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VB Merch-Lob: A Growth-and-Yield Prediction System with a Merchandising Optimizer for Planted Loblolly Pine in the West Gulf Region

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Abstract

A Visual Basic computer model that can be used to estimate the harvest value of loblolly pine plantations in the west gulf region is presented. The model uses a dynamic programming algorithm to convert stand tables predicted by COMPUTE_P-LOB into a listing of seven products that maximizes the harvested value of the stand.

Keywords: Dynamic programming, economics, merchandising, optimization, *Pinus taeda* L.

Summary

An updated growth-and-yield model with a merchandising optimizer can predict volumes and values of thinned or unthinned loblolly pine (*Pinus taeda* L.). Visual Basic (VB) Merch-Lob forecasts product volumes and stand values for stands partitioned into 1-inch diameter-at-breast-height (d.b.h.) classes at any stage of plantation development from ages 10 through 50 years. The minimum initial variables necessary to run the program are age, density, site quality, minimum and maximum dimensions of products, and product prices. The merchandising optimizer converts predicted stand tables into an estimated optimum product mix with a dynamic programming algorithm that maximizes the selling value of the stand.

Introduction

An updated computer program, VB Merch-Lob, has been developed to estimate the product mix and per-acre stumpage values of planted, thinned or unthinned, loblolly pine. VB Merch-Lob is an updated version of the program COMPUTE_MERCHLOB (Busby and others 1990). As a result the text of this paper closely follows that of COMPUTE_MERCHLOB. This program is written in Visual Basic.

Loblolly pine is one of the most important commercial tree species and also a widely planted southern pine. Managers of loblolly pine plantations need accurate and complete predictions of product volumes and values to formulate management guidelines. For example, they must decide whether or not to thin; if the decision is to thin, they must decide when, how much, and how often. The effects of management actions on the types of products that can be produced dictate timing, quantity, and frequency of thinning. The stand must be premerchandised.

Baldwin and Feduccia (1987) developed a yield prediction system for thinned and unthinned loblolly pine plantations in the west gulf region. A computer program for this system, called Comprehensive Outlook for Managed Pines Using Simulated Treatment Experiments for Plantation Loblolly Pine (COMPUTE_P-LOB) (Ferguson and Baldwin 1987), appeared shortly thereafter. This growth-and-yield prediction system provides both weight and volume yields in a stand/stock table format for the aboveground portion of the trees by 1-inch d.b.h. classes for 10- to 50-year-old loblolly plantations on cutover sites. Many users want yields to be separated into product classes.

Busby and Ward (1989) developed a merchandising optimization routine called MERCHOP for growth-and-yield prediction systems. The routine gives users a wide selection of product categories and mathematically derives optimum product mixes for any yield output. The algorithm divides a stand table into six products plus residual wood. Users specify product prices, maximum and minimum product sizes, minimum harvest volumes, and a factor to account for degrade due to form and other defects.

VB Merch-Lob updates and converts COMPUTE_MERCHLOB (Busby and others 1990) from Fortran to Visual Basic. This paper provides essential background information about the growth-and-yield prediction system from Busby and others (1990), which was based upon the growth-and-yield subroutines in Ferguson and Baldwin (1987) and the merchandising optimization system from Busby and Ward (1989). It also provides input requirements needed to run the model, an example of output, and a typical forest management example to guide system users.

Program Components

Growth-and-Yield Subroutines

The growth-and-yield subroutines are based on measurement data from study plots in unthinned and thinned loblolly pine plantations located in east Texas, north and central

Louisiana, and eastern Mississippi. Plot age (from time of planting) ranged from 10 to 45 years; site index (base age 25), from 40 to 90 feet; and initial planting density, from 109 to 2,700 trees per acre. The thinning interval for stands in the long-term studies was 5 years, and residual densities after thinning ranged from 50 to 130 square feet of basal area per acre (Baldwin and Feduccia 1987).

The three-parameter Weibull function (Bailey and Dell 1973) describes the d.b.h. distribution in a plantation. At any time in a stand's development, the model predicts the minimum (X_1), quadratic mean (X_{qmd}), and 93rd percentile (X_{93}) stand diameters as functions of the number of trees surviving (TS), stand age from planting (A), and dominant height (HD) or site index (SI). Algebraic and numerical techniques then estimate Weibull parameters (Baldwin and Feduccia 1987). Thus, given the prediction of the number of trees surviving, the model can partition the total number of trees into 1-inch d.b.h. classes, and construct a stand table.

Growth and Yield of Unthinned Stands

When starting with an unthinned stand, the model requires A, HD, and TS as input. If HD is not available as input, an SI function can predict HD. If the user does not know TS, it can be predicted as a function of trees planted per acre (TP), A, and HD, or as a function of HD and basal area per acre (BA).

Given this initial information, the prediction of X_1, X_{qmd}, and X_{93} as functions of HD, TS, and A can describe the current stand. The next step estimates the Weibull parameters and produces stand/stock tables.

To estimate future stand attributes and future stand/stock table information in unthinned stands, the first step projects TS from time A_1 to time A_2 using a survival function $TS_2 = f(TS_1, SI, A_1, A_2)$. The SI equation then produces HD_2 at A_2. These values produce estimates of X_1, X_{qmd}, and X_{93} at time A_2. In the final step, the model yields new Weibull parameters and derives a new stand/stock table.

Stand Attributes After Thinning

The model determines aspects of the residual stand after thinning by predicting values for $X_{1,a}$, $X_{qmd,a}$, $X_{93,a}$, TS_a, and BA_a ("$_a$" denotes an after-thinning value). The next step uses these values to obtain the Weibull parameters. Data were only available for a modified low thinning. Because there was a significant difference in the resulting stand between the first and subsequent thinnings, Baldwin and Feduccia (1987) developed two separate sets of equations. One predicts stand characteristics following the first thinning, and the other predicts the residual stand after any subsequent thinning.

