VB Merch-Slash: A Growth-and-Yield Prediction System with a Merchandising Optimizer for Planted Slash 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 slash pine plantations in the west gulf region is presented. The model uses a dynamic programming algorithm to convert stand tables predicted by COMPUTE_P-SLASH into a listing of seven products that maximizes the harvested value of the stand.

Keywords: Dynamic programming, economics, merchandising, optimization, *Pinus elliottii* Engelm. var. *elliottii*.

Summary

A new growth-and-yield model with a merchandising optimizer can predict volumes and values of thinned or unthinned slash pine (*Pinus elliottii* Engelm. var. *elliottii*). Visual Basic (VB) Merch-Slash 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

A new computer program, VB Merch-Slash, can estimate the product mix and per-acre stumpage values of planted, thinned or unthinned, slash pine. VB Merch-Slash is the counterpart of COMPUTE_MERCHLOB (Busby and others 1990). This program is written in Visual Basic.

Slash pine is one of the most important commercial tree species and also a widely planted southern pine. Managers of slash 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.

Zarnoch and others (1991) developed a yield prediction system for thinned and unthinned slash pine plantations for the west gulf region. A computer program for this system, called Comprehensive Outlook for Managed Pines using Simulated Treatment Experiments for Plantation Slash Pine (COMPUTE_P-SLASH) (Baldwin and Ferguson 1991) 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 slash 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-Slash represents the first attempt to merge MERCHOP with the slash pine stand growth-and-yield prediction system. Zarnoch and others (1991) earlier presented a general overview of the growth-and-yield model system. This paper now provides essential background information about the growth-and-yield prediction system from Baldwin and Ferguson (1991) and the merchandising optimization system from Busby and Ward (1989). We also provide the input requirements 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 slash pine plantations. The data pool consisted of 507 unthinned-stand yield observations and 543 thinned-stand growth-period observations from 0.10- to 0.25-acre plots in slash pine plantations established on problem-free, cutover forestland. The growth period was generally 5 years, but

ranged from 3 to 11 years. The plots avoided areas where survival was poor or where heavy insect, disease, or other damage was present. For the most part the thinning was from below, but at later ages a good distribution of tree diameters across the plot was also a criterion. In addition, there were 530 residual-stand observations of postthinning conditions (Zarnoch and others 1991).

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 (Zarnoch and others 1991). 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, a 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 the residual stand after thinning by predicting "thinned" 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 available only for a modified low thinning. Because there was a significant difference in the resulting stand between the first thinning and subsequent thinnings, Zarnoch and others (1991) developed two separate sets of equations. One predicts the 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. Zarnoch and others (1991) 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 the 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 Ferguson (1991).

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 percentage of defect due to form and other defects. 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 other 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 being produced.

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-SLASH routines. The equation for thinned and unthinned stands (Baldwin and Ferguson 1991) is:

$$ln(TV_{ib}) = -6.93385 + 2.07195(ln\ D) \\ + 1.13645(ln\ H) \qquad (2)$$

where

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

The second step finds the cubic-foot volume of any particular log. Baldwin and Ferguson (1991) 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 thinned and unthinned stands is:

$$\frac{MV_{ib}}{TV_{ib}} = \exp\left[-12.68894\left(\frac{d^{5.96264}}{D^{6.40722}}\right)\right] \qquad (3)$$

where

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

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 equation 2 calculated.

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 slash pine that has midlength outside bark diameters of < 6 inches (Koch 1972). Users may supply their own values for CUFTCD, but entries must range from 55 to 95, inclusive.

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 Ferguson (1991):

$$ln(TGW_{ob}) = -2.00410 + 2.10282(ln\ D) \\ + .96566(ln\ H) \qquad (4)$$

where

All variables are as previously defined.

The second step is to find the weight of the particular log. Baldwin and Ferguson (1991) 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 thinned and unthinned stands is:

$$\frac{MGW_{ob}}{TGW_{ob}} = \exp\left[-1.37971\left(\frac{d^{5.15075}}{D^{5.06016}}\right)\right] \qquad (5)$$

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):

$$Doyle\ board\ feet = 0.0625\ DIB^2\ L \\ - 0.500\ (DIB)L + L \tag{6}$$

$$Scribner\ board\ feet = 0.0494\ DIB^2\ L \\ - 0.124(DIB)L - 0.269\ L \tag{7}$$

where

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

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

$$International \\ 1/4 - inch\ board\ feet = 0.0498\ DIB^2\ L \\ - 0.185\ (DIB)\ L + 0.0422\ L \\ + 0.00622\ (DIB)\ L^2 \\ + 0.000259\ L^3 - 0.0116\ L^2 \tag{8}$$

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 the log being used as a pole. 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-Slash Program is currently available in Visual-basic 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-SLASH, 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-Slash meets some of these management needs.

