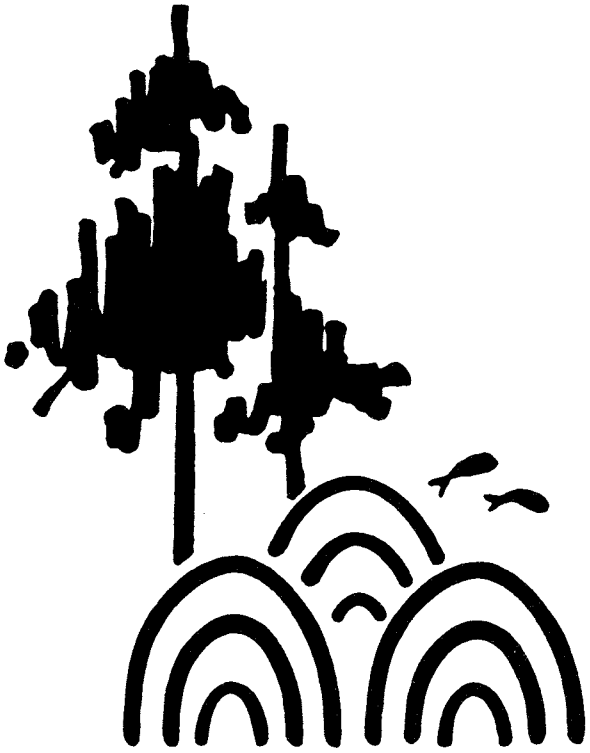
Diameter Distributions and Yields of Natural Stands of Loblolly Pine



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

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DIAMETER DISTRIBUTIONS AND YIELDS OF NATURAL STANDS OF LOBLOLLY PINE

by

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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
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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

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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) 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

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

$$\ln(h) = \ln(a_0) + a_1/dbh \tag{1}$$

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

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

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

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

where H = height of dominants and codominants (feet)
B = basal area (square feet per acre)
$\bar{H}$ = height of tree of dbh $\bar{D}_2$ (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

