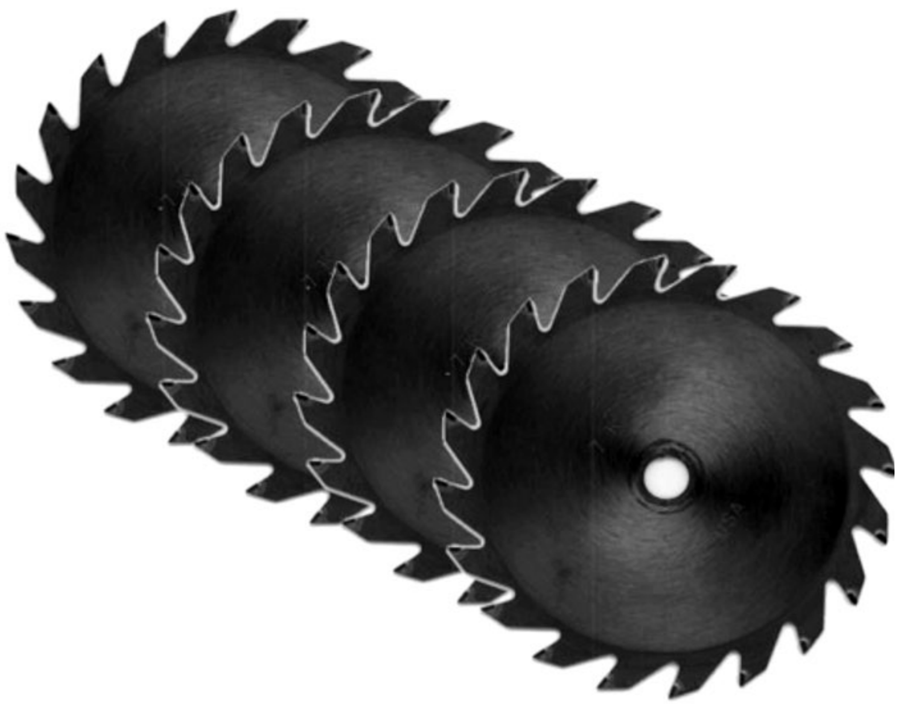
United States Department of Agriculture

ROMI 4.0: Rough Mill Simulator 4.0 Users Manual

R. Edward Thomas, Timo Grueneberg,
and Urs Buehlmann



Forest Service | Northern Research Station | General Technical Report NRS-143 | January 2015

Abstract

The Rough MIll simulator (ROMI Version 4.0) is a computer software package for personal computers (PCs) that simulates current industrial practices for rip-first, chop-first, and rip and chop-first lumber processing. This guide shows how to set up the software; design, implement, and execute simulations; and examine the results. ROMI 4.0 accepts cutting bills with as many as 600 solid and/or panel part sizes. Plots of boards processed are easily viewed or printed as are detailed summaries of processing data (number of rips and crosscuts) and yields for each grade. ROMI 4.0 optimization algorithms are based on a red oak database containing 3,500 boards of all common National Hardwood Lumber Association grades. Even though ROMI is based on red oak, the digitized board information can be adapted and modified to several other common hardwood species.

Note: This report is updated from ROMI 3: Rough Mill Simulator Version 3.0: User's Guide, General Technical Report NE-328, by J. Weiss and R.E. Thomas, published in 2005.

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For an executable copy of the program, write to:

U.S. FOREST SERVICE	VIRGINIA TECH
NORTHERN RESEACH STATION	DEPT. OF SUSTAINABLE BIOMATERIALS
ATTN: EDWARD THOMAS	ATTN: URS BUEHLMANN
241 MERCER SPRINGS ROAD	BROOKS CENTER 0503
PRINCETON, WV 24740	BLACKSBURG, VA 24061

or email: ethomas@fs.fed.us

or download from: www.nrs.fs.fed.us/tools/ROMI

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1 INTRODUCTION

Version 4.0 of the ROMI (Rough Mill Simulator) is the latest in a series of rough mill simulation programs developed by the U.S. Forest Service in cooperation with the Department of Sustainable Biomaterials at Virginia Polytechnic Institute and State University (Virginia Tech). The ROMI 4.0 installation CD contains sample runs, all required programs, and the publication 1998 Data Bank for Kiln-Dried Red Oak Lumber (Gatchell et al. 1998), which includes nearly 3,500 digitized boards. A digitized board is a board with dimensions and defects expressed in x/y coordinates, e.g., a digital representation of the actual board. A custom data file creation utility included in the software package allows users to create board samples that correspond to their specific lumber supply. ROMI 4.0 processes the board data according to users' processing specifications. Outputs, including part counts and yields, graphical plots of boards processed, and processing requirements are available for each simulation run. This manual shows users how to install and run ROMI 4.0, as well as how to design simulations to answer questions related to rough mill processing.

The ROMI 4.0 simulator incorporates the simulation modes rip-first, chop-first, and rip and chop-first into a single program. Thus, ROMI 4.0 officially replaces all previous versions of the ROMI 3.0 Rough-Mill Simulator (Thomas and Weiss 2006), the ROMI-RIP 2.0 (Thomas 1999), and ROMI-CROSS (Thomas 1997) computer programs. ROMI 4.0 can import all settings and cutting bills from these earlier simulators. Like earlier versions, ROMI 4.0 can produce parts of different quality specifications to simulate the production of clear-two-face (C2F), clear-one-face (C1F), and sound-two-face (S2F) parts. ROMI 4.0 also can handle different predefined part grades and includes the Least-Cost-Grade Mix feature (Buehlmann et al. 2011, Zou et al. 2004).

The ROMI 4.0 simulator incorporates several new tools that improve user capabilities to accurately simulate and improve rough mill operations while simplifying the simulation process. The core functions and routines remain similar to the previous version for practiced users. Versions up to ROMI 3.0 were optimized for computer operating systems up to Windows® XP. ROMI 4.0 received a new installation routine that is now compatible with Windows 7. The improvements will allow an easier setup, improved performance, and better analysis of the simulation's output data.

ROMI 4.0 also includes several additional new features, such as a thickness option, a combined rip and chop option, and predefined grades for part qualities rules. These features give users more options to simulate specific rough mill operation settings and optimize output. Also, implementation and update of the National Hardwood Lumber Association's 2011 grading rules (NHLA 2011) was part of this updated version of ROMI 4.0 as were improvements and verifications of the optimization algorithms.

Limitations to ROMI 4.0 are listed in Appendix I.

The minimum computer system requirements to run ROMI 4.0 are:

- An IBM Compatible PC with a 1.0 GHz Pentium IV processor or newer
- 512 MB of RAM
- 200 MB hard drive space available
- Microsoft Windows® 2000/XP/Windows7[1]
- CD-ROM drive (for installation from a ROMI 4.0 CD-ROM)
- Internet connection (for installation via download)
- Printer (optional but recommended)

To avoid confusion and make this users guide easier to understand, several conventions have been adopted for displaying operating system and ROMI 4.0 prompts and inputs. For all prompts and buttons, text is in *italics*. For choices on the user interface, **bold** is used.

[1]Microsoft Windows® 2000/XP/Windows7 are registered trademarks of Microsoft Corporation, Inc.

2 INSTALLATION OF ROMI 4.0 UNDER WINDOWS 7

The installation of ROMI 4.0 under the Windows 7 environment requires some additional actions compared to earlier versions of Windows. To install and run ROMI 4.0 under Windows 7, two options are shown in this manual. You can decide which will be best for your personal needs. Also, local requirements, such as user privileges, have to be determined with the computer's administrator.

With the release of Windows 7, Microsoft Corporation changed the default folder and file attributes. Per default, all folders and files are selected as read only (Fig. 2.1.1). Even though Windows 7 might let users change the attributes from read only to full access, the change is not transferred, which means that the option chosen will not be saved and Windows 7 will overrule the users' specifications based on the system's security settings (Fig. 2.1.2)

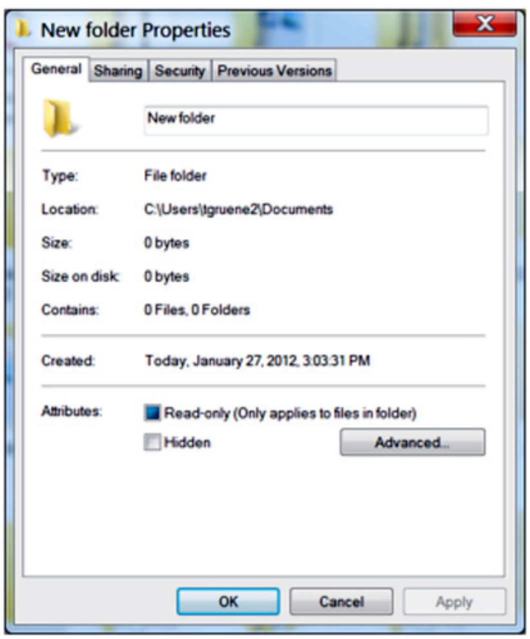


Figure 2.1.1—Properties of a folder with its attributes; read-only option is the default setting that cannot be removed.

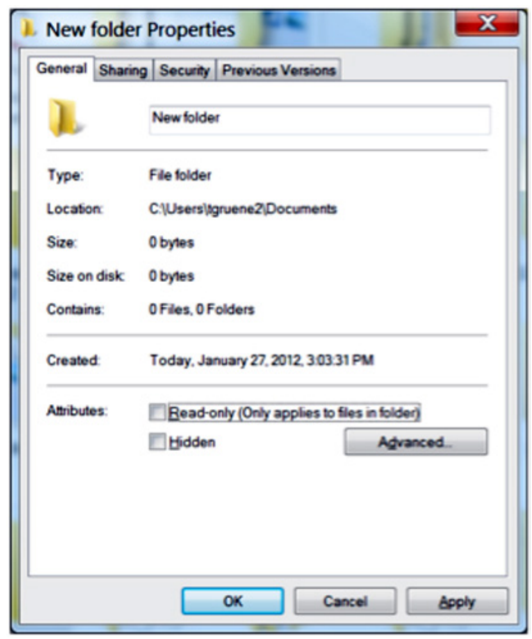


Figure 2.1.2.—Read-only option setting change is not transferred by Windows 7 and is "overruled" by the system.

The installation and operation of ROMI 4.0 requires that full attributes (reading and writing rights) of folders and subfolders are granted (Fig. 2.1.3). With the original attribute settings of Windows 7, ROMI 4.0 cannot be used. Therefore, this manual explains two ways to solve the issue of installing and operating ROMI 4.0 under Windows 7.

Figure 2.1.3—Advanced attributes of Windows 7 folders.

2.1 Windows Virtual PC (XP mode system)

The first option to run ROMI 4.0 is the installation of a Windows Virtual PC using a XP Mode System, which needs to be downloaded for free from Microsoft. This setup allows you to install ROMI 4.0 in any directory or folder. Due to the setup of the XP system, the "read and write"-attributes can be modified and will not be overruled by the XP system. To download and install the Windows Virtual PC, visit the Web address below:

http://www.microsoft.com/en-us/download/details.aspx?id=19889

Once you have successfully installed Windows Virtual PC XP mode, you can proceed with the installation of ROMI 4.0 in the installed Virtual PC XP mode.

2.2 In the Users Directory of Windows 7

Another way to install ROMI 4.0 in Windows 7 is to install ROMI 4.0 in the Users Directory. Note, if you are using Windows 7, it is recommended that you change the install directory to your user directory. Figure 3.1.2 shows the Users Directory folders for the installation of ROMI 4.0.

You can browse the directories by double clicking the file names or by manually entering a path in the box at the top of the window. To change the drive you are browsing, click the drop down arrow at the top left of the screen. For example, under Windows 7, if your user name is "Johnson," then you would install ROMI 4.0 to the directory "c:\users\johnson\ROMI-4." Click OK when you are satisfied with the install directory.

2.3 On the Desktop under Windows 7 (default installation)

The default option for installing ROMI 4.0 is on the user's desktop. Using this installation procedure, you can follow the instruction given in the following chapters. If you are operating in a network environment and an installation on your desktop is not possible, the authors recommend the installation described in 2.2.

3 INSTALLATION

3.1 Running the Install Program

To install ROMI 4.0 on your computer, place the ROMI 4.0 CD into the CD-ROM drive of your computer. Alternatively, you can download ROMI 4.0 from the following URL:

www.nrs.fs.fed.us/tools/ROMI/

You can start the install by navigating to the CD ROM drive using the “My Computer” icon and then clicking on the file named “**ROMI40**.” You can also start the install by clicking *start* and then *run*. In the run window, type “**d:\ROMI40**” (if installing from a CD) without the quotes substituting the letter ‘d’ for the appropriate letter of your CD-ROM drive and click *OK*. Now you should see the window shown in Figure 3.1.1.

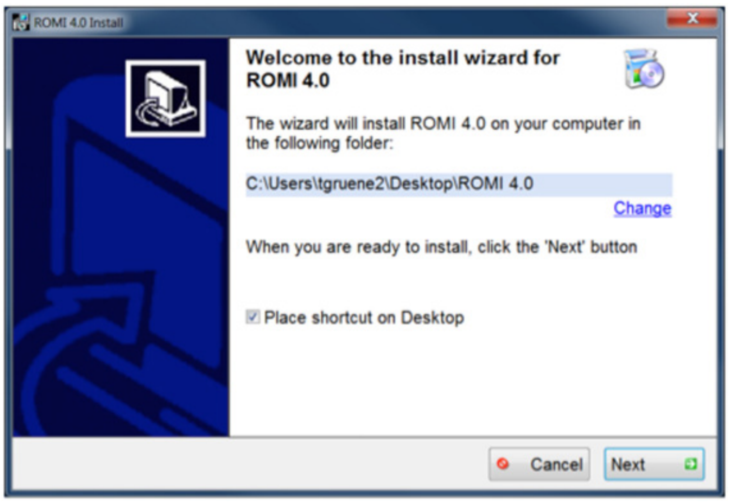


Figure 3.1.1.—ROMI 4.0 Setup Wizard window.

If you want to keep the default install directory, click *next*. If you want to change the default, click on *Change* and you will see the screen shown in Figure 3.1.2.

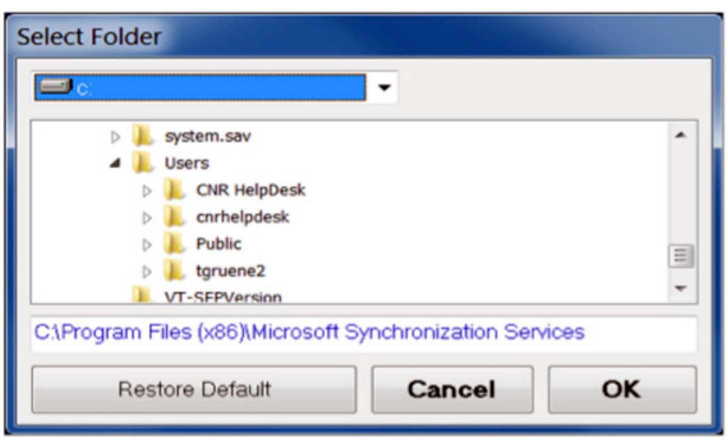


Figure 3.1.2.—Depending on the user’s installation routine, the destination folder may need to be changed (e.g., Users Directory).

If you want the install procedure to place a shortcut icon on your desktop, leave the checkmark in the box (Fig. 3.1.1 last line) and click *next*. If you do not want an icon, then remove the checkmark in the box and click *next*. You are now ready to install ROMI 4.0. The window shown in Figure 3.1.2 now shows the setup options and folder destination you have selected. The installation starts and may take some time depending on the speed of your computer.

Click *next* and you will see the default installation screen of ROMI 4.0. To install ROMI 4.0, you have to read and agree to the ROMI 4.0 guidelines (Fig. 3.1.3). Once you agree to the ROMI 4.0 guidelines, the *Next* button will become active (Fig. 3.1.4). After you hit the *Next* button, ROMI 4.0 will start the installation (Fig. 3.1.5).

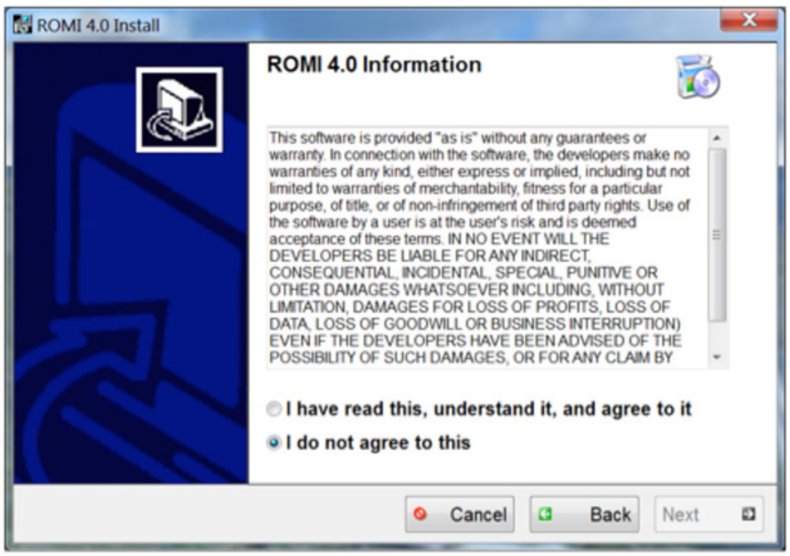


Figure 3.1.3.—ROMI 4.0 installation guidelines, *Next* button is not active because the user did not yet agree with the software agreement.

