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A Computer Program For Variable Density Yield Tables For Loblolly Pine Plantations

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SUMMARY

The computer program described here uses relationships developed from research on loblolly pine growth to predict volumes and yields of planted stands, over the site range of the species, under a wide range of management alternatives. Timing and severity of thinnings, length of rotation, and type of harvest can be modified to compare the effects of various management strategies on wood yield. The program can be modified readily for other conditions or species.

Additional keywords: Timber management, forest management, simulation, *Pinus taeda*.

CONTENTS

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INTRODUCTION

Most decisions in forest management require predictions of growth and yield. Managers plan thinnings to increase volume and value of future growth; they schedule harvest cuts to maximize returns. Sound planning must be based on good estimates of future yield, not only for one set of management actions but for enough possible alternative plans to assure that optimum choices are made. Personal experience, past production records, and published yield tables from research plots afford a basis for such predictions, but they usually apply to single combinations of stand and management options.

Described here is a computer program that uses relationships developed from research on loblolly pine (Pinus taeda L.) growth to predict volumes and yields of planted stands, over the site range of the species, under a wide range of management alternatives. The program estimates yields in cubic feet, board feet, and cords per acre, together with numbers of trees, their mean diameter and height, and basal area. It prints these values as predicted for specified time intervals, and immediately before and after each scheduled cut or thinning. Timing and severity of thinnings, length of rotation, and type of harvest (clearcut, seed-tree, two- or three-cut shelterwood) can be modified to compare the effects of various management measures on wood yield. The program can serve as a part of other programs that simulate forest management activities and aid in preparing timber management plans (Myers 1973, 1974).

The program prints a yield table for each stand (uniform in site quality, species, stand structure, and age) for which a single set of management options is specified. The stand may be hypothetical, with assumed initial spacing, or an actual stand for which age, site index, and current measurement statistics are available. Alternative yield tables for an initial stand can be developed by changing one or more management options.

The program thus inexpensively prints expected amounts of thinnings and harvest cuts for such combinations of management actions as may be of interest. Estimates of costs and returns based on such growth projections afford guides to optimum management decisions. In effect, such projections permit the manager to examine probable future impacts of contemplated operations, to consider changes, and to study their effects before money is spent on them.

The program, YLDTBL, written in ANS standard FORTRAN IV, has been tested on XEROX 560, CDC 6400, and UNIVAC 1108 computers. Readily available equations and data are incorporated in the program. Each equation and constant should be checked for local applicability for use in management planning for specific ownerships. Procedures for any necessary modifications are outlined in the Program Modifications section.

DESCRIPTION OF PROGRAM YLDTBL

Program YLDTBL consists of a main program and six subroutines. Operations performed by each routine are described below and identified by comment statements in the listing of the program in Appendix 1. Subsequent sections of this paper describe the input variables and the

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equations used to compute growth, mortality, and volumes.

Main Program

The main program performs the following operations:

1. Reads the number of stands to be processed and checks that this number is greater than zero. An error message is printed, and the entire job is terminated if a zero or negative number is found.
2. Calls subroutine BEGIN to initiate processing of each stand.
3. Checks five variables of each set of stand data for unwanted zero values. An error message is printed, and processing of the stand terminates if errors are found.
4. Determines from input variables the final age to be reported in each yield table.
5. Calls subroutines CUTS, TABLE, and PROJ in the sequence appropriate to the type and frequency of cuttings to be simulated. These three subroutines simulate the cuttings, write the results of the operations, and compute growth projections.
6. Adds volumes of the final cut to the yields from earlier removals and writes the totals at the bottom of the volume columns of the yield tables.

Subroutine BEGIN

Operations performed by BEGIN are as follows:

1. Assigns a value of zero to 26 variables to clear computer memory of data from previous computations.
2. Reads four data cards to enter inventory data and management options for each stand. These stand and control variables are defined in table 1.
3. Computes average height of the stand, if height is not entered as an item of stand inventory.
4. Computes a theoretical initial number of trees for the stand, for later use in a mortality equation that contains initial stand density as an independent variable.
5. Writes the main heading and column heads of each yield table.

Subroutine CUTS

CUTS simulates the thinnings and regeneration cuts called for by the variables specifying management controls. Volumes before and after partial cutting are computed and stored for later printing in the yield table.

Four regeneration methods can be simulated: (1) clearcutting, (2) seed-tree, (3) two-cut shelterwood, and (4) three-cut shelterwood. Seed-tree and shelterwood cuts are followed by computation of after-cutting values for average stand diameter (d.b.h.) and other stand variables.

Scheduled thinnings are not simulated if either of the following conditions apply:

a. Current basal area is not greater than the specified reserve after thinning.
b. Volumes removed would be less than specified minimums.

Subroutine TABLE

TABLE writes the first line of the body of each yield table. It also performs the following operations each time a partial cut is simulated:

1. Computes amounts to be removed and rounds off values for printing where required.
2. If removals equal or exceed specified minimum commercial limits, adds volumes removed to totals and stores the information.
3. Prints two lines in the body of the table to report status of the stand before and after cutting.

Table 1.—Order and contents of the data deck

Card type	Variable name	Punch card columns	Format	Description of variable
1	NSTND	1-4	I4	Number of sets of cards 2 to 5, inclusive, to be processed.
2	NOTE(I)	1-80	20A4	Location and description of the stand, silvicultural system, etc. Stand, as here used, refers to the usual unit area of reasonably uniform site quality, species, stand structure, and age, but subjected to a single combination of management options; i.e., it is the unit for which a yield table is printed.
3	SPEC(I)	1-32	8A4	Species name to be included in the table heading.
	KAK	33-36	I4	Identification number of the tree species in the stand being processed.
	RINT	37-40	F4.0	Number of years for one projection of growth or change. Must never equal zero.
4	ICUT	1-4	I4	To choose: (1) no noncommercial thinnings, (2) initial thinning may be noncommercial, (3) all thinnings may be noncommercial, or (4) no thinnings to be made.
	DSTY	5-8	F4.0	Basal area to be left in thinnings after the first.
	THIN	9-12	F4.0	Basal area to be left after initial thinning.
	THN1	13-16	F4.0	Stand age when first thinning is considered. Must equal AGEO plus a multiple of CYCL.
	CYCL	17-20	F4.0	Number of years between scheduled thinnings. Must be a multiple of RINT.
	COMBF	21-24	F4.0	Minimum cut in board feet for inclusion in merchantable yield printed at bottom of yield table.
	COMCU	25-28	F4.0	Minimum cut in cubic feet for inclusion in merchantable yield printed at bottom of yield table. Also controls the summation of cordwood volumes.
	REGN(1)	29-32	F4.0	Stand age when first regeneration cut is to be made. Must never equal zero. This is the age for clearcutting if rest of the card is blank, and must equal AGEO plus a multiple of RINT.
	VLLV(1)	33-36	F4.1	Basal area in square feet to be left at age REGN(1). Will be zero for clearcutting.
	REGN(2)	37-40	F4.0	Stand age at which second regeneration cut, if any, will occur. Age for removal of seed trees or second cut of shelterwood; must equal AGEO plus a multiple of RINT.
	VLLV(2)	41-44	F4.1	Basal area to be left at age REGN(2). Will be zero except for three-cut shelterwood.
	REGN(3)	45-48	F4.0	Stand age at which third regeneration cut, if any, will occur. Final cut of three-cut shelterwood; must equal AGEO plus a multiple of RINT.
5	STAND	1-4	F4.0	Identification number of the stand.
	SITE	5-8	F4.0	Site index of the stand (base age 50 years) from averages of dominant and codominant trees. Must never equal zero.
	AGEO	9-12	F4.0	Stand age at first entry in the yield table. Present age of an actual stand or any age of a hypothetical stand. Must never equal zero.
	DBHO	13-16	F4.1	Average d.b.h. (inches) of all live trees at stand age AGEO. From average basal area.
	HTSO	17-20	F4.1	Average height (feet) of dominant and codominant trees at age AGEO.
	DENO	21-24	F4.0	Number of live trees in the stand at age AGEO, regardless of crown class. Must never equal zero.