VB Merch-Slash 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 slash pine in the west gulf region.

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Appendix

Input Specifications for VB Merch-Slash

Input to run the model is entered on four forms. The first three forms contain inputs to run the growth-and-yield routines. The fourth form contains product information needed by the merchandising routines. The 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-Slash are the same variables required to run COMPUTE_P-SLASH.

Initially, VB Merch-Slash 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 co-dominant 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-SLASH 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, it is advised to use the same priorities that

COMPUTE_P-SLASH uses, if all three measures are provided: (1) TS, (2) BA, and finally (3) TP (fig. A.1).

Next, the user must answer the question: Has the stand been thinned before? If it has, the user must state 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 in the second screen. Users may also provide the number of thinnings desired with this run and the thinning method as residual basal area 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 before and after-thinning tables plus the cut table for each thinning.

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

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

Title of the run	Test of VB Merch-Slash
Number of thinnings to be done during the run (0 - 7)	1
Thinning method	○ Residual No of trees ● Residual basal area
Age at first thinning	15
Target residual basal area (or) Trees/acre for first thinning	80
Age at second thinning	
Target residual basal area (or) Trees/acre for second thinning	
Age at third thinning	
Target residual basal area (or) Trees/acre for third thinning	
Age at fourth thinning	
Target residual basal area (or) Trees/acre for fourth thinning	
Age at fifth thinning	
Target residual basal area (or) Trees/acre for fifth thinning	
Age at sixth thinning	
Target residual basal area (or) Trees/acre for sixth thinning	
Age at seventh thinning	
Target residual basal area (or) Trees/acre for seventh thinning	

[continue]   [Reset]

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

Number of tables requested excluding those at thinning ages	3
Age for first requested table	20
Age for second requested table	25
Age for third requested table	30
Age for fourth requested table	
Age for fifth requested table	
Age for sixth requested table	
Age for seventh requested table	
Age for eighth requested table	
Age for ninth requested table	
Age for tenth requested table	
Age for eleventh requested table	
Age for twelfth requested table	
Age for thirteenth requested table	
Age for fourteenth requested table	
Age for fifteenth requested table	

[Continue]   [Reset]

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.

The fourth form (fig. A.4) gathers information for the model's economic subroutines. The first listed variable is the name of each product. The user may analyze six products. He or she chooses a particular product by marking a "Y" in the "PRODUCE?" column; "N" means that the product will not be considered. The user should choose "Y" or "N" for each product.

Five scale measures are possible in the model. They are: (1) cords (C), (2) Doyle MBF (D), (3) International l/4-inch MBF (I), (4) Scribner MBF (S), or (5) tons (T). Users express their choice by placing the proper letter in "Scale" column. The following are the default 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

A user marks the price per unit of each product, in column "Price"; note that residual wood is not priced. A user places the minimum and maximum scaling diameters for product i in the next two columns; note, that these are expressed in inches. 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 that the ranges of scaling diameters will normally 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 sufficient dimensions to produce a particular product might have certain defects that preclude its use for that product. A user marks the 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.

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.

If a 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 the units of $SCALE_i$. This input value should be placed in column "Harvest".

The user can save the results of the run to a file, print the run, exit the program, or run the program again using the original defaults of the program or with the previous settings.

To illustrate the application of the VB Merch-Slash system, a user can practice a relatively simple but realistic example. It assumes an unthinned slash pine plantation with a site index of 60 (base age 25) that is 15 years old and has 500 surviving trees per acre (fig. A.1). The user contemplates immediately thinning the stand to 70 square feet of basal area (fig. A.2). In addition to the information about thinning at age 15 stand, the user enters stock, and value tables without thinning for ages 20, 25, and 30 years (fig. A.3). Sawtimber logs on Scribner scale, chip-n-saw logs in cords, pulpwood bolts in cords, and chips in cords are the intermediate and final products desired (fig. A.4). The example produces the amount and value of each product produced, for each time period requested (fig. A.5).

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================================================================================
                              Test of VB Merch-Slash
================================================================================
                    Visual Basic MERCH-SLASH