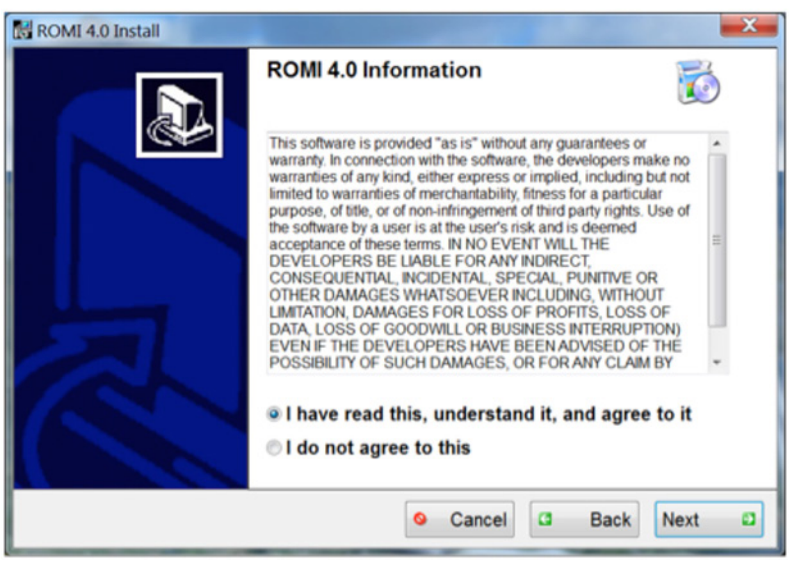


Figure 3.1.4.—Once the user agrees with the ROMI 4.0 software usage agreements, the *Next* button becomes active.

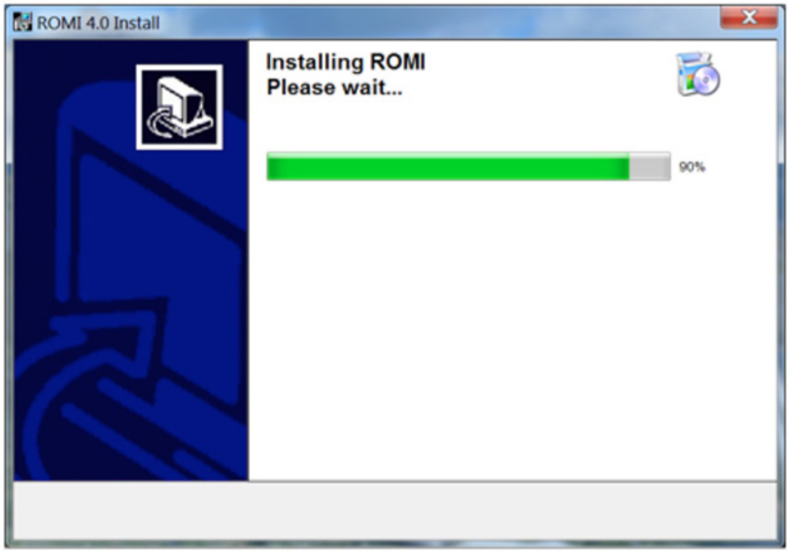


Figure 3.1.5.—ROMI 4.0 installation in progress window.

After about 90 percent of the installation process is done, a second installation window will open. This window will guide you through the installation process of the Oracle's Java™, a free program that is necessary to run ROMI 4.0 on your computer. Figure 3.1.6 shows the Java Setup window. You must accept the license agreement to proceed with the installation.

Because an Internet connection is optional for the use of ROMI 4.0, when installing the Java Program you might choose whether the Ask-Browser should be set as *Default Search Provider* or not. The setting does not have an influence on ROMI 4.0's performance (see Fig. 3.1.7 and Fig. 3.1.8). Click on *Next* and Java will be installed (Fig. 3.1.9). After the successful installation of Java®, click *Close* (Fig. 3.1.10).

Figure 3.1.6.—Java setup window.

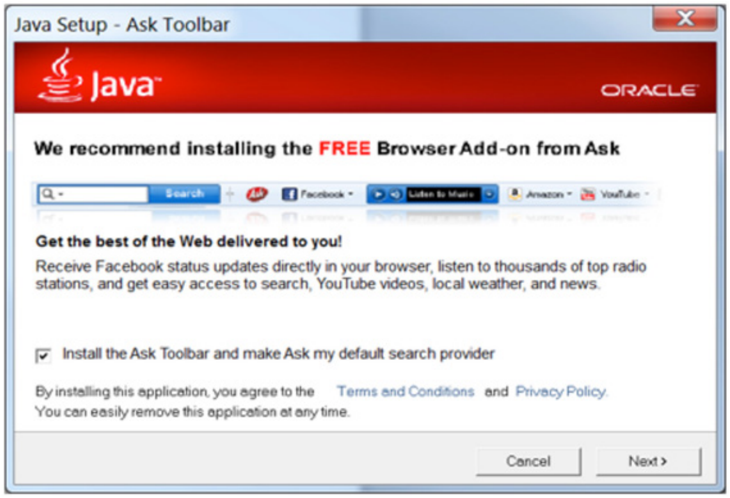


Figure 3.1.7.—Java Setup - Ask Toolbar window (Ask chosen as default search provider based on user preferences).

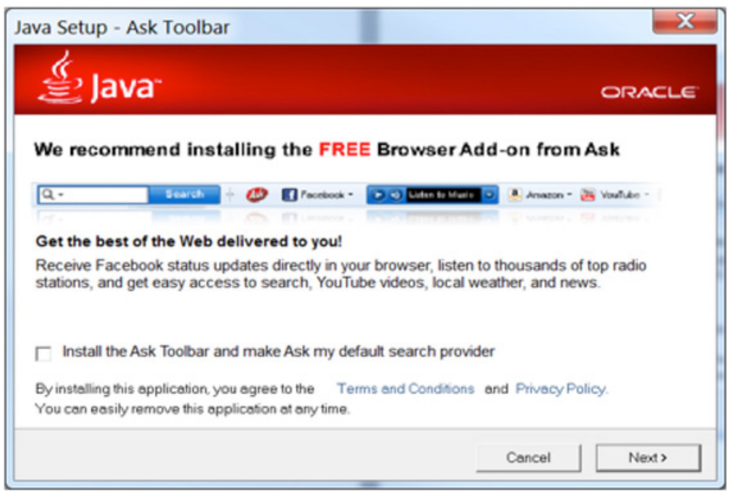


Figure 3.1.8. —Java Setup - Ask Toolbar window (Ask not chosen as default search provider based on user preferences).

Figure 3.1.9.—Java Setup progress window (Installation progress).

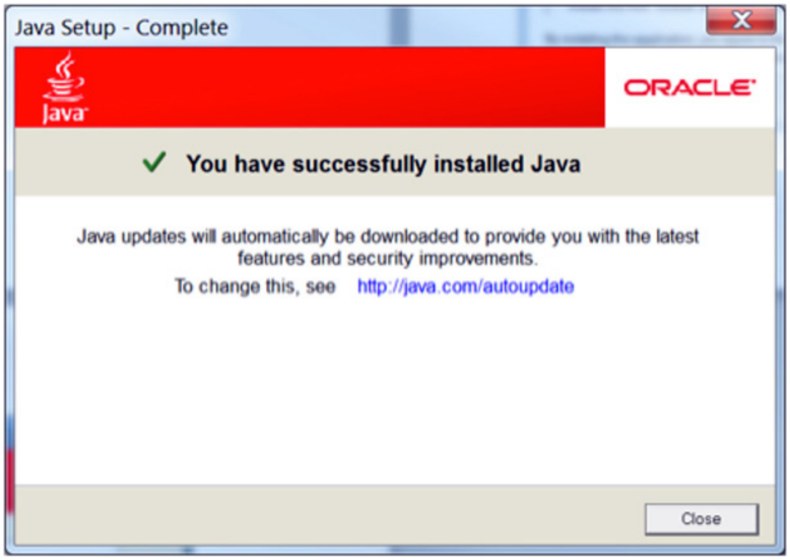


Figure 3.1.10.—Java installation finished window.

After Java has been installed, ROMI 4.0 finishes its installation procedures and you will see the following screen (Fig. 3.1.11) at the end of the installation.

Figure 3.1.11.—Install finished window.

If you want ROMI 4.0 to start immediately, leave the check in the box and click *finish*. If you want to wait before starting ROMI 4.0, make sure the check box is clear and click *finish*.

3.2 Starting ROMI 4.0

There are two ways to start ROMI 4.0. If you chose to create a desktop icon (by leaving the desktop icon in Fig. 3.1.1 activated), you can simply double click the desktop icon *ROMI 4.0* and you will see the main interface (Fig. 3.2.1) after startup. Or, click *start* in Windows, then click *programs* ("All Programs" in Windows 7 or Virtual XP Mode) and you will see the name you chose to install the ROMI 4.0 program (users name in the Users Directory of your chosen system). Let's assume the user's name is Jim Brown; the setup will look as follows: Computer/Local Disk (C:)/Users/Jim Brown/ROMI 4.0. If you kept the default name, it will be ROMI 4.0. You should see an arrow out scroll down menu from the name indicating that there is a submenu. Move the mouse over the name and the menu will show four items. The first item is ROMI 4.0. Clicking this will start ROMI 4.0, and ROMI 4.0's main window will appear (Fig. 3.2.1).

Figure 3.2.1.—ROMI 4.0 main interface window.

4 USING ROMI 4.0

4.1 Defining and Selecting Part Grades

You can specify a range of defect types, sizes, acceptable distances (from the part edge[s]), and whether each defect is acceptable on the face, back, or on both faces. There is no limitation on the number of part grades you may define. A part grade is composed of one or more rules defining the grade. Each rule specifies that a defect or category of defects is acceptable on a part face. To open the Part Grades Editor, click the *Part Grades* button in the main ROMI 4.0 interface (Fig. 3.2.1). You will then see a window displaying the current part grade's information (Fig. 4.1.1). The setup and customization options for the ROMI 4.0 part grades are explained in the following sections.

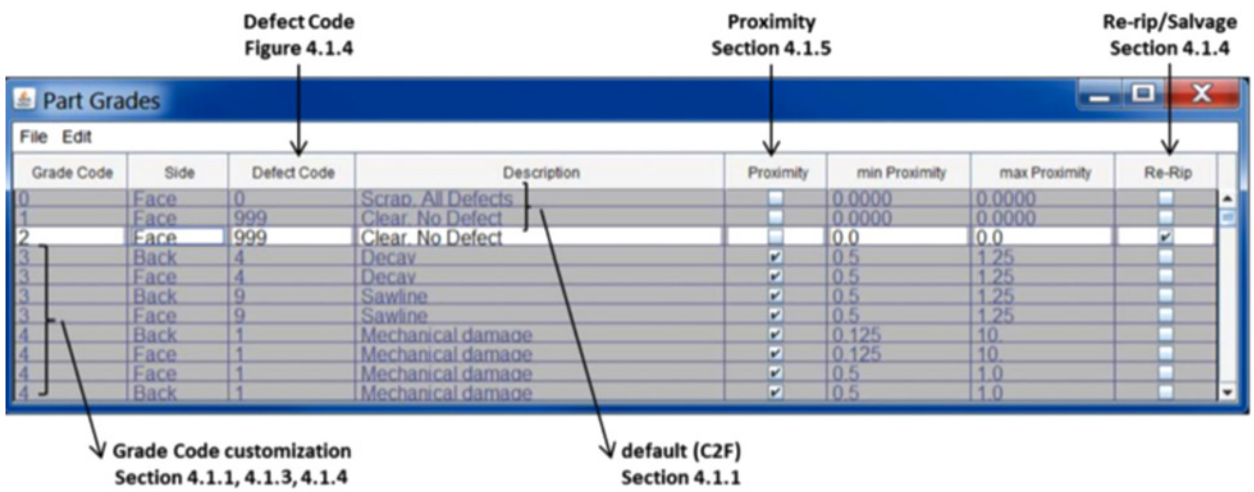


Figure 4.1.1. —Part Grades Editor window showing default part grade's file.

By default, the file named Grade.def, which is installed with ROMI 4.0 and is the standard grade definition file, is loaded into the Part Grades Editor. However, after opening the Part Grades Editor, you can save your own part grades definitions under new file names. Part grades definition files from ROMI versions 3.0 and 3.1 can be used with ROMI 4.0. To use a saved definition file, click *File* and then *Open*. You will now see the file open window displayed in Figure 4.1.2.

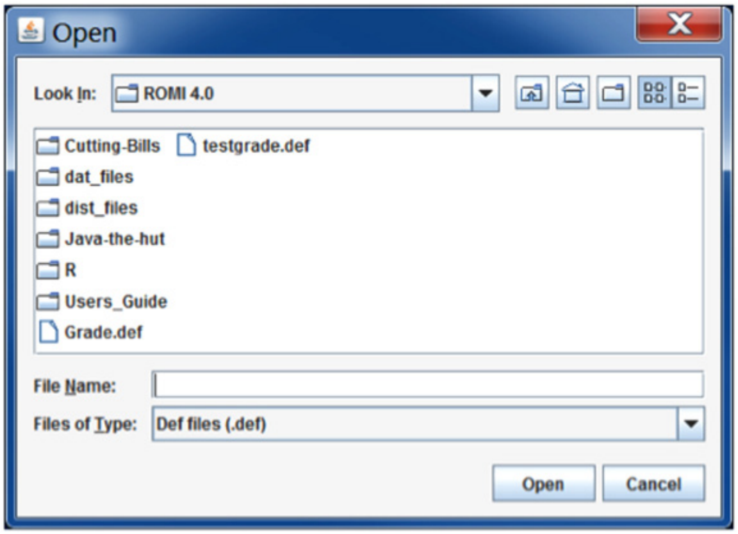


Figure 4.1.2. —Part Grades Definition file selection window.

Navigate to the file you want and double click on the file name to open it. Your chosen definition file will now show in the Part Grades Editor.

To define a set of custom part grades, you may start a blank file or edit an existing file. To start a new part grades file, click *File* and then *New*. You will have a clear grade definition window except for the first two rows. The first two rows, scrap and clear-two-face (C2F), are mandatory and may not be changed. ROMI 4.0 uses scrap internally to identify all board areas that do not meet any part grade definition and, therefore, no parts may be cut from scrap. A part grades specification file is composed of one or more part grades, where, in turn, part grades are composed of one or more rules. The rules that make up a single grade all have the same grade code (Fig. 4.1.1). The grade codes are sorted so that all the rules of a single grade are listed together. Several types of information must be specified for a part grades specification file. This information is covered in detail in this section. Starting at the third row, when you double click in the *Grade Code*, *min Proximity*, or the *max Proximity* columns, you will see a window like the one in Figure 4.1.3. Simply enter the desired value into the text box and click *OK*.

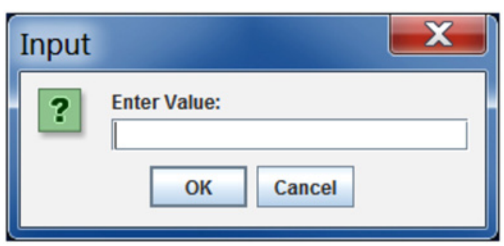


Figure 4.1.3.—Input dialog box.

The second column indicates the Side of the board on which to allow the defect to be on. The values may be toggled from Face to Back by double clicking in the cell that you want to change. The third column is Defect Codes and the fourth column is Description. Each defect code has a description so if you change the value in one it will place the corresponding code or description in the other. To change these, double click in the *cell* and you will see a window like the one in Figure 4.1.4.

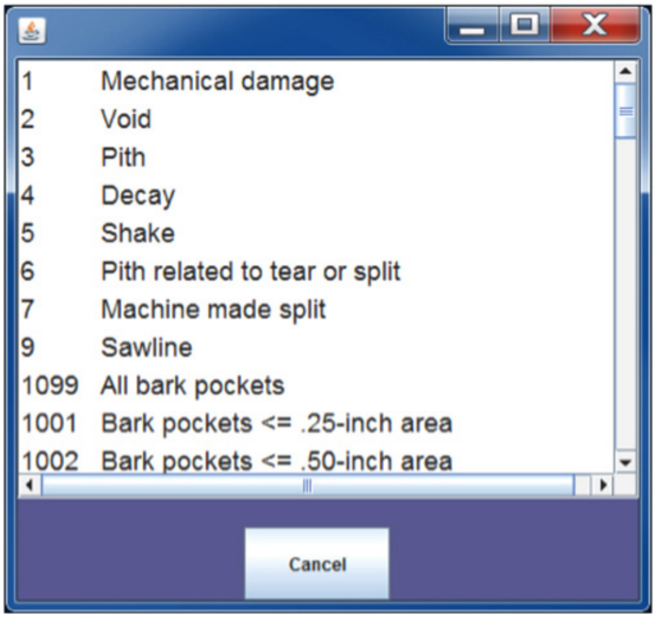


Figure 4.1.4.—Defect selection window.

Use the scroll bar to view all of the defects available and click on the one you want. Column five is Proximity and column eight is Re-Rip. Both Proximity and Re-Rip contain check boxes where a check means yes and the absence of a check means no. You can either click the *box* with the mouse or move to the cell and hit the space bar to toggle them *on* or *off*. To delete a grade, click on the grade that you want to delete and the whole row will be highlighted. Click *Edit* and then *Delete* and the table will be updated.

4.1.1. Clear-Two-Face (C2F) Part Grades

Before we start, let's clear the table by clicking *File* and then *New*. This will clear the table except for the first two rows as described above and shown in Figure 4.1.5. These two rows are mandatory predefined grades in the grade definition file that we cannot modify. These rows are all that is needed to define a clear-two-face (C2F) part grade. Note: You are able to run all your simulations with this part grade. It is the most "conservative" approach of determining yield.

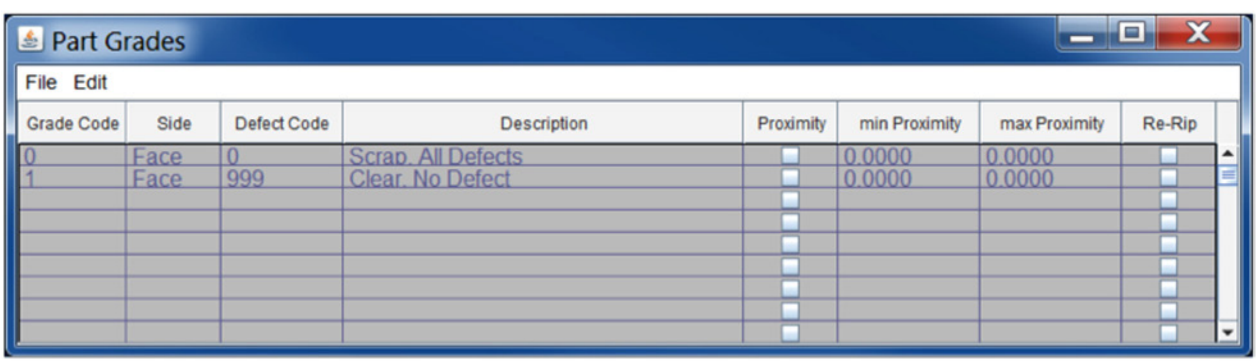


Figure 4.1.5.—Part Grades Editor window showing a Clear-Two-Face part.