Subroutine PROJ

PROJ performs the following three operations:

1. Projects average d.b.h., height, and number of trees for one growth period and computes the corresponding volumes. Length of the projection period is selected by the program user.
2. Tests to determine if the time of a scheduled thinning or regeneration cut has been reached; if so, transfers program control to subroutine CUTS.
3. Rounds off values for printing and prints one line of the body of the table, if cutting is not scheduled.

Subroutine SWITCH

SWITCH is called by CUTS and PROJ to select sets of species-specific equations and constants to be used in computations. The tree species for which a table is to be computed is identified by the program user. This identification is used in SWITCH to call the group of equations and constants appropriate to the species.

As listed in Appendix 1, SWITCH calls only subroutine LOBPL (species identification number one). Additional calls (i.e., other species relationships) can be substituted, using procedures described in the section on modifications, below.

Subroutine LOBPL

Subroutine LOBPL contains all the equations and constants that apply to loblolly pine plantations. Any one of the 10 sets of statements, described in the next section, is called as needed by other subroutines. A call consists of (1) identification of the type of computation to be made, (2) assignment of values to temporary variables, if necessary, and (3) call to subroutine SWITCH.

PROGRAM RELATIONSHIPS, LOBPL

Nine types of information are computed by the 10 sets of FORTRAN statements in subroutine LOBPL. These sets, numbered in the order in which they appear in LOBPL, are described below.

Set 1--Periodic Increase in Basal Area and Average Stand D.b.h.

An equation derived by Clutter (1963) estimates potential basal area at the end of each projection period. This equation, based on data from natural stands, was used because similar equations for plantations are not yet available. The future number of trees per acre is computed by applying expected mortality percent (Statement 100, 102, LOBPL, Appendix 1) to present number of trees. Dividing projected basal area by projected number of trees provides estimated mean d.b.h.

Set 2 and 8--Initial Average Dominant and Codominant Height and Periodic Increases in Height

An equation by Lenhart (1972) is used to estimate heights at ages under 25, and one by Farrar (1973) for older stands (Statements 20, 21, 22, LOBPL, Appendix 1). Lenhart's equation was modified slightly to permit use of site indexes with a base age of 50 years. Farrar's equation is a mathematical expression of values originally published in Miscellaneous Publication 50 (U.S. Dep. Agric. 1976). This combination better simulated actual plot performance than either equation alone.

Set 3--Initial Basal Area and D.b.h. of Very Young Stands

These values, needed only when simulation begins with a new plantation of 1-foot-tall trees, are based on data from Smalley and Bailey (1974). D.b.h. and basal area are first computed when the stand reaches a height of 4.5 feet and diameter measurements at breast height are possible (Statement 30, LOBPL, Appendix 1).

Set 4--Cubic- and Board-Foot Volumes Per Acre

Cubic-foot volume inside bark is computed from the tree of average diameter, average dominant and codominant height, and the number of trees per acre (Statement 40, LOBPL, Appendix 1). Cubic-foot volume includes all trees 5 inches in d.b.h. and larger to a 4-inch top diameter outside bark. Volumes for the stand equation were obtained by summation of tree volumes from an equation by Hasness and Lenhart (1972). Similar results were obtained with the Forest Service's tree volume equation for national forests in the west Gulf.

Volumes in rough cords per acre are obtained by dividing each cubic volume by 76.3 (Mesavage 1947).

Cubic volumes are converted to board feet Scribner Rule (Statement 43, LOBPL, Appendix 1) for all trees 9 inches in d.b.h. and larger to a 7-inch top diameter inside bark. Board-foot volumes used to compute the conversion factors were obtained with equations for the national forests in Texas.

Because merchantable volumes estimated for stands of small average d.b.h. are unreliable, cubic volumes are not computed by YLDTBL if average d.b.h. is less than 5.0 inches. Minimum average stand d.b.h. is 6.0 inches for board-foot volumes. Ignoring the small merchantable volume present in stands of smaller d.b.h. has little effect on yields, as volumes per acre would be less than the minimum for commercial cuts.

Set 5--Change in Average D.b.h. and Height due to Initial Thinning

Initial thinnings may increase or decrease average residual diameter by removing trees that are larger or smaller than average. Changes estimated by subroutine LOBPL (Statements 50, 51, LOBPL, Appendix 1) are based on available data from actual thinnings. The program estimates decreases in average d.b.h. ranging from 0.5 inch for very heavy thinnings to zero where 40 percent of the stand is removed, and increases of 0.1 to 0.2 inch for lighter cuts. Independent data from 59 stands in Louisiana tended to confirm this pattern of changes.

Effect of initial thinning on average height of dominant and codominant trees is not well documented. From available data, the program estimates average reductions of 1 foot in height where removal is over 60 percent and 0.5 foot where removal is 45 to 60 percent, an average increase of 0.5 foot where removal is 45 to 10 percent, and no change for lesser cuts (Statements 52, 53, LOBPL, Appendix 1). Modification of Statements 50, 51, 52, or 53 is advised if local practice results in different changes.

Sets 6 and 7--Change in Average D.b.h. and Height from Partial Cuttings after the First

Based on the observation that most partial cuts after the first remove trees that are on the average smaller than those that are retained, the program estimates that such cuts will increase both average diameters and average heights. Subroutine LOBPL (Statements 60, 61, 62, Appendix 1) estimates diameter increases ranging from about 1.5 inches where only 20 percent of the basal area is retained to near zero where less than 1 percent is cut. Similarly, Statements 63, 64, 65 estimate height increases after cutting, ranging from 1 foot where 45 percent or less of the basal area is retained to zero for cuts retaining 91 percent or more. For cuts retaining between 45 and 91 percent, an increase of 0.5 foot is predicted. Where these relationships are not applicable, the subroutine should be modified to better simulate local practice.

Set 9--Theoretical Initial Number of Trees per Acre

Mortality in unthinned stands is estimated with an equation that includes initial planting density. Set 9 uses a modification of that equation to estimate initial number of trees as a basis for mortality projections in plantations already more than 1 year old (Statement 90, LOBPL, Appendix 1). If stand age at the beginning of simulation is 1 year, actual or assumed initial density is necessary for mortality computations.

Set 10—Change in Number of Trees per Acre Because of Noncatastrophic Mortality

Mortality in unthinned stands is estimated (Statement 100, LOBPL, Appendix 1) with an equation by Smalley and Bailey (1974). Future number of trees in thinned stands is obtained from an equation based on 288 observations in previously-thinned plantations (Statement 102, LOBPL, Appendix 1). These estimates cover the gradual reductions in numbers of trees from competition and endemic insects and diseases. Effects of forest fires, epidemics, and other abrupt changes are not computed by program YLDTBL.

Suitability of the equations and constants in LOBPL were tested by comparing actual and computed performance of 59 plots in Louisiana.[1] Stand values at age 25 were used as initial conditions in the computer runs. Differences between actual and computed values at age 45 were expressed as percentages of actual values. Eighty percent of the computed numbers of trees were within ± 10 percent of actual numbers. Ninety-five percent of the computed average diameters and 76 percent of the cubic volumes per acre were also within 10 percent of actual. Ninety-seven percent of the computed basal areas and 93 percent of average stand heights were within ± 5 percent of actual values.

USER-SUPPLIED INFORMATION

Persons using program YLDTBL must supply values for 23 variables that describe stand conditions, control program execution, and specify management options. Variable names, input formats, and data card sequence are given in table 1. Each variable is also defined there and in the program (Appendix 1). Several of these variables are discussed further in this section.

Data cards are identified by type numbers that, with one exception, show their sequence in the data deck. A type 1 card is required for each computer run. This card is followed by as many sets of four cards of types 2 to 5 as there are yield tables to be computed. For example, a data deck to produce two yield tables will have data cards in the sequence: 1, 2, 3, 4, 5, 2, 3, 4, 5.

[1]Feduccia, D. P. 1974. Thinning in a loblolly spacing plantation. Progress report on file at Southern Forest Experiment Station, Pineville, La.

Intermediate Cuts

The first seven variables on data card type 4 control execution of intermediate cuts. Certain precautions must be observed when selecting values for these variables.

