT)                      NAT03980
C      X1P-PERTUBATED VALUE OF X1(OUTPUT)                         NAT03990
C      X2P-VALUE OF X2 IMPLIED BY A NONCONVERGENT SOLUTION(OUTPUT) NAT04000
C      IER-ERROR PARAMETER(OUTPUT)                                NAT04010
C                                                                    NAT04020
C      REMARKS                                                       NAT04030
C      IER=0                                                         NAT04040
C      SUCCESSFUL SOLUTION OBTAINED WITH NO CHANGES.              NAT04050
C      IER=1                                                         NAT04060
C      ITERATION DID NOT CONVERGE. X2P IS THE VALUE OF X2          NAT04070
C      CORRESPONDING TO THE SOLUTION OBTAINED. THE USER MUST     NAT04080
C      DETERMINE IF THIS IS CLOSE ENOUGH TO X2 FOR HIS PURPOSES. NAT04090
C      IER=2                                                         NAT04100
C      SOLUTION OBTAINED AFTER PERTUBATING X1. X1 IS PERTUBATED   NAT04110
C      IN INCREMENTS OF .01 UNTIL A SOLUTION IN THE ALLOWABLE     NAT04120
C      RANGE IS FOUND. X1P CONTAINS THE PERTUBATED VALUE OF X1.   NAT04130
C      IER=3                                                         NAT04140
C      A SOLUTION IN THE ALLOWABLE RANGE COULD NOT BE FOUND       NAT04150
C      EVEN UPON PERTUBATING X1.                                    NAT04160
C                                                                    NAT04170
C      METHOD                                                         NAT04180
C      THE SECANT METHOD IS USED FOR ITERATION ON THE SHAPE        NAT04190
C      PARAMETER.                                                  NAT04200
C                                                                    NAT04210
C      IER=0                                                         NAT04220
C      A=DBLE(LOCA)                                                 NAT04230
C      SCALE=0.0                                                    NAT04240
C      SHAPE=0.0                                                    NAT04250
C      D2=DBLE(X2)                                                  NAT04260
C      X1P=X1                                                       NAT04270
C      X2P=X2                                                       NAT04280
C      IFLAG=0                                                      NAT04290
C                                                                    NAT04300
C      INSURE THAT SHAPEL AND SHAPEU BRACKET THE SOLUTION(FCV IS A STRICTLY NAT04310
C      INCREASING FUNCTION OF THE SHAPE PARMETER IN THIS CASE). IF NOT, NAT04320
C      ADJUST X1 AS NECESSARY.                                       NAT04330
C                                                                    NAT04340
C      10  D1=DBLE(X1P)                                              NAT04350
C          XN=DBLE(SHAPEL)                                           NAT04360
C          FXN=FCV(XN)                                               NAT04370
C          IF(FXN.LT.0.D0)GO TO 30                                    NAT04380
C          IER=2                                                      NAT04390
C          IF(IFLAG.EQ.0)GO TO 20                                    NAT04400

```

FORTRAN LISTING (continued)

```

      IER=3
      RETURN
20    X1P=X1P+.01
      GO TO 10
30    XN1=DBLE(SHAPEU)
      FXN1=FCV(XN1)
      IF(FXN1.GT.0.D0)GO TO 40
      IER=2
      IFLAG=1
      X1P=X1P-.01
      GO TO 10
C
C DO 5 BISECTION ITERATIONS TO GET STARTED
C
40    DO 60 J=1,5
      TEMP=(XN+XN1)/2.D0
      FTEMP=FCV(TEMP)
      IF(FTEMP*FXN.LE.0.D0)GO TO 50
      XN=TEMP
      FXN=FTEMP
      GO TO 60
50    XN1=TEMP
      FXN1=FTEMP
60    CONTINUE
C
C BEGIN SECANT ITERATION
C
      DO 70 J=1,100
      TEMP=XN-FXN*(XN-XN1)/(FXN-FXN1)
      XN1=XN
      FXN1=FXN
      XN=TEMP
      FXN=FCV(XN)
      IF(DABS(FXN).LE.0.00001)GO TO 80
70    CONTINUE
      IER=1
      X2P=SNGL(D2-FXN)
80    SHAPE=SNGL(C)
      SCALE=SNGL(B)
      RETURN
      END
C
C DOUBLE PRECISION FUNCTION FCV(ZX)
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON/BLKM22/A,B,C,D1,D2
C
C THIS FUNCTION EVALUATES THE FUNCTION WHOSE ROOT IS DESIRED.
C
      C=ZX
      G1=DGAMMA(1.0+1.0/C)
      G2=DGAMMA(1.0+2.0/C)
      B=(D1-A)/G1
      FCV=D2-A*A-2.0*A*B*G1-B*B*G2
      RETURN
      END

```