4.1.2 Clear-One-Face Part Grades (C1F)

To create a clear-one-face (C1F) part grade, we need to define it as two separate grades: one with defects located on the face and one with defects located on the back of the parts. Let's say you want a C1F with sound knots containing a surface area of less than ½ inch. To add this grade, you double click in the *first blank cell* in the Grade Code column. The next available grade code will be added. Looking at Figure 4.1.1, if you click the blank cell below the Grade Code 1, a 2 will be added as the next Grade Code. To change this code, simply double click on it and change it to the number (with this number representing your chosen lumber grade) you want and update your part grades specification table. The lumber grade can be chosen in a popup window when you double click on the code cell. Next, you double click in the Side column and the value will become **Face**. Now, double click in the Defect Code column. You will see the window shown in Figure 4.1.4. Scroll down the list until you find the sound knot defects and select the one that says **sound knots ≤0.50-inch area**. The Defect Code and corresponding Description will now be added to the table. We do not want Proximity enabled, so we will leave the Proximity columns alone. We do not want to Re-Rip, so we leave it as is. The table should now look like Figure 4.1.6.

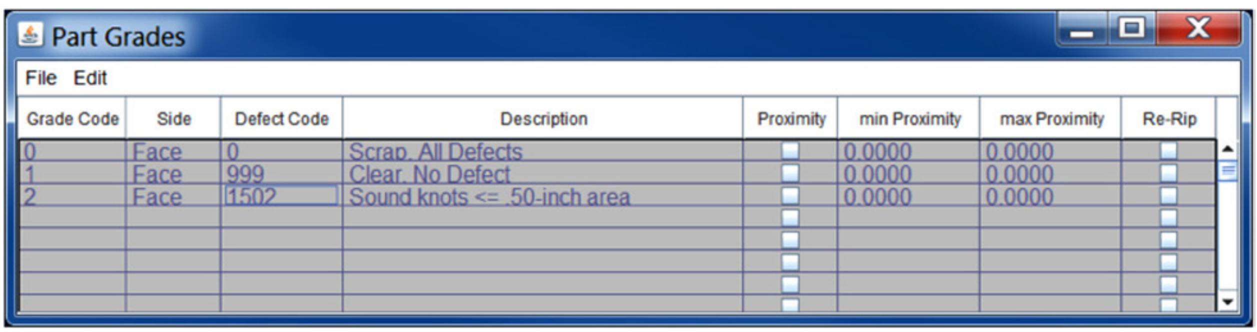
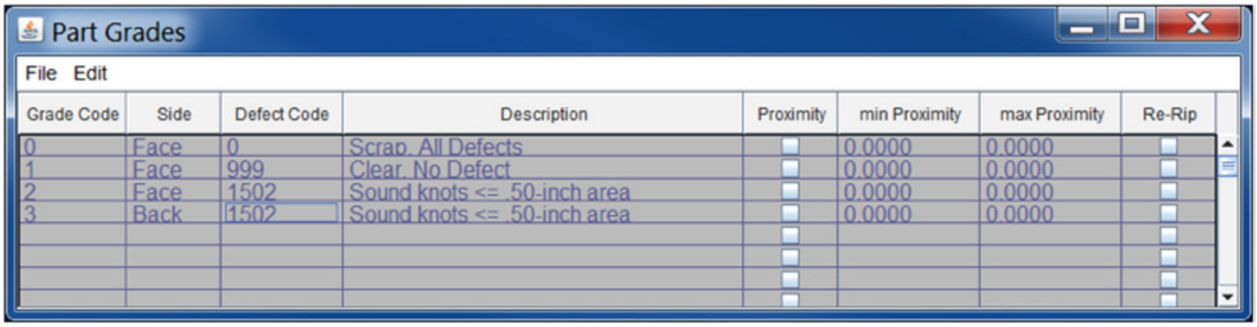


Figure 4.1.6.—Part Grades Editor window showing a Clear-One-Face part defined on the face of a board.

Because this is a C1F grade, we need to make two grades with the second one having defects located on the back face. You can repeat the previous steps for adding a rule and change the side or use the shortcut for adding rules. First, you click the *rule* you want to duplicate and it will be highlighted. Now, you click *Edit* and then click *Copy Rule*. You will now see an exact copy of the rule in the next row. Double click in the cell containing the side and it will change to the back of the part. We also must change the Grade Code so double click in the *Grade Code cell* and enter 3. The Part Grades Editor should look like the example in Figure 4.1.7. We now have two grades that define the C1F part quality for that specific part. The conjunction between a defined part grade and the part itself is done in the cutting bill. The specification is done for all parts with that particular specification.



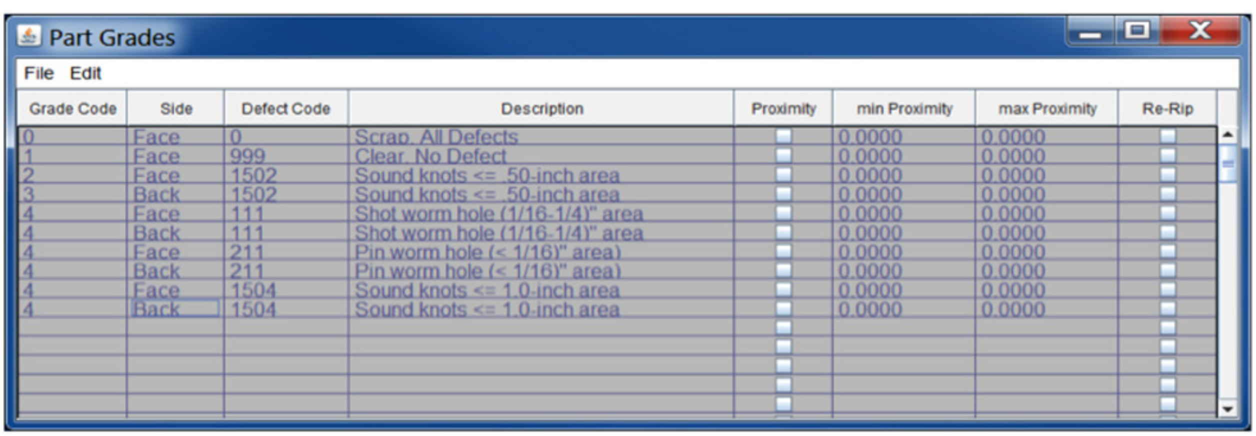
Grade Code	Side	Defect Code	Description	Proximity	min Proximity	max Proximity	Re-Rip
0	Face	0	Scrap. All Defects		0.0000	0.0000	
1	Face	999	Clear. No Defect		0.0000	0.0000	
2	Face	1502	Sound knots <= .50-inch area		0.0000	0.0000	
3	Back	1502	Sound knots <= .50-inch area		0.0000	0.0000	

Figure 4.1.7.—Part Grades Editor window showing a Clear-One-Face (C1F) part defined on the back of a board.

Remember that we have to define the Defect Codes for the Face and Back side of each board, because ROMI handles each side as an independent surface. If you do not specify the defect for a given side, it is handled as an acceptable defect for that side.

4.1.3 Sound-Two-Face Part Grades (C2F)

In most cases, Sound-Two-Face (S2F) part qualities are easier to define than C1F part qualities, because you need to define one grade and then copy it to make it applicable to the opposite part side. Let's say you want a S2F grade that defines three defects on each side. First, you double click in the *next blank* Grade Code cell and the next available code will be added. Next, double click on the side and Face will be added. Now double click in the defect code cell and choose Defect Code **111 Shot worm hole (1⁄16 -1⁄4) area** from the list. Because we want this rule for both sides, we click the row to highlight it and click *Edit*, then click *Copy Rule*. Double click in the side to change it from Face to Back. Now, copy the rule and change the side to Face and change the Defect Code to a **211 Pin worm hole (< 1⁄16) area**. Next, copy this rule and change the side to Back. Last, we want **Defect Code 1504 Sound knots ≤1.0-inch area** on both the Face and Back. When you are finished, your editor should look like Figure 4.1.8.

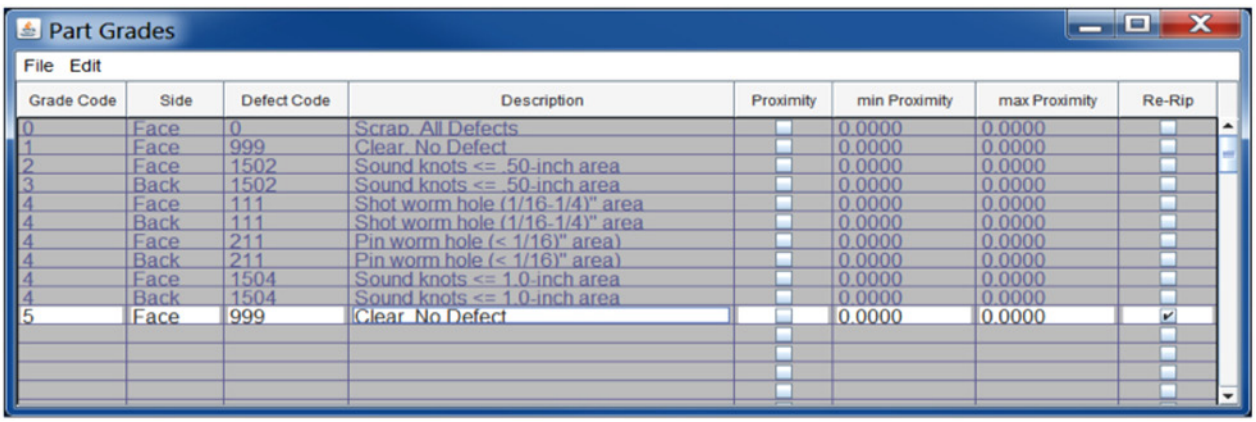


Grade Code	Side	Defect Code	Description	Proximity	min Proximity	max Proximity	Re-Rip
0	Face	0	Scrap. All Defects		0.0000	0.0000	
1	Face	999	Clear. No Defect		0.0000	0.0000	
2	Face	1502	Sound knots <= .50-inch area		0.0000	0.0000	
3	Back	1502	Sound knots <= .50-inch area		0.0000	0.0000	
4	Face	111	Shot worm hole (1/16-1/4)" area		0.0000	0.0000	
4	Back	111	Shot worm hole (1/16-1/4)" area		0.0000	0.0000	
4	Face	211	Pin worm hole (< 1/16)" area)		0.0000	0.0000	
4	Back	211	Pin worm hole (< 1/16)" area)		0.0000	0.0000	
4	Face	1504	Sound knots <= 1.0-inch area		0.0000	0.0000	
4	Back	1504	Sound knots <= 1.0-inch area		0.0000	0.0000	

Figure 4.1.8.—Part Grades Editor window showing a Sound-Two-Face (C2F) part.

4.1.4 Re-Rip/Salvage Part Grades

The last grade we **have to** define is a re-rip or salvage part grade, independently, if we use the salvage option or not. Let's say we want our salvage parts to be C2F. Double click in the next empty Grade Code cell and the value "5" will appear as the next available code. Because this is a S2F, we need to define our defects on only the Face or Back, but not both. Double click in the cell in the Side column that makes it Face. Next, double click the *defect code cell* and choose defect code 999 Clear, No Defect. Because we want this to be a re-rip, double click on the box in the last column under the heading Re-Rip and a check mark will now be in the box. The completed part grades definition for all our grades should look like Figure 4.1.9. Remember, ROMI allows you to define only one salvage grade,



Part Grades

File Edit

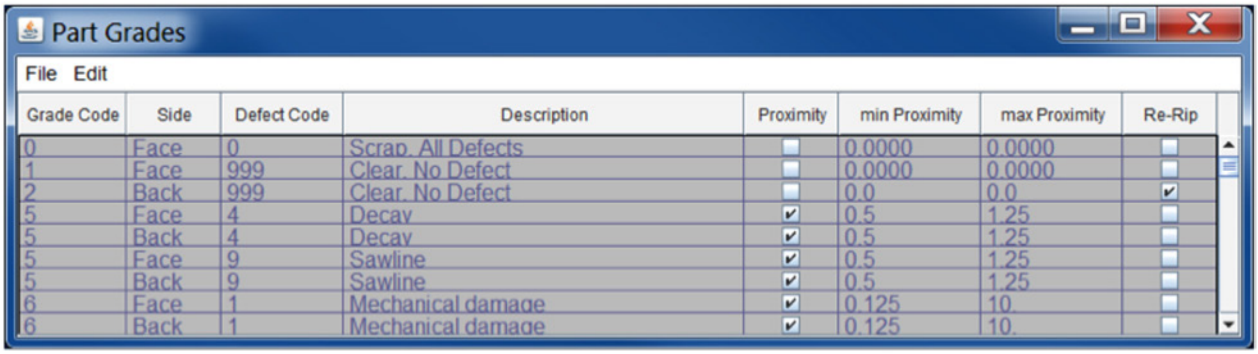
Grade Code	Side	Defect Code	Description	Proximity	min Proximity	max Proximity	Re-Rip
0	Face	0	Scrap, All Defects		0.0000	0.0000	
1	Face	999	Clear, No Defect		0.0000	0.0000	
2	Face	1502	Sound knots <= .50-inch area		0.0000	0.0000	
3	Back	1502	Sound knots <= .50-inch area		0.0000	0.0000	
4	Face	111	Shot worm hole (1/16-1/4)" area		0.0000	0.0000	
4	Back	111	Shot worm hole (1/16-1/4)" area		0.0000	0.0000	
4	Face	211	Pin worm hole (< 1/16)" area)		0.0000	0.0000	
4	Back	211	Pin worm hole (< 1/16)" area)		0.0000	0.0000	
4	Face	1504	Sound knots <= 1.0-inch area		0.0000	0.0000	
4	Back	1504	Sound knots <= 1.0-inch area		0.0000	0.0000	
5	Face	999	Clear, No Defect		0.0000	0.0000	✓

Figure 4.1.9.—Part Grades Editor window showing a salvage part grade.

Now, all we need to do is save the file. Click *File* and then *Save,* choose a name for the file, and click the *OK* button.

4.1.5 Part Grades: An Additional Feature

A feature not used in the previous examples allows you to define defect types that are acceptable when they occur a specific distance from the edge. This feature is useful for moulding and millwork parts where defects are acceptable as long as they are not in an area that will be machined. To enable this feature in part grades, double click on the proximity check box in the row of the desired rule. Next, double click on the min Proximity cell and enter the minimum acceptable distance from the edge. Do the same for max Proximity and the result should look like Figure 4.1.10. If there is no maximum acceptable distance, enter the maximum strip width on which it will be used. The Proximity needs to be defined for each side of the board.



Part Grades

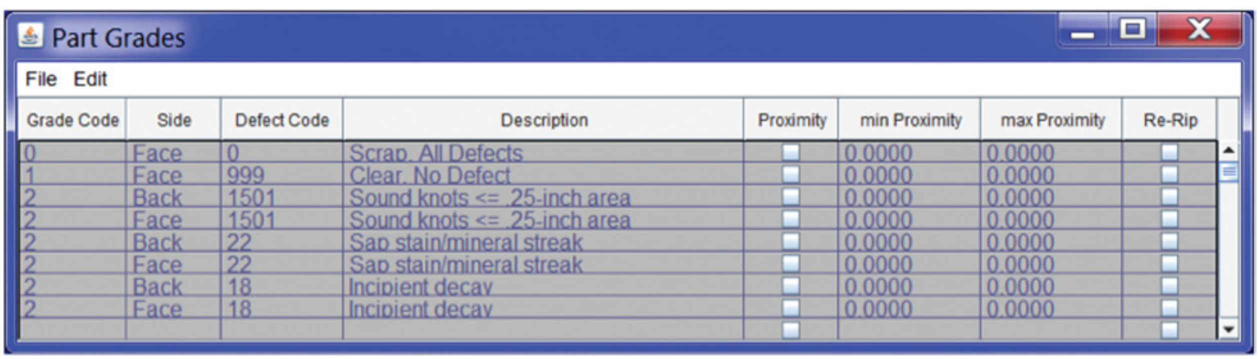
File Edit

Grade Code	Side	Defect Code	Description	Proximity	min Proximity	max Proximity	Re-Rip
0	Face	0	Scrap, All Defects		0.0000	0.0000	
1	Face	999	Clear, No Defect		0.0000	0.0000	
2	Back	999	Clear, No Defect		0.0	0.0	✔
5	Face	4	Decay	✔	0.5	1.25	
5	Back	4	Decay	✔	0.5	1.25	
5	Face	9	Sawline	✔	0.5	1.25	
5	Back	9	Sawline	✔	0.5	1.25	
6	Face	1	Mechanical damage	✔	0.125	10.	
6	Back	1	Mechanical damage	✔	0.125	10.	

Figure 4.1.10.—Part Grades Editor window showing the use of min and max proximity.

4.1.6 Predefined Part Grades based on Wood Component Manufacturer Association specifications

In ROMI 4.0, a set of predefined part grades based on Rules and Specifications for Dimension and Woodwork by the Wood Component Manufacturers Association (WCMA 2007) has been implemented as part of the standard software package and will help users operate and simulate their tests more efficiently. Following the WCMA part grades, these part grades are predefined in three different quality grades: slight, medium, and heavy defects. Thus, sound knots would be allowed in different sizes in the different classes: slight ≤ ¼ inch, medium ≤ ½ inch, and heavy ≤1 inch. Each predefined part grade can be modified by the user and be adapted to the specific needs and circumstances of a given supplier-customer relationship. A detailed overview about the specification for each Face is given in Section 11.2.1 (Table 3). Figure 4.1.11 shows the predefined Part Grades for C1F Face A parts.