Each of the four thinning controls (DSTY, THIN, THN1, CYCL) must be assigned a value greater than zero if ICUT is given a value of 1, 2, or 3. Fields for the four controls may be left blank if ICUT has a value of 4.

Stand age at initial thinning, THN1, must equal the initial age, AGEO, plus a multiple of the projection period, RINT, and the interval between intermediate cuts, CYCL, must also be a multiple of RINT. For example, if AGEO is 15 and RINT equals 5, THN1 may be assigned a value of 15, 20, 25, etc., and CYCL can have values of 5, 10, etc.

Minimum commercial volumes, COMBF and COMCU, determine whether or not a scheduled thinning will yield a commercial cut. Noncommercial thinnings will not be made if the value given ICUT prevents the action. Volumes removed in permitted noncommercial thinnings are not included in column totals, but projected growth will reflect the effect of such thinnings. A footnote printed at the bottom of each yield table is a reminder of the user's decision.

Regeneration Cuts

The last five entries on data card type 4 determine the regeneration method to be simulated. Stand age when each cut will be made and the basal area of seed trees or shelterwood, if any, are specified. Stand ages at regeneration cuts must equal the sum of AGEO plus appropriate multiples of the value of RINT.

For clearcutting, stand age at time of final cutting, REGN(1), is entered on card type 4, and the other four regeneration variables are left blank or given values of zero.

Seed-tree cutting requires non-zero values for REGN(1), VLLV(1), and REGN(2). REGN(1) is the stand age at first regeneration cutting, and REGN(2) is stand age when the seed trees are removed. VLLV(1) is the basal area to be left as seed trees at age REGN(1).

Shelterwood cuttings are controlled in the same manner as seed-tree cuts. The program simulates up to three regeneration cuts. Two-cut shelterwood requires that values be assigned to the same three variables as for the seed-tree method. Basal area to be left as a shelterwood is specified by VLLV(1). For three-cut shelterwood, REGN(1) and REGN(2) are stand ages at time of the removal cuts, and REGN(3) is stand age at the final cut. VLLV(1) is the basal area left at age REGN(1), and VLLV(2) is the basal area left at REGN(2).

Initial Stand Measurements

Initial stand information is entered on card type 5, columns 5 through 24. Where performance of an actual stand is to be projected, inventory data must be supplied for all five stand variables. Projections for hypothetical stands of any age may be made if reasonable estimates of the variables are supplied; if no initial height is entered, a height appropriate to the site index will be computed. New plantations should be assigned an age of 1 year, a height of 1 foot, and an appropriate number of trees per acre.

Yield tables for hypothetical stands can be used to select rotation lengths, thinning regimes, and other controls on silvicultural operations. Yield tables for actual stands provide information on expected yields for the remainder of the rotation.

Stand age, AGEO, and average height, HTSO, describe dominant and codominant trees only. Stand age includes any growing period in nursery beds.

PROGRAM MODIFICATIONS

Program YLDTBL can be modified to simulate a variety of conditions not covered by the version in Appendix 1. It can be adapted to compute yield tables for other species or for improved genetic strains of loblolly pine. Estimates of potential yields may be needed in metric units or for other standards of utilization. Whatever the reason, YLDTBL is organized to make modification a relatively easy operation.

Complete modification of the program, as for another species, requires two changes. A new subroutine equivalent to LOBPL is added to the program. One of the CONTINUE cards in subroutine SWITCH is then replaced by a statement calling the new subroutine. No other changes are needed in the program if the new subroutine duplicates the sequence of operations of subroutine LOBPL exactly. The species identification number punched on data card type 3 will be the label of the new statement in subroutine SWITCH. Addition of more than nine subroutines to the program will require replacement of the GO TO statement in SWITCH.

Individual statements in subroutine LOBPL can be replaced to convert to other utilization standards, to introduce new growth and mortality equations, or to describe natural stands. No other changes in the program will be needed, unless the equations contain independent variables not already computed.

YLDTBL can be converted readily to increase reserve basal area as tree height increases, as is current practice in the Forest Service's Southern Region. A series of statements of the form "IF(HTSO .LE. 45.0) THIN = 70.0" is placed at the beginning of Subroutine CUTS to produce this modification. The series is followed by the statement "DSTY = THIN."

AN EXAMPLE

Appendix 2 affords an example of many computations performed by YLDTBL and some of the management alternatives that can be simulated. It may be used as a test problem for adapting YLDTBL to other computing systems.

Assume a forest composed of loblolly pine plantations of various ages. Some of the many questions of interest to the forest manager are:

1. With a specified initial density and no thinning during a 30-year rotation, what volume of cordwood will be produced, and how much of this will be marketable as sawlogs?

2. What will be the volume production for the remainder of the rotation of the stands that were inventoried recently?

3. For a given initial spacing, rotation, and regeneration method, what volumes of sawtimber will be produced with various thinning schedules?

Only three of the many yield tables that would be computed to answer these questions are reproduced in Appendix 2. Species, minimum commercial volumes, site index, and projection interval are the same for all tables, as shown. Regeneration by clearcutting and planting and by two-cut shelterwood are simulated. Other information supplied by the manager appears in the heading, footnotes, and age column of each table.

The data deck consists of 13 cards punched as shown in figure 1. The first card (line 1, containing a single digit) is the type 1 card read by the main program. The next four cards are the type 2, 3, 4, and 5 cards needed to produce the first table. The remaining eight cards are the type 2, 3, 4, and 5 cards for the other two tables.

Each table provides a partial answer to the manager's questions. The table for stand 101 shows potential yields for rotation lengths of 15 to 30 years. Longer rotations could have been included by giving REGN(1) a value larger than 30.

The table for stand 81, now 20 years old, shows estimated yields from an existing stand, if thinned at 5-year intervals. Rotations of 20 to 50 years, terminated by clearcutting and planting, may be compared. Additional yield tables can be obtained to evaluate other thinning and regeneration alternatives.

The third table for stand 102 shows the potential of a silvicultural system involving thinnings at 10-year intervals and regeneration by a two-cut shelterwood. The removal cut is made at age 60, and the final cut is made at age 65.

Tables for other thinning programs are needed to fully evaluate thinning alternatives. They cost about five cents each, once the program has been compiled into machine language.

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   3
HYPOTHETICAL STAND TO EXAMINE CLEARCUTTING WITH SHORT ROTATION,
 LOBLOLLY PINE PLANTATION,                1    5
   4                 1000 229  30
 101  85   1   0  101210
SWAMPY COMPARTMENT OF THE PINEY WOODS TRACT, INVENTORIED 1976,
 LOBLOLLY PINE PLANTATION,                1    5
   2  68  68  20   51000 229  50
  81  85  20  72 500 490
HYPOTHETICAL STAND TO EXAMINE SAWLOG ROTATION AND SHELTERWOOD,
 LOBLOLLY PINE PLANTATION,                1    5
   1 100 110  20  101000 229  60 300  65
 102  85   1   0  101000
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Figure 1.—Data deck for the sample problem.