The model can express the target density for each thinning as residual stand BA or TS. Baldwin and Feduccia (1987) developed the equations for $X_{1,a}$, $X_{qmd,a}$, $X_{93,a}$ as functions of the before-thinned values of the predictor variable, HD_b, and BA_a/BA_b ("$_b$" denotes a before-thinning value). If the chosen thinning target is TS_a, the model first predicts the value for BA_a from an equation relating $TS_a/TS_b = f(BA_a/BA_b)$.

Growth and Yield of Thinned Stands

Equations in the thinned stand section of the yield system take either predicted or user supplied after-thinning stand information at age A_1. The model projects these values into the future to A_2 to provide stand table predictions at the new stand age. The model predicts the same stand diameter and height attributes as elsewhere, and these values yield Weibull parameters to describe the new stand.

The model predicts diameters at a second age ("$_2$") in thinned stands ($X_{1,2}$, $X_{qmd,2}$, and $X_{93,2}$). Equations use initial values of the predicted variables $X_{1,1}$, $X_{qmd,1}$, or $X_{93,1}$, respectively, and TS_1, A_1, and A_2. Another survival equation, $TS_2 = f(TS_1, SI, A_1, A_2)$, predicts survival in thinned stands.

Stand/Stock Table Estimation

The model generates stand tables for any age by apportioning the total number of surviving trees into 1-inch d.b.h. classes according to the predicted Weibull distribution for that age. Development of a stock table requires a total height prediction equation, volume or weight equations, and taper equations. We used two height prediction equations—one for trees from unthinned stands and one for trees from thinned stands. They predict total tree height as a function of d.b.h., HD, A, and TS. The volume, volume ratio, weight, weight ratio, and taper equations are obtained from Baldwin and Feduccia (1987).

Merchandising Routines

The merchandising routines use dynamic programming to find the optimal mix of products that can be cut from stands described by the growth-and-yield routines. Users specify allowable products, product prices, maximum and minimum product sizes, minimum product harvest per-acre volumes, and the percent defect due to poor form and other anomalies. Six different products can be specified: (1) poles, (2) veneer bolts, (3) saw logs, (4) chip-n-saw logs, (5) pulpwood bolts, and (6) chips. Residual wood can account for any available wood in the boles of the trees not accounted for in the six products.

The basic problem is to find the highest value of stumpage that may be cut from a stand (*STDVAL*) given certain constraints. The optimal solution, *STDVAL*, has a particular combination of associated products ($STDVOL_i$). Each $STDVOL_i$ volume must meet the minimum product-specific harvest value ($HARVST_i$) constraint if the product is to be considered in the analysis at all. The solution technique is summarized in equation 1 (Busby and Ward 1989):

$$STDVAL = \sum_{i=1}^{I} (STDVOL_i)(VALUE_i) \qquad (1)$$

subject to: $STDVOL_i \geq HARVST_i$,

where

$VALUE_i$ = per-unit value of product *i*

All other variables are as previously defined.

Busby and Ward (1989) give details on how this problem is solved.

Program Description

The model allocates the entire bole of each tree to one or more of the six product categories or to residual wood.

The units of measurement for the products are cords, tons, and board feet (in Doyle, Scribner, or International 1/4-inch), depending upon the type of product.

A three-step process calculates cords. The first step calculates the total cubic-foot volume of the solid wood inside bark (i.b.) for each log using COMPUTE_P-LOB routines. The equation for unthinned stands (Baldwin and Feduccia 1987) is:

$$\begin{aligned} ln(TV_{ib}) = &- 6.897192 + 1.886827(ln\,D) \\ &+ 1.245844(ln\,H) \end{aligned} \qquad (2)$$

where

TV_{ib} = the total stem volume (cubic feet, i.b.)
D = the d.b.h.
H = total tree height (feet)

The equation for thinned stands is:

$$\begin{aligned} ln(TV_{ib}) = &- 6.885331 + 2.040995(ln\,D) \\ &+ 1.150022(ln\,H) \end{aligned} \qquad (3)$$

where

all variables are as previously defined.

The second step finds the cubic-foot volume of any particular log. Baldwin and Feduccia (1987) provide coefficients for an equation to estimate the ratio of total merchantable volume, to any top diameter, to the total volume in the tree. The equation for unthinned stands is:

$$\frac{MV_{ib}}{TV_{ib}} = \exp\left[-0.938014\left(\frac{d^{4.950338}}{D^{4.706034}}\right)\right] \qquad (4)$$

where

MV_{ib} = the merchantable volume i.b.
d = the upper stem diameter limit (outside bark, in inches)

The equation for thinned stands is:

$$\frac{MV_{ib}}{TV_{ib}} = \exp\left[-2.177444\left(\frac{d^{5.239462}}{D^{5.314077}}\right)\right] \qquad (5)$$

where

All variables are as previously defined.

The equation calculates the cubic-foot volume for any log by finding MV_{ib}/TV_{ib} to the top and bottom. The difference between the two ratios represents the volume of that log. Total cubic-foot volume is the product of multiplying the ratio by the total volume in the tree, which was calculated in equation 2 for an unthinned stand, or by using equation 3 for the thinned case.

The third step in calculating cord volume is to divide the resulting cubic-foot volume by the appropriate cubic-foot-per-cord ratio (CUFTCD), which is the number of cubic feet of solid wood per cord. The default value of CUFTCD is 76, which is the conversion factor for straight and smooth loblolly pine that has midlength outside bark diameters of < 6 inches as reported in Koch (1972).