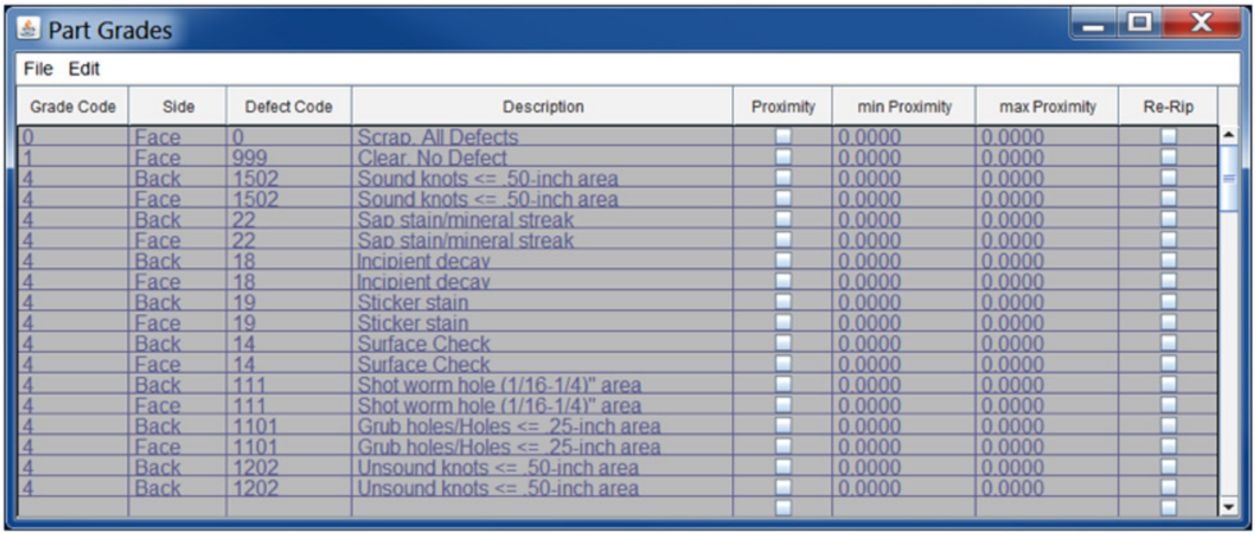


Part Grades

File Edit

Grade Code	Side	Defect Code	Description	Proximity	min Proximity	max Proximity	Re-Rip
0	Face	0	Scrap, All Defects		0.0000	0.0000	
1	Face	999	Clear, No Defect		0.0000	0.0000	
2	Back	1501	Sound knots <= .25-inch area		0.0000	0.0000	
2	Face	1501	Sound knots <= .25-inch area		0.0000	0.0000	
2	Back	22	Sap stain/mineral streak		0.0000	0.0000	
2	Face	22	Sap stain/mineral streak		0.0000	0.0000	
2	Back	18	Incipient decay		0.0000	0.0000	
2	Face	18	Incipient decay		0.0000	0.0000	

Figure 4.1.11.—Predefined Part Grades based on WCMA specification; for example, Face A Grade Code 2 (Clear-One-Face [C1F]).



Grade Code	Side	Defect Code	Description	Proximity	min Proximity	max Proximity	Re-Rip
0	Face	0	Scrap, All Defects		0.0000	0.0000	
1	Face	999	Clear, No Defect		0.0000	0.0000	
4	Back	1502	Sound knots <= .50-inch area		0.0000	0.0000	
4	Face	1502	Sound knots <= .50-inch area		0.0000	0.0000	
4	Back	22	Sap stain/mineral streak		0.0000	0.0000	
4	Face	22	Sap stain/mineral streak		0.0000	0.0000	
4	Back	18	Incipient decay		0.0000	0.0000	
4	Face	18	Incipient decay		0.0000	0.0000	
4	Back	19	Sticker stain		0.0000	0.0000	
4	Face	19	Sticker stain		0.0000	0.0000	
4	Back	14	Surface Check		0.0000	0.0000	
4	Face	14	Surface Check		0.0000	0.0000	
4	Back	111	Shot worm hole (1/16-1/4)" area		0.0000	0.0000	
4	Face	111	Shot worm hole (1/16-1/4)" area		0.0000	0.0000	
4	Back	1101	Grub holes/Holes <= .25-inch area		0.0000	0.0000	
4	Face	1101	Grub holes/Holes <= .25-inch area		0.0000	0.0000	
4	Back	1202	Unsound knots <= .50-inch area		0.0000	0.0000	
4	Back	1202	Unsound knots <= .50-inch area		0.0000	0.0000	

Figure 4.1.12.—Predefined Part Grades based on WCMA specification; for example, Face C Grade Code 4 (Sound-Two-Face [S2F]).

Note: Birdseye and color parameters are not part of Gatchell’s 1998 Red Oak Database and therefore cannot be included in the predefined part grades. Also, the size of strips and the board width need to be defined in the arbor setup settings (Section 4.2.5).

4.2 Cutting Bill Setup

Once part grades have been defined and saved or a part grade file has been selected, you are ready to begin working with the cutting bill. The cutting bill is the central part of a simulation run because it defines the part sizes in respect to quantities and qualities that are required. As such, it ties together the part grade definitions with the individual part requirements and dictates the arbor setup as well as other processing options. Figure 4.2.1 shows the main interface of ROMI 4.0 in which the cutting bill is always displayed.

Figure 4.2.1.—Sample window showing table where the cutting bill information is entered and displayed.

4.2.1 Opening and Importing Cutting Bills

If you have been using ROMI-RIP 2 or ROMI-CROSS, you can import your old cutting bills into ROMI 4.0. To do this, click *File*, then move the mouse down to *Import*, and under the submenu click *ROMI-Rip File* (.rip) or *ROMI-Cross File* (.rmx .cut). You will see a File Open window as shown in Figure 4.2.2.

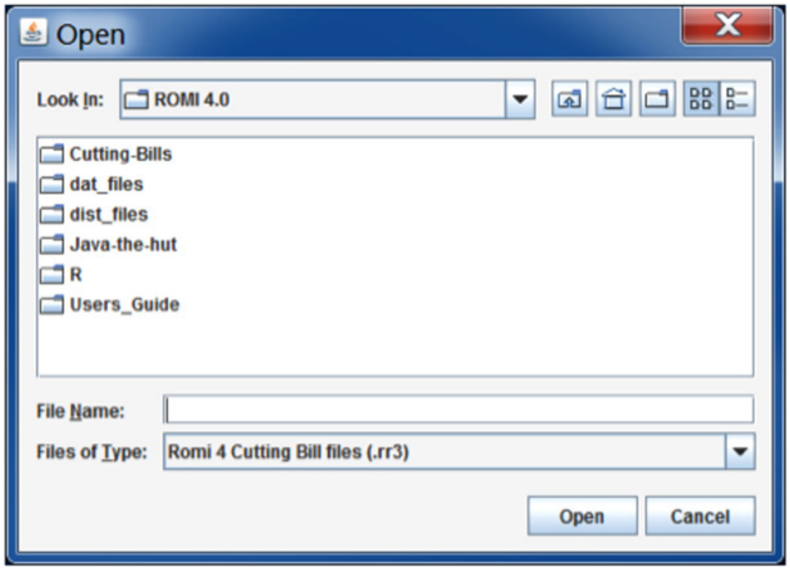


Figure 4.2.2.—ROMI 4.0 file selection window.

Navigate to where your files are saved and double click on the *file name*. Once you have imported your cutting bill, you will have to save it in the ROMI 4.0 format that has the **.rr3** extension. The rr3. file extension, which was originally introduced for ROMI 3.0, was retained for use in ROMI 4.0 to maintain compatibility with files from the earlier version. To open a ROMI 4.0 file, use the same process as importing, except click *File*, and then click *Open*. You will once again see the File Open window shown in Figure 4.2.1. Navigate to where your files are saved and double click on the file name or click the file name and click *Open*. Your settings will be loaded and the cutting bill will be displayed in the table.

4.2.2 Cutting Bill Editing

Data are entered into the cutting bill editing window just like data are entered into an MS Excel spreadsheet. Hitting the *tab* key will move the cursor to the cell to the right of the current position. If you are in the last column, then the cursor will advance to the first column of the next row. Hitting the *enter* key will move the cursor to the next row but in the same column that you are currently editing. You also can use the arrow keys to move between cells. To enter data into the table, simply move to the desired cell and start typing. There are two methods of editing the data contained in a cell. One method is moving the cursor to the cell and pressing the *backspace* key, which erases data from right to left. Or, you can double click in the cell, which will cause a blinking cursor to appear where you will start editing. Two columns must be handled differently: the Random Y/N and the Panel Y/N. These columns contain check boxes where a check means yes and the absence of a check means no. You can either click the box with the mouse or move to the cell and hit the space bar to toggle them *on* or *off*.

More editing features include *cut, copy, paste, and insert row*. The *cut* and *copy* features are similar except cut removes the data from the table whereas copy does not. To use the cut feature, select the items in the table by holding the mouse button down and dragging the cursor along the rows, which highlights these rows. Next click *Edit* and click *Cut*, or to use *Copy* click *Edit* and then click *Copy*. The items that were highlighted are now on the system clipboard. This means that you can paste them to another position in the table. You can also copy the information to an external application, such as a spreadsheet, using this procedure. To paste, click the cell where you want the data to appear and click *Edit* then click *Paste*. If you cut or copy a cell that has a checkbox and then paste it into an external Excel spreadsheet, the checkbox data will be displayed as either 0, meaning no check, or 1, meaning it is checked. Therefore, if you edit your cutting bill in Excel, you will put a 0 if you do not want a check and a 1 if you do. The last editing feature is *insert row*. To insert a row, click in the table where you want the blank row to be placed and click *Edit* and then click *Insert Row*. One blank line will appear and the data below will be moved down one position. If you want to insert more than one blank row, click and drag the mouse downward, highlighting the same number of rows that you want to insert.

A new feature in ROMI 4.0 is the ability to process random length and fixed length parts for the same strip width. Earlier versions could process either fixed length parts or random length parts for a specific width, but not both at the same time. Due to the requirements of modern rough mills and cutting bills, a feature to process random length and random width parts simultaneously was implemented in ROMI 4.0.

4.2.3 Cutting Modes

At the top of the main interface window on the left side, there is a drop-down box besides Mode that contains three items (rip first mode, chop first mode, and a combined rip and chop-option mode, Fig. 4.2.3). Choosing *Rip-First* will allow you to define all the system parameters to perform a rip-first simulation. Similarly, choosing *Chop-First* allows you to setup a chop-first simulation. The third option, *Rip and Chop*, allows you to define a simulation capable of performing either rip-first or chop-first processing. In *Rip and Chop*, the potential prioritized part value, based on the resulting yield, is determined for each processing mode and evaluated. The prioritized part values used for determining the best processing methods are calculated using the part-prioritization method selected for a given cutting bill. For more information about part prioritization, see Section 10.2. The method that has the highest prioritized part value is used to process the board. With *Rip and Chop*, ROMI 4.0 reports the volume and number of boards processed using rip-first and chop-first processing, as well as overall.

As you change the cutting modes, the setup items displayed on ROMI 4.0’s main user interface changes to reflect the selected cutting mode. For example, chop-first has fewer setup options resulting in simpler configuration windows and menus.

Figure 4.2.3.—ROMI 4.0 cutting modes.

4.2.4 ChopSaw Setup

The Chopsaw setup is a rather simple setup compared to the rip-first setup. If you click on the *ChopSaw* button while you are in *Chop First mode*, you will see the ChopSaw window (shown in Fig. 4.2.4).The ChopSaw window allows you to set the parameters for a Chop-first simulation.

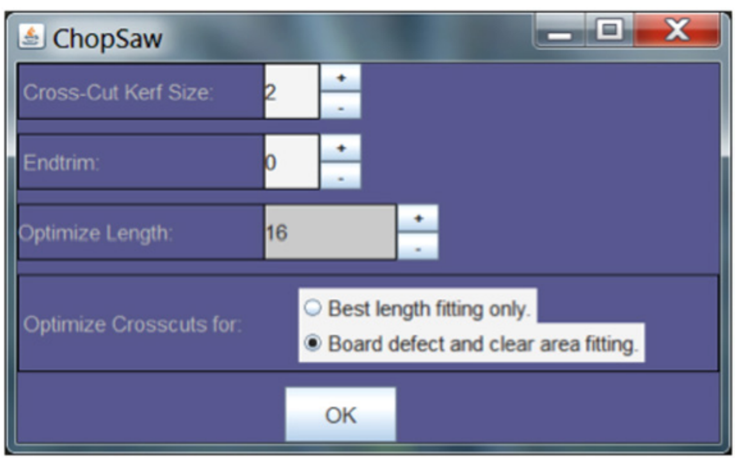


Figure 4.2.4.—Chopsaw setup in Chop-first cutting mode.

If you click the *ChopSaw* button while you are in *Rip-First mode*, you will see a different setup window (shown in Fig. 4.2.5). The Chopsaw setup, when in rip-first mode, allows you only to define end trim solutions and parameters.

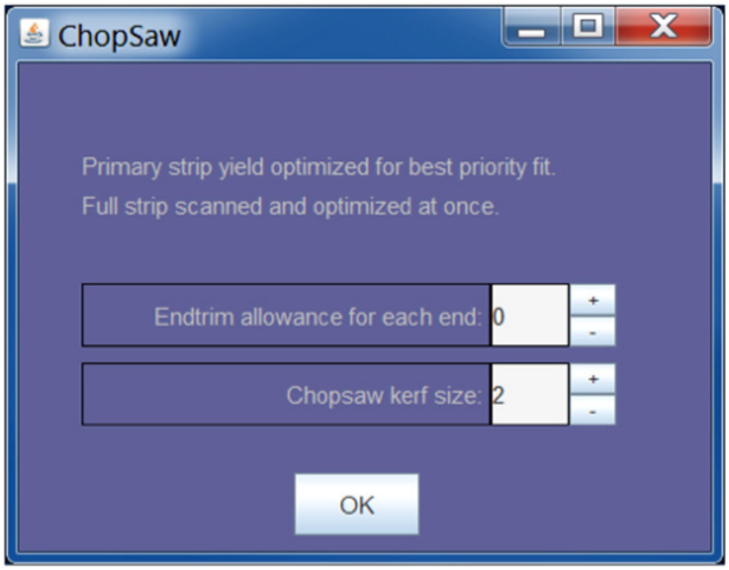


Figure 4.2.5.—Chopsaw setup window in Rip-first cutting mode.

There are two settings you can modify in this window. By using the plus (+) and minus (-) buttons, you can increase or decrease the values. The top setting indicates the amount of end trim that you want to allow in sixteenths of an inch. A zero indicates that there will be no endtrimming. The bottom shows the amount of kerf and the saw blade thickness that will be used in your simulations. Figure 4.2.5 shows no endtrim and an eighth inch kerf. When you are satisfied with the settings, click *OK* and the window will be closed. Note that you must save your cutting bill file before the settings will take effect, a rule that applies to all changes made throughout the ROMI 4.0 software.

4.2.5 RipSaw Setup

Clicking *RipSaw* button causes the window shown in Figure 4.2.6. to appear.

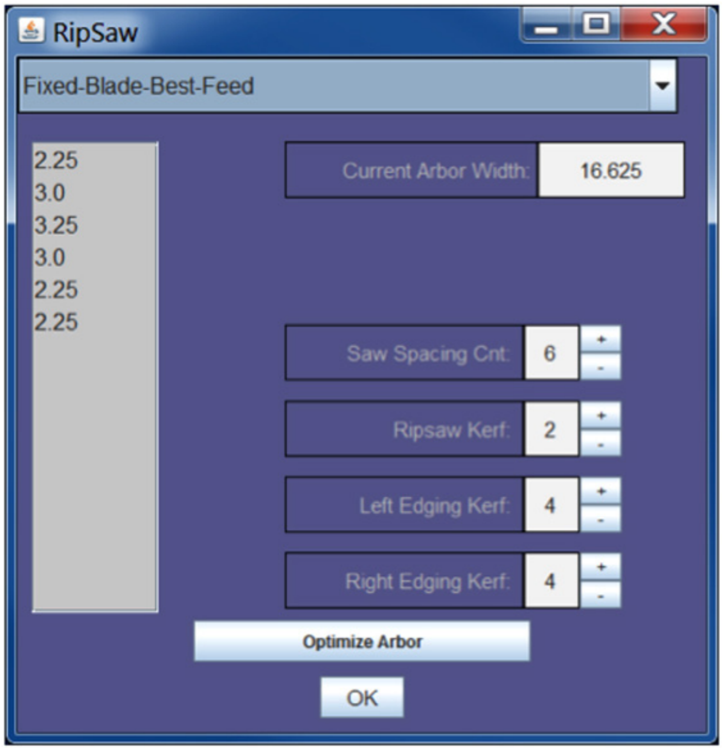


Figure 4.2.6.—Ripsaw setup window.

The box on the left side of the window shows the distance between the blades on the arbor. Adding these widths together including ripsaw kerfs between spacings gives you the total arbor width. As an example, six saw spacings require seven blades; if each outside blade kerf is $\frac{4}{16}$ and each interior blade kerf is $\frac{2}{16}$, the arbor width should be $2(\frac{4}{16}) + 5(\frac{2}{16}) = 17.125$. However, the outer edging blades or “hogging blades” are applied to the board before it enters the arbor in separate operations of the simulation. These edging blades were included to simulate the removal of crook from boards, to simulate strip flooring production, and similar operations. The boards were edged and afterwards processed through the arbor. Thus, the true arbor width is 16.625 inches as reported in the ripsaw setup window as shown in Figure 4.2.6. This is displayed in the box next to the label *Current Arbor Width*. The plus and minus buttons beside *Saw Spacing Cnt* control the number of blades on the arbor. Increasing the number adds blades to the arbor and decreasing removes them. If you add a blade, it will appear in the list of arbors with a value of zero. You must then click on that *number* and a popup window will appear allowing you to select a width for the spacing (Fig. 4.2.7).