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          Based on:               Compute_P-Slash    developed by
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================================================================================
                M                                       I        A
   C            E                 D       D                       N        L
 P A          P A               M I     M I     M       M         C        L                O
 R T          R S               I A     A A     I L     A L       L R      O        D       M P H
 O E          O U S    P        N M     X M     N E     X E       E E      W        E       I E A
 D G          D R C    R   U    I E     I E     I N     I N       N M      T A      F       N R R
 U O          U I A    I P N    M T     M T     M G     M G       G E      R N      E       I A V
 C R          C N L    C E I    U E     U E     U T     U T       T N      I C      C       M B E
 T Y          E G E    E R T    M R     M R     M H     M H       H T      M E      T       U L S
                                                                                            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   = 040.56
 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-Slash (continued to next page).

```
                          SLASH   PINE
                          Before thinning information
                          Site index = 60
                          Base age   = 25
                          Basal area = 88.62


GROWING           STEMS  ------------volume----------------
SEASONS    DBH    PER    sawtimb  C-N-S  pulpwood   chips
SINCE      CLASS  ACRE   (MBFS)   (CORD)  (CORD)    (CORD)
EST
15
           02     002    000.00   000.00  000.00    000.00
           03     021    000.00   000.00  000.00    000.12
           04     073    000.00   000.00  000.00    000.88
           05     143    000.00   000.00  000.48    002.64
           06     157    000.00   000.00  003.22    002.23
           07     085    000.00   000.00  003.53    000.76
           08     018    000.00   000.10  001.04    000.12
           09     001    000.00   000.03  000.06    000.01
                         ---------------------------------
                  500    0000.00  0000.13 0008.34   0006.76


GROWING           STEMS  ------------value-----------------
SEASONS    DBH    PER    sawtimb  C-N-S  pulpwood   chips
SINCE      CLASS  ACRE   ($)      ($)     ($)       ($)
EST
15
           02     002    000.00   000.00  000.00    000.00
           03     021    000.00   000.00  000.00    000.12
           04     073    000.00   000.00  000.00    000.88
           05     143    000.00   000.00  007.10    002.64
           06     157    000.00   000.00  047.93    002.23
           07     085    000.00   000.00  052.55    000.76
           08     018    000.00   003.31  015.52    000.12
           09     001    000.00   001.03  000.84    000.01
                         ---------------------------------
                  500    0000.00  0004.34 0123.95   0006.76


The total value of the harvest from this stand is
$135.04/acre

                                               continued
```

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

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


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       015    000.00   000.00   000.00     000.08
            04       058    000.00   000.00   000.00     000.70
            05       121    000.00   000.00   000.40     002.23
            06       141    000.00   000.00   002.89     002.00
            07       081    000.00   000.00   003.37     000.73
            08       019    000.00   000.10   001.10     000.13
            09       001    000.00   000.03   000.06     000.01
                     ----------------------------------------
                     437    0000.00  0000.13  0007.83    0005.88


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       015    000.00   000.00   000.00     000.08
            04       058    000.00   000.00   000.00     000.70
            05       121    000.00   000.00   006.01     002.23
            06       141    000.00   000.00   043.05     002.00
            07       081    000.00   000.00   050.08     000.73
            08       019    000.00   003.49   016.39     000.13
            09       001    000.00   001.03   000.84     000.01
                     ----------------------------------------
                     437    0000.00  0004.52  0116.36    0005.88


The total value of the harvest from this stand is
$126.76/acre

                                                    continued
```

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

```
                              SLASH PINE
                   Stand component removed by thinning
                   Site index = 60
                   Base age   = 25
                   Basal area = 8.62


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        006    000.00   000.00  000.00     000.03
           04        015    000.00   000.00  000.00     000.18
           05        022    000.00   000.00  000.07     000.41
           06        016    000.00   000.00  000.33     000.23
           07        004    000.00   000.00  000.17     000.04
                            ------------------------------------
                     63     0000.00  0000.00 0000.57    0000.88


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        006    000.00   000.00  000.00     000.03
           04        015    000.00   000.00  000.00     000.18
           05        022    000.00   000.00  001.09     000.41
           06        016    000.00   000.00  004.88     000.23
           07        004    000.00   000.00  002.47     000.04
                            ------------------------------------
                     63     0000.00  0000.00 0008.45    0000.88


  The total value of the harvest from this stand is
  $9.33/acre

                                                    continued
```

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

```
                         SLASH PINE
                    No thinning this Year
                    Site index = 60
                    Base age   = 25
                    Basal area = 107.94


GROWING          STEMS ------------volume----------------
SEASONS   DBH    PER   sawtimb  C-N-S  pulpwood  chips
SINCE     CLASS  ACRE  (MBFS)   (CORD)  (CORD)   (CORD)
EST
20
          03     004   000.00   000.00  000.00   000.03
          04     020   000.00   000.00  000.00   000.29
          05     052   000.00   000.00  000.74   000.64
          06     091   000.00   000.00  002.93   000.87
          07     108   000.00   000.00  005.88   000.77
          08     083   000.00   003.26  003.36   000.43
          09     037   000.00   002.41  001.55   000.14
          10     009   000.00   000.90  000.34   000.03
          11     001   000.00   000.14  000.04   000.00
                      -------------------------------------
                 405  0000.00  0006.71 0014.84  0003.20