A two-step process calculates tons. First, the green weight of the total stem, including bark (TGW_{ob}), comes from the equation in Baldwin and Feduccia (1987):

$$\begin{aligned} ln(TGW_{ob}) = &- 2.06033 + 1.93926(ln\,D) \\ &+ 1.05077(ln\,H) + 0.000061(A^2) \end{aligned} \qquad (6)$$

where

A = the age from planting

All variables are as previously defined.

The second step is to find the weight of the particular log. Baldwin and Feduccia (1987) provide coefficients for equations to estimate the ratio of merchantable green weight outside bark (MGW_{ob}) to any top diameter and TGW_{ob}. The equation for unthinned stands is:

$$\frac{MGW_{ob}}{TGW_{ob}} = \exp\left[-1.153726\left(\frac{d^{4.911545}}{D^{4.723876}}\right)\right] \tag{7}$$

where

All variables are as previously defined.

The equation for thinned stands is:

$$\frac{MGW_{ob}}{TGW_{ob}} = \exp\left[-2.058914\left(\frac{d^{5.124867}}{D^{5.170415}}\right)\right] \tag{8}$$

where

All variables are as previously defined.

The total weight in pounds for any log is calculated by finding MGW_{ob}/TGW_{ob}, first to the top and then to the bottom of the log being examined. The difference between the two ratios is the ratio represented by that log. Multiplying that log's ratio by the total weight of the tree (calculated in equation 4) yields total log weight. Dividing total log weight by 2,000 expresses the result in tons.

Doyle and Scribner volumes in board feet are calculated with the formulae from Grosenbaugh (1952):

$$\begin{aligned} \textit{Doyle board feet} = {} & 0.0625\, DIB^2 L \\ & - 0.500\, (DIB)L + L \end{aligned} \tag{9}$$

$$\begin{aligned} \textit{Scribner board feet} = {} & 0.0494\, DIB^2 L \\ & - 0.124(DIB)L - 0.269\, L \end{aligned} \tag{10}$$

where

DIB = the diameter inside bark at the top end of the log
L = the length of the log

International 1/4-inch volumes in board feet are calculated using the formula from Koch (1972):

$$\begin{aligned} &\textit{International} \\ &\textit{1/4 - inch board feet} = 0.0498\, DIB^2\, L \\ &\quad - 0.185\, (DIB)\, L + 0.0422\, L \\ &\quad + 0.00622\, (DIB)\, L^2 \\ &\quad + 0.000259\, L^3 - 0.0116\, L^2 \end{aligned} \tag{11}$$

where

All variables are as previously defined.

The model then requires price and product dimensions. The user must specify unit prices by product, minimum and maximum top-end diameters, minimum and maximum piece lengths, the piece-length increment, and allowance for trim. These inputs allow the user to specify the size and value for each product. For example, the user could say that poles must have a top-end diameter between 4 and 10 inches and be between 40 and 70 feet in length. The user is asked to define only possible products. The model solves the problem of finding the best product mix.

Two problems arise when attempting to estimate the best product mix: (1) the growth-and-yield model does not provide form and disease product degrade information, and (2) small quantities of even high-valued products may be too expensive to sort out and sell. Form and disease product degrade may be modeled by including the input variable DEFECT, defined as the percentage of properly sized trees incapable of making a particular product. For example, not all trees 40 feet tall to a 6-inch top are suitable for pole production because some may have bad form or a defect that precludes such use. If 60 percent of all properly sized trees have defects, DEFECT would be set to 60.

The second problem, the high price of sorting and selling small quantities of even high-valued products, is solved by including the HARVST variable. The user sets the minimum harvest volume required in a stand if that product is going to be produced at all (HARVST), and any solution to the model must meet that constraint. For example, the user may specify that a minimum of 1,000 board feet per acre of sawtimber logs must be produced.

Program Operation

The VB Merch-Lob Program is currently available in VB for use on the Microsoft Windows™-based systems. Copies of the executable version of the program are available from the authors. The appendix provides a detailed example of executing the model.

Discussion and Conclusions

Diameter distribution and individual-tree-based growth-and-yield prediction systems will each provide stand and stock table output. Some, such as COMPUTE_P-LOB, include weight as well as volume yields. These features can help a forest manager predict future product yield. However, economic and product specification information are also required to merchandise a stand effectively. Forest managers have needed a method to estimate the economic impact of proposed management practices (such as thinning), which will not only alter total volume and weight yields, but also alter the size and shape of tree boles and the ratio of branchwood to bolewood. Thinning changes the product mix of a stand that will ultimately be harvested. VB Merch-Lob meets some of these management needs.

VB Merch-Lob provides two tables at the output stage—a product yield table of specified product possibilities and a value table predicting monetary amounts for the products. The model describes the exact combination of products that will yield the highest value. These represent the highest value solutions, subject to the constraints imposed by the users. Using model predictions, a manager can make profits marketing wood products using plantation loblolly pine in the west gulf region.

Literature Cited

Bailey, Robert L.; Dell, T.R. 1973. Quantifying diameter distributions with the Weibull function. Forest Science. 19: 97-104.

Baldwin, V.C., Jr. 1987. Green and dry-weight equations for above-ground components of planted loblolly pine trees in the west gulf region. Southern Journal of Applied Forestry. 11: 212-218.

Baldwin, V.C., Jr.; Feduccia, D.P. 1987. Loblolly pine growth and yield prediction for managed west gulf region plantations. Res. Pap. SO-235. New Orleans: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 32 p.

Busby, Rodney L.; Ward, Keith B. 1989. MERCHOP: a dynamic programming model for estimating the harvest value of unthinned loblolly and slash pine plantations. Res. Pap. SO-254. New Orleans: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 19 p.

Busby, R.L.; Ward, K.B.; Baldwin, V.C., Jr. 1990. COMPUTE_MERCHLOB: a growth and yield prediction system with a merchandising optimizer for planted loblolly pine in the west gulf region. Res. Pap. SO-255. New Orleans: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 22 p.