```

NAT04410
NAT04420
NAT04430
NAT04440
NAT04450
NAT04460
NAT04470
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NAT04670
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NAT04690
NAT04700
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NAT04720
NAT04730
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NAT04750
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NAT04950
NAT04960

```

BASIC LISTING

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10 REM PROGRAM NATLOB--Natural stand loblolly pine diameter distribution
 growth and yield model--T.E. Burk VPI&SU 1/20/84

20 REM height of dominants and codominants--Schumacher, F.X. and T.S.
 Coile. 1960. Growth and yield of natural stands of the southern
 pines. T.S. Coile, Inc., 115pp.

30 DEF FNHTDOM=S1*EXP(-15.0313*(1/AGE-.02))

40 DEF
 FNTREES=EXP(8.3931+1.836*LOG(BA)-.01968*AGE-2.4754*LOG(HD)-.1112*BA/
 AGE) 'trees equation

50 DEF
 FNBA=EXP(2.8078+.5027*LOG(IR)+9.135001E-03*AGE+12.4668/AGE-100.6073/
 HD) 'basal area equation

60 DEF
 FNDVAVG=D2-EXP(32.9856-4.7745*LOG(HD)-326.1481/HD-1.7136*LOG(BA)-
 109.5631/BA) 'arithmetic mean dbh equation

70 DEF FNAPARM=-3.6732+.01111*BA+.6876*D2 'weibull location parm equation

80 DEF FNPSAW(X)=1/(1+EXP(-10.8908+122.6106/X-.0224*BA))
 'sawtimber merchandizing equation

90 DEF FNHT(X)=EXP(A0+A1/X) 'individual tree height equation

100 REM board foot volume of one tree--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, 63pp.

110 DEF FNBDF(X,Y)=-23.67532+.01102*Y*Y*X

120 REM site index--Schumacher, F.X. and T.S. Coile. 1960. Growth and yield
 of natural stands of the southern pines. T.S. Coile, Inc., 115pp.

130 DEF FNSITE=HD*EXP(15.0313*(1/AGE-.02))

140 GOTO 330

150 REM height equation coefficient estimates

160 HD2=HD*EXP(-1*HD^.9053/(D2+4.2566)^2.4606)

170 A0=HD*(1+3.4831/BA^.6504*EXP(.01088*HD))

180 A0=LOG(A0)

190 A1=D2*(LOG(HD2)-A0)

200 RETURN

210 REM cubic foot volume to top diameter equation--Burkhart, H.E. 1977.
 Cubic foot volume of loblolly pine to any merchantable top
 limit. So. J. Appl. Forestry 2:7-9

220 V=.00828+.00205*XK*XK*H

230 R=1-.48402*(CF1^3.3835/XK^3.0881)

240 CCUFT=V*R

250 RETURN

BASIC LISTING (continued)

```

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260  REM basal area projection--Sullivan, A.D. and J.L. Clutter. 1972. A
      simultaneous growth and yield model for loblolly pine. Forest
      Sci. 18:76-86