$$P = 1.0/(1.0 + \exp(b_0 + b_1/\text{dbh} + b_2 B)) \qquad (5)$$

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

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

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

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

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

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

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

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

where $\overline{D}_1$ = arithmetic mean dbh (inches)
$\Gamma_k = \Gamma(1 + k/c)$
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 determinedusing (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	$\ln(N) = 8.3931 + 1.8360 \ln(B) - .01968 A - 2.4754 \ln(H) - .1112 B/A$
	$R^2(N) = .77$ 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	$\ln(\overline{D}_2-\overline{D}_1) = 32.9856 - 4.7745 \ln(H) - 326.1481/H - 1.7136 \ln(B) - 109.5631/B$
	$R^2(\overline{D}_1) = .99$ bias $(\overline{D}_1) = .01$ MAD$(\overline{D}_1) = .06$
Probability of sawtimber tree	$P = 1.0/(1.0 + \exp(-10.8908 + 122.6106/dbh - .0224 B))$
	$R^2(P) = .53$ bias$(P) = 0$ MAD$(P) = .24$ $\overline{P} = .48$ $n = 2052$
Total tree height	$\ln(h) = \ln(a_0) + a_1/dbh$
	$a_0 = H\ (1.0 + 3.4831B^{-.6504} \exp(.01088\ H))$
	$\overline{H} = H \exp(-H^{.9053}/(\overline{D}_2 + 4.2566)^{2.4606})$
	$a_1 = \overline{D}_2\ (\ln(\overline{H}) - \ln(a_0))$
	$R^2(h) = .86$ bias$(h) = .2$ MAD$(h) = 3.3$ $\overline{h} = 55.7$ $n = 1651$
Weibull location parameter	$a = \text{maximum}\ (0.0, -3.6732 + .01111\ B + .6876\ \overline{D}_2)$
	$R^2(a) = .54$ 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)
$\bar{D}_1$ = 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
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
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 Burkhart et al. (1972) and Burkhart (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 Burkhart et al. (1972). The cubic foot volumes were computed using the equations in Burkhart (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	39.4	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 7.9 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	13.1	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 9.1 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	42.5	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 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	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 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	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 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	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 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
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
9	27.5	12.1	51	137	231
10	13.0	7.1	53	40	316
11	5.2	3.4	54	8	220
12	1.7	1.4	55	1	105
13	0.5	0.5	56	0	38
14	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	22.8	60	371	250
9	51.4	22.7	62	205	963
10	35.6	19.4	64	68	1416
11	21.8	14.4	66	19	1314
12	11.8	9.3	67	5	958
13	5.7	5.3	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 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 CUBIC FOOT VOLUME 4.0-INCH O.B. TOP	INTERNATIONAL 1/4 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	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	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	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	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 595
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	991
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 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	16.4	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 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	65.4	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 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	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 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	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    (14)
 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
```

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	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 HTCOEF 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, PAGE-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 CF1 below). The corresponding variables in BASIC are H, XK, and CF1. 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 BDFT 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                                                                       NAT00010
C  PROGRAM NATLOB--DIAMETER DISTRIBUTION MODEL FOR NATURAL STANDS OF    NAT00020
C                  LOBLOLLY PINE. T.E. BURK VPI&SU NOVEMBER 1, 1983     NAT00030
C                                                                       NAT00040
      COMMON/BLK1/AGE,SI,BA,TR,HD,D1,D2                                 NAT00050
C                                                                       NAT00060
C  CONTROL PROGRAM                                                      NAT00070
C                                                                       NAT00080
      WRITE(6,1000)                                                     NAT00090
10    WRITE(6,1001)                                                     NAT00100
      READ(5,*)IOPT                                                     NAT00110
      IF(IOPT)20,40,30                                                  NAT00120
20    SI=0.0                                                            NAT00130
      CALL INIT                                                         NAT00140
      GO TO 10                                                          NAT00150
30    CALL PROJ                                                         NAT00160
      GO TO 10                                                          NAT00170
40    STOP                                                              NAT00180
1000  FORMAT(//' DIAMETER DISTRIBUTION MODEL FOR UNTHINNED, NATURAL ',  NAT00190
     +'LOBLOLLY PINE STANDS')                                           NAT00200
1001  FORMAT(/' SELECT OPTION -1(INITIALIZE),0(STOP), OR 1(PROJECT)')   NAT00210
      END                                                               NAT00220
C                                                                       NAT00230
C                                                                       NAT00240
C                                                                       NAT00250
      SUBROUTINE INIT                                                   NAT00260
C                                                                       NAT00270
C  INITIALIZE DISTRIBUTION                                              NAT00280
C                                                                       NAT00290
      COMMON/BLK1/AGE,SI,BA,TR,HD,D1,D2                                 NAT00300
10    WRITE(6,1000)                                                     NAT00310
C                                                                       NAT00320
C  READ AND CHECK INPUTS                                                NAT00330
C                                                                       NAT00340
      READ(5,*)AGE,HD,BA,TR                                             NAT00350
      IF(AGE.GE.10.0.AND.AGE.LE.80.0   .AND.                            NAT00360
     +   HD.GE.30.0.AND.HD.LE.120.0)GO TO 20                            NAT00370
      WRITE(6,1001)AGE,HD                                               NAT00380
      GO TO 10                                                          NAT00390
20    IF(BA.GT.0.0.OR.TR.GT.0.0)GO TO 30                                NAT00400
      WRITE(6,1002)                                                     NAT00410
      GO TO 10                                                          NAT00420
30    IF(BA.LE.0.0)BA=BAA(TR,AGE,HD)                                    NAT00430
      IF(TR.LE.0.0)TR=TREES(BA,AGE,HD)                                  NAT00440
      IF(BA.GE.50.0.AND.BA.LE.225.0    .AND.                            NAT00450
     +   TR.GE.100.0.AND.TR.LE.1300.0)GO TO 40                          NAT00460
      WRITE(6,1003)BA,TR                                                NAT00470
      GO TO 10                                                          NAT00480
C                                                                       NAT00490
C  COMPUTE STAND ATTRIBUTES AND RECOVER DISTRIBUTION                    NAT00500
C                                                                       NAT00510
40    D2=SQRT(BA/TR/.005454)                                            NAT00520
      SI=SITE(HD,AGE)                                                   NAT00530
      D1=DAVG(D2,HD,BA)                                                 NAT00540
      A=APARM(D2,BA)                                                    NAT00550
```

