

SIMULATION OF DYNAMICS OF SOUTHERN PINE BEETLE HAZARD RATING WITH RESPECT TO SILVICULTURAL TREATMENT AND STAND DEVELOPMENT

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Abstract—The hazard of southern pine beetle (SPB) infestations is affected by characteristics such as stand density, stand age, site quality, and tree size. COMPUTE P-LOB is a model that simulates the growth and development of loblolly pine plantations in the west gulf coastal plain. P-LOB was rewritten as COMPUTE SPB-Lob to update it for current operating systems and to incorporate three hazard rating models for SPB. The new program allows a user to simulate the growth of a loblolly pine plantation with different starting conditions and thinning criteria to provide an estimate of growth and yield along with the hazard of SPB infestation. This paper explains how to use this program with its added capabilities of more volume options and triggers that specify thinning by the level of basal area, trees per acre, or SPB hazard. Examples of output that show a range of different stand conditions and treatments are presented.

INTRODUCTION

COMPUTE SPB-Lob is a program written by the first author to predict the growth of loblolly pine (*Pinus taeda* L.) plantations in the West Gulf Coastal Plain of the United States and to predict the associated Southern Pine Beetle (*Dendroctonus frontalis* Zimmermann) hazard rating. Southern pine beetle is an important factor to be considered in management of loblolly pine plantations due to the potentially explosive tree-killing nature of infestations. This new version of COMPUTE SPB-Lob calculates the hazard rating for southern pine beetle and simulates stand development. Additional features of this new program are a choice of output as a text file or an MS Excel[®] spreadsheet and graphs of the growth and hazard ratings of the predicted stand. The original P-LOB program, on which this new program is based, was written in FORTRAN (Ferguson and Baldwin 1987); the interface and output options no longer meet current standards for computer programs running in the MS Windows[®] environment. This paper will serve as a user's guide to the new COMPUTE SPB-Lob.

PROGRAM OPERATION

System Requirements

COMPUTE SPB-Lob is a Windows[®] program; some version of Microsoft Windows 95[®] operating system or higher is necessary. At least 22 MB of hard disk space for installation of the program and help files is required. When running, the program uses 10 MB of RAM. The onscreen forms were designed to have a resolution of 800 x 600 pixels, but they will scale to other sizes. To get all of the program features, including graphical output, the user must install Microsoft Excel[®] on his or her computer. Although the program will run without Microsoft Excel[®], unless that program is installed, only text output will be provided. Spreadsheets created with this program may well be useable with other compatible software, but the actual Excel[®] program is needed to create them.

Installation

COMPUTE SPB-Lob is a standard Windows[®] program, which may be obtained as a ZIP file or on a CD from the lead

author. The ZIP file is available at <http://www.srs.fs.usda.gov/longleaf/downloads.html>. To perform the installation a user opens the ZIP file, double-clicks on setup.exe, and follows the prompts. The CD is designed to start installation automatically. On systems like Windows 2000[®] and above, administrative privileges are required to install SPB-Lob. The program may be uninstalled using the Add/Remove Programs icon in the Windows[®] control panel.

Usage

COMPUTE SPB-Lob can be selected and run from the Start menu. This will produce the title screen shown in figure 1. The user can wait 5 seconds or click on the picture to move immediately to the initial parameters screen.

The initial parameters screen (fig. 2) supplies most of the information necessary to begin the simulation. To make this screen easier to explain, numeric tags have been attached to some of the fields in the figure. They are referenced and explained below.

Tag 1 points to the starting and ending age. Both the starting and final age must be at least 10 but no more than 50 years, in multiples of 5 years. The final age, of course, must be greater than or equal to the starting age.

Tag 2 points to a description of site quality, where the user can specify the height of dominant and codominant trees at the initial age given above or can specify a site index and base age of 25 or 50 years. Base age is selected using the radio buttons. To prevent confusion, the program will not accept both a height and a site index; only one can be specified.

Tag 3 points to the section dealing with previous thinning. The user must specify if the stand has been thinned before. If it has not been thinned, information otherwise provided here will be grayed-out. If thinning has occurred, the user must supply the number of thinnings and the stand age when the last thinning occurred. The user also must supply basal area

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in square feet per acre after the last thinning or the surviving number of trees after the last thinning. If both basal area and number of trees are provided, both will be used.

Tag 4 points to the section specifying initial stand density. The user can provide data in terms of surviving trees per acre, current basal area in square feet per acre, or trees planted per acre. If a stand has not been thinned, the user must provide any or all of the following: surviving trees per acre, current basal area per acre, or trees planted per acre. If the stand has been thinned, these data can be omitted. The original FORTRAN version of COMPUTE P-LOB only allowed the user to enter one of these density indicators. This version allows you to enter them all. Bear in mind that it is possible to specify a stand that could not exist in reality and the simulation will be affected by the numbers that you supply. If you enter both basal area and trees per acre, both parameters will be used to create the initial stand table. Trees planted per acre have no effect if either of surviving trees per acre or basal area per acre has been supplied.