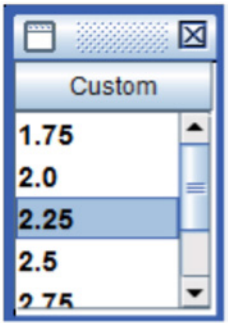


Figure 4.2.7.—Popup window for choosing arbor spacings.

Click on a width to select or click *Custom* to enter your own width (in quarter-inch increments). Custom width entry allows you to enter spacing widths that are not represented as a part size requirement in the cutting bill. This can be especially useful if the cutting bill is composed primarily of panel parts, where the addition of extra widths will improve strip and resulting part yield. The next three settings control the kerf and edgings and are represented in sixteenth inch increments. Eight different types of arbors may be used in the ripsaw setup. They are selected from the drop-down box at the top of the window (Fig. 4.2.8).

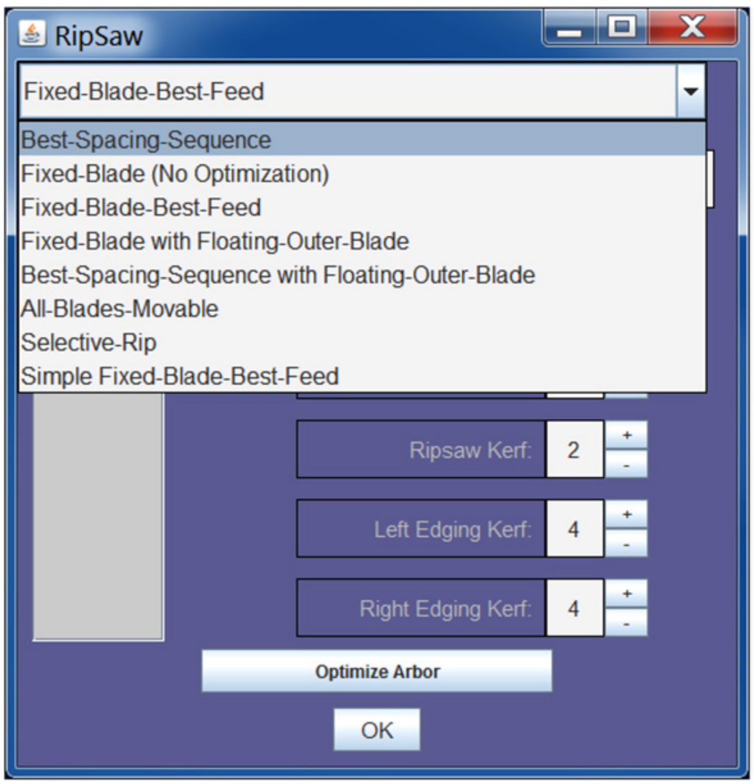


Figure 4.2.8.—Drop-down box showing types of arbors that may be used.

If you choose *Selective Rip* from the arbor drop-down box, two fields in the ripsaw settings window (Fig. 4.2.9) are enabled. One field allows each blade on the arbor to be specified as either fixed or movable. Clicking on the fixed or movable setting alternates between the two settings. Note that the selective rip arbor does not allow adjacent blades to be specified as movable. If you require this feature, use the *All-Blades-Movable* arbor. The second field enabled for the movable-blade arbors (Saw Blade Proximity) allows you to specify how close (1⁄16 inch) the moving blades on the arbor can come to adjacent blades. This setting is usually set to 12⁄16 (3⁄4) inch or 14⁄16 (7⁄8) inch and corresponds to the collar thicknesses and mechanical limits of gang-ripsaws.

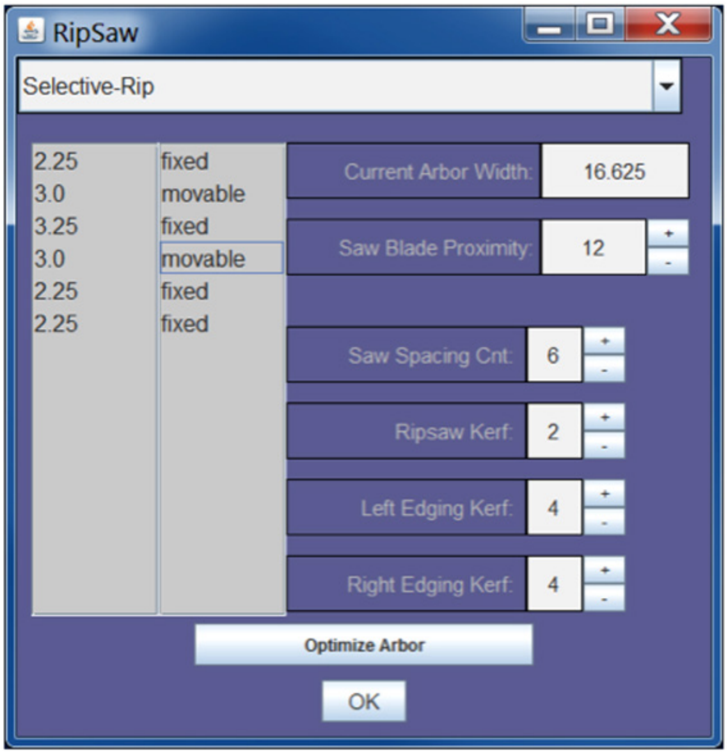


Figure 4.2.9.—Ripsaw setup using Selective-Rip arbor.

Clicking the *Optimize Arbor* button will bring up the window shown in Figure 4.2.10. The arbor optimizer will examine your current cutting bill and determine the best possible arbor for you. The arbor optimizer takes a modified approach to the arbor design algorithm created by Gatchell (1996). The arbor optimizer was developed at North Carolina State University in cooperation with the U.S. Forest Service (Mitchell and Zou 2001).

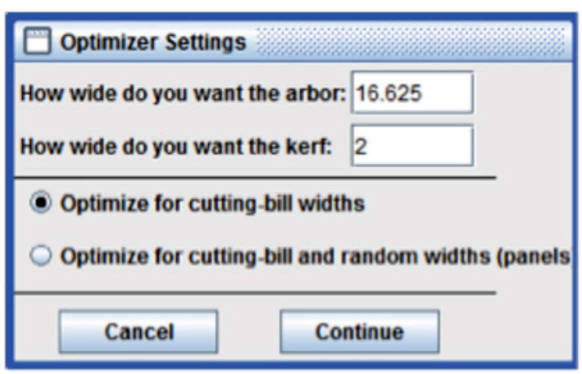


Figure 4.2.10.—Optimizer Arbor setup window.

Enter your arbor width in inches, the kerf (saw blade thickness in 1⁄16 inch), and whether you want to optimize for just the solid widths or widths including panels. When you are ready, click *Continue*. It may take a few minutes to get the results depending on your computer's speed. When the optimizer is finished, you will see the arbor results window (Fig. 4.2.11).

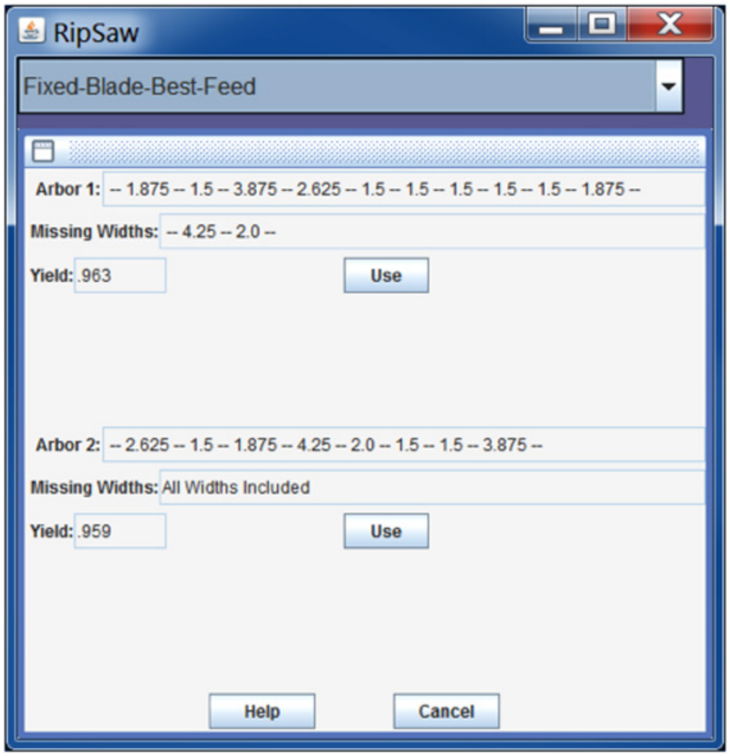


Figure 4.2.11.—Arbor optimizer results window.

Depending on your options and your cutting bill part widths, you may have two different arbors to choose from. If the optimizer gets a good yield while not including all of the widths in your cutting bill, the arbor setup will be displayed followed by the arbor that include all widths. ROMI 4.0 gives users two arbors to choose from when a higher yield can be realized from omitting a specified width (or two) and if the width omitted is not associated with a large part requirement. Remember that ROMI can mix in random-width parts to improve yield when producing panels. In some cases, users may not want to include these random-width parts in the arbor. You can examine the yield results and choose the arbor you want by clicking the *Use* button.

4.2.6 Mill Control Setup

Clicking the *Mill Control* button in the main interface window will bring up the Mill Control window (Fig. 4.2.12).

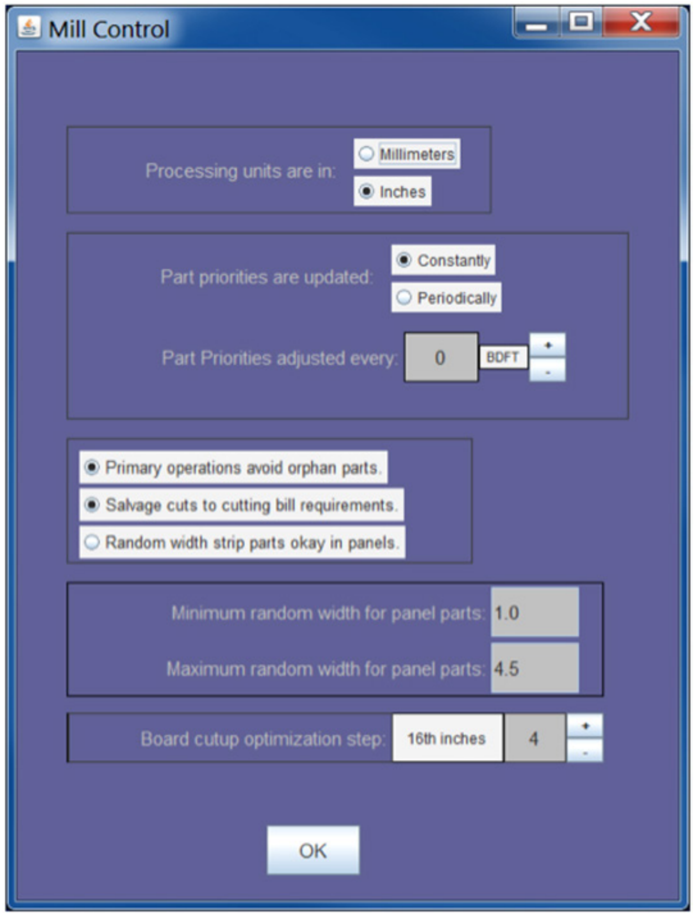


Figure 4.2.12.—Mill Control setup window.

The top two buttons in the Mill Control setup window allow you to toggle between using inches or millimeters throughout your setup. Note that this button does not do any conversions. For example, 4⁄16 inch simply becomes 4 mm. The part counts settings control how often part counts and priorities, when using a dynamic prioritization method, are updated. Use the plus (+) and minus (-) buttons to change how often the count is updated or set it to zero to update constantly. The *Primary operations avoid orphan parts* and *Salvage cuts to cutting bill requirements* settings instruct the simulator not to cut excess primary parts without determining whether the area can be salvage ripped to obtain a narrower cutting bill part. Use the *Random width strip parts okay in panels* setting if you are not concerned with what width parts are used to make up panels. If you are using a moving-blade arbor, then you should enable this setting to take full advantage of the arbor. You also may use the option (as shown in Fig. 4.2.12) to set the minimum and maximum widths to use to make up a panel. For fixed-blade-best-feed and selective-rip arbors, this setting controls how many feed positions are examined per inch of arbor width. For example, a cut-up optimization step of 4 would examine one feeding position every 4⁄16 inch. For a 24-inch-wide arbor, ROMI 4.0 would examine 96 ((24 * 16) ÷ 4) feed positions. For the all-blades-movable arbor, the setting controls how many random widths are examined by the arbor. A cut-up optimization step of 4⁄16 inch would examine widths to the nearest quarter inch, while a setting of 2⁄16 inch would examine widths to the nearest eighth inch. Note that the smaller the optimization step becomes, the longer the simulation run time will be as the software's calculations increase.

4.2.7 Salvage Parts Setup

Clicking the *Salvage Parts* button from the main window will bring up the window shown in Figure 4.2.13.

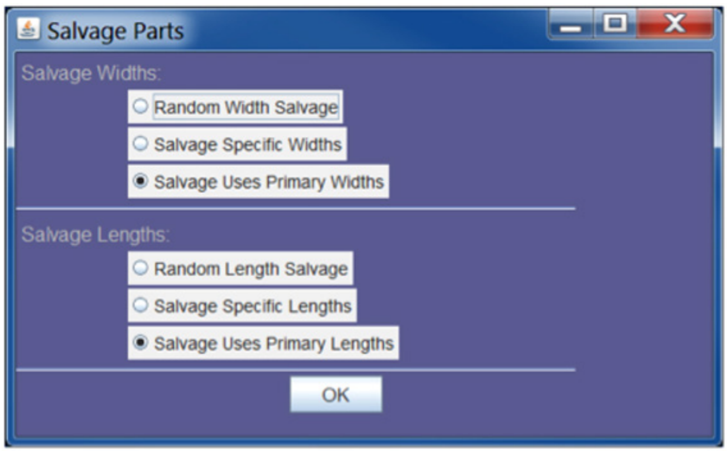


Figure 4.2.13.—Salvage Parts setup window.

There are three possible settings each for the salvage widths and lengths. *Random Salvage* allows the program to randomly pick the parts it tries to obtain from salvage. Picking *Salvage Specific Widths* or *Lengths* will enable a box that lets you pick the widths or lengths for salvage parts manually (Fig. 4.2.14).

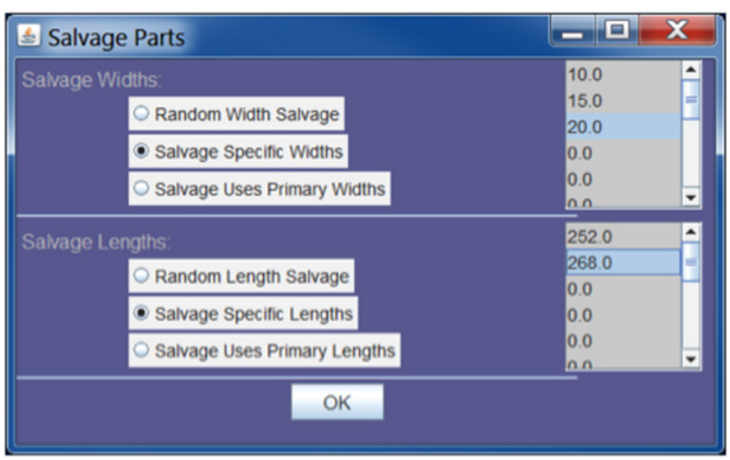


Figure 4.2.14.—Salvage settings using specific widths and lengths.

To edit a width or length, click on it and you will see the window shown in Figure 4.2.15.

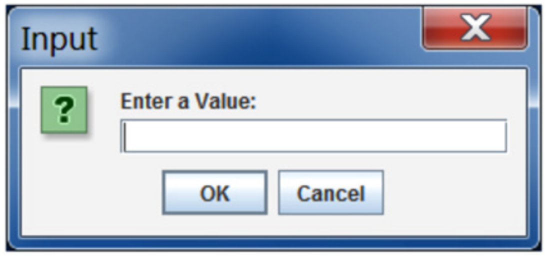


Figure 4.2.15.—Window used to enter specific widths and lengths.

Enter the value that you want and click *OK*. To delete a width, click on it and enter zero in the window. The last option is *Salvage Uses Primary Widths* or *Lengths*. This will make ROMI 4.0 try to obtain salvage parts with the same widths and/or lengths found in the cutting bill.

4.2.8 Prioritization Setup

When processing to meet a cutting bill's requirements, the goal is to cut all the required part sizes from a minimal amount of lumber while generating a minimal number of excess parts. This problem is made more difficult by variations in lumber grades and dimensions. To solve these problems in simulation, seven part-prioritization strategies are available that range from simple to complex (Thomas 1996). The simple methods prioritize parts based on their area. Complex methods generate part priorities based on each part's size and current required quantity. The complex methods are dynamic in that a part priority can be updated continually as parts are cut and the current quantity decreases. As the quantity requirements for a part size are met, emphasis shifts to other part sizes. The decision on which combination of parts to cut from a board is based on maximizing the total weighted area of parts for each board resulting in maximum yield. More information on individual part-prioritization strategies can be found in Section 10.2.

The *Prioritization* button is located at the top of the main interface window. Clicking it will bring up the Prioritization window (Fig. 4.2.16). In this window, you can select the type of prioritization strategy that you want to use.