FORTRAN LISTING (continued)

```
      IF(A.LT.0.0)A=0.0                                                 NAT00560
      D22=D2*D2                                                         NAT00570
      CALL WEIBM2(D1,D22,A,1.0,5.0,B,C,D1P,D2P,IER)                     NAT00580
      D1=D1P                                                            NAT00590
      IF(IER.EQ.0.OR.IER.EQ.2)GO TO 50                                  NAT00600
      WRITE(6,1004)                                                     NAT00610
      RETURN                                                            NAT00620
50    WRITE(6,1005)                                                     NAT00630
      CALL TABOUT(A,B,C)                                                NAT00640
      RETURN                                                            NAT00650
1000  FORMAT(/' INPUT LOBLOLLY PINE AGE,DOM./CODOM. HEIGHT,BASAL AREA,TRNAT00660
     +EES PER ACRE')                                                    NAT00670
1001  FORMAT(' AGE AND/OR HEIGHT ARE OUTSIDE'/' DATABASE BOUNDS--',     NAT00680
     +'VALUES ARE ',2G12.6)                                             NAT00690
1002  FORMAT(' MUST SPECIFY EITHER BASAL AREA OR TREES PER ACRE OR BOTH'NAT00700
     +)                                                                 NAT00710
1003  FORMAT(' BASAL AREA AND/OR TREES PER ACRE ARE OUTSIDE'/' DATABASE'NAT00720
     +,' BOUNDS--VALUES ARE ',2G12.6)                                   NAT00730
1004  FORMAT(' MOMENT SOLUTION NOT POSSIBLE FOR GIVEN STAND ATTRIBUTES')NAT00740
1005  FORMAT(/'     INITIAL CONDITIONS'/)                               NAT00750
      END                                                               NAT00760
C                                                                       NAT00770
C                                                                       NAT00780
C                                                                       NAT00790
      SUBROUTINE PROJ                                                   NAT00800
C                                                                       NAT00810
C  PROJECT DISTRIBUTION                                                 NAT00820
C                                                                       NAT00830
      COMMON/BLK1/AGE,SI,BA,TR,HD,D1,D2                                 NAT00840
      IF(SI)10,10,20                                                    NAT00850
10    WRITE(6,1000)                                                     NAT00860
C                                                                       NAT00870
C  READ AND CHECK INPUTS                                                NAT00880
C                                                                       NAT00890
      RETURN                                                            NAT00900
20    WRITE(6,1001)                                                     NAT00910
      READ(5,*)PAGE                                                     NAT00920
      IF(PAGE.GT.AGE.AND.PAGE.LE.80.0)GO TO 30                          NAT00930
      WRITE(6,1002)                                                     NAT00940
      RETURN                                                            NAT00950
C                                                                       NAT00960
C  COMPUTE STAND ATTRIBUTES AND RECOVER DISTRIBUTION                    NAT00970
C                                                                       NAT00980
30    BA=PROJBA(AGE,PAGE,BA,SI)                                         NAT00990
      AGE=PAGE                                                          NAT01000
      HD=HTDOM(SI,AGE)                                                  NAT01010
      PTR=TREES(BA,AGE,HD)                                              NAT01020
C  CHECK TO SEE THAT TREES DECREASE                                     NAT01030
C   (SURVIVAL EQUATION WILL GO HERE)                                    NAT01040
      IF(PTR.LE.TR)GO TO 40                                             NAT01050
      WRITE(6,1003)                                                     NAT01060
      GO TO 50                                                          NAT01070
40    TR=PTR                                                            NAT01080
50    D2=SQRT(BA/TR/.005454)                                            NAT01090
      D1=DAVG(D2,HD,BA)                                                 NAT01100
```

FORTRAN LISTING (continued)

```
      A=APARM(D2,BA)
C  SINCE BA AND D2 MUST INCREASE SO MUST A
      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 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
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
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
```

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*XK*XK*CTR
      TTR=TTR+CTR
      TBA=TBA+CBA
      H=HT(A0,A1,XF)
      CBDFT=0.0
      PTR=CTR
      IF(K.LT.8)GO TO 15
      STR=PSAW(XK,BA)*CTR
      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
      ITBDFT=TBDFT+.5
C
C  PRINT TABLE TOTALS
C
      WRITE(6,1005)TTR,TBA,ITCUFT,ITBDFT
      RETURN
1001  FORMAT('  AGE ',I3,' YEARS'/'  SITE INDEX(BASE 50) ',I3,' FEET'/
     +'  BASAL AREA ',I3,' SQ.FT.'/'  TREES PER ACRE ',I4/
     +'  DOM./CODOM. HEIGHT ',I3,' 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 VOLU
     +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,I2,5X,F5.1,7X,F5.1,6X,I3,9X,I4,16X,I4)
1005  FORMAT(1X,78('-')/3X,'TOTAL',3X,F6.1,7X,F5.1,6X,'---',8X,I5,15X,I5
     +//)
      END
C
C
C
      REAL FUNCTION HTDOM(SI,AGE)
C
```

FORTRAN LISTING (continued)