Ferguson, R.B.; Baldwin, V.C., Jr. 1987. Comprehensive outlook for managed pine using simulated treatment experiments - planted loblolly pine (COMPUTE_P-LOB): a users guide. Res. Pap. SO-241. New Orleans: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 64 p.

Grosenbaugh, L.R. 1952. Shortcuts for cruisers and scalers. Occas. Pap. 126. New Orleans: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 24 p.

Koch, Peter. 1972. Utilization of the southern pines. Agric. Handb. 420. Washington, DC: U.S. Department of Agriculture. 1,663 p. 2 vol.

Appendix

Input Specifications for VB Merch-Lob

Input to run the model is entered on four forms. The first three contain inputs to run the growth-and-yield routines, and the fourth contains product information needed by the merchandising routines. Output from the model goes to a file or a printer.

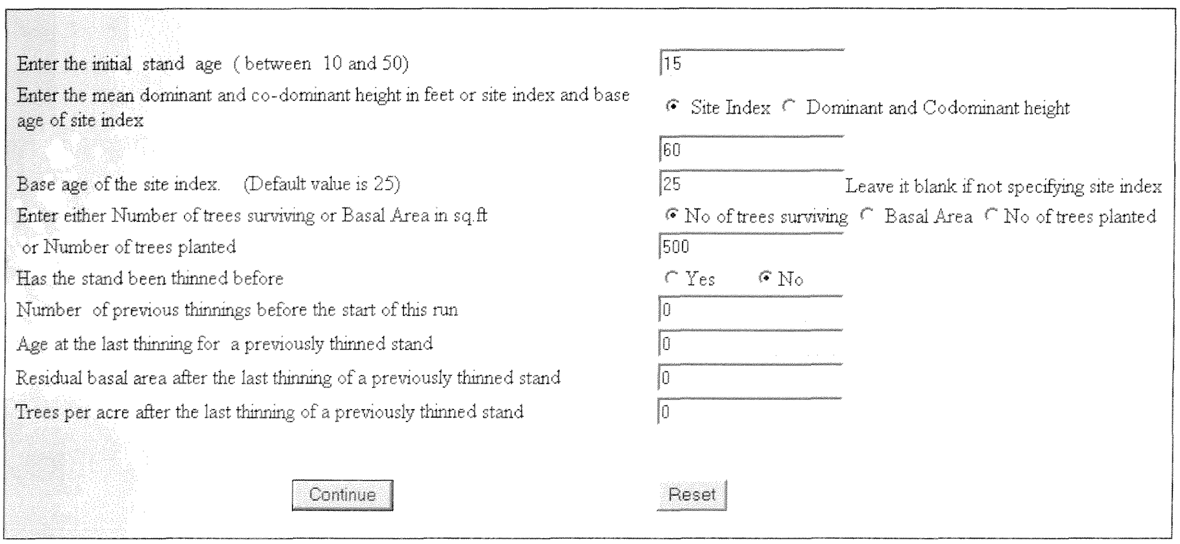
Growth-and-yield data—The growth-and-yield data needed to run VB Merch-Lob are the same variables required to run COMPUTE_P-LOB.

Initially, VB Merch-Lob requires the user to provide the age of the stand (A), an indication of site quality, and a measure of stand density. There are two ways to indicate site quality. The user may supply the mean dominant and codominant height of the stand (HD) to calculate site index (SI). Alternatively, the user may supply the stand's site index and base age for the site index measure (BSAG). Note the BSAG must be either 25 or 50 years. If the user has estimates of both HD and SI, HD is preferred, because the growth-and-yield model COMPUTE_P-LOB would ignore SI and BSAG if both measures of site productivity were supplied. The user must also supply a measure of stand density by choosing to provide either the basal area (BA), trees surviving at the starting stand age (TS), or the number of trees planted (TP). If the user has more than one measure of stand density, we advise use of the same priorities used in COMPUTE_P-LOB, if all three measures are provided: (1) TS, (2) BA, and finally (3) TP (fig. A.1).

Next, the user is asked: Has the stand been thinned before? If it has, the user must provide the number of previous thinnings, the age of the last thinning, and either the residual BA or the number of trees per acre remaining after the last thinning (fig. A.1). The title of the run to be printed in the output is entered on the second screen. Users also may provide the number of thinnings desired with this run and the thinning method as residual BA or residual number of trees. Note that the model allows the user to specify up to seven different thinnings. The remaining entries on that form are the ages of thinnings and their corresponding target values (fig. A.2). The model will automatically print both prethinning and post thinning tables, as well as the cut table for each thinning.

The third form (fig. A.3) allows the user to specify ages, other than thinning ages, for which the model should generate output. The user supplies the number of tables desired and the ages for which the information is required. A single run may produce a maximum of 15 tables. Because the model will generate a prethinning table and postthinning table at each thinning, these will be subtracted from the total of 15 tables.

The fourth form (fig. A.4) gathers information for the model's economic subroutines. The first listed variable is product name. The user may analyze up to six products by marking a "Y" in the "Produce" column; marking an "N"



Enter the initial stand age (between 10 and 50)	15
Enter the mean dominant and co-dominant height in feet or site index and base age of site index	◉ Site Index ○ Dominant and Codominant height
	60
Base age of the site index. (Default value is 25)	25 Leave it blank if not specifying site index
Enter either Number of trees surviving or Basal Area in sq.ft or Number of trees planted	◉ No of trees surviving ○ Basal Area ○ No of trees planted
	500
Has the stand been thinned before	○ Yes ◉ No
Number of previous thinnings before the start of this run	0
Age at the last thinning for a previously thinned stand	0
Residual basal area after the last thinning of a previously thinned stand	0
Trees per acre after the last thinning of a previously thinned stand	0
Continue	Reset

Figure A.1—Input information is entered for the existing stand to be modeled.