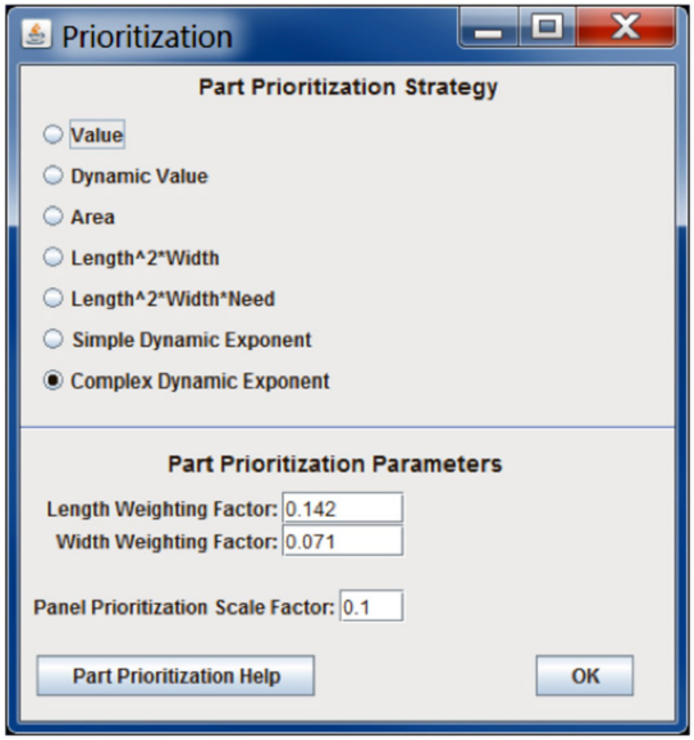


Figure 4.2.16.—Prioritization setup window.

4.2.9 Part Scheduling and Replacement

A scheduling problem exists when the number of different part sizes in a cutting bill exceeds a rough mill's sorting capacity. Decisions have to be made about that parts will be processed first and the order in which the remaining part will be processed as initial part requirements are met. ROMI 4.0 allows this scheduling with the *Scheduling Level* variable (Fig.4.2.1) associated with each part. Parts with a level of 1 are cut first. Parts with a level of 2 are used to replace Level 1 parts as Level 1 parts requirements are met. Parts with larger level values are entered in sequence. The total number of parts with a Level 1 is the total number of different sorts that are available in a given rough mill.

4.2.10 Predefined Cutting Bill Examples

To give the novice user an easier start with creating a cutting bill, ROMI contains several simple examples of common operations, such as millwork or cabinet doors. These examples show a simplified cutting bill of a given operation and can be customized to your needs.

Figure 4.2.17 shows an example from a standard millwork operation. The cutting bill contains parts of rather narrow width and random length. This feature allows you to use the raw material in an optimal way, because no fixed length is needed to satisfy the requirements of the cutting bill. When the random length feature is enabled, the *Quantity* measure automatically adjusts from piece count to linear board feet (a common measure in the millwork industry). For this operation, a Scheduling level is not recommended because it will influence the yield, i.e., ROMI is unable to provide the ideal solution.

Figure 4.2.17.—ROMI 4.0 simplified millwork example.

Figure 4.2.18 shows an example from a cabinet door operation. Unlike the mill work example, the cabinet door example contains fixed length parts and a panel part. As shown in the example, the cutting mode is rip-first; when the *Panel* feature is enabled and a significant portion of panel stock is produced, ROMI will offer you two options after the arbor optimization run. While the first arbor would be satisfactory for processing the cutting bill, the second would result in higher yield due to its efficient generation of panel stock. These two arbor choices reflect two common ways of designing rip-first arbors.

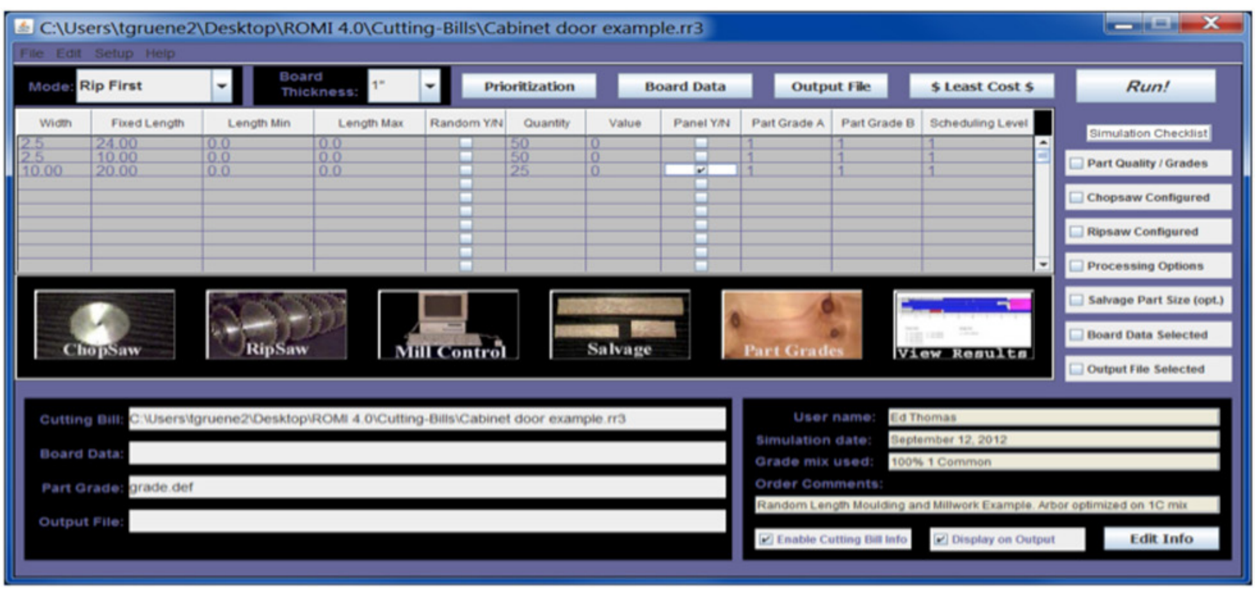


Figure 4.2.18.—ROMI 4.0 cabinet door example.

5 DATAFILE SELECTION

5.1 Customize BoardData for Datafile Selection

Clicking the *Board Data* button at the top of the main ROMI 4.0 window brings up the Datafile selection window (Fig. 5.1.1). This window is where you choose files containing digitized boards from the databank (Gatchell et al. 1998). The top box shows the available board files (see Gatchell et al. 1998 for more information about the content of each board file) and the bottom box shows the selected board files to use. To choose a board file, double click on the name of the file and it will be shown in the bottom box. You can use multiple files and the same file multiple times. To remove a file, double click on the name in the bottom box. When you have activated all the board data files you need, click the *OK* button.

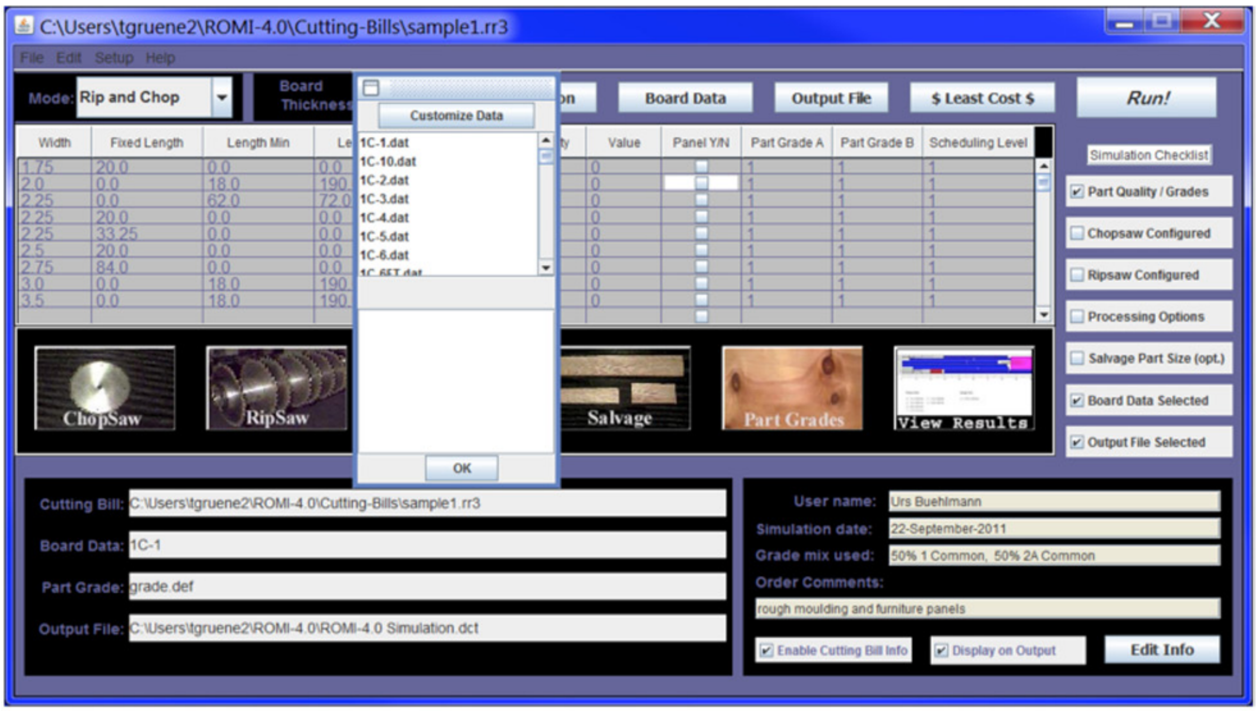


Figure 5.1.1.—Datafile selection window.

5.2 Creating Custom Grade Mix and Specified Files

You can create custom board data files by clicking the *Customize Data* button. This will start the *MakeFile* program (Fig. 5.2.1) that allows you to specify a grade mix or choose individual boards for your simulations. By using the *MakeFile* program, you can create board data sets that closely resemble the characteristics (width and length distribution, grades) of the actual lumber being processed in your rough mill. The board data included with ROMI 4.0 are from the 1988 Data Bank for Kiln-Dried Red Oak Lumber (Gatchell et al. 1998) and are graded to 1998 NHLA rules (NHLA 1998). For more information about the lumber data, see Appendix II and the Help menu.

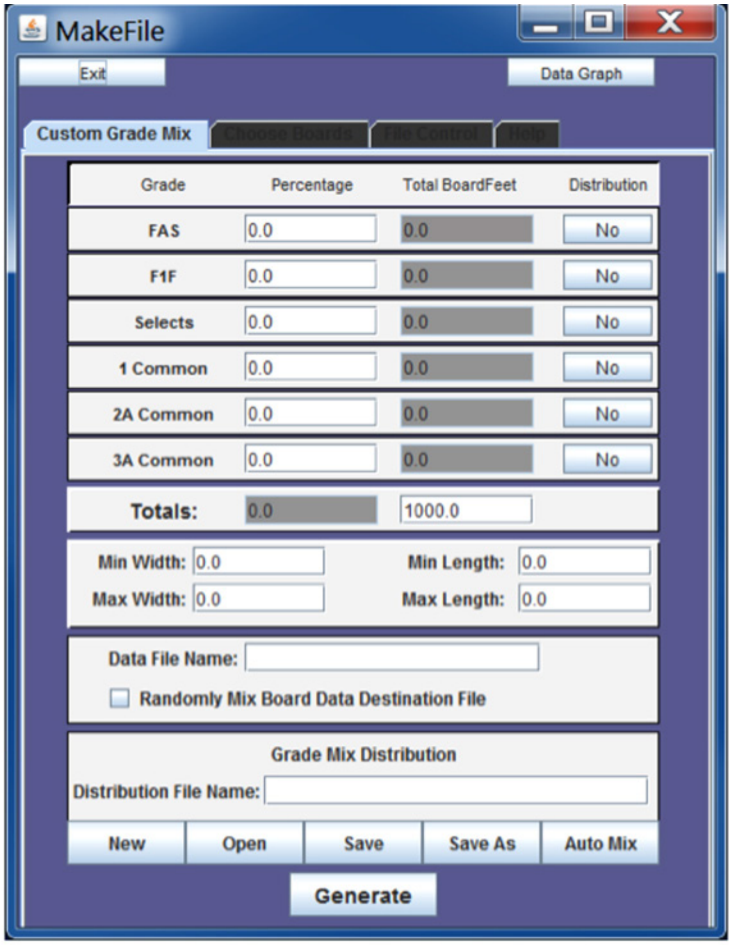


Figure 5.2.1.—*MakeFile* program.

5.2.1 Custom Grade Mix

Custom Grade Mix is the default tab that is selected when *MakeFile* is started. This tab allows you to specify percentages of desired lumber grades from the lumber databank. The percentage column is where you specify the percentage of each grade. If you want 50 percent No. 1 Common, select the cell next to 1 Common and enter 50; if you want 20 percent 2A Common, select the cell next to 2A Common and enter 20. The total percentage for all grades is displayed on the Totals line and must be 100 before generating the file. As you change the percentages, you will see the Totals field change. If you go over 100 percent, the total number will change to red indicating that total percentage is too high. Under the Total Board Feet column, you will notice that the default sample size is 1,000 board feet. To change the sample size, select the cell and enter the amount of board feet you want. When the sample size is changed, *MakeFile* automatically recalculates the total board feet needed for each grade based on the percentage entered. It also is possible to specify board minimum and maximum width and lengths. Both length and width are measured in inches to the nearest ¼ inch. In the example shown in Figure 5.2.2, we specified a 2,500 board foot (BDFT) sample consisting of a 30 percent No. 1 Common and 70 percent No. 2A Common grade mix with no minimum or maximum length or width.

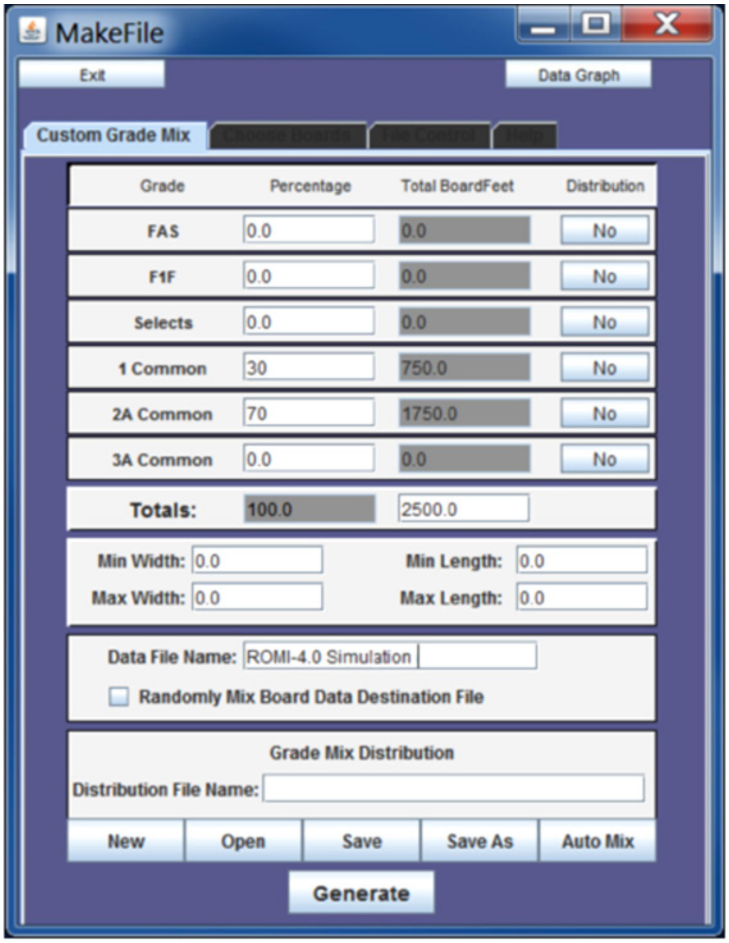


Figure 5.2.2—*MakeFile* showing a sample grade mix.

For those who wish to match a specific width and/or length distribution, a distribution editor is available. For each grade, a distribution of as many as 20 size ranges can be specified. There is a button for each grade under the Distribution column that is labeled *No* by default. Clicking any of the *Distribution* buttons will bring up the window shown in Figure 5.2.3.

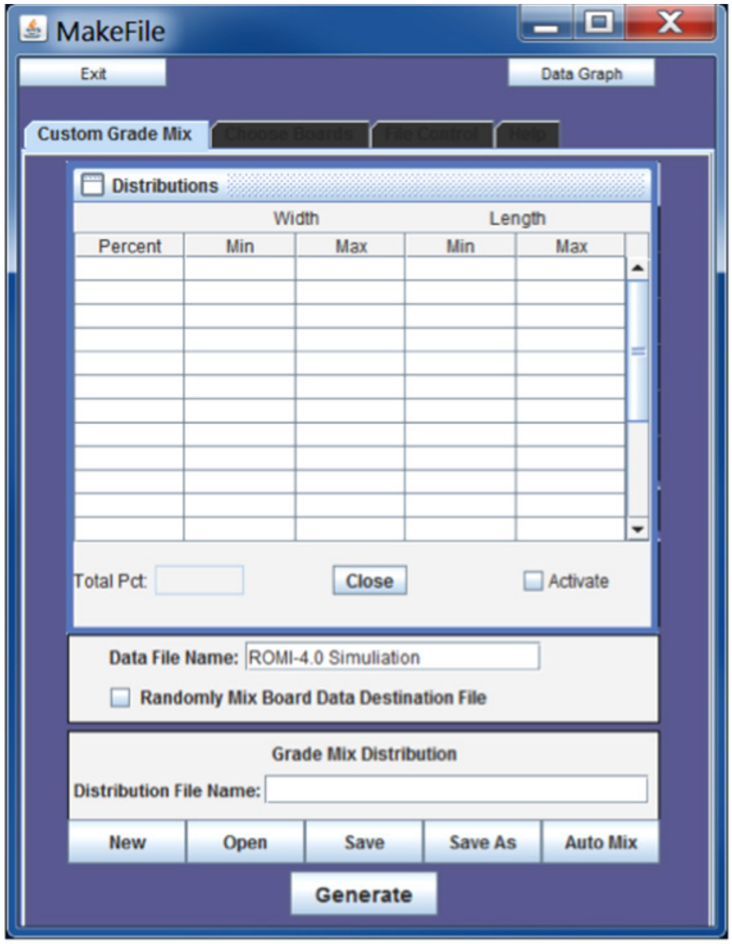


Figure 5.2.3.—Distribution editor window.