```
C  HEIGHT OF DOMINANTS AND CODOMINANTS--SCHUMACHER, F.X., AND T.S. COILENAT02210
C  1960. GROWTH AND YIELD OF NATURAL STANDS OF THE SOUTHERN PINES.       NAT02220
C  T.S. COILE, INC., 115PP.                                              NAT02230
C                                                                        NAT02240
      HTDOM=ALOG10(SI)-6.528*(1.0/AGE-.02)                               NAT02250
      HTDOM=10**HTDOM                                                    NAT02260
      RETURN                                                             NAT02270
      END                                                                NAT02280
C                                                                        NAT02290
C                                                                        NAT02300
C                                                                        NAT02310
      REAL FUNCTION TREES(BA,AGE,HD)                                     NAT02320
C                                                                        NAT02330
C  CURRENT TREES PER ACRE                                                NAT02340
C                                                                        NAT02350
      TREES=8.3931+1.8360*ALOG(BA)-.01968*AGE-2.4754*ALOG(HD)-.1112*BA/ NAT02360
     +AGE                                                                NAT02370
      TREES=EXP(TREES)                                                   NAT02380
      RETURN                                                             NAT02390
      END                                                                NAT02400
C                                                                        NAT02410
C                                                                        NAT02420
C                                                                        NAT02430
      REAL FUNCTION BAA(TR,AGE,HD)                                       NAT02440
C                                                                        NAT02450
C  CURRENT BASAL AREA                                                    NAT02460
C                                                                        NAT02470
      BAA=2.8078+.5027*ALOG(TR)+.009135*AGE+12.4668/AGE-100.6073/HD      NAT02480
      BAA=EXP(BAA)                                                       NAT02490
      RETURN                                                             NAT02500
      END                                                                NAT02510
C                                                                        NAT02520
C                                                                        NAT02530
C                                                                        NAT02540
      REAL FUNCTION DAVG(D2,HD,BA)                                       NAT02550
C                                                                        NAT02560
C  ARITHMETIC MEAN DBH                                                   NAT02570
C                                                                        NAT02580
      DAVG=32.9856-4.7745*ALOG(HD)-326.1481/HD-1.7136*ALOG(BA)-109.5631/NAT02590
     +BA                                                                 NAT02600
      DAVG=D2-EXP(DAVG)                                                  NAT02610
      RETURN                                                             NAT02620
      END                                                                NAT02630
C                                                                        NAT02640
C                                                                        NAT02650
C                                                                        NAT02660
      REAL FUNCTION APARM(D2,BA)                                         NAT02670
C                                                                        NAT02680
C  WEIBULL LOCATION PARAMETER                                            NAT02690
C                                                                        NAT02700
      APARM=-3.6732+.01111*BA+.6876*D2                                   NAT02710
      RETURN                                                             NAT02720
      END                                                                NAT02730
C                                                                        NAT02740
C                                                                        NAT02750
```

FORTRAN LISTING (continued)

```
C
      REAL FUNCTION PSAW(D,BA)
C
C  PROBABILITY (PROPORTION) OF SAWTIMBER TREES
C
      PSAW=EXP(-10.8908+122.6106/D-.0224*BA)
      PSAW=1.0/(1.0+PSAW)
      RETURN
      END
C
C
C
      SUBROUTINE HTCOEF(HD,D2,AGE,BA,A0,A1)
C
C  COEFFICIENTS OF TOTAL HEIGHT-DBH EQUATION
C
      HD2=HD*EXP(-1.0*HD**.9053/(D2+4.2566)**2.4606)
      A0=HD*(1.0+3.4831/BA**.6504*EXP(.01088*HD))
      A0=ALOG(A0)
      A1=D2*(ALOG(HD2)-A0)
      RETURN
      END
C
C
C
      REAL FUNCTION HT(A0,A1,D)
C
C  INDIVIDUAL TREE TOTAL HEIGHT
C
      HT=EXP(A0+A1/D)
      IF(HT.LT.5.0)HT=5.0
      RETURN
      END
C
C
C
      REAL FUNCTION BDFT(H,D)
C
C  BOARD FOOT VOLUME OF ONE TREE--BURKHART, H.E., R.C. PARKER, AND R.G.
C  ODERWALD. 1972. YIELDS FOR NATURAL STANDS OF LOBLOLLY PINE. DIV.
C  OF FORESTRY AND WILDLIFE RESOURCES, VA. POLYTECH. INST. AND STATE
C  UNIV., FWS-2-72, 63PP.
C
      BDFT=-23.67532+.01102*D*D*H
      RETURN
      END
C
C
C
      REAL FUNCTION CUFT(H,D,TD)
C
C  CUBIC FOOT VOLUME OF ONE TREE--BURKHART, H.E. 1977. CUBIC FOOT VOLUME
C  OF LOBLOLLY PINE TO ANY MERCHANTABLE TOP LIMIT. SO. J. APPL.
C  FORESTRY. 2:7-9.
C
```

FORTRAN LISTING (continued)