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APPENDIX 1

Listing of Program YLDTBL

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C       PROGRAM YLDTBL
C
C TO COMPUTE AND PRINT YIELD TABLES FOR EVEN-AGED STANDS.
C PROGRAM BY CLIFFORD A. MYERS, SOUTHERN FOREST EXP. STN., 1976.
C
C DEFINITIONS OF VARIABLES.
C
C       ADDHT = CHANGE IN AVERAGE STAND HEIGHT BY THINNING.
C       AGEO = AGES REPORTED IN YIELD TABLE.
C       BASO = BASAL AREA BEFORE PARTIAL CUT.
C       BAST = BASAL AREA AFTER PARTIAL CUT.
C       BDFC = BOARD FEET REMOVED PER ACRE.
C       BDFO = BOARD FEET BEFORE PARTIAL CUT.
C       BDFT = BOARD FEET AFTER PARTIAL CUT.
C       CFMC = MERCH. CU. FT. REMOVED PER ACRE.
C       CFMO = MERCH. CU. FT. BEFORE PARTIAL CUT.
C       CFMT = MERCH. CU. FT. AFTER PARTIAL CUT.
C       CHD = CHANGE IN AVE. STAND D.B.H. FROM PARTIAL CUTTING.
C       COMBF = MINIMUM COMMERCIAL CUT, BOARD FEET.
C       COMCU = MINIMUM COMMERCIAL CUT, CU. FT.
C       CRDC = NUMBER OF CORDS REMOVED.
C       CRDO = NUMBER OF CORDS BEFORE PARTIAL CUT.
C       CRDT = NUMBER OF CORDS AFTER PARTIAL CUT.
C       CYCL = INTERVAL BETWEEN INTERMEDIATE CUTS.
C       DBHO = AVERAGE STAND D.B.H. BEFORE PARTIAL CUT.
C       DBHT = AVERAGE STAND D.B.H. AFTER PARTIAL CUT.
C       DENO = TREES PER ACRE BEFORE PARTIAL CUT.
C       DENT = TREES PER ACRE AFTER PARTIAL CUT.
C       DSTY = RESIDUAL BASAL AREA FOR PARTIAL CUTS AFTER THE FIRST.
C       HTSO = AVE. DOM AND CODOM TREE HEIGHT BEFORE CUT.
C       HTST = AVE. DOM AND CODOM TREE HEIGHT AFTER CUT.
C       ICUT = FLAG WITH INPUT VALUE TO CONTROL THINNINGS OF--
C            1 = NO NONCOMMERCIAL THINNINGS.
C            2 = INITIAL THINNING MAY BE NONCOMMERCIAL.
C            3 = ALL THINNINGS MAY BE NONCOMMERCIAL.
C            4 = NO THINNINGS TO BE MADE.
C       JSBD = TOTAL BD. FT. FROM ALL CUTS OF COMBF OR LARGER.
C       JSMC = TOTAL MERCH. CU. FT. FROM CUTS OF COMCU OR LARGER.
C       KAK = SPECIES NUMBER TO SELECT SET OF SPECIES-SPECIFIC STATEMENTS.
C       MAC = NUMBER TO SELECT APPROPRIATE OPERATION.
C       NOTE(I) = DESCRIPTION TO BE WRITTEN IN YIELD TABLE.
C       NSTND = NUMBER OF STANDS TO BE PROCESSED BY THE RUN.
C       PRET = PERCENTAGE OF BASAL AREA RETAINED AFTER PARTIAL CUT.
C       PROD = FACTOR TO CONVERT MERCH. CU. FT. TO BOARD FEET.
C       REGN(I) = STAND AGE WHEN REGENERATION CUT I OCCURS.
C       RINT = NUMBER OF YEARS FOR WHICH A SINGLE PROJECTION IS MADE.
C       ROTA = FINAL AGE IN YIELD TABLE.
C       SCRD = TOTAL YIELD IN CORDS FROM COMMERCIAL CUTS.
C       SITE = SITE INDEX.
C       SPEC(I) = SPECIES NAME FOR TABLE HEADING.
C       STND = STAND IDENTIFICATION NUMBER.
C       STRT = INITIAL TREES PER ACRE FOR MORTALITY COMPUTATIONS.
C       THIN = RESIDUAL BASAL AREA FOR INITIAL THINNING.
C       THN1 = AGE OF STAND WHEN FIRST THINNED.
C       VAR(I) = ARRAY FOR STORAGE OF INITIAL VALUES OF VARIABLES.
C       VLLV(I) = BASAL AREA TO BE LEFT AT REGN(I).
C
       COMMON /BLKA/ AGEO,BASO,BAST,BDFO,CFMO,CRDO,CYCL,DBHO,DBHT,DENO,
      1DENT,HTSO,HTST,KAK,MAC,REGN(3),RINT,ROTA,THN1,STRT,KTI
```

```
C
      COMMON /BLKB/ BDFT,CFMT,COMBF,COMCU,CRDT,ICUT,JBDFO,JCFMO,JDENT,
     1JSBD,JSMC,SCRD,STND,VAR(5)
C
      COMMON /BLKC/ ADDHT,CHD,DSTY,PRET,SITE,THIN,VLLV(3)
C
      COMMON /BLKD/ BA,BDF,CFM,CRD,DBH,DEN,HT,IMX,KBL
C
C READ NUMBER OF STANDS TO BE PROCESSED FROM CARD TYPE ONE.
C
      READ (5,20) NSTND
   20 FORMAT (I4)
      IF(NSTND .LE. 0)  GO TO 230
C
C EXECUTE PROGRAM ONCE FOR EACH STAND.
C
      DO 200 I=1,NSTND
      CALL BEGIN
C
C CHECK FOR UNWANTED ZEROS OR BLANKS IN DATA.
C
      DO 30 L=1,5
      IF(VAR(L) .LE. 0.0) GO TO 190
   30 CONTINUE
C
C DETERMINE OLDEST AGE TO BE REPORTED IN TABLE.
C
      DO 40 NA=1,3
      L = 4 - NA
      IF(REGN(L) .EQ. 0.0) GO TO 40
      ROTA = REGN(L)
      GO TO 50
   40 CONTINUE
   50 BASO = DENO * 0.0054542 * DBHO * DBHO
C
C COMPUTE VOLUMES PER ACRE.
C
      MAC = 4
      BA = BASO
      DBH = DBHO
      DEN = DENO
      HT = HTSO
      CALL SWITCH
      BDFO = BDF
      CFMO = CFM
      CRDO = CRD
C
C ENTER LOOP FOR REMAINING COMPUTATIONS AND PRINTOUT.
C
      KAN = (ROTA - AGEO) / RINT + 1.5
      IF (AGEO .EQ. 1.0) KAN = KAN + 1
      DO 100 K=1,KAN
      IF(AGEO .GE. ROTA) GO TO 105
   80 CALL CUTS
      IF(IMX .GT. 0) GO TO 90
      CALL TABLE
   90 CALL PROJ
      IF(KBL .GT. 0) GO TO 80
```

```
  100 CONTINUE
C
C ADD FINAL CUTS TO TOTAL YIELDS AND WRITE TOTAL YIELDS.
C
  105 CFMO = JCFMO
      IF(CFMO .LT. COMCU) GO TO 110
      JSMC = JSMC + JCFMO
      SCRD = SCRD + CRDO
  110 BDFO = JBDFO
      IF(BDFO .LT. COMBF) GO TO 120
      JSBD = JSBD + JBDFO
  120 WRITE (6,130) JSMC,SCRD,JSBD
  130 FORMAT (1H0,/,65X,12HTOTAL YIELDS,23X,I6,4X,F6.1,3X,I7)
C
C WRITE FOOTNOTES TO YIELD TABLE.
C
      WRITE (6,140)
  140 FORMAT (1H0,//,11X,89HCORD AND BOARD-FOOT VOLUME INCLUDED IN CUBIC
     1 VOLUME. BOARD-FOOT VOLUME INCLUDED IN CORDS.)
      WRITE (6,150) COMCU,COMBF
  150 FORMAT (1H ,10X,44HMINIMUM CUTS FOR INCLUSION IN TOTAL YIELDS--,F6
     1.0,15H CUBIC FEET AND,F7.0,12H BOARD FEET.)
      GO TO (160,165,170,175), ICUT
  160 WRITE(6,163)
  163 FORMAT (1H ,10X,35HNO NONCOMMERCIAL THINNINGS ALLOWED.)
      GO TO 200
  165 WRITE (6,168)
  168 FORMAT (1H ,10X,43HONLY INITIAL THINNING MAY BE NONCOMMERCIAL.)
      GO TO 200
  170 WRITE (6,173)
  173 FORMAT (1H ,10X,35HALL THINNINGS MAY BE NONCOMMERCIAL.)
      GO TO 200
  175 WRITE (6,178)
  178 FORMAT (1H ,10X,39HNO THINNINGS SCHEDULED DURING ROTATION.)
      GO TO 200
C
C PROGRAM CONTROL GOES HERE IF ANY UNWANTED ZEROS OR BLANKS IN DATA.
C
  190 WRITE (6,195) STND
  195 FORMAT (1H0,///,10X,73HEXECUTION STOPPED BECAUSE OF NEGATIVE OR ZE
     1RO ITEM ON DATA CARDS OF STAND,F6.0)
  200 CONTINUE
      GO TO 250
C
C PROGRAM CONTROL GOES HERE IF NSTND ILLEGAL.
C
  230 WRITE (6,240)
  240 FORMAT (1H1,////,30X,52HEXECUTION STOPPED BECAUSE OF ILLEGAL VALUE
     1 OF NSTND.)
  250 STOP
      END
      SUBROUTINE BEGIN
C
C TO INITIALIZE VARIABLES AND READ IN DATA.
C
      COMMON /BLKA/ AGEO,BASO,BAST,BDFO,CFMO,CRDO,CYCL,DBHO,DBHT,DENO,
     1DENT,HTSO,HTST,KAK,MAC,REGN(3),RINT,ROTA,THN1,STRT,KTI
C
```