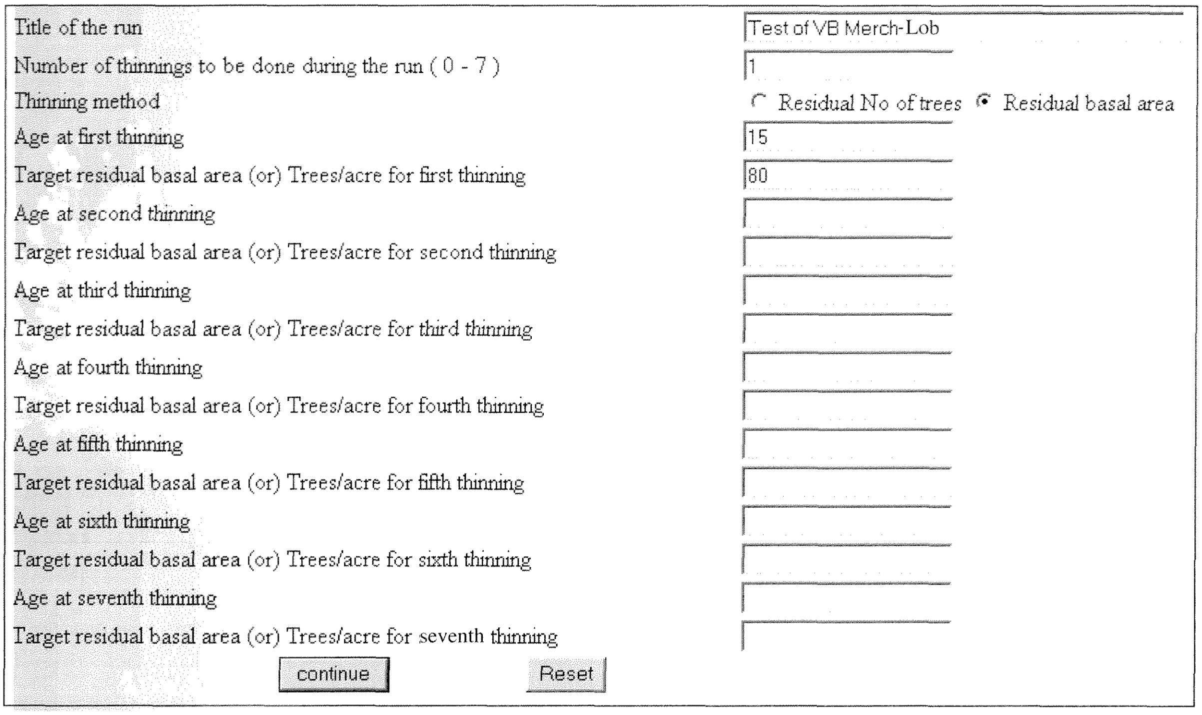


Figure A.2—The user supplies a title to the run and indicates the number and type of thinnings to be modeled.

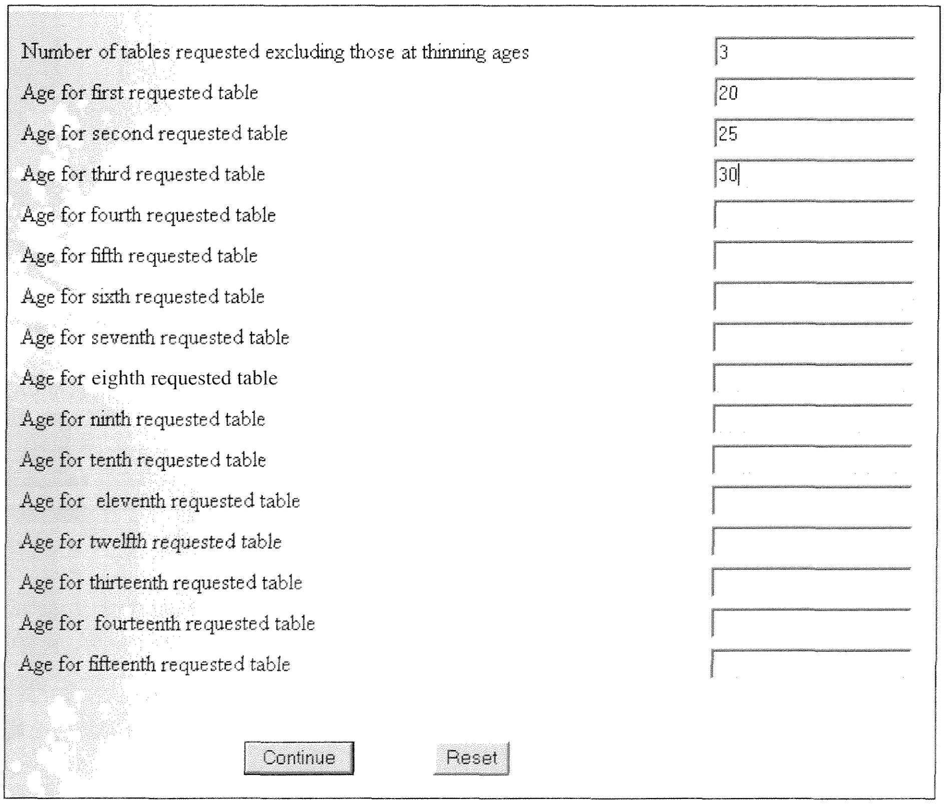


Figure A.3—The user then specifies the years desired for a stand stable. Stand tables will automatically be produced for years in which a thinning occurs.