```
      V=.00828+.00205*D*D*H                                             NAT03310
      R=1.0-.48402*(TD**3.3835/D**3.0881)                               NAT03320
      CUFT=V*R                                                          NAT03330
      RETURN                                                            NAT03340
      END                                                               NAT03350
C                                                                       NAT03360
C                                                                       NAT03370
C                                                                       NAT03380
      BLOCK DATA                                                        NAT03390
C                                                                       NAT03400
C  INITIALIZE TABLE LABELS                                              NAT03410
C                                                                       NAT03420
      INTEGER CF2,BF1(5),BF3                                            NAT03430
      COMMON/LABELS/CF1,CF2,BF1,BF2,BF3                                 NAT03440
      DATA CF1,BF2/4.0,6.0/                                             NAT03450
      DATA CF2,BF3/'O.B.','I.B.'/                                       NAT03460
      DATA BF1/' INT','ERNA','TION','AL 1','/4  '/                      NAT03470
      END                                                               NAT03480
C                                                                       NAT03490
C                                                                       NAT03500
C                                                                       NAT03510
      REAL FUNCTION SITE(HD,AGE)                                        NAT03520
C                                                                       NAT03530
C  SITE INDEX--SCHUMACHER, F.X. AND T.S. COILE. 1960. GROWTH AND YIELD  NAT03540
C  OF NATURAL STANDS OF THE SOUTHERN PINES. T.S. COILE, INC., 115PP.    NAT03550
C                                                                       NAT03560
      SITE=ALOG10(HD)+6.528*(1.0/AGE-.02)                               NAT03570
      SITE=10**SITE                                                     NAT03580
      RETURN                                                            NAT03590
      END                                                               NAT03600
C                                                                       NAT03610
C                                                                       NAT03620
C                                                                       NAT03630
      REAL FUNCTION PROJBA(AGE,PAGE,BA,SI)                              NAT03640
C                                                                       NAT03650
C  PROJECT BASAL AREA--SULLIVAN, A.D. AND J.L. CLUTTER. 1972. A         NAT03660
C  SIMULTANEOUS GROWTH AND YIELD MODEL FOR LOBLOLLY PINE.               NAT03670
C  FOREST SCI. 18:76-86.                                                NAT03680
C                                                                       NAT03690
      R=AGE/PAGE                                                        NAT03700
      R1=1.0-R                                                          NAT03710
      PROJBA=R*ALOG(BA)+3.4344*R1+.026748*R1*SI                         NAT03720
      PROJBA=EXP(PROJBA)                                                NAT03730
      RETURN                                                            NAT03740
      END                                                               NAT03750
C                                                                       NAT03760
C                                                                       NAT03770
C                                                                       NAT03780
      SUBROUTINE WEIBM2(X1,X2,LOCA,SHAPEL,SHAPEU,SCALE,SHAPE,X1P,       NAT03790
     +X2P,IER)                                                          NAT03800
      REAL*8 A,B,C,D1,D2,XN,FXN,XN1,FXN1,TEMP,FTEMP                     NAT03810
      REAL LOCA                                                         NAT03820
      COMMON/BLKM22/A,B,C,D1,D2                                         NAT03830
C                                                                       NAT03840
C         PURPOSE                                                       NAT03850
```

· 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 PARM. 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
      IER=0                                                              NAT04220
      A=DBLE(LOCA)                                                       NAT04230
      SCALE=0.0                                                          NAT04240
      SHAPE=0.0                                                          NAT04250
      D2=DBLE(X2)                                                        NAT04260
      X1P=X1                                                             NAT04270
      X2P=X2                                                             NAT04280
      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
10    D1=DBLE(X1P)                                                       NAT04350
      XN=DBLE(SHAPEL)                                                    NAT04360
      FXN=FCV(XN)                                                        NAT04370
      IF(FXN.LT.0.D0)GO TO 30                                            NAT04380
      IER=2                                                              NAT04390
      IF(IFLAG.EQ.0)GO TO 20                                             NAT04400
```