Tag 5 points to the section where the user is asked to specify units of volume or weight desired in final output. It is possible to check any, all, or none of these boxes depending on your product interests. There is also a check box (6) to display all possible units. One of the volume units (7), cords, is special because the calculation requires cubic-foot volume. It is simply a conversion from cubic-foot volume so it is disabled if the user does not request the calculation cubic-foot volume. The user can also supply any conversion factor that they want with a default value supplied. This conversion factor is saved like all other parameters, if the user saves the simulation input.

There are three command buttons on this screen. The one labeled "clear all" (8) eliminates entries shown on the screen. The user might want to establish an entirely new scenario. If settings have been saved from a previous COMPUTE SPB-Lob run, there will be one or more INI files stored on

the user's computer. Windows® OS remembers the last place that you last saved these files from one program execution to the next. Clicking on the "recover saved options" button (9) will load all of the parameters from the run saved in one of these INI files. This is very convenient if the user wants to do many similar runs of COMPUTE SPB-Lob with only minor variations, or if he/she wants to establish a set of different scenarios for demonstration purposes. To continue with the next input screen of the simulation, click on the continue (10) button.

When a run of COMPUTE SPB-Lob is finished, the user is returned to this screen (fig. 2) and may generate results for another scenario or choose "quit" from the menu at the top of the screen.

The next screen that appears contains three choices, which are checkboxes for the southern pine beetle models that a user may want to run (fig. 3); any or all of the boxes may be checked. If the user chooses the Texas model (1) it will be necessary also to choose a landform, ridge, bottom, or other. Landform actually is more an indicator of moisture regime than a descriptor of true topological position. Ridge refers to drier upland sites; a bottom refers to moist, low-lying pine sites; and other refers to intermediate conditions. For more details on these models see Mason and others (1985).

After all model selections have been made the user can click "continue" or "go back" (The latter selection will return the user to the main parameters screen.).

Clicking "continue" will provide the user with the future thinnings screen (fig. 4). Here one can specify the management of a simulated stand.

Two main parameters affect thinning: the trigger and the target. The trigger (1) is an event that determines if there will be a thinning. The user can choose from six trigger criteria: basal area levels, numbers of trees per acre, stand density



Figure 1—The title screen of the COMPUTE SPB-Lob program.

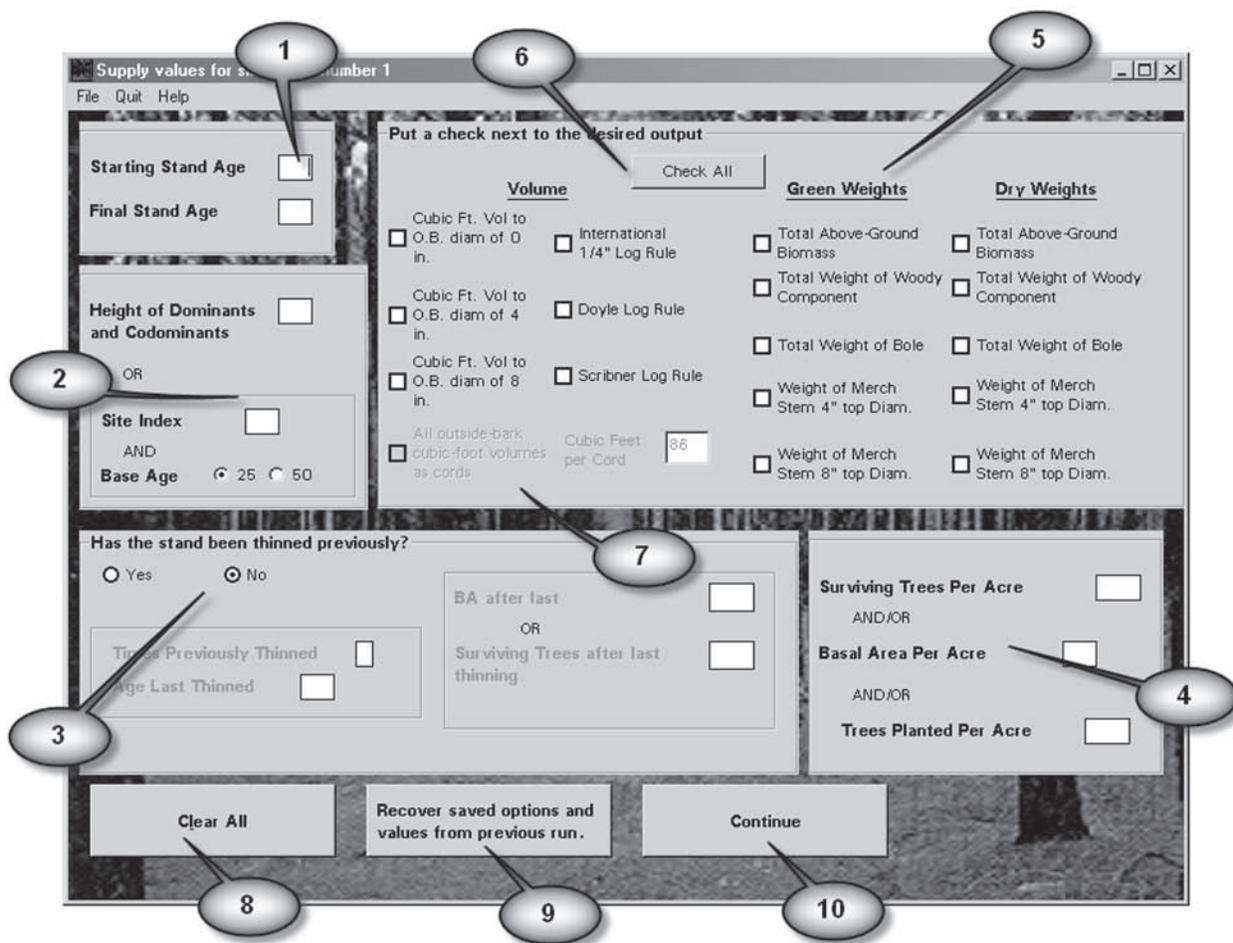


Figure 2—The main information screen for the program. The numbered balloons refer to elements of the screen that are discussed in the text in the usage section.