```
      COMMON /BLKB/ BDFT,CFMT,COMBF,COMCU,CRDT,ICUT,JBDFO,JCFMO,JDENT,
     1JSBD,JSMC,SCRD,STND,VAR(5)
C
      COMMON /BLKC/ ADDHT,CHD,DSTY,PRET,SITE,THIN,VLLV(3)
C
      COMMON /BLKD/ BA,BDF,CFM,CRD,DBH,DEN,HT,IMX,KBL
C
      DIMENSION NOTE(20),SPEC(8)
C
      ADDHT = 0.0
      BDFO = 0.0
      BDFT = 0.0
      CFMO = 0.0
      CFMT = 0.0
      CRDO = 0.0
      CRDT = 0.0
      BASO = 0.0
      BAST = 0.0
      IMX = 0
      JSBD = 0
      JSMC = 0
      KTI = 0
      SCRD = 0.0
      STRT = 0.0
      DO 5 I=1,5
    5 VAR(I) = 0.0
      DO 10 I=1,3
      REGN(I) = 0.0
      VLLV(I) = 0.0
   10 CONTINUE
C
C READ TREATMENT DESCRIPTION FROM CARD TYPE TWO.
C
      READ (5,30) (NOTE(I),I=1,20)
   30 FORMAT (20A4)
C
C READ SPECIES IDENTIFICATION FROM CARD TYPE THREE.
C
      READ (5,40) (SPEC(I),I=1,8),KAK,RINT
   40 FORMAT (8A4,I4,F4.0)
C
C READ CUTTING INSTRUCTIONS FROM CARD TYPE FOUR.
C
      READ (5,50) ICUT,DSTY,THIN,THN1,CYCL,COMBF,COMCU,REGN(1),VLLV(1),
     1REGN(2),VLLV(2), REGN(3)
   50 FORMAT (I4,7F4.0,F4.1,F4.0,F4.1,F4.0)
C
C READ INITIAL STAND VALUES FROM CARD TYPE FIVE.
C
      READ (5,60) STND,SITE,AGEO,DBHO,HTSO,DENO
   60 FORMAT (3F4.0,2F4.1,F4.0)
      VAR(1) = AGEO
      VAR(2) = DENO
      VAR(3) = RINT
      VAR(4) = SITE
      VAR(5) = REGN(1)
C
C COMPUTE AVE. DOM AND CODOM HEIGHT IF NOT READ IN.
```

```
C
      IF(HTSO .GT. 0.0) GO TO 70
      MAC = 8
      CALL SWITCH
C
C COMPUTE THEORETICAL INITIAL NUMBER OF TREES.
C
   70 IF(AGEO .EQ. 0.0) GO TO 80
      IF(DENO .EQ. 0.0) GO TO 80
      MAC = 9
      CALL SWITCH

C
C WRITE HEADINGS FOR YIELD TABLE.
C
      JSITE = SITE
   80 WRITE (6,100) STND,SPEC
  100 FORMAT(1H1,//,32X,31HYIELDS PER ACRE OF STAND NUMBER,F7.0,1H,,8A4)
      WRITE (6,110) JSITE,THIN,DSTY
  110 FORMAT (1H0,58X,10HSITE INDEX,I4/1H ,38X,29HRESIDUAL BASAL AREA- I
     1NITIAL-,F6.0,12H SUBSEQUENT-,F6.0)
      WRITE (6,120) (NOTE(J),J=1,20)
  120 FORMAT (1H0,25X,20A4)
      WRITE (6,130)
  130 FORMAT (1H0,/,4X,74H-------------------CHARACTERISTICS OF STANDING
     1 TREES-----------------------,4X,45H------------PERIODIC REDUCTION
     2S-------------)
      WRITE (6,140)
  140 FORMAT (1H0,2X,5HSTAND,13X,5HBASAL,5X,7HAVERAGE,3X,7HAVERAGE,43X,5
     1HBASAL)
      WRITE (6,150)
  150 FORMAT (1H ,3X,3HAGE,5X,5HTREES,4X,4HAREA,7X,6HD.B.H.,3X,6HHEIGHT,
     15X,6HVOLUME,4X,6HVOLUME,4X,6HVOLUME,4X,5HTREES,4X,4HAREA,6X,6HVOLU
     2ME,4X,6HVOLUME,4X,6HVOLUME)
      WRITE (6,160)
  160 FORMAT (1H ,2X,5H(YRS),5X,3HNO.,5X,6HSQ.FT.,6X,3HIN.,7X,3HFT.,6X,
     16HCU.FT.,4X,5HCORDS,5X,6HBD.FT.,5X,3HNO.,5X,6HSQ.FT.,4X,6HCU.FT.,4
     2X,5HCORDS,5X,6HBD.FT.)
C
C ASSIGN VALUES TO PREVENT THINNING IF THINNING NOT WANTED.
C
      IF(ICUT .GT. 0 .AND. ICUT .LT. 4) GO TO 200
      DSTY = 500.0
      THIN = 500.0
      CYCL = REGN(1) - AGEO
      THN1 = REGN(1)
  200 RETURN
      END
      SUBROUTINE CUTS
C
C TO EXECUTE INTERMEDIATE AND REGENERATION CUTS.
C
      COMMON /BLKA/ AGEO,BASO,BAST,BDFO,CFMO,CRDO,CYCL,DBHO,DBHT,DENO,
     1DENT,HTSO,HTST,KAK,MAC,REGN(3),RINT,ROTA,THN1,STRT,KTI
C
      COMMON /BLKB/ BDFT,CFMT,COMBF,COMCU,CRDT,ICUT,JBDFO,JCFMO,JDENT,
     1JSBD,JSMC,SCRD,STND,VAR(5)
C
      COMMON /BLKC/ ADDHT,CHD,DSTY,PRET,SITE,THIN,VLLV(3)
```

```
C
      COMMON /BLKD/ BA,BDF,CFM,CRD,DBH,DEN,HT,IMX,KBL
C
      IF(AGEO .LT. THN1) GO TO 90
C
C EXECUTE SCHEDULED REGENERATION CUTS.
C
      IF(AGEO .GE.ROTA) GO TO 100
      IF(AGEO .LT. REGN(1)) GO TO 30
      IF(AGEO .NE. REGN(1)) GO TO 10
      MAC = 7
      CALL SWITCH
      GO TO 70
   10 IF(AGEO .NE. REGN(2)) GO TO 30

      MAC = 7
      CALL SWITCH
      GO TO 70
C
C CHANGE AVE. D.B.H. AND AVE. HT. BY INTERMEDIATE CUTTING.
C
   30 IF(AGEO .NE. THN1) GO TO 40
   35 PRET = (THIN / BASO) * 100.0
      BAST = THIN
      MAC = 5
      CALL SWITCH
      GO TO 70
   40 DO 50 IK=1,20
      TEM = IK
      TMPY = THN1 + (CYCL * TEM)
      IF(TMPY .GE. REGN(1)) GO TO 90
      IF(AGEO .EQ. TMPY) GO TO 60
   50 CONTINUE
      GO TO 90
   60 IF(KTI .EQ. 0) GO TO 35
      PRET = (DSTY / BASO) * 100.0
      BAST = DSTY
      MAC = 6
      CALL SWITCH
   70 DBHT = DBHO + CHD
      HTST = HTSO + ADDHT
      JDENT = (BAST / (0.0054542 * DBHT * DBHT)) + 0.5
      DENT = JDENT
      BAST = 0.0054542 * DBHT * DBHT * DENT
      IF(BAST .GE. BASO) GO TO 90
      MAC = 4
      BA = BAST
      DBH = DBHT
      DEN = DENT
      HT = HTST
      CALL SWITCH
      BDFT = BDF
      CFMT = CFM
      CRDT = CRD
C
C DO NOT EXECUTE THINNING IF FORBIDDEN BY STANDARDS.
C
      TEM = CFMO - CFMT
      IF(TEM .GE. COMCU) GO TO 100
```