Category	Produce	Scale	Price	Amind	Amaxd	Aminl	Amaxl	Aincl	Trim	Defect	Harvest
Poles	N	S	205.00	4.00	10.00	35.00	90.00	5.00	0.25	75	0.00
Veneer	N	S	158.00	8.00	24.00	8.00	8.00	0.00	0.25	50	0.00
SawTimber	Y	S	148.00	9.50	18.00	8.00	16.00	2.00	0.25	20	0.00
ChipN'saw	Y	C	34.17	6.00	12.00	6.00	16.00	2.00	0.25	10	0.00
PulpWood	Y	C	14.87	3.50	12.00	5.00	5.00	0.00	0.00	0	0.00
Chips	Y	C	1.00	0.00	30.00	0.25	0.25	0.00	0.00	0	0.00

Scale :
C - Cords
D - Doyle MBF
I - Int'L 1/4 inch MBF
S - Scribner MBF
T - Tons

Submit Reset

Figure A.4—The user then provides key economic and product information needed to merchandise the stand.

means that the product will not be considered. The user must choose "Y" or "N" for each.

Five scale measures are possible in the model. They are: (1) cords (C), (2) Doyle MBF (thousand board feet) (D), (3) International 1/4-inch MBF (I), (4) Scribner MBF (S), or (5) tons (T). Users express their choice by placing the proper letter in the "Scale" column. The following are default options and allowed output measurement scales for each product:

Product	Model default	Measurement scale allowed
Poles	Scribner	Scribner, Doyle, or International
Veneer bolts	Scribner	Scribner, Doyle, International, or cords
Sawtimber	Scribner	Scribner, Doyle, or International
Chip-n-saw logs	Cords	Scribner, Doyle, International, or cords
Pulpwood bolts	Cords	Cords or tons
Chips	Cords	Cords or tons

The user marks a price per unit for each product in column "Price"; note, residual wood is not priced. The user then provides the minimum and maximum scaling diameters (in inches) for product *i* in the next two columns. If the log segment's top-end diameter is within the range of the minimum and maximum scaling diameter, then that product is considered for production. Note the ranges of scaling diameters normally will overlap. This allows for the same diameter log to be used for more than one product. The exact combination of products depends on which combination will yield the highest value.

The minimum, maximum, and increment of log lengths for each product examined are marked in the next three columns, respectively.

The final input requirement for the product dimensions is "$Trim_i$", which is the trim allowance for each product.

The value for the stage interval used in the dynamic programming subroutines is 0.25 foot. Therefore, the total length of all logs, including trim allowance, must be a multiple of the stage interval. The model will print an error message if this condition is violated.

A log with dimensions sufficient for a particular product might have certain defects that preclude such use. The user assigns a value for $DEFECT_i$, an estimate of the defect in the product *i*-sized trees, in column "Defect" for each product-specific line. If a log can provide product *i*, then all products *i*+1 are assumed from that log. Hence, as one inputs the data, $DEFECT_i$ must be $\leq DEFECT_{i+1}$ for all products.

If the user does not allocate part of the bole of the tree to one of the first six products, the model automatically produces residual wood.

The next required input is $HARVST_i$. This is the minimum stand volume of a particular product. The units of measure for this variable are the same as for $SCALE_i$. Input values should be placed in column "Harvest". Figure A.5 shows an example of the output of a run of the model.

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==========================================================================================
                                Test of VB Merch-Lob
==========================================================================================
         Visual Basic Version Of COMPUTE_MERCHLOB

            Developed by:
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            Based on:
                             Compute_Merchlob developed by
                             Busby, Ward, and Baldwin (1990)
                             USDA Forest Service, Southern Research Station
                             Research Paper SO-225
========================================================================================
              M                                             I        A
    C         E               D      D                      N        L             O
  P A      P  A            M I    M I    M       M         C        L           M P H
  R T      R  S            I A    A A    I L     A L     L R        O    D      I E A
  O E      O  U S  P       N M    X M    N E     X E     E E        W    E      N R R
  D G      D  R C  R   U   I E    I E    I N     I N     N M      T A    F      I A V
  U O      U  I A  I P N   M T    M T    M G     M G     G E      R N    E      M B E
  C R      C  N L  C E I   U E    U E    U T     U T     T N      I C    C      U L S
  T Y      E  G E  E R T   M R    M R    M H     M H     H T      M E    T      M E T

poles       N  S  205.00  04.00  10.00  035.00  090.00  005.00  000.25  075.00  000.00
veneer      N  S  158.00  08.00  24.00  008.00  008.00  000.00  000.25  050.00  000.00
sawtimber   Y  S  148.00  09.50  18.00  008.00  016.00  002.00  000.25  020.00  000.00
chip-n-saw  Y  C  034.17  06.00  12.00  006.00  016.00  002.00  000.25  010.00  000.00
pulpwood    Y  C  014.87  03.50  12.00  005.00  005.00  000.00  000.00  000.00  000.00
chips       Y  C  001.00  00.00  30.00  000.25  000.25  000.00  000.00  000.00  000.00
residual    Y  T  000.00  00.00  40.00  000.25  000.25  000.00  000.00  000.00  000.00

=========================================================================================
 Measurement Scale :

 D - Doyle Scale(MBF)
 S - Scribner Scale (MBF)
 I - International -1/4 Scale
 Other Model Parameters:
 cubic foot to cord ratio = 76
 stage interval =0.25
 stump height  = 0.5

 Initial Stand Parameters are :
 Age  = 15
 HD   = 044.48
 Si   = 60
 Bsag = 25
 Ts   = 500
 Ba   = 0
 Tp   = 0
 Previous thins = N
 Ipthin = 0
 Itage  = 0
 Iba    = 0
 Itpa   = 0
```

Figure A.5—Example output of VB Merch-Lob (continued to next page).