index, or any of the southern pine beetle hazard ratings (if they have been calculated on the previous screen). Select one of these indicators by clicking on the appropriate model radio button. The target (2) is a goal for the stand after thinning. Any of three target criteria may be used: basal area levels, numbers of trees per acre, or stand density index. Although matching trigger types and target values are not necessary, the user is limited to one type of trigger or target per simulation, which is selected by clicking on the appropriate radio button.

COMPUTE SPB-Lob calculates and shows the simulated stand every 5 years. The user can thin at any of these 5 year intervals by setting a trigger and a target. The thinning will happen if the current value for that variable exceeds the trigger value. For any of the SPB models, the specified hazard level can be met or exceeded. If any of these values are blank or zero for a given age, a thinning will not be considered. It is possible to force a thinning by setting a low value for the trigger that is still above zero. In addition to meeting the thinning trigger, there must also be a low enough value for the thinning target before a thinning is triggered

(i.e., if thinning to 300 trees per acre is desired, but there are only 299 trees per acre present, there will be no thinning). Only ages that are part of your simulation will show (3).

There are a few convenience features added to this screen. The column of “clear” buttons (4) allows elimination of a thinning without requiring excessive deletion of on-screen data. The button labeled “copy above” (5) makes it easy to repeat the same trigger and target values for several or all years in the simulation.

Note: if the thinning trigger is any of the southern pine beetle models, the numeric-entry box will change to a list box as shown in figure 5. Use arrows on the right of the box to select the hazard rating, which will trigger thinning. Additionally, the user should be aware that the default method of operation for a Microsoft list box is that you must click on a selection in a list box to make it active. This is not the case for these boxes. Whatever risk level shows is the one that will be used.

Another convenience feature is that all parameters entered in the last three screens can be saved as a starting point for

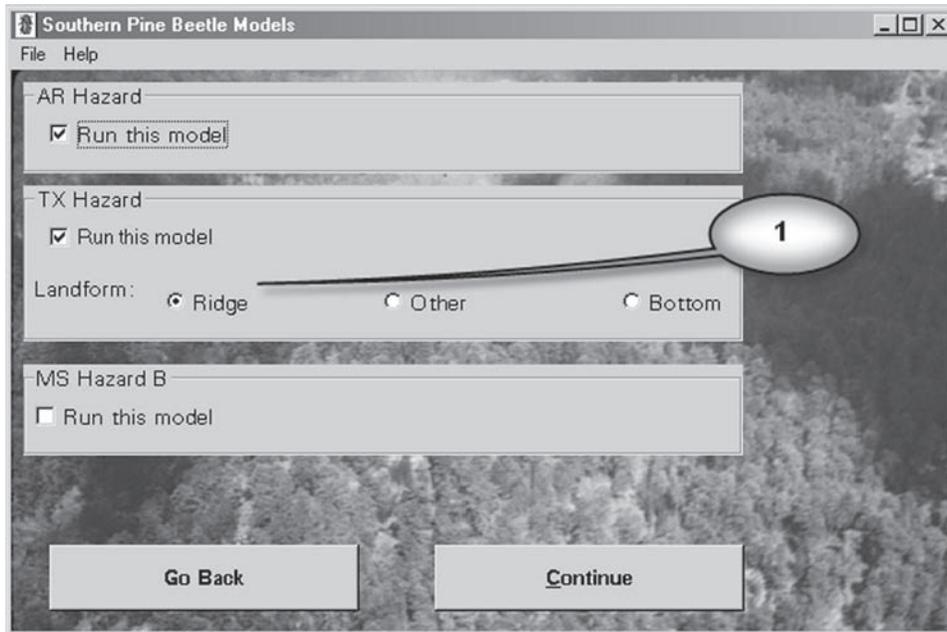


Figure 3—The screen for selecting the southern pine beetle hazard rating models to be calculated. The number in the balloon is referred to in the text in the usage section.