Click on the *percent* or *length* and *width* cells to edit them. As you add percentages, you will notice that they will be added and displayed in the Total Pct: box (Fig. 5.2.4). The total must add up to 100 percent. Note that these distributions are a percent of a percentage. Thus, if 30 percent of the sample is No. 1 Common and 20 percent of the No. 1 Common distribution is to be 6 to 7 inches wide, we are referring to 6 percent of the total sample size. Once a distribution has been defined, it must be activated before it can be used. To do this, click the *Activate check box* that will place a check in the box (Fig. 5.2.4).

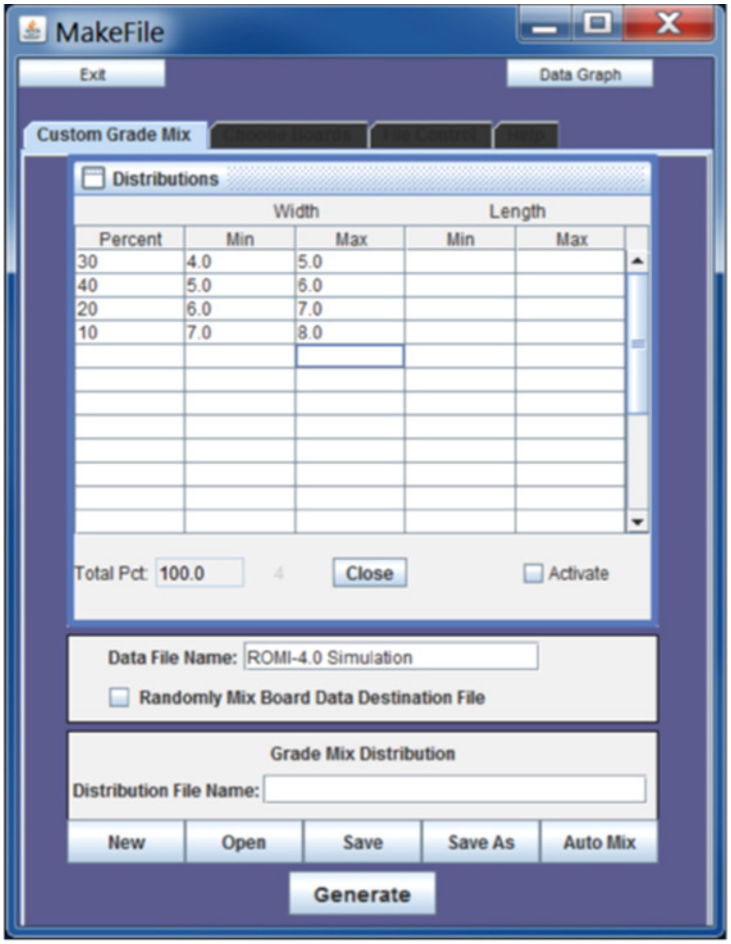


Figure 5.2.4.—Sample data in MakeFile Distribution editor.

If you choose not to use the distribution, simply remove the check from the box. When you are satisfied with your distribution, click *Close* and you will be taken back to the main screen; if you enabled the distribution, the button will now say *Yes* in red. All grades that have a distribution defined will say *Yes* on the button.

You must now enter a name for the data file in the box that says *Data File Name* (Fig. 5.2.2). If you want the boards in the resulting file to be randomly mixed, then put a check in the box next to the Randomly Mix Board Data Destination File label. To create the data file, click on the *Generate* button. Depending on the speed of your computer and the size of the file created, you will see a box that says Generation Successful. Click *OK* and your file will appear in the list of available data files (Fig. 5.2.1). You are now finished creating a data file and can exit the *MakeFile* program or save your grade mix settings. Click the *Save* button to bring up the file selection. Navigate to where you want to save your current settings and click *Save*. You may return to *MakeFile* at any time and open your grade mix by clicking the *Open* button and navigating to the location of your file and opening it. Click *Exit* to close the *MakeFile* program.

5.2.2. Choose Boards

ROMI 4.0 and *MakeFile* give users the ability to create a data file that contains boards from several different data files. If you click the tab at the top of the main window that says *Choose Boards*, you will see the window shown in Figure 5.2.5. You will notice that the left list shows all of the available board data files. A single click on any of the *data files* will open it and display all of the boards in that file (Fig. 5.2.6).

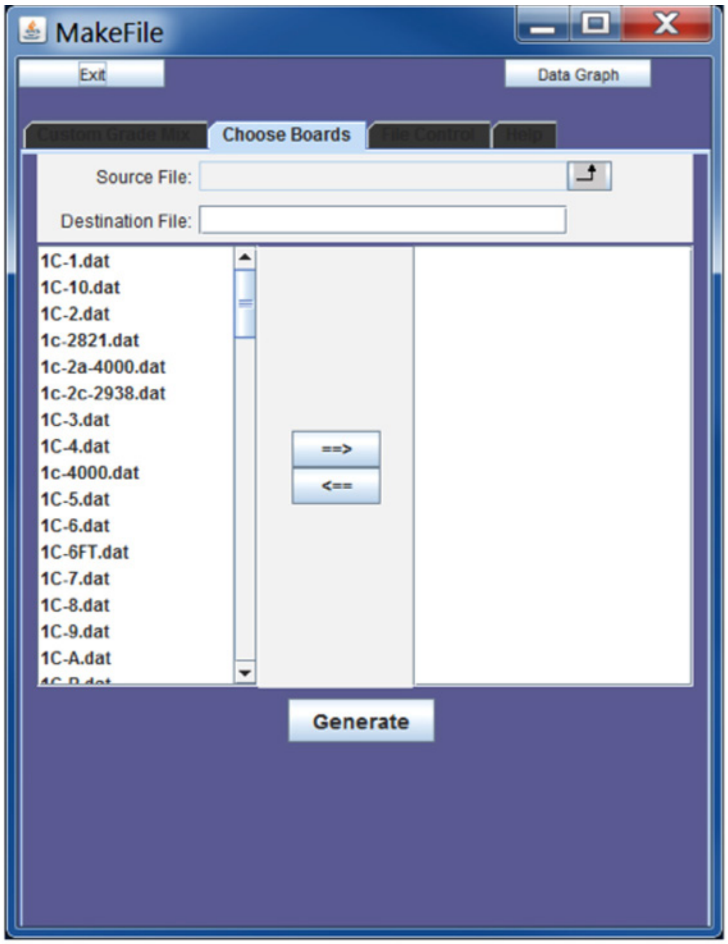


Figure 5.2.5.—Choose boards window.

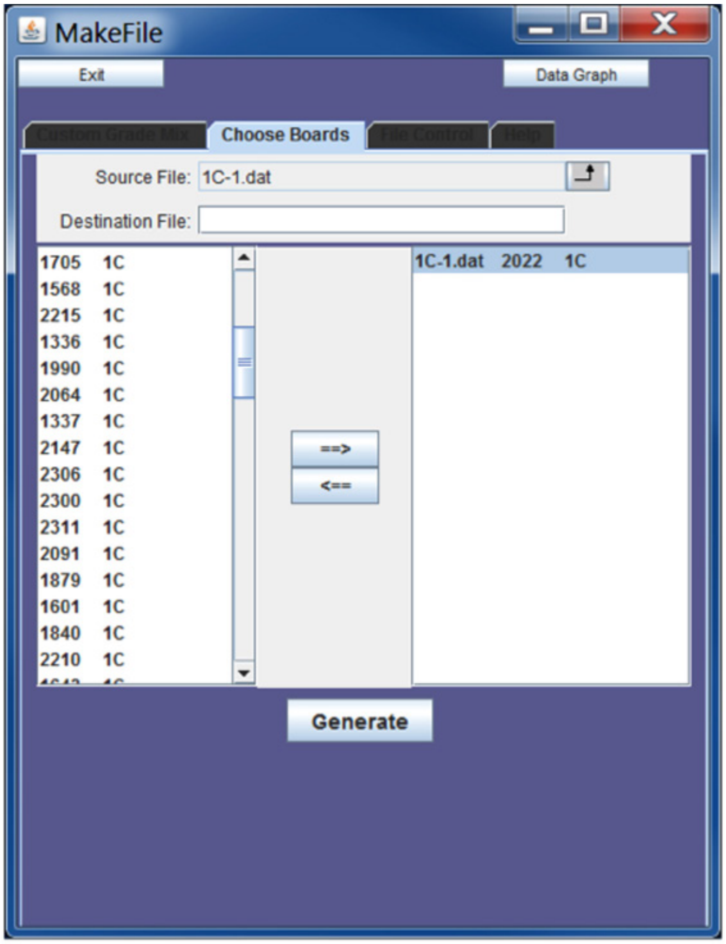


Figure 5.2.6.—Contents of a board data file in Choose Boards window.

As you can see in Figure 5.2.6, the source file name is 1C-1.dat. The left list shows the individual boards and grade in the 1C-1.dat file. To choose a board, you can double click on it or click once and then click the *arrow* button. You also may choose more than one board at a time by clicking a board to highlight it and then hold down *shift* and click another board in the list that will highlight everything in between the two click-selected boards. Now, click the *arrow* button to move them to the board list on the right. To choose multiple boards that are not next to each other in the list, hold down *ctrl* and click each board you want. When you are ready, click the *arrow* button and all selected boards will be placed in the list on the right. You also may use boards from other board data files by clicking the up arrow  beside the source file box. This arrow will take you back to the list of data files. Repeat the process to choose individual boards and the result should be similar to that shown in Figure 5.2.7.

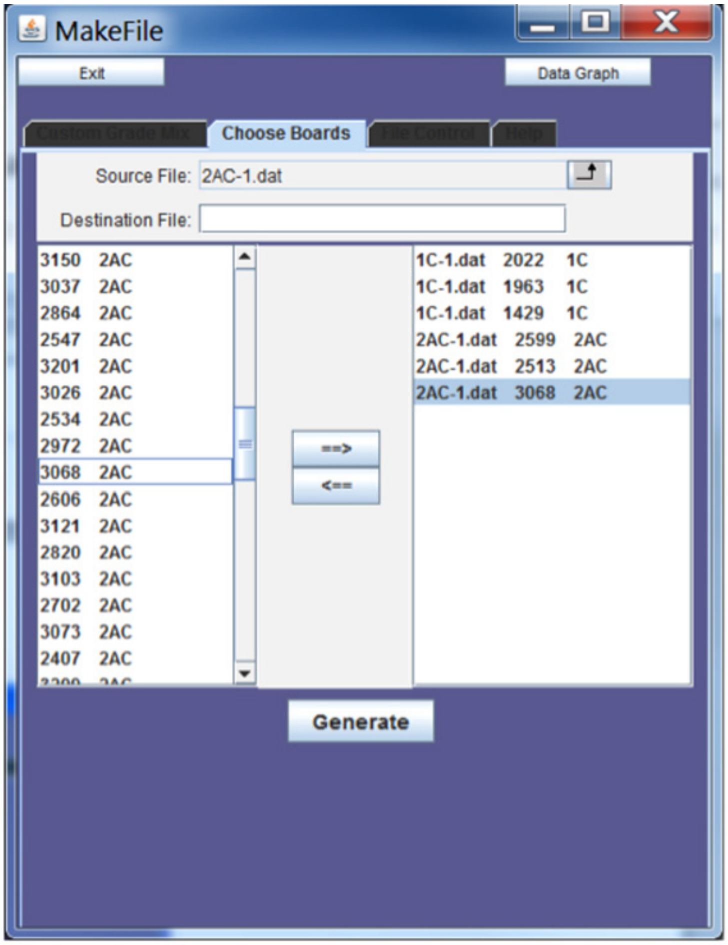


Figure 5.2.7.—Selected boards in Choose Boards window.

Notice that the list on the right also contains the data file name that the boards came from as well as the board number and grade. When you have all of the boards that you want, type a file name in the Destination File box and click *Generate*. Depending on the speed of your computer and the size of the file created, you will see a box that says Generation Successful. Click *OK* and your file will now show up in the list of available data files (Fig. 5.1.1). You have now finished creating your data file and can click the button at the top of the window that says *Exit*.

You also have the ability to see the width class (e.g., the class-wise distribution of widths, rounded to the next inch, Gatchell et al. 1998) over standard length distribution of a chosen board data set by clicking on the *Data Graph* button. Figure 5.2.8 shows the width class of a standard length distribution of a 1 Common board data set based on the 1998 Gatchell database (Gatchell et al. 1998).

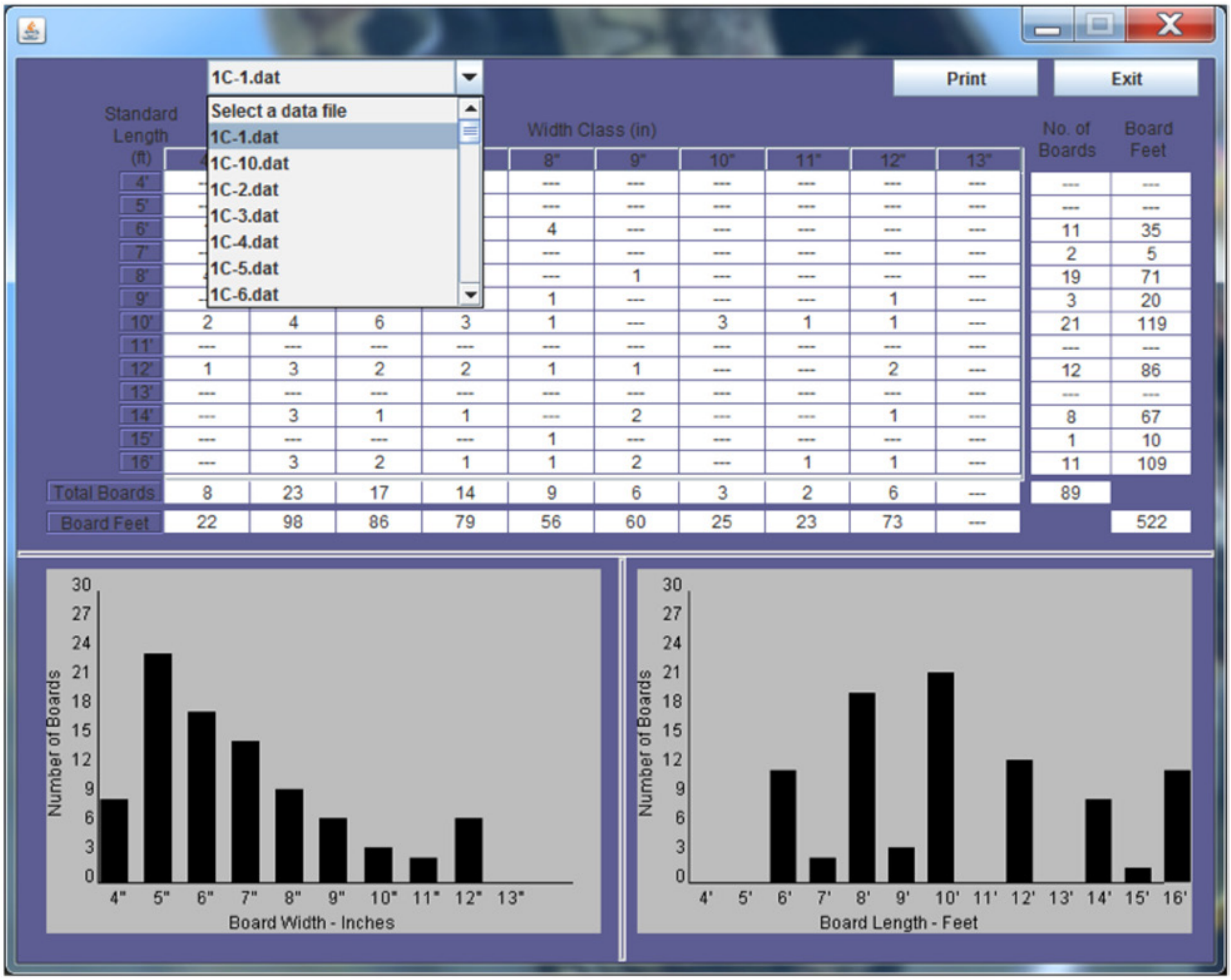


Figure 5.2.8.—Width class of a standard length distribution of a board data set (here 1 Common).

5.2.3. File Control

Clicking the *File Control* tab will show the window in 5.2.9. To delete a file, click the file name to highlight it and click the button that says *Delete*.

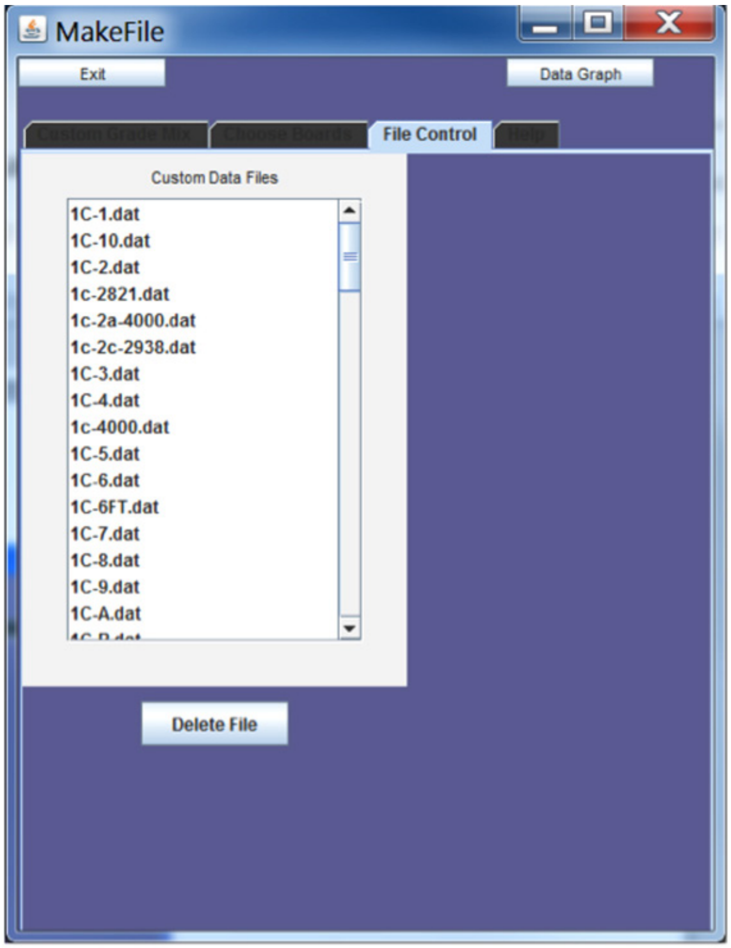


Figure 5.2.9.—File Control window.