```
                     LOBLOLLY  PINE
                  Before thinning information
                  Site index = 60
                  Base age   = 25
                  Basal area = 109.51

GROWING          STEMS -------------------volume-------------
SEASONS   DBH     PER   sawtimb  C-N-S  pulpwood    chips
SINCE     CLASS   ACRE  (MBFS)   (CORD)   (CORD)    (CORD)
EST
15
           02     001   000.00   000.00   000.00   000.00
           03     016   000.00   000.00   000.00   000.10
           04     054   000.00   000.00   000.00   000.80
           05     101   000.00   000.00   001.35   001.30
           06     129   000.00   000.00   004.20   001.05
           07     110   000.00   000.00   005.63   000.73
           08     062   000.00   002.13   002.57   000.19
           09     022   000.00   001.36   000.80   000.07
           10     005   000.00   000.47   000.14   000.02
                 ----------------------------------------
                  500  0000.00  0003.96  0014.69  0004.26

GROWING          STEMS -------------------value--------------
SEASONS   DBH     PER   sawtimb  C-N-S  pulpwood    chips
SINCE     CLASS   ACRE    ($)     ($)      ($)       ($)
EST
15
           02     001   000.00   000.00   000.00   000.00
           03     016   000.00   000.00   000.00   000.10
           04     054   000.00   000.00   000.00   000.80
           05     101   000.00   000.00   020.04   001.30
           06     129   000.00   000.00   062.48   001.05
           07     110   000.00   000.00   083.67   000.73
           08     062   000.00   072.62   038.20   000.19
           09     022   000.00   046.50   011.87   000.07
           10     005   000.00   016.15   002.14   000.02
                 ----------------------------------------
                  500  0000.00  0135.26  0218.40  0004.26

The total value of the harvest from this stand
is $357.93.

                                                 continued
```

Figure A.5—Example output of VB Merch-Lob (continued to next page).

LOBLOLLY PINE
Residual stand -- after thinning
Site index = 60
Base age = 25
Basal area = 80.00

GROWING SEASONS SINCE EST	DBH CLASS	STEMS PER ACRE	sawtimb (MBFS)	C-N-S (CORD)	pulpwood (CORD)	chips (CORD)
			volume			
15						
	03	007	000.00	000.00	000.00	000.04
	04	030	000.00	000.00	000.00	000.45
	05	064	000.00	000.00	000.85	000.82
	06	089	000.00	000.00	002.90	000.72
	07	083	000.00	000.00	004.25	000.55
	08	050	000.00	001.71	002.07	000.15
	09	018	000.00	001.11	000.65	000.05
	10	004	000.00	000.38	000.12	000.01
		345	0000.00	0003.21	0010.84	0002.81

GROWING SEASONS SINCE EST	DBH CLASS	STEMS PER ACRE	sawtimb ($)	C-N-S ($)	pulpwood ($)	chips ($)
			value			
15						
	03	007	000.00	000.00	000.00	000.04
	04	030	000.00	000.00	000.00	000.45
	05	064	000.00	000.00	012.70	000.82
	06	089	000.00	000.00	043.11	000.72
	07	083	000.00	000.00	063.13	000.55
	08	050	000.00	058.57	030.81	000.15
	09	018	000.00	038.04	009.71	000.05
	10	004	000.00	012.92	001.71	000.01
		345	0000.00	0109.52	0161.17	0002.81

The total value of the harvest from this stand
is $273.51.

continued

Figure A.5—Example output of VB Merch-Lob (continued to next page).

```
                         LOBLOLLY  PINE
                      Stand component removed by thinning
                      Site index = 60
                      Base age   = 25
                      Basal area = 29.51


GROWING          STEMS ------------------volume-------------
SEASONS   DBH    PER    sawtimb  C-N-S  pulpwood    chips
SINCE     CLASS  ACRE   (MBFS)   (CORD)   (CORD)    (CORD)
EST
15
            02   001    000.00   000.00   000.00    000.00
            03   009    000.00   000.00   000.00    000.06
            04   024    000.00   000.00   000.00    000.36
            05   037    000.00   000.00   000.49    000.48
            06   040    000.00   000.00   001.30    000.32
            07   027    000.00   000.00   001.38    000.18
            08   012    000.00   000.41   000.50    000.04
            09   004    000.00   000.25   000.15    000.01
            10   001    000.00   000.09   000.03    000.00
                ----------------------------------------
                 155   0000.00  0000.75  0003.85   0001.45

GROWING          STEMS -------------------value-------------
SEASONS   DBH    PER    sawtimb  C-N-S  pulpwood    chips
SINCE     CLASS  ACRE     ($)     ($)      ($)       ($)
EST
15
            02   001    000.00   000.00   000.00    000.00
            03   009    000.00   000.00   000.00    000.06
            04   024    000.00   000.00   000.00    000.36
            05   037    000.00   000.00   007.34    000.48
            06   040    000.00   000.00   019.37    000.32
            07   027    000.00   000.00   020.54    000.18
            08   012    000.00   014.06   007.39    000.04
            09   004    000.00   008.45   002.16    000.01
            10   001    000.00   003.23   000.43    000.00
                ----------------------------------------
                 155   0000.00  0025.74  0057.23   0001.45


The total value of the harvest from this stand is
$84.42.

                                                 continued
```

Figure A.5—Example output of VB Merch-Lob (continued to next page).