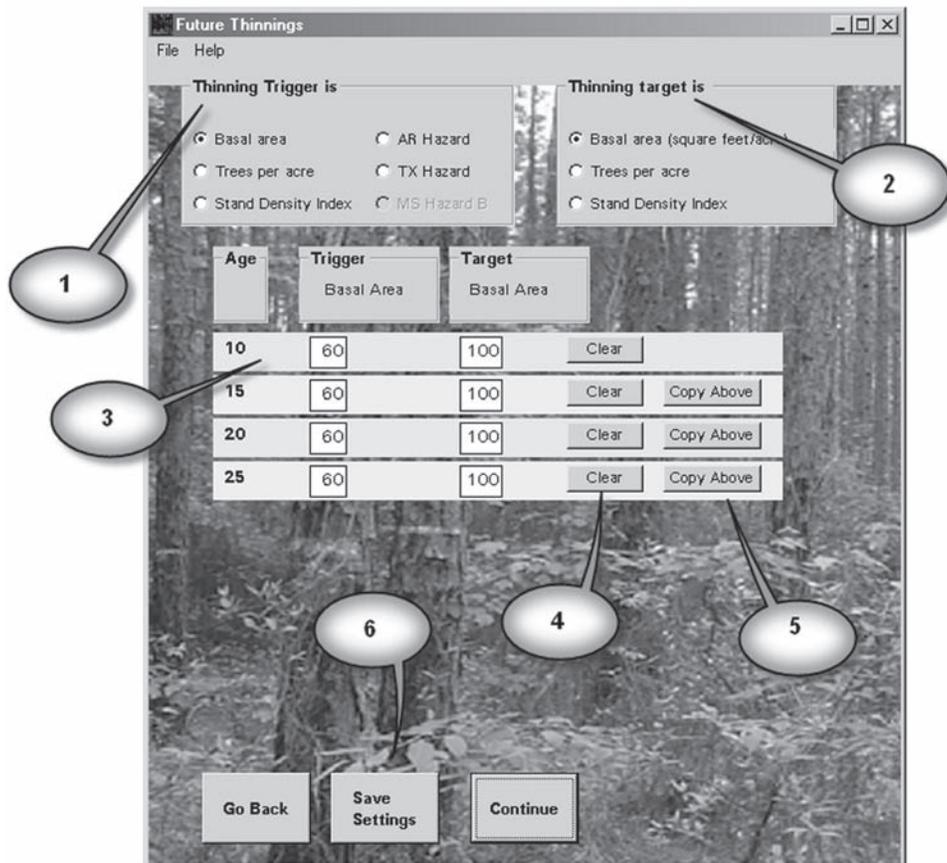


Figure 4—The screen used to select the thinning regime in its default form. The numbered balloons refer to elements of the screen that are discussed in the text in the usage section.

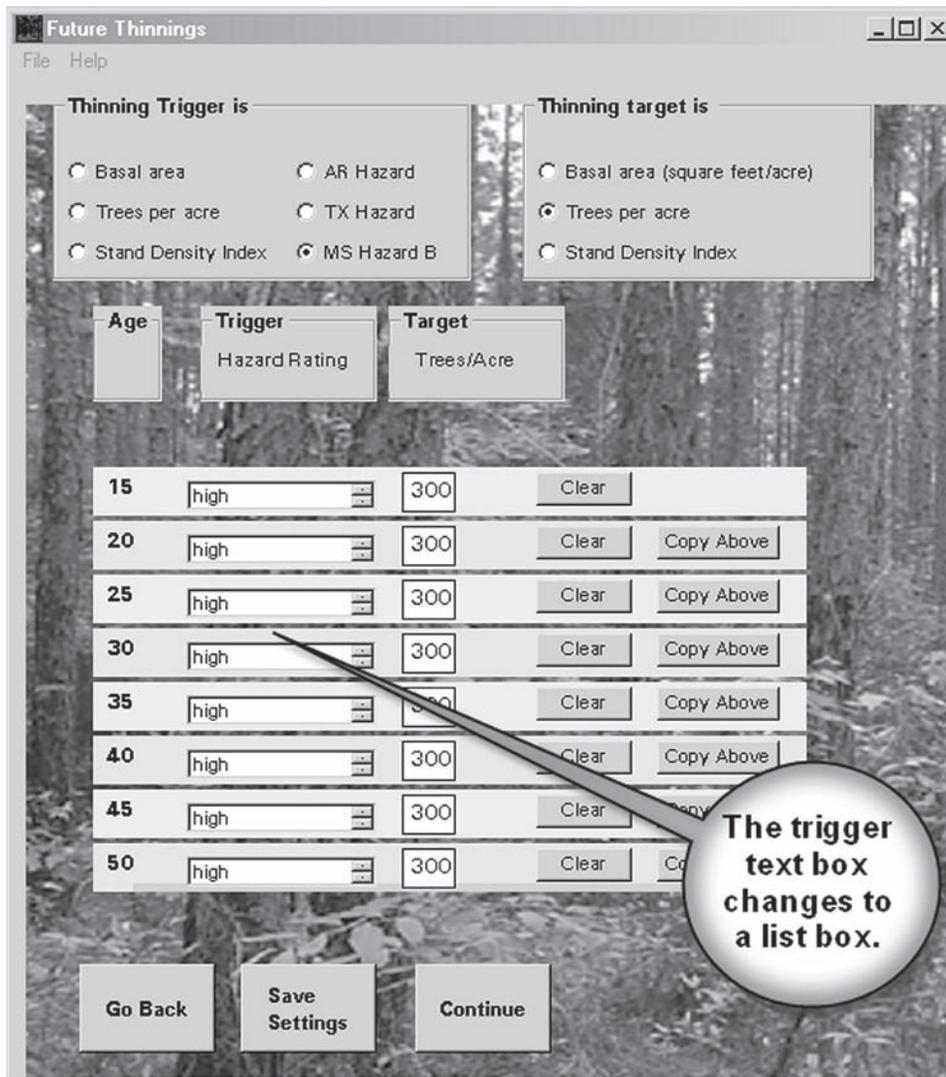


Figure 5—The alternative form of the screen used to select a thinning regime if the thinning triggers are to be based on the hazard rating in a stand. The specific difference between this screen and the default form of figure 4 is highlighted by the balloon.

another simulation. To do this, click on the “save settings” (fig. 4, #6) button, this prompts the user to supply a file name to store the parameters. The default extension is INI for initialization file.