270  R=AGE/PAGE
280  R1=1-R
290  BA=R*LOG(BA)+3.4344*R1+.026748*R1*S1
300  BA=EXP(BA)
310  RETURN

320  REM initialize table totals

330  READ CF1,CF2$,BF2,BF3$,BF1$
340  DATA
      4.0,
      0.B.,
      6.0,
      1.B.
350  DATA
      " INTERNATIONAL 1/4 "

360  REM control program

370  PRINT:
      PRINT:
      PRINT"DIAMETER DISTRIBUTION MODEL FOR UNTHINNED, NATURAL LOBLOLLY PINE S
      TANDS"

380  PRINT:
      INPUT "SELECT OPTION -1(INITIALIZE), 0(STOP), OR 1(PROJECT) ",IOPT%
390  IOPT%=IOPT%+2
400  IF
      IOPT%<1 OR IOPT%>3
      THEN
      GOTO 380

410  ON
      IOPT%
      GOSUB 440,430,610
420  GOTO 380
430  END

440  REM initialize distribution

450  SI=0

460  REM read and check inputs

470  PRINT:
      PRINT"INPUT LOBLOLLY PINE AGE,DOM./CODOM. HEIGHT,BASAL AREA,TREES PER AC
      RE":
      INPUT" ",AGE,HD,BA,TR
480  IF
      AGE > 9 AND AGE <81 AND HD >29.9 AND HD < 120.1
      THEN
      GOTO 490

```

BASIC LISTING (continued)

```

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      ELSE
        PRINT"AGE AND/OR HEIGHT ARE OUTSIDE":
        PRINT "DATABASE BOUNDS--VALUES ARE"AGE,HD:
        GOTO 470
490  IF
      BA > 0 OR TR > 0
      THEN
        GOTO 500
      ELSE
        PRINT
          "MUST SPECIFY EITHER BASAL AREA OR TREES PER ACRE OR BOTH":
        GOTO 470
500  IF
      BA <= 0
      THEN
        BA=FNBAA
510  IF
      TR<=0
      THEN
        TR=FNTREES
520  IF
      BA >49.9 AND BA<225.1 AND TR>99.9 AND TR<1300.1
      THEN
        GOTO 540
      ELSE
        PRINT "BASAL AREA AND/OR TREES PER ACRE ARE OUTSIDE":
        PRINT "DATABASE BOUNDS--VALUES ARE"BA,TR:
        GOTO 470

530  REM calculate stand attributes and recover distribution
540  D2=SQR(BA/TR/.005454):
      S1=FNSITE:
      D1=FNDAVG:
      A=FNAPARM
550  IF
      A < 0
      THEN
        A=0
560  D22=D2*D2
570  GOSUB 1150:
      D1=D1P
580  IF
      IER=0 OR IER=2
      THEN
        GOTO 590
      ELSE
        PRINT
          "MOMENT SOLUTION NOT POSSIBLE FOR GIVEN STAND ATTRIBUTES":
        RETURN
590  PRINT :
      PRINT " INITIAL CONDITIONS":
      PRINT
600  GOSUB 780:

```

BASIC LISTING (continued)

```

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  RETURN

610  REM project distribution
620  IF
      SI<=0
      THEN
          PRINT "NO CURRENT STAND TABLE EXISTS":
          RETURN

630  REM read and check inputs
640  PRINT :
      INPUT;"INPUT PROJECTION AGE ",PAGE
650  IF
      PAGE<=AGE OR PAGE>80
      THEN
          PRINT :
          PRINT "PROJECTION AGE MUST BE > CURRENT AGE AND < 80":
          RETURN

660  REM survival equation should go here
670  GOSUB 260:
      AGE=PAGE:
      HD=FNHTDOM
680  PTR=FN TREES
690  IF
      PTR>TR
      THEN
          PRINT :
          PRINT
              "****WARNING*** PROJECTED NUMBER OF TREES SET EQUAL TO CURREN
              T NUMBER":
          PRINT
      ELSE
          TR=PTR