FORTRAN LISTING (continued)

```
      IER=3                                                             NAT04410
      RETURN                                                            NAT04420
20    X1P=X1P+.01                                                       NAT04430
      GO TO 10                                                          NAT04440
30    XN1=DBLE(SHAPEU)                                                  NAT04450
      FXN1=FCV(XN1)                                                     NAT04460
      IF(FXN1.GT.0.D0)GO TO 40                                          NAT04470
      IER=2                                                             NAT04480
      IFLAG=1                                                           NAT04490
      X1P=X1P-.01                                                       NAT04500
      GO TO 10                                                          NAT04510
C                                                                       NAT04520
C  DO 5 BISECTION ITERATIONS TO GET STARTED                             NAT04530
C                                                                       NAT04540
40    DO 60 J=1,5                                                       NAT04550
      TEMP=(XN+XN1)/2.D0                                                NAT04560
      FTEMP=FCV(TEMP)                                                   NAT04570
      IF(FTEMP*FXN.LE.0.D0)GO TO 50                                     NAT04580
      XN=TEMP                                                           NAT04590
      FXN=FTEMP                                                         NAT04600
      GO TO 60                                                          NAT04610
50    XN1=TEMP                                                          NAT04620
      FXN1=FTEMP                                                        NAT04630
60    CONTINUE                                                          NAT04640
C                                                                       NAT04650
C  BEGIN SECANT ITERATION                                               NAT04660
C                                                                       NAT04670
      DO 70 J=1,100                                                     NAT04680
      TEMP=XN-FXN*(XN-XN1)/(FXN-FXN1)                                   NAT04690
      XN1=XN                                                            NAT04700
      FXN1=FXN                                                          NAT04710
      XN=TEMP                                                           NAT04720
      FXN=FCV(XN)                                                       NAT04730
      IF(DABS(FXN).LE.0.00001)GO TO 80                                  NAT04740
70    CONTINUE                                                          NAT04750
      IER=1                                                             NAT04760
      X2P=SNGL(D2-FXN)                                                  NAT04770
80    SHAPE=SNGL(C)                                                     NAT04780
      SCALE=SNGL(B)                                                     NAT04790
      RETURN                                                            NAT04800
      END                                                               NAT04810
C                                                                       NAT04820
C                                                                       NAT04830
      DOUBLE PRECISION FUNCTION FCV(ZX)                                 NAT04840
      IMPLICIT REAL*8 (A-H,O-Z)                                         NAT04850
      COMMON/BLKM22/A,B,C,D1,D2                                         NAT04860
C                                                                       NAT04870
C  THIS FUNCTION EVALUATES THE FUNCTION WHOSE ROOT IS DESIRED.          NAT04880
C                                                                       NAT04890
      C=ZX                                                              NAT04900
      G1=DGAMMA(1.0+1.0/C)                                              NAT04910
      G2=DGAMMA(1.0+2.0/C)                                              NAT04920
      B=(D1-A)/G1                                                       NAT04930
      FCV=D2-A*A-2.0*A*B*G1-B*B*G2                                      NAT04940
      RETURN                                                            NAT04950
      END                                                               NAT04960
```

BASIC LISTING

```
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  10  REM PROGRAM NATLOB--Natural stand loblolly pine diameter distribution
         growth and yield model--T.C. 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
         FNBAA=EXP(2.8078+.5027*LOG(TR)+9.135001E-03*AGE+12.4668/AGE-100.6073/
            HD)                         'basal area equation
  60  DEF
         FNDAVG=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 FNBDFT(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*SI
 300  BA=EXP(BA)
 310  RETURN

 320  REM initialize table totals

 330  READ CF1,CF2$,BF2,BF3$,BF1$
 340  DATA
         4.0,
         O.B.,
         6.0,
         I.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):
      SI=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=FNTREES
 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 FNCDF(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 FOO
         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=FNCDF(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
         CTR>.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=FNHT(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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      IBM Personal Computer BASIC Formatter and Cross-Reference  V 1.00

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)

```
NATLOBB                          14:38:35   01-15-1984                        PAGE 8
      IBM Personal Computer BASIC Formatter and Cross-Reference  V 1.00

             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:
      |  FTEMP#=FVAL#
1250  |  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
```