Once the user has clicked the “continue,” he/she will be asked to select an output file. The file selection box for output from COMPUTE SPB-Lob is like most file dialog boxes produced by Windows® programs with directory selection at the top, a list of files fitting your pattern in the large middle box, a place to type new files names below this box, and a line for file type below that. The only unique thing about this box is that there are only two output types that can be saved: text files or Excel® spreadsheets. The actual type of output is governed by the file extension. The file extension must be XLS to produce an Excel® file. Any other extension is assumed to be a text file. Text files provide all of the output numbers from the model and run extremely fast. Excel® files, on the other hand, also contain all of the output numbers from the

model, but they allow further analysis to be done more easily and generate several graphs of stand development; but are considerably slower to produce.

When the simulation is done, the text file or spreadsheet is opened if you have an appropriate viewer. The main parameter screen (fig. 2) of this program is selected so that you can do another simulation or quit, but it is minimized so that it does not hide the output. An example of the tables produced as text output is shown as figure 6, and the tables produced in the Excel® format are shown in figure 7. Additionally, the Excel® output produces some explanatory graphs like figure 8 for basal area and figure 9 for the Mississippi Hazard B model.

Troubleshooting

We have tried to anticipate problems and prevent them when possible, but have also provided a mechanism for diagnosis. When SPB-Lob runs, it attempts to open a log file in the

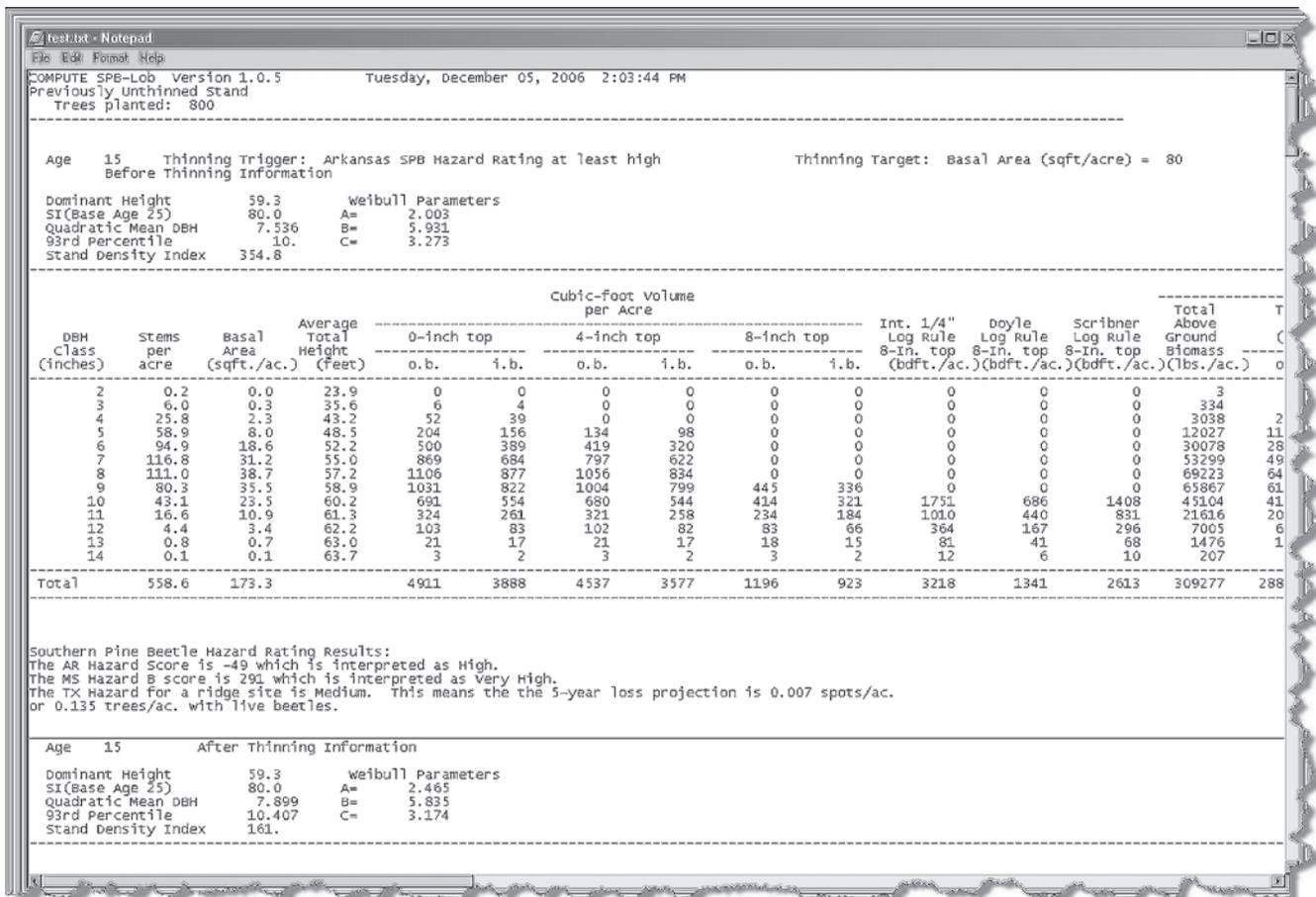


Figure 6—An example showing how part of text output may look. The ripped-edge is used to show that the actual file is larger than the figure shows it to be.