700  REM calculate stand attributes and recover distribution
710  D2=SQR(BA/TR/.005454):
      D1=FNDAVG:
      A=FNAPARM
720  IF
      A<0
      THEN
          A=0
730  D22=D2*D2
740  GOSUB 1150:
      D1=D1P
750  IF
      IER=0 OR IER=2
      THEN
          GOTO 760

```

BASIC LISTING (continued)

```

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      ELSE
        PRINT
          "MOMENT SOLUTION NOT POSSIBLE FOR GIVEN STAND ATTRIBUTES":
        RETURN
760 PRINT:
    PRINT :
    PRINT "  PROJECTED CONDITIONS":
    PRINT
770 GOSUB 780:
    RETURN

780 REM output stand table
790 DEF FNCFD(X)=1-EXP(-1*((X-A)/B)^C)
800 REM print whole stand information
810 PRINT USING "AGE ### YEARS";AGE
820 PRINT USING "SITE INDEX(BASE 50) ### FEET";SI
830 PRINT USING "BASAL AREA ### SQ.FT.";BA
840 PRINT USING "TREES PER ACRE ###";TR
850 PRINT USING "DOM./CODOM. HEIGHT ### FEET";HD
860 PRINT USING "ARITHMETIC MEAN D.B.H. ##.# INCHES";D1
870 PRINT USING "QUADRATIC MEAN D.B.H. ##.# INCHES";D2
880 PRINT :
    PRINT TAB(30) "STAND/STOCK TABLE"
890 GOSUB 1130
900 PRINT TAB(34) "TOTAL    MERCHANTABLE    ";:
    PRINT USING "&";BF1$
910 PRINT
    "    DBH      TREES      BASAL AREA      HEIGHT CUBIC FOOT VOLUME  BOARD FOOT
      T VOLUME"
920 PRINT " (INCHES) PER ACRE (SQ.FT./ACRE) (FEET)";
930 PRINT USING " #.#_-INCH & TOP ##.#_-INCH & TOP";CF1,CF2$,BF2,BF3$
940 GOSUB 1130:
    GOSUB 150

950 REM compute and print one class's information
960 IFLAG%=0:
    TCUFT=0:
    TBDFT=0:
    TTR=0:
    TBA=0:
    CLOW=0:
    K%=A
970 XK=K%:
    XUP=XK+.5:
    CUP=FNCFD(XUP):
    CTR=(CUP-CLOW)*TR
980 REM note that estimates for 1st class are biased low as 1-inch class
    midpoint dbh is used

```

BASIC LISTING (continued)

```

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 990  IF
      CIR>.05
      THEN
          GOTO 1010
1000  IF
      IFLAG%=1
      THEN
          GOTO 1110
      ELSE
          GOTO 1090
1010  IFLAG%=1:
      CBA=.005454*XK*XK*CTR:
      TTR=TTR+CTR:
      TBA=TBA+CBA
1020  H=FNIIT(XK):
      IF
          H<5
          THEN
              H=5
1030  CBDFT=0:
      PTR=CTR
1040  IF
      K%<8
      THEN
          GOTO 1060
      ELSE
          STR=FNPSAW(XK)*CTR:
          PTR=CTR-STR:
          CBDFT=FNBDFT(H,XK)*STR:
          IF
              CBDFT<0
              THEN
                  CBDFT=0
1050  TBDFT=TBDFT+CBDFT
1060  GOSUB 210:
      CCUFT=CCUFT*PTR:
      IF
          CCUFT<0
          THEN
              CCUFT=0
1070  TCUFT=TCUFT+CCUFT
1080  PRINT USING "    ##    ##.#    ##.#    ###";K%,CTR,CBA,H;:
      PRINT SPC(9);:
      PRINT USING "#####";CCUFT;:
      PRINT SPC(15);:
      PRINT USING "#####";CBDFT
1090  K%=K%+1:
      CLOW=CUP:
      GOTO 970