```
      IF(ICUT .EQ. 3) GO TO 100
      IF(AGEO .EQ. THN1 .AND. ICUT .EQ. 2) GO TO 100
   90 BAST = BASO
      HTST = HTSO
      DENT = DENO
      JDENT = DENO + 0.5
      DBHT = DBHO
      CRDT = CRDO
      BDFT = BDFO
      CFMT = CFMO
      IF(AGEO .EQ. THN1) KTI = 0
  100 RETURN
      END
      SUBROUTINE TABLE
C
C TO PRINT RESULTS OF PROJECTIONS AND CUTS.
C
      COMMON /BLKA/ AGEO,BASO,BAST,BDFO,CFMO,CRDO,CYCL,DBHO,DBHT,DENO,
     1DENT,HTSO,HTST,KAK,MAC,REGN(3),RINT,ROTA,THN1,STRT,KTI
C
      COMMON /BLKB/ BDFT,CFMT,COMBF,COMCU,CRDT,ICUT,JBDFO,JCFMO,JDENT,
     1JSBD,JSMC,SCRD,STND,VAR(5)
C
C ROUND OFF VALUES FOR PRINTING.
C
      JAGEO = AGEO
      JDENO = DENO + 0.5
      JHTSO = HTSO + 0.5
      JBASO = BASO + 0.5
      JCFMO = (CFMO * 0.1) + 0.5
      JCFMO = JCFMO * 10
      JBDFO = (BDFO * 0.01) + 0.5
      JBDFO = JBDFO * 100
      IF(DENT .EQ. DENO) GO TO 20
      JHTST = HTST + 0.5
      JCFMT = (CFMT * 0.1) + 0.5
      JCFMT = JCFMT * 10
      IF(JCFMT .GT. JCFMO) JCFMO = JCFMT
      IF(CRDT .GT. CRDO) CRDO = CRDT
      JBDFT = (BDFT * 0.01) + 0.5
      JBDFT = JBDFT * 100
      IF(JBDFT .GT. JBDFO) JBDFO = JBDFT
      JBAST = BAST + 0.5
      JDENC = JDENO - JDENT
      JBASC = JBASO - JBAST
      CRDC = CRDO - CRDT
      JCFMC = JCFMO - JCFMT
      IF(JCFMC .LE. 0) JCFMC = 0
      JBDFC = JBDFO - JBDFT
      IF(JBDFC .LE. 0) JBDFC = 0
C
C SUM PERIODIC CUTS FOR LAST LINE OF YIELD TABLE.
C
      IF(AGEO .GE. ROTA) GO TO 20
      CFMC = JCFMC
      IF(CFMC .LT. COMCU) GO TO 10
      SCRD = SCRD + CRDC
      JSMC = JSMC + JCFMC
```

```
   10 BDFC = JBDFC
      IF(BDFC .LT. COMBF) GO TO 20
      JSBD = JSBD + JBDFC
C
C WRITE TABLE ENTRIES OF DIAMETER, VOLUMES, ETC.
C
   20 WRITE (6,30) JAGEO,JDENO,JBASO,DBHO,JHTSO,JCFMO,CRDO,JBDFO
   30 FORMAT (1H0,2X,I4,5X,I5,4X,I4,7X,F5.1,5X,I3,7X,I5,5X,F5.1,4X,I6)
      IF(AGEO .GE. ROTA) GO TO 60
      IF(DENT .EQ. DENO) GO TO 60
      WRITE (6,40) JAGEO,JDENT,JBAST,DBHT,JHTST,JCFMT,CRDT,JBDFT,JDENC,
     1JBASC,JCFMC,CRDC,JBDFC
   40 FORMAT (1H ,2X,I4,5X,I5,4X,I4,7X,F5.1,5X,I3,7X,I5,5X,F5.1,4X,I6,4X
     1,I5,5X,I4,6X,I5,5X,F5.1,4X,I6)
   60 RETURN
      END
      SUBROUTINE PROJ
C
C TO CHANGE STAND CHARACTERISTICS THROUGH GROWTH AND MORTALITY.
C
      COMMON /BLKA/ AGEO,BASO,BAST,BDFO,CFMO,CRDO,CYCL,DBHO,DBHT,DENO,
     1DENT,HTSO,HTST,KAK,MAC,REGN(3),RINT,ROTA,THN1,STRT,KTI
C
      COMMON /BLKD/ BA,BDF,CFM,CRD,DBH,DEN,HT,IMX,KBL
C
      IMX = 0
      KBL = 0
      IF(RINT .EQ. 1.0) GO TO 5
      IF(AGEO .EQ. 1.0) AGEO = 0.0
    5 AGEO = AGEO + RINT
      IF(AGEO .GT. ROTA) GO TO 100
C
C PROJECT STAND VALUES FOR ONE PERIOD.
C
      MAC = 2
      CALL SWITCH
      MAC = 10
      CALL SWITCH
      IF(HTSO .GE. 4.5 .AND. BASO .EQ. 0.0) GO TO 10
      GO TO 20
   10 MAC = 3
      CALL SWITCH
      GO TO 25
   20 MAC = 1
      CALL SWITCH
   25 MAC = 4
      BA = BASO
      DBH = DBHO
      DEN = DENO
      HT = HTSO
      CALL SWITCH
      BDFO = BDF
      CFMO = CFM
      CRDO = CRD
C
C TEST FOR INTERMEDIATE OR REGENERATION CUT.
C
      DO 30 KU=1,3
```

```
      IF(AGEO .EQ. REGN(KU)) GO TO 60
   30 CONTINUE
      IF(AGEO .EQ. THN1) GO TO 60
      DO 40 IK=1,20
      TEM = IK
      TMPY = THN1 + (CYCL * TEM)
      IF(TMPY .GE. REGN(1)) GO TO 70
      IF(AGEO .EQ. TMPY) GO TO 60
   40 CONTINUE
      GO TO 70
   60 KBL = 1
      GO TO 100
C
C CHANGE MODE AND ROUND OFF FOR PRINTING.
C
   70 KDENO = DENO + 0.5
      KAGEO = AGEO
      KHTSO = HTSO + 0.5
      KBASO = BASO + 0.5
      KCFMO = (CFMO * 0.1) + 0.5
      KCFMO = KCFMO * 10
      KBDFO = (BDFO * 0.01) + 0.5
      KBDFO = KBDFO * 100

C
C WRITE VALUES FOR THE PERIOD IF CUTTING NOT SCHEDULED.
C
      WRITE (6,80) KAGEO,KDENO,KBASO,DBHO,KHTSO,KCFMO,CRDO,KBDFO
   80 FORMAT (1H0,2X,I4,5X,I5,4X,I4,7X,F5.1,5X,I3,7X,I5,5X,F5.1,4X,I6)
      BAST = BASO
      DBHT = DBHO
      DENT = DENO
      HTST = HTSO
      IMX = 1
  100 RETURN
      END
      SUBROUTINE SWITCH
C
C TO CALL SUBROUTINES WITH SPECIES-SPECIFIC STATEMENTS.
C
      COMMON /BLKA/ AGEO,BASO,BAST,BDFO,CFMO,CRDO,CYCL,DBHO,DBHT,DENO,
     1DENT,HTSO,HTST,KAK,MAC,REGN(3),RINT,ROTA,THN1,STRT,KTI
C
      COMMON /BLKC/ ADDHT,CHD,DSTY,PRET,SITE,THIN,VLLV(3)
C
      COMMON /BLKD/ BA,BDF,CFM,CRD,DBH,DEN,HT,IMX,KBL
C
      GO TO (1,2,3,4,5,6,7,8,9,10),KAK
C
C REPLACE CONTINUES WITH CALLS FOR OTHER SPECIES OR CONDITIONS.
C
    1 CALL LOBPL
      RETURN
    2 CONTINUE
      RETURN
    3 CONTINUE
      RETURN
    4 CONTINUE
      RETURN
```