directory where it is running. In this log file, program events are recorded as they happen. It is possible to use this file to diagnose potential problems, or, more likely, to help the author in debugging the program. If the log file cannot be opened, the program will run normally without a log file.

One problem that was anticipated, but which may still confuse the user, is the program's inability to calculate a set of Weibull parameters to model the diameter distribution for some specified stands. If this occurs, an error message box will appear (see fig. 10). After clicking OK, the user will be returned to the initial parameters screen to correct input data. The Weibull distribution is calculated based on minimum d.b.h., the quadratic mean diameter, and the diameter at the 93rd percentile. In turn, these parameters can be based on the number of surviving trees, the height of dominant and codominant trees, the thinning basal area, the age, and the number of times the stand has been thinned. To proceed, the user must adjust any such stand parameters. It is quite possible that the exact stand cannot be simulated, and the user may have to use parameters or data that are reasonably close.

RESULTS

A nearly infinite number of possibilities exist for simulating the growth of loblolly pine in plantations that are managed under different thinning regimes. Figure 11 is a collection of four related simulations showing how some management decisions and stand characteristics affect the SPB hazard in terms of the Mississippi Hazard B rating. All of the lines show the stand from age 10 to age 50. Varying choices were made for site index, number of trees planted, and thinning trigger. In all cases thinning was to 80 square feet of basal area. Lines (a) through (c) are all thinned when a high hazard condition is present. The first thinning occurs at a different age for each, and subsequent thinnings occur at 10 to 15 year intervals. Line (a) represents a lower site quality, and captures the fact that the first thinning occurs later than on other site types. Line (b) differs from line (c) in that fewer trees were planted in the former, and it would take 5 years longer to achieve a high-hazard condition. Line (d) is thinned when basal area reaches 100 square feet regardless of the hazard rating. This stand doesn't develop as high a hazard rating as the other stands, but the stand requires two more thinnings than the others. These scenarios show how small parameter changes affect the susceptibility of a stand to SPB-caused losses, but one might also consider how having an estimate of SPB hazard can help optimize management when SPB is a concern.

1	COMPUTER	SPB-Lob Version 1.0.7	Wednesday, March 07, 2007 1:32:25 PM			
2	SI (Base Age 25)=	0	Previously Unthinned Stand			
3	Surviving trees:	500	Current basal area: 80.			
4						
5	Age=	15	No Thinning This Year			
6	Thinning Trigger:	Trees per acre > 500.				
7	Thinning Target:	Trees per Acre = 500.				
8						
9	Dominant Height=	40.0	Weibull Parameters			
10	Quadratic Mean DBH=	5.416	A= 1.581			
11	93rd Percentile=	7.743	B= 4.042			
12	Stand Density Index=	186.9	C= 2.319			
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36						
37	Age=	20	Before Thinning Information			
38	Thinning Trigger:	Trees per acre > 450.				
39	Thinning Target:	Trees per Acre = 450.				
40						
41	Dominant Height=	47.6	Weibull Parameters			
42	Quadratic Mean DBH=	6.768	A= 1.914			
43	93rd Percentile=	8.901	B= 5.209			
44	Stand Density Index=	241.7	C= 3.331			
45						
46						

DBH Class (inches)	Stems per acre	Basal Area (sqft./ac.)	Average Height (feet)	Scribner Log Rule Vol	Green Weight of Merch. Stem 8 inch Top Diam.		Dry Weight of Merch. Stem 8 inch Top Diam.	
					o.b.	i.b.	o.b.	i.b.
2	15.8	0.36	17.7	0	0	0	0	
3	65.5	3.22	26.3	0	0	0	0	
4	106.1	9.26	32.0	0	0	0	0	
5	115.4	15.73	35.9	0	0	0	0	
6	93.8	18.42	38.7	0	24	18	20	
7	59.0	15.75	40.7	0	662	550	432	
8	28.9	10.10	42.3	0	1963	1695	1113	
9	11.1	4.92	43.6	0	2023	1777	1061	
10	3.3	1.82	44.6	74	1121	993	561	
11	0.8	0.52	45.4	26	399	355	194	
12	0.2	0.13	46.1	8	114	102	55	
Total	500.0	80.22		108	6306	5489	3436	

Southern Pine Beetle Hazard Rating Results:

The MS Hazard B score is 51 which is interpreted as Low.

Figure 7—An example of some output shown in spreadsheet form. The ripped-edge is used to show that the tables continue down the page. This page is only one of several sheets that can be generated in spreadsheet output.