GROWING          STEMS -------------value----------------
SEASONS   DBH    PER   sawtimb  C-N-S  pulpwood  chips
SINCE     CLASS  ACRE  ($)      ($)     ($)      ($)
EST
20
          03     004   000.00   000.00  000.00   000.03
          04     020   000.00   000.00  000.00   000.29
          05     052   000.00   000.00  011.02   000.64
          06     091   000.00   000.00  043.50   000.87
          07     108   000.00   000.00  087.44   000.77
          08     083   000.00   111.27  049.99   000.43
          09     037   000.00   082.50  023.02   000.14
          10     009   000.00   030.60  005.11   000.03
          11     001   000.00   004.74  000.53   000.00
                      -------------------------------------
                 405  0000.00  0229.11 0220.61  0003.20


The total value of the harvest from this stand is
$452.92/acre

                                              continued
```

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

```
                         SLASH  PINE
                    No thinning this Year
                    Site index = 60
                    Base age   = 25
                    Basal area = 112.11


GROWING            STEMS  --------------volume--------------
SEASONS    DBH     PER    sawtimb  C-N-S  pulpwood   chips
SINCE      CLASS   ACRE   (MBFS)   (CORD)  (CORD)    (CORD)
EST
25
           03      003    000.00   000.00  000.00    000.02
           04      014    000.00   000.00  000.00    000.24
           05      036    000.00   000.00  000.60    000.51
           06      063    000.00   000.00  002.33    000.75
           07      081    000.00   000.00  005.04    000.64
           08      079    000.00   003.65  003.42    000.68
           09      054    000.00   004.20  002.40    000.28
           10      025    000.00   002.93  001.05    000.13
           11      007    000.00   001.09  000.32    000.02
           12      001    000.00   000.20  000.04    000.00
                   ---------------------------------------------
                   363    0000.00  0012.08 0015.19   0003.28


GROWING            STEMS  --------------value--------------
SEASONS    DBH     PER    sawtimb  C-N-S  pulpwood   chips
SINCE      CLASS   ACRE   ($)      ($)     ($)       ($)
EST
25
           03      003    000.00   000.00  000.00    000.02
           04      014    000.00   000.00  000.00    000.24
           05      036    000.00   000.00  008.85    000.51
           06      063    000.00   000.00  034.58    000.75
           07      081    000.00   000.00  074.87    000.64
           08      079    000.00   124.77  050.86    000.68
           09      054    000.00   143.66  035.71    000.28
           10      025    000.00   100.12  015.66    000.13
           11      007    000.00   037.39  004.72    000.02
           12      001    000.00   006.97  000.61    000.00
                   ---------------------------------------------
                   363    0000.00  0412.93 0225.85   0003.28


The total value of the harvest from this stand is
$642.06/acre

                                              continued
```

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

```
                          SLASH PINE
                     No thinning this Year
                     Site index = 60
                     Base age   = 25
                     Basal area = 120.20


GROWING          STEMS  ------------volume----------------
SEASONS   DBH    PER    sawtimb  C-N-S   pulpwood   chips
SINCE     CLASS  ACRE   (MBFS)   (CORD)  (CORD)     (CORD)
EST
30
          04     008    000.00   000.00  000.00     000.15
          05     021    000.00   000.00  000.37     000.33
          06     041    000.00   000.00  001.67     000.50
          07     059    000.00   000.00  003.97     000.58
          08     068    000.00   003.45  003.43     000.44
          09     060    000.00   005.21  002.85     000.48
          10     040    000.00   005.11  001.80     000.29
          11     019    000.00   003.34  000.90     000.06
          12     007    000.20   000.77  000.32     000.04
          13     002    000.07   000.51  000.10     000.01
                 ---------------------------------------
                 325    0000.27  0018.38 0015.41    0002.87


GROWING          STEMS  ------------value----------------
SEASONS   DBH    PER    sawtimb  C-N-S   pulpwood   chips
SINCE     CLASS  ACRE   ($)      ($)     ($)        ($)
EST
30
          04     008    000.00   000.00  000.00     000.15
          05     021    000.00   000.00  005.54     000.33
          06     041    000.00   000.00  024.87     000.50
          07     059    000.00   000.00  059.09     000.58
          08     068    000.00   117.75  051.03     000.44
          09     060    000.00   177.89  042.34     000.48
          10     040    000.00   174.59  026.73     000.29
          11     019    000.00   114.14  013.41     000.06
          12     007    029.63   026.33  004.70     000.04
          13     002    010.49   017.39  001.45     000.01
                 ---------------------------------------
                 325    0040.12  0628.08 0229.16    0002.87


The total value of the harvest from this stand is
$900.23/acre
```

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

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

Keywords: Dynamic programming, economics, merchandising, optimization, *Pinus elliottii* Engelm. var. *elliottii*.