```
    5 CONTINUE
      RETURN
    6 CONTINUE
      RETURN
    7 CONTINUE
      RETURN
    8 CONTINUE
      RETURN
    9 CONTINUE
      RETURN
   10 CONTINUE
      RETURN
      END
      SUBROUTINE LOBPL
C
C SPECIES-SPECIFIC STATEMENTS FOR LOBLOLLY PINE PLANTATIONS.
C
      COMMON /BLKA/ AGEO,BASO,BAST,BDFO,CFMO,CPDO,CYCL,DBHO,DBHT,DENO,
     1DENT,HTSO,HTST,KAK,MAC,REGN(3),RINT,ROTA,THN1,STRT,KTI
C
      COMMON /BLKC/ ADDHT,CHD,DSTY,PRET,SITE,THIN,VLLV(3)
C
      COMMON /BLKD/ BA,BDF,CFM,CRD,DBH,DEN,HT,IMX,KBL
C
      DIMENSION TMH(2)
      GO TO (10,20,30,40,50,60,70,80,90,100), MAC

C
C COMPUTE D.B.H. AT END OF PERIOD.
C COMPUTE BASAL AREA USING AN EQUATION FROM CLUTTER (1963).
C
   10 AA = (AGEO - RINT) / AGEO
      BB = 1.0 - AA
      IF(BAST .EQ. 0.0) GO TO 11
      SQFT = EXP(AA*ALOG(BAST)+4.6012 * BB + 0.013597 * BB * SITE)
      GROB = SQFT - BAST
      BOLE = DBHO - 3.0
      IF(DBHO .LT. 4.0) BOLE = DBHO
      BMORT = 0.0054542 * BOLE * BOLE * DIE
      BASO = BAST + GROB - BMORT
      DBHO = BASO / (0.0054542 * DENO)
      DBHO = SQRT(DBHO)
   11 RETURN
C
C COMPUTE AVE. DOM AND CODOM HEIGHT USING EQUATIONS FROM LENHART (1972)
C MODIFIED AND FROM FARRAR (1973).
C
   20 BO = AGEO
      DO 24 K=1,2
      IF(K .EQ. 2) BO = AGEO - RINT
      IF(BO .LE. 0.0) BO = 1.0
      IF(BO .LT. 3.0) GO TO 21
      IF(BO .GE. 25.0) GO TO 22
      TMH(K) = ALOG10(SITE * 0.65) + 0.1489 - 3.72183 / BO
      TMH(K) = 10.0 ** TMH(K)
      GO TO 24
   21 TMH(K) = 1.4 * BO
      GO TO 24
   22 TEM = BO * BO
```

```
      TMH(K) = ALOG10(SITE) - 2.41737 / 80 - 273.824 / TEM + 4227.7 /
     1 (80 * TEM) - 19758.5 / (TEM * TEM) + 0.1272
      TMH(K) = 10.0 ** TMH(K)
   24 CONTINUE
      HTSO = HTST + (TMH(1) - TMH(2))
      RETURN
C
C COMPUTE INITIAL D.B.H. OF VERY YOUNG STANDS.
C BASED ON INITIAL ENTRIES IN TABLES OF SMALLEY AND BAILEY (1974).
C
   30 TEM = 0.0
      IF(AGEO .LE. 3.0) GO TO 33
      TEM = 0.10451 - 0.04765 * ALOG10(STRT) + 0.00707 * SITE - 0.00166
     1 * ALOG10(STRT) * SITE
      TEM = TEM * 0.142857 * (AGEO - 3.0)
      BASO = DENO * TEM
      DBHO = BASO / (0.0054542 * DENO)
      DBHO = SQRT(DBHO)
   33 RETURN
C
C COMPUTE VOLUMES PER ACRE IN DESIRED UNITS.
C
   40 BDF = 0.0
      CFM = 0.0
      CRD = 0.0
      PROD = 0.0
      IF(DBH .LT. 5.0) GO TO 45
      D2H = DBH * DBH * HT
C
C MERCH. CU. FT. I.B. IN TREES 5 INCHES D.B.H. AND LARGER TO 4-INCH TOP
C D.O.B.
C N=280.  R=0.999  SEE=0.2274 OR 2.8 PCT OF MEAN.
C
      CFM = (0.00196 * D2H - 0.00229 * BA - 0.63813) * DEN
      CRD = CFM / 76.3
C
C BD. FT. SCRIBNER IN TREES 9 INCHES D.B.H. AND LARGER TO 7-INCH TOP
C D.I.B.
C N=143.  R=0.991  SEE=0.2125 OR 6.5 PCT OF MEAN.
C N=21.  R=0.929  SEE=0.09984 OR 17.3 PCT OF MEAN.
C
      IF(DBH .LT. 6.0) GO TO 45
      IF(DBH .LT. 7.2) GO TO 41
      PROD = 12.46511 - 0.00643 * DBH * DBH - 78.29543 / DBH
      GO TO 43
   41 PROD = 1.0330 * DBH - 6.1949
   43 BDF = CFM * PROD
   45 RETURN
C
C COMPUTE CHANGE IN AVE. D.B.H. AND HT., INITIAL THINNING.
C N=39.  R=0.788  SEE=0.158 OR 15.8 PCT OF MEAN.
C N=14.  R=0.607  SEE=0.121 OR 9.9 PCT OF MEAN.
C
   50 KTI = 1
      IF(PRET .GT. 74.0) GO TO 51
      CHD = 0.0193 * PRET - 1.1591
      IF(PRET .LT. 40.0) CHD = -0.5
      GO TO 52
```

```
   51 CHD = 1.0543 - 0.0106 * PRET
   52 IF(PRET .LT. 65.0) GO TO 53
      ADDHT = 0.5
      IF(PRET .GT. 90.0) ADDHT = 0.0
      GO TO 54
   53 ADDHT = 0.0
      IF(PRET .LT. 55.0) ADDHT = -0.5
      IF(PRET .LT. 40.0) ADDHT = -1.0
   54 RETURN
C
C COMPUTE CHANGE IN AVE. D.B.H. AND HT. DUE TO THINNINGS AFTER THE FIRST
C
   60 IF(PRET .GT. 66.0) GO TO 61
      CHD = 0.90052 - 0.02486 * PRET
      CHD = EXP(CHD)
      GO TO 63
   61 IF(PRET .GT. 90.0) GO TO 62
      CHD = 0.12539 + 0.0157 * PRET - 0.000157 * PRET * PRET
      GO TO 63
   62 CHD = 2.666 - 0.02666 * PRET
   63 IF(PRET .LT. 90.0) GO TO 64
      ADDHT = 0.0
      GO TO 66
   64 IF(PRET .LT. 45.0) GO TO 65
      ADDHT = 0.5
      GO TO 66
   65 ADDHT = 1.0
   66 RETURN
C
C COMPUTE CHANGES IN STAND VARIABLES DUE TO PARTIAL REGENERATION CUTS.
C
   70 IF(AGEO .EQ. REGN(2)) GO TO 73
      BAST = VLLV(1)
      GO TO 75
   73 BAST = VLLV(2)
   75 PRET = (BAST / BASO) * 100.0
      CHD = 0.90052 - 0.02486 * PRET
      CHD = EXP(CHD)
      DBHT = DBHO + CHD
      DENT = BAST / (0.0054542 * DBHT * DBHT)
      ADDHT = 0.0
      RETURN
C
C COMPUTE INITIAL HEIGHT IF NOT READ IN.
C
   80 IF(AGEO .LT. 3.0) GO TO 81
      IF(AGEO .GE. 25.0) GO TO 82
      HTSO = ALOG10(SITE * 0.65) + 0.1489 - 3.72183 / AGEO
      HTSO = 10.0 ** HTSO
      GO TO 84
   81 HTSO = 1.4 * AGEO
      GO TO 84
   82 TEM = AGEO * AGEO
      HTSO = ALOG10(SITE) - 2.41737 / AGEO - 273.824 / TEM + 4227.7 /
     1 (AGEO * TEM) - 19758.5 / (TEM * TEM) + 0.1272
      HTSO = 10.0 ** HTSO
   84 RETURN
C
```