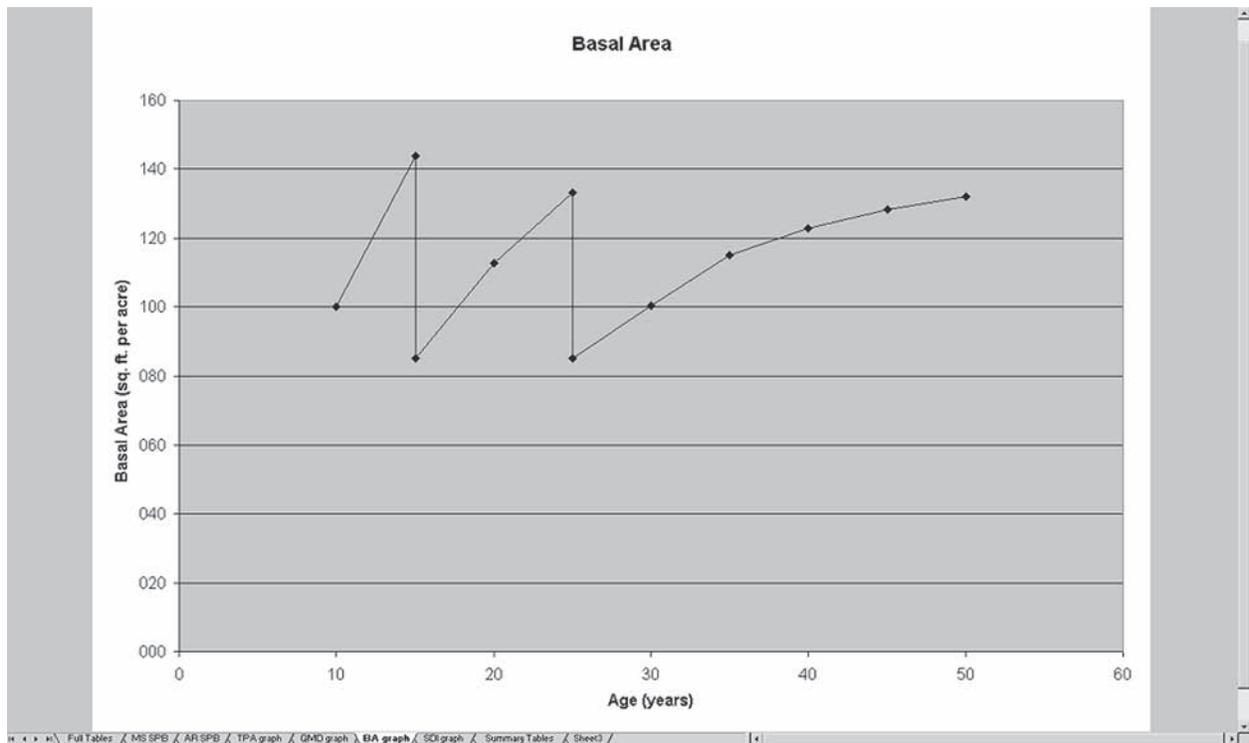


Figure 8—An example of a basal area graph from spreadsheet output. This is only one of several sheets in the spreadsheet output; at the bottom of the figure appear tabs for the other sheets.