```
                    LOBLOLLY  PINE
                 No thinning this year
                 Site index = 60
                 Base age   = 25
                 Basal area = 107.37


GROWING          STEMS -----------------volume------------
SEASONS   DBH     PER   sawtimb  C-N-S  pulpwood   chips
SINCE     CLASS  ACRE   (MBFS)   (CORD)   (CORD)   (CORD)
EST
20
            04    006   000.00   000.00   000.00   000.09
            05    024   000.00   000.00   000.37   000.29
            06    048   000.00   000.00   001.71   000.44
            07    067   000.00   000.00   003.81   000.58
            08    070   000.00   002.58   003.22   000.50
            09    054   000.00   004.12   002.08   000.24
            10    030   000.00   003.39   000.98   000.16
            11    012   000.00   001.82   000.40   000.03
            12    003   000.10   000.37   000.09   000.02
            13    001   000.06   000.12   000.03   000.00
                  ----------------------------------------
                  315  0000.16  0012.40  0012.70  0002.36

GROWING          STEMS ------------------value------------
SEASONS   DBH     PER   sawtimb  C-N-S  pulpwood   chips
SINCE     CLASS  ACRE    ($)      ($)      ($)      ($)
EST
20
            04    006   000.00   000.00   000.00   000.09
            05    024   000.00   000.00   005.54   000.29
            06    048   000.00   000.00   025.37   000.44
            07    067   000.00   000.00   056.69   000.58
            08    070   000.00   087.99   047.89   000.50
            09    054   000.00   140.88   030.94   000.24
            10    030   000.00   115.94   014.52   000.16
            11    012   000.00   062.02   005.99   000.03
            12    003   015.18   012.70   001.38   000.02
            13    001   008.75   004.11   000.52   000.00
                  ----------------------------------------
                  315  0023.93  0423.64  0188.85  0002.36

The total value of the harvest from this stand
is $638.78.

                                                 continued
```

Figure A.5—Example output of VB Merch-Lob (continued to next page).

LOBLOLLY PINE
No thinning this year
Site index = 60
Base age = 25
Basal area = 124.57

GROWING SEASONS SINCE EST	DBH CLASS	STEMS PER ACRE	sawtimb (MBFS)	C-N-S (CORD)	pulpwood (CORD)	chips (CORD)
25						
	04	002	000.00	000.00	000.00	000.03
	05	011	000.00	000.00	000.18	000.15
	06	026	000.00	000.00	000.95	000.30
	07	042	000.00	000.00	002.73	000.27
	08	054	000.00	002.28	002.87	000.24
	09	057	000.00	004.81	002.36	000.36
	10	045	000.00	005.64	001.85	000.16
	11	029	000.00	004.92	001.07	000.11
	12	014	000.49	002.02	000.55	000.03
	13	005	000.33	000.66	000.22	000.01
	14	002	000.19	000.25	000.09	000.01
		287	0001.01	0020.58	0012.86	0001.66

GROWING SEASONS SINCE EST	DBH CLASS	STEMS PER ACRE	sawtimb ($)	C-N-S ($)	pulpwood ($)	chips ($)
25						
	04	002	000.00	000.00	000.00	000.03
	05	011	000.00	000.00	002.61	000.15
	06	026	000.00	000.00	014.08	000.30
	07	042	000.00	000.00	040.57	000.27
	08	054	000.00	077.88	042.73	000.24
	09	057	000.00	164.20	035.13	000.36
	10	045	000.00	192.56	027.55	000.16
	11	029	000.00	168.21	015.91	000.11
	12	014	072.58	069.09	008.11	000.03
	13	005	048.57	022.72	003.26	000.01
	14	002	028.32	008.45	001.32	000.01
		287	0149.48	0703.12	0191.28	0001.66

The total value of the harvest from this stand is $1,045.54.

continued

Figure A.5—Example output of VB Merch-Lob (continued to next page).

LOBLOLLY PINE
No thinning this year
Site index = 60
Base age = 25
Basal area = 134.46

GROWING SEASONS SINCE EST	DBH CLASS	STEMS PER ACRE	sawtimb (MBFS)	C-N-S (CORD)	pulpwood (CORD)	chips (CORD)
			volume			
30						
	05	005	000.00	000.00	000.08	000.08
	06	014	000.00	000.00	000.60	000.12
	07	026	000.00	000.00	001.74	000.23
	08	039	000.00	001.83	002.10	000.19
	09	046	000.00	004.20	002.18	000.16
	10	045	000.00	006.04	001.99	000.20
	11	037	000.00	006.81	001.49	000.20
	12	024	000.96	003.64	001.03	000.08
	13	013	000.94	001.92	000.62	000.02
	14	005	000.54	000.63	000.26	000.01
	15	002	000.28	000.26	000.08	000.03
	16	001	000.17	000.11	000.04	000.04
		257	0002.89	0025.44	0012.21	0001.36

GROWING SEASONS SINCE EST	DBH CLASS	STEMS PER ACRE	sawtimb ($)	C-N-S ($)	pulpwood ($)	chips ($)
			value			
30						
	05	005	000.00	000.00	001.21	000.08
	06	014	000.00	000.00	008.88	000.12
	07	026	000.00	000.00	025.91	000.23
	08	039	000.00	062.67	031.22	000.19
	09	046	000.00	143.47	032.46	000.16
	10	045	000.00	206.26	029.53	000.20
	11	037	000.00	232.61	022.13	000.20
	12	024	142.71	124.36	015.37	000.08
	13	013	138.82	065.60	009.17	000.02
	14	005	080.11	021.65	003.93	000.01
	15	002	041.23	008.84	001.21	000.03
	16	001	025.13	003.70	000.58	000.04
		257	0427.99	0869.15	0181.60	0001.36

The total value of the harvest from this stand is $1,480.10.

Figure A.5—Example output of VB Merch-Lob.

Chang, S.J.; Busby, R.L.; Pasala, P.R.; Leduc, D.J. 2005. VB Merch-Lob: a growth-and-yield prediction system with a merchandising optimizer for the planted loblolly pine in the west gulf region. Res. Pap. SRS–35. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 15 p.

A Visual Basic computer model that can be used to estimate the harvest value of loblolly pine plantations in the west gulf region is presented. The model uses a dynamic programming algorithm to convert stand tables predicted by COMPUTE_P-LOB into a listing of seven products that maximizes the harvested value of the stand.

Keywords: Dynamic programming, economics, merchandising, optimization, *Pinus taeda* L.