```
C COMPUTE THEORETICAL INITIAL NUMBER OF TREES FOR MORTALITY EQUATION.
C
   90 RED = ALOG10(DENO)+0.0009*HTSO*AGEO - 0.0109 * SQRT(HTSO) * AGEO
      RED = RED / (1.0 - 0.0130 * AGEO)
      STRT = 10.0 ** RED
      IF(AGEO .EQ. 1.0) STRT = DENO
      RETURN
C
C COMPUTE NUMBER OF TREES PER ACRE WITH NONCATASTROPHIC MORTALITY.
C
  100 DIE = 0.0
      IF(AGEO .GE. THN1 .AND. KTI .GT. 0) GO TO 102
C
C MORTALITY IN UNTHINNED STANDS - SMALLEY AND BAILEY (1974).
C
      RED = AGEO * (0.013 * ALOG10(STRT) + 0.0009 * HTSO - 0.0109 *
     1SQRT(HTSO))
      RED = 10.0 ** RED
      DENO = STRT / RED
      IF(DENO .GT. DENT) DENO = DENT
      DIE = DENT - DENO
      GO TO 105
C
C MORTALITY IN THINNED STANDS.
C FITTED TO D.B.H. CLASS AVERAGES, 83 PCT OF OBSERVATIONS WERE ZERO.
C
  102 RED = 0.0311 - 0.0020 * DBHT
      RED = RED * (RINT / 5.0)
      IF(RED .LT. 0.0) RED = 0.0
      DENO = DENT * (1.0 - RED)
  105 RETURN
      END
```

APPENDIX 2

Output of Sample Problem.

YIELDS PER ACRE OF STAND NUMBER 81., LOBLOLLY PINE PLANTATION.

SITE INDEX 85
RESIDUAL BASAL AREA= INITIAL= 68, SUBSEQUENT= 68.

SWAMPY COMPARTMENT OF THE PINEY WOODS TRACT, INVENTORIED 1976.

----CHARACTERISTICS OF STANDING TREES----								----PERIODIC REDUCTIONS----				
STAND AGE (YRS)	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	VOLUME CU.FT.	VOLUME CORDS	VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	VOLUME CU.FT.	VOLUME CORDS	VOLUME BD.FT.
20	490	139	7.2	50	2020	26.5	2500					
20	255	68	7.0	50	1010	13.2	1000	235	71	1010	13.3	1500
25	251	92	8.2	54	1580	20.7	4000					
25	167	68	8.7	54	1200	15.8	3500	84	24	380	4.9	500
30	165	88	9.9	63	1850	24.3	7300					
30	117	68	10.3	63	1450	19.0	6100	48	20	400	5.3	1200
35	116	84	11.6	70	2040	26.8	9900					
35	88	68	11.9	71	1670	21.9	8300	28	16	370	4.8	1600
40	87	83	13.2	77	2210	29.0	12000					
40	68	68	13.5	77	1830	24.0	10100	19	15	380	5.0	1900
45	68	81	14.8	82	2320	30.4	13400					
45	55	68	15.1	82	1980	26.0	11500	13	13	340	4.4	1900
50	55	80	16.3	86	2430	31.8	14500					
							TOTAL YIELDS			5310	69.5	22600

CORD AND BOARD-FOOT VOLUME INCLUDED IN CUBIC VOLUME, BOARD-FOOT VOLUME INCLUDED IN CORDS.
MINIMUM CUTS FOR INCLUSION IN TOTAL YIELDS-- 229. CUBIC FEET AND 1000. BOARD FEET.
ONLY INITIAL THINNING MAY BE NONCOMMERCIAL.

YIELDS PER ACRE OF STAND NUMBER 101., LOBLOLLY PINE PLANTATION.

SITE INDEX 85
RESIDUAL BASAL AREA- INITIAL- 0. SUBSEQUENT- 0.

HYPOTHETICAL STAND TO EXAMINE CLEARCUTTING WITH SHORT ROTATION.

	CHARACTERISTICS OF STANDING TREES							PERIODIC REDUCTIONS				
STAND AGE (YRS)	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	VOLUME CU.FT.	VOLUME CORDS	VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	VOLUME CU.FT.	VOLUME CORDS	VOLUME BD.FT.
1	1210	0	.0	1	0	.0	0					
5	1053	37	2.5	14	0	.0	0					
10	1026	107	4.4	33	0	.0	0					
15	939	153	5.5	44	1470	19.3	0					
20	835	180	6.3	50	2380	31.2	700					
25	733	196	7.0	55	3050	40.0	3100					
30	593	200	7.9	63	3890	51.0	8200					
							TOTAL YIELDS			3890	51.0	8200

CORD AND BOARD-FOOT VOLUME INCLUDED IN CUBIC VOLUME. BOARD-FOOT VOLUME INCLUDED IN CORDS.
MINIMUM CUTS FOR INCLUSION IN TOTAL YIELDS-- 229. CUBIC FEET AND 1000. BOARD FEET.
NO THINNINGS SCHEDULED DURING ROTATION.

YIELDS PER ACRE OF STAND NUMBER 102., LOBLOLLY PINE PLANTATION.

SITE INDEX 85
RESIDUAL BASAL AREA- INITIAL- 110. SUBSEQUENT- 100.

HYPOTHETICAL STAND TO EXAMINE SAWLOG ROTATION AND SHELTERWOOD.

	CHARACTERISTICS OF STANDING TREES							PERIODIC REDUCTIONS				
STAND AGE (YRS)	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	VOLUME CU.FT.	VOLUME CORDS	VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	VOLUME CU.FT.	VOLUME CORDS	VOLUME BD.FT.
1	1000	0	.0	1	0	.0	0					
5	881	35	2.7	14	0	.0	0					
10	869	105	4.7	33	0	.0	0					
15	805	150	5.9	44	1560	20.5	0					
20	726	178	6.7	50	2450	32.2	1800					
20	444	110	6.7	50	1590	20.9	1200	282	68	860	11.3	600
25	436	136	7.6	55	2260	29.6	3900					
30	429	156	8.2	63	3130	41.0	7700					
30	244	100	8.7	64	2080	27.3	6200	185	56	1050	13.7	1500
35	241	118	9.5	71	2780	36.5	10100					
40	238	133	10.1	77	3450	45.2	14100					
40	164	100	10.6	77	2620	34.4	11400	74	33	830	10.8	2700
45	162	114	11.3	82	3190	41.8	15100					
50	161	126	12.0	86	3720	48.8	18600					
50	120	100	12.3	86	2980	39.1	15400	41	26	740	9.6	3200
55	119	111	13.1	89	3450	45.2	18500					
60	119	121	13.7	92	3890	51.0	21500					
60	24	29	15.0	92	960	12.5	5500	95	92	2930	38.4	16000
65	24	35	16.4	94	1180	15.5	7000					
							TOTAL YIELDS			7590	99.3	30400

CORD AND BOARD-FOOT VOLUME INCLUDED IN CUBIC VOLUME, BOARD-FOOT VOLUME INCLUDED IN CORDS.
MINIMUM CUTS FOR INCLUSION IN TOTAL YIELDS-- 229. CUBIC FEET AND 1000. BOARD FEET.
NO NONCOMMERCIAL THINNINGS ALLOWED.

Myers, Clifford A.
1977. A computer program for variable density yield tables for loblolly pine plantations. South. For. Exp. Stn., New Orleans, La. 31 p. (USDA For. Serv. Gen. Tech. Rep. SO-11)

The computer program described here uses relationships developed from research on loblolly pine growth to predict volumes and yields of planted stands, over the site range of the species, under a wide range of management alternatives. Timing and severity of thinnings, length of rotation, and type of harvest can be modified to compare the effects of various management strategies on wood yield. The program can be modified readily for other conditions or species.

Additional keywords: Timber management, forest management, simulation, *Pinus taeda*.

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