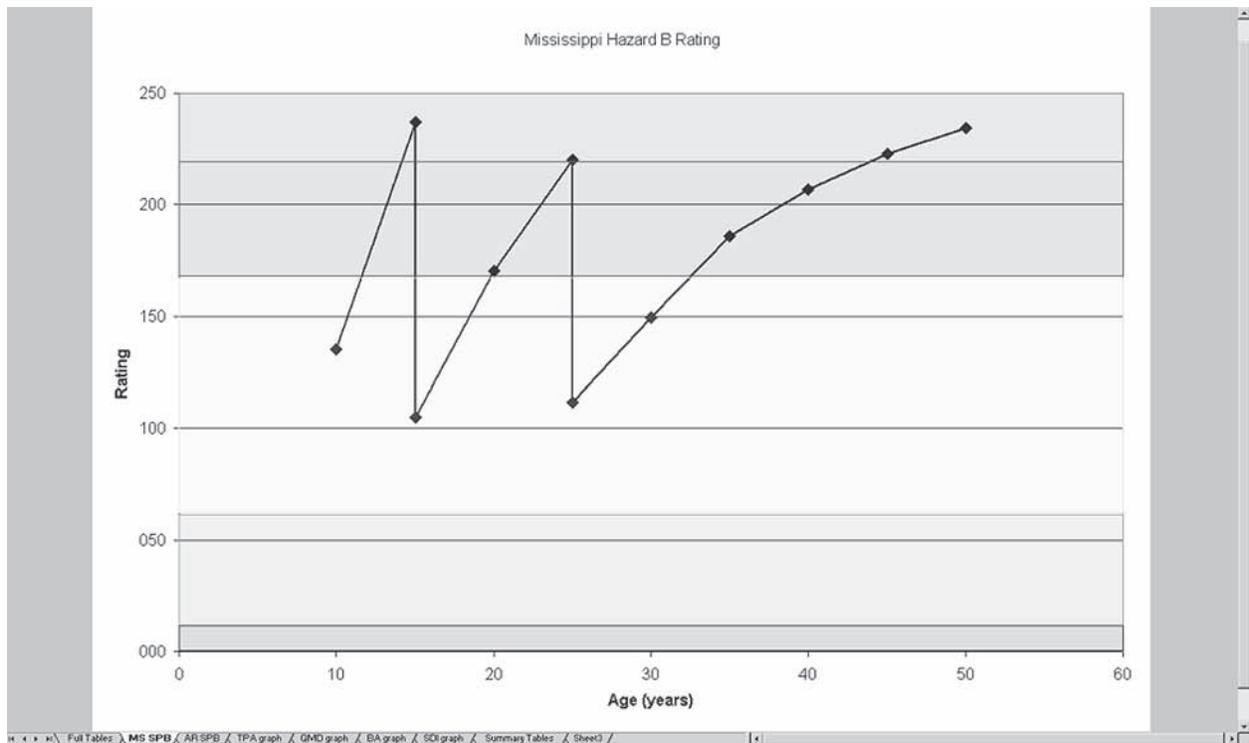


Figure 9—An example of a Mississippi Hazard-B rating graph from the spreadsheet output. This is only one of several sheets in the spreadsheet output; at the bottom of the figure appear tabs for the other sheets. While not obvious in this grayscale version, regions representing different hazard ratings are shaded to indicate the hazard level (i.e., red=high, green=low).

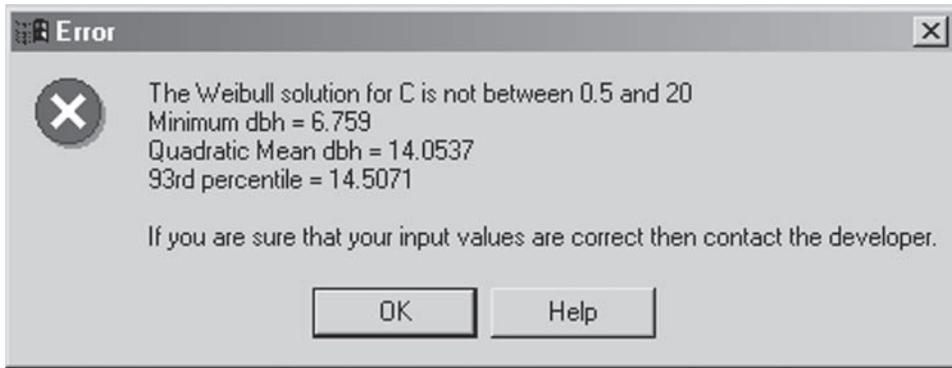


Figure 10—The error message box produced when SPB-Lob cannot calculate a set of Weibull parameters for a stand diameter distribution.

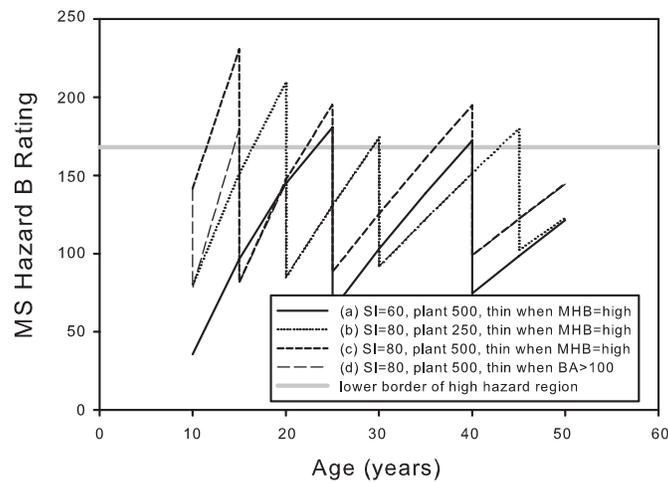


Figure 11—The Mississippi Hazard B rating (MHB) over the treatment life of four simulated stands. Line (a) has site index (base age 25) of 60, with 500 trees planted per acre, and was thinned to a basal area of 80 square feet whenever MHB achieved a high level; line (b) has site index (base age 25) of 80, with 250 trees planted per acre, and was thinned to a basal area of 80 square feet whenever MHB achieved a high level; line (c) has site index (base age 25) of 80, with 500 trees planted per acre, and was thinned to a basal area of 80 square feet whenever MHB achieved a high level; line (d) has site index (base age 25) of 80, with 500 trees planted per acre, and was thinned to a basal area of 80 square feet whenever the basal area exceeded 100 square feet per acre. The horizontal gray line marks the lower boundary of the MHB high rating.

CONCLUSIONS

We could present many other simulations scenarios, but individual land managers can find those which would most consistently address their needs. This program is available online. We welcome input from those who choose to test this new simulation tool. The program is a revision of the COMPUTE-PLOB, a program that was written about 20 years ago. It has an improved interface and, more importantly, makes it possible to see how management actions affect the southern pine beetle hazard. Nonetheless, it is based on a 20 year old model (Baldwin and Feduccia, 1987) for stand growth and with SPB risk models that are at least 16 years old. Its greatest potential for development will be realized as the model is updated with more recently collected data and, possibly, with insect models that better reflect stand conditions found today in the west gulf region.

ACKNOWLEDGMENTS

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