1100  REM print totals

1110  GOSUB 1130:
      PRINT " TOTAL ";

```

BASIC LISTING (continued)

```

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1120 PRINT USING "####.#      ###.#";TTR,TBA;;
PRINT SPC(6) "----" SPC(8);;
PRINT USING "#####";TCUFT;;
PRINT SPC(15);;
PRINT USING "#####";TBDFT;
RETURN

1130 REM print dashed line

1140 FOR I%=1 TO 78:
| PRINT "-";:
NEXT:
PRINT:
RETURN

1150 REM recover weibull parameters

1160 SHAPEL=1:
SHAPEU=5:
!this program will not work properly with shapel<.1
1170 IER%=0:
A#=A:
B=0:
C=0:
D22#=D22:
D1P=D1:
D2P=D22:
IFLAG%=0
1180 D1#=D1P:
XN#=SHAPEL:
C#=XN#:
( THEN )
GOSUB 1340:
FXN#=FVAL#
1190 IF
FXN#<0
THEN
GOTO 1210
ELSE
IER%=2
1200 IF
IFLAG%<>0
THEN
IER%=3:
RETURN
ELSE
D1P=D1P+.01:
GOTO 1180
1210 XN1#=SHAPEU:
C#=XN1#:
GOSUB 1340:
FXN1#=FVAL#
1220 IF
FXN1#>0

```

BASIC LISTING (continued)

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```

      THEN
        GOTO 1230
      ELSE
        IER%=2:
        IFLAG%=1:
        D1P=D1P-.01:
        ( THEN )
          GOTO 1180
1230  FOR J%=1 TO 5
1240  | TEMP#=(XN#+XN1#)/2#:
      | C#=TEMP#:
      | GOSUB 1340:
1250  | FTEMP#=FVAL#
      | IF
      |   FTEMP#*FXN#<0
      |   THEN
      |     XN1#=TEMP#:
      |     FXN1#=FTEMP#
      |   ELSE
      |     XN#=TEMP#:
      |     FXN#=FTEMP#
1260  NEXT
1270  FOR J%=1 TO 100
1280  | TEMP#=XN#-FXN#*(XN#-XN1#)/(FXN#-FXN1#)
1290  | XN1#=XN#:
      | FXN1#=FXN#:
      | XN#=TEMP#:
      | C#=XN#:
      | GOSUB 1340:
      | FXN#=FVAL#
1300  | IF
      |   FXN#>-.00001# AND FXN#<.00001#
      |   THEN
      |     GOTO 1330
1310  NEXT
1320  IER%=1:
      D2P=D22#-FXN#
1330  B=B#:
      C=C#:
      RETURN

1340  REM function for recovering weibull parameters
1350  ZX#=1#+1#/C#:
      GOSUB 1390:
      G1#=GAMMA#
1360  ZX#=1#+2#/C#:
      GOSUB 1390:
      G2#=GAMMA#
1370  B#=(D1#-A#)/G1#
1380  FVAL#=D22#-A#*A#-2#*A#*B#*G1#-B#*B#*G2#:
      RETURN

1390  REM double precision gamma for an argument >+1

```

BASIC LISTING (continued)

```

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      IBM Personal Computer BASIC Formatter and Cross-Reference V 1.00

1400  N%=ZX#-.5# :
      XI#=N% :
      N%=XI#-1#
1410  FRAC#=ZX#-XI#
1420  GAMMA#=1#+FRAC#*(-.577191652#+FRAC#*(.988205891#+FRAC#*(-.897056937#+
      FRAC#*(.918206857#))))
1430  GAMMA#=GAMMA#+FRAC#^5*(-.756704078#+FRAC#*(.482199394#+FRAC#*(-
      .193527818#+FRAC#*(.035868343#))))
1440  IF
      N%=0
      THEN
      RETURN
1450  PROD#=1#
1460  FOR L%=1 TO N% :
      | L#:=L% :
      | PROD#:=PROD#*(FRAC#+L#) :
      NEXT
1470  GAMMA#=GAMMA#*PROD# :
      RETURN

```