6 OUTPUT OPTIONS

6.1 Selecting an Output File

The name of the file in which your output will be stored is listed at the bottom of the screen in the Output File entry box. Figure 6.1.1 indicates that an output file has not yet been selected (no *File Name* insert). Selecting an output file will bring up a window like the one in Figure 4.1.2. You may select where you want to put the file and either enter a name or write over an existing file. When you have the file name that you want, click the *Save As* button.

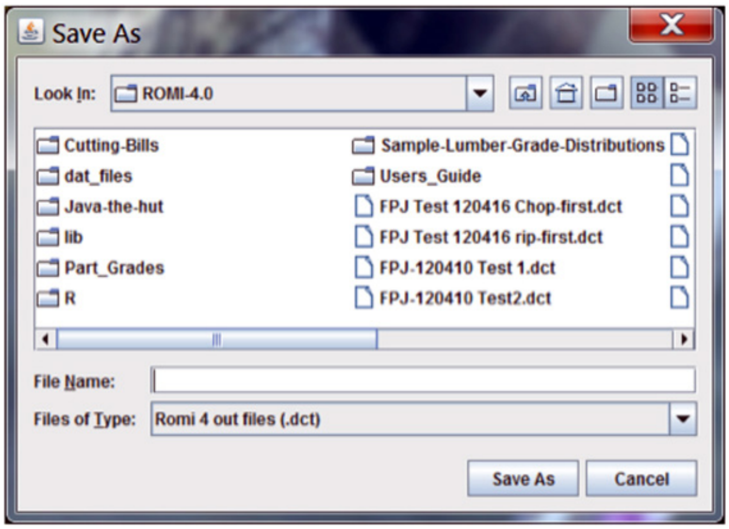


Figure 6.1.1.—Configure Output Options window.

6.2 Thickness Option

Beginning with ROMI 4.0, you can choose between different thicknesses based on the National Hardwood Lumber Association (NHLA 2011) lumber grading guidelines. You have the option to choose among standard thicknesses from $\frac{3}{8}$ inch to $\frac{24}{4}$ inch (Fig. 6.2.1).

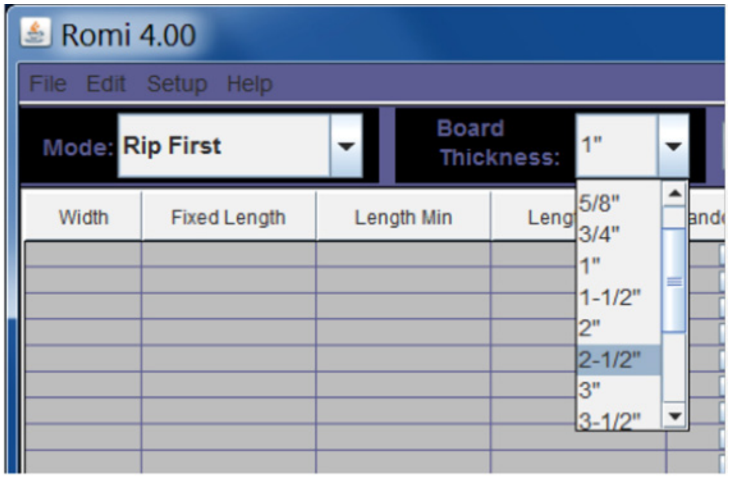


Figure 6.2.1.—Pull down menu of ROMI 4.0 for the thickness option based on NHLA Rules.

The selected board thickness measurement is used by ROMI to adjust the volume of lumber processed. The board data are based on 4⁄4 boards from Gatchell et al.'s (1998) red oak database. Thus, any adjustment other than 4⁄4 thickness is an estimate based on the original 4⁄4 board data contained in Gatchell et al. (1998).

7 STARTING THE ANALYSIS

All the preceding work you have done has been in preparation for this step – producing rough dimension parts from your lumber grade mix using the cutting bill and processing options. The Simulation Checklist (at the right hand side of the main user interface) helps you to see directly and easily which setup parameters have been completed for the simulation. The actual simulation of your input can take from a few minutes to hours to complete depending on the size of your cutting bill, processing options, and computer. In most cases, the simulation analysis is done rather speedily. If a simulation started successfully, the saw blades in the simulation window are moving. If the saw blades are not moving, the simulation did not start and the chosen parameters (sections before) need to be double checked.

7.1 Pre-Run Checking for Errors

Your cutting bill and processing settings are automatically checked for errors before each run. If any errors are found, you will see the error report window shown in Figure 7.1.1. Errors, if any, should be corrected before continuing. If you suspect that something might be wrong with your cutting bill or process settings while you are setting up a simulation, you can manually run error checking at any time. To do this, select *File* from the ROMI 4.0 main window (Fig. 3.2.1) and then press *Check for Errors*.

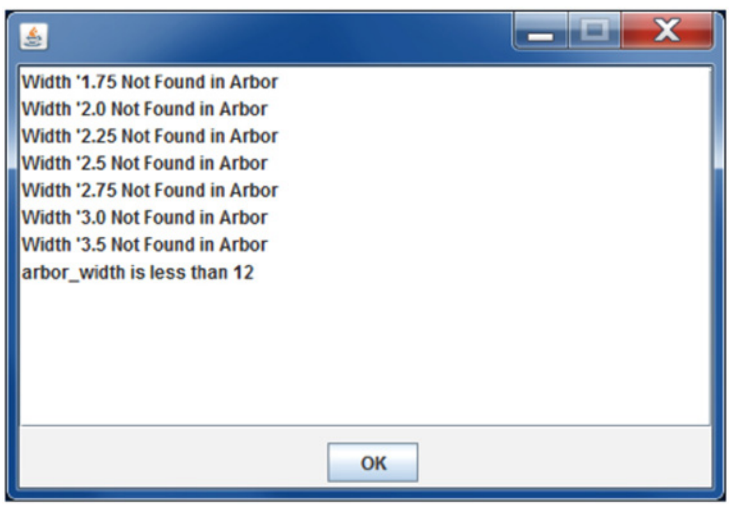


Figure 7.1.1.—Example Error Report window.

There are two ways to run the analysis: interactive or batch. Running the analysis interactively is the easiest way but may tie the computer up for long periods of time. Running the analysis in batch mode is slightly more difficult but allows you to run more than one analysis at a time. Batch mode also allows you to run the analysis at night or when you will be away from your computer.

7.2 Interactive Mode

To start the analysis, click the button labeled *Run* in the main interface window (Fig. 3.2.1). If you failed to select any board data files for processing or have any other errors, ROMI 4.0 will inform you. A processing window will open and list board numbers and dimensions as they are processed. ROMI 4.0 will automatically stop processing when all cutting bill requirements have been met or all boards in the selected data files have been processed (Fig. 7. 2.1.).

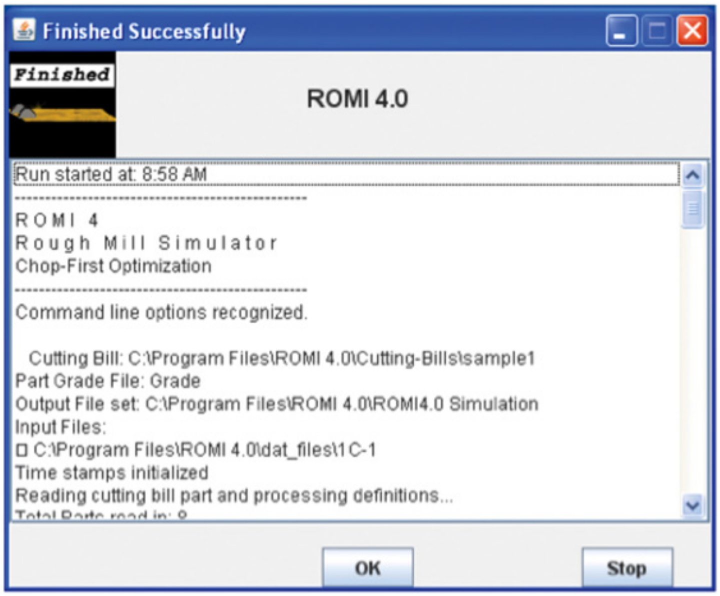


Figure 7. 2.1.—Simulation Run window (Example run).

7.3 Batch Mode

ROMI 4.0. has extensive batch-run capabilities. This feature is useful if you have several large simulations you would like to run overnight. Remember that you should run each cutting bill in interactive mode before running in batch mode to ensure that all settings are adjusted correctly. To start the batch mode editor, click *Setup* from the ROMI 4.0 main interface window (Fig. 3.2.1), then click *Batch Job*, and the window shown in Figure 7.3.1 will open.

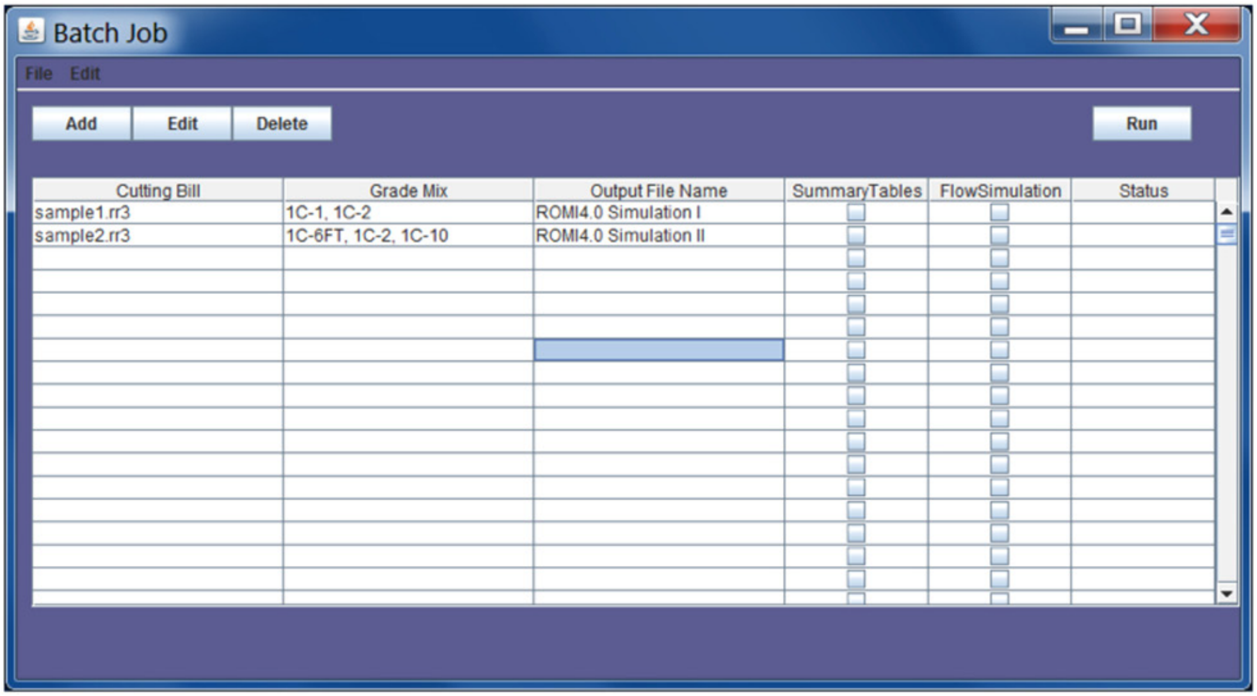


Figure 7.3.1.—Example Batch Job Editor window.

To set up a batch run, click the button labeled *Add.* This will bring up a file selection as shown in Figure 4.1.2. Here you will select your cutting bill files. Next a window will open showing all possible board data files. This window is comparable to the data file selection window in the main ROMI 4.0 users interface. The last window to open will allow you to choose where you want to store the output of the run. You may turn on summary tables, but they must be set up in the main interface first (see Section 8.3).

Click the *Add* button again and repeat the previous steps for additional runs. You need to ensure that the output file names do not get duplicated because this will overwrite your results with the last run. If at any time you need to change the setup, click the desired cell and click the *Edit* button. This will open a new window for that cell that will allow you to change the contents. The *Delete* button is used to remove an entire row from the list. To do this, click the first cell of the row containing the cutting bill name and click the *Delete* button. All of the settings will be adjusted.

Another feature of the batch editor is the ability to copy and paste the cells that already contain data. To use this feature, click on a single cell or highlight a group of cells and click *Edit* on the menu bar and then click *Copy*. Now, click the cell where you want to start pasting and click the *Edit* menu again and click *Paste*. You will now see an exact copy of your data.

The last feature of the batch editor is the ability to save your batch file setup and reopen it at any time. If you want to save your current setup, click *File* then click *Save*. You will now see a file selection window and can navigate to where you want to save your file. The batch files are saved with a .btc extension. When you want to open this file or any other, click *File* and then click *Open*. Your settings will now be displayed in the editor.

To start the batch run, click the *Run* button. You will notice that each cell in the status column (Fig. 7.3.1.) will now contain one of three values: Waiting, Running, or Finished. When all of the runs are done, a window will open telling you that the simulation is complete. Click the *OK* button and you will be back in the editor. Close the editor window and you will be back in the ROMI 4.0 main interface window.

8 SIMULATION RESULTS

8.1 View Simulation Results

ROMI 4.0 provides users with numerous ways to see and analyze results for each simulation. These include summary tables, yields and processing requirements, cutting bill reports, and board plots. The report types are intended to be printed out or examined using the Viewer in ROMI 4.0. To run the Viewer, click the button labeled *View Results* in the main ROMI 4.0 interface (Fig. 3.2.1). Figure 8.1.1 shows the *Viewer* window.

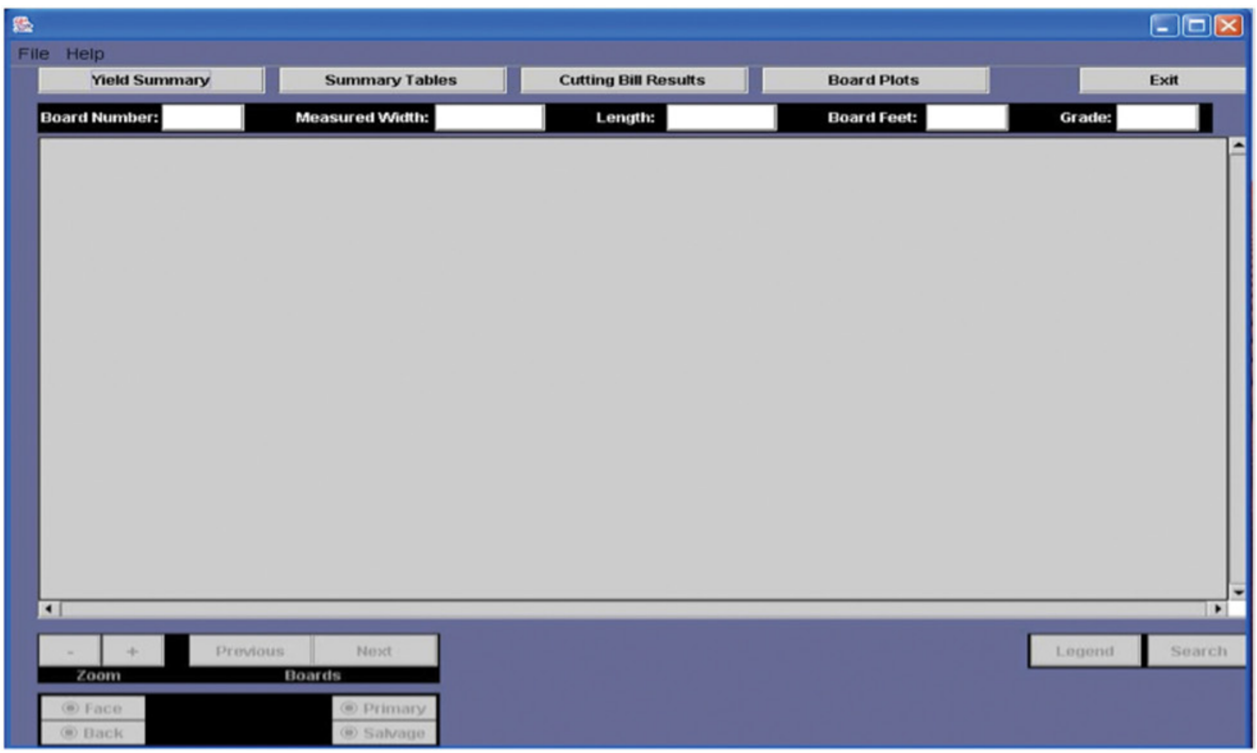


Figure 8.1.1.—Results Viewer main window.

When the viewer is first opened, the screen will be gray until you open a file and select a result type using the buttons at the top of the window (Fig. 8.1.1). To select a results type, click *File* and then click *Open*. You will see a file selection just like the one in Figure 4.1.2. Select the file that contains the ROMI 4.0 output that you wish to view. To view results, select one of the result buttons at the top of the window. When you have finished viewing and printing summaries and board plots, click the *Exit* button to leave the viewer.

8.2 Yield Summary Results

To view yield summary results, click the *Yield Summary* button at the top of the window (Fig. 8.1.1). The first part of the yield report summarizes the processing options used in the analysis. Items such as arbor type, kerf sizes, and prioritization settings are listed. Yield summary tables (Fig. 8.2.1) are displayed after this summary of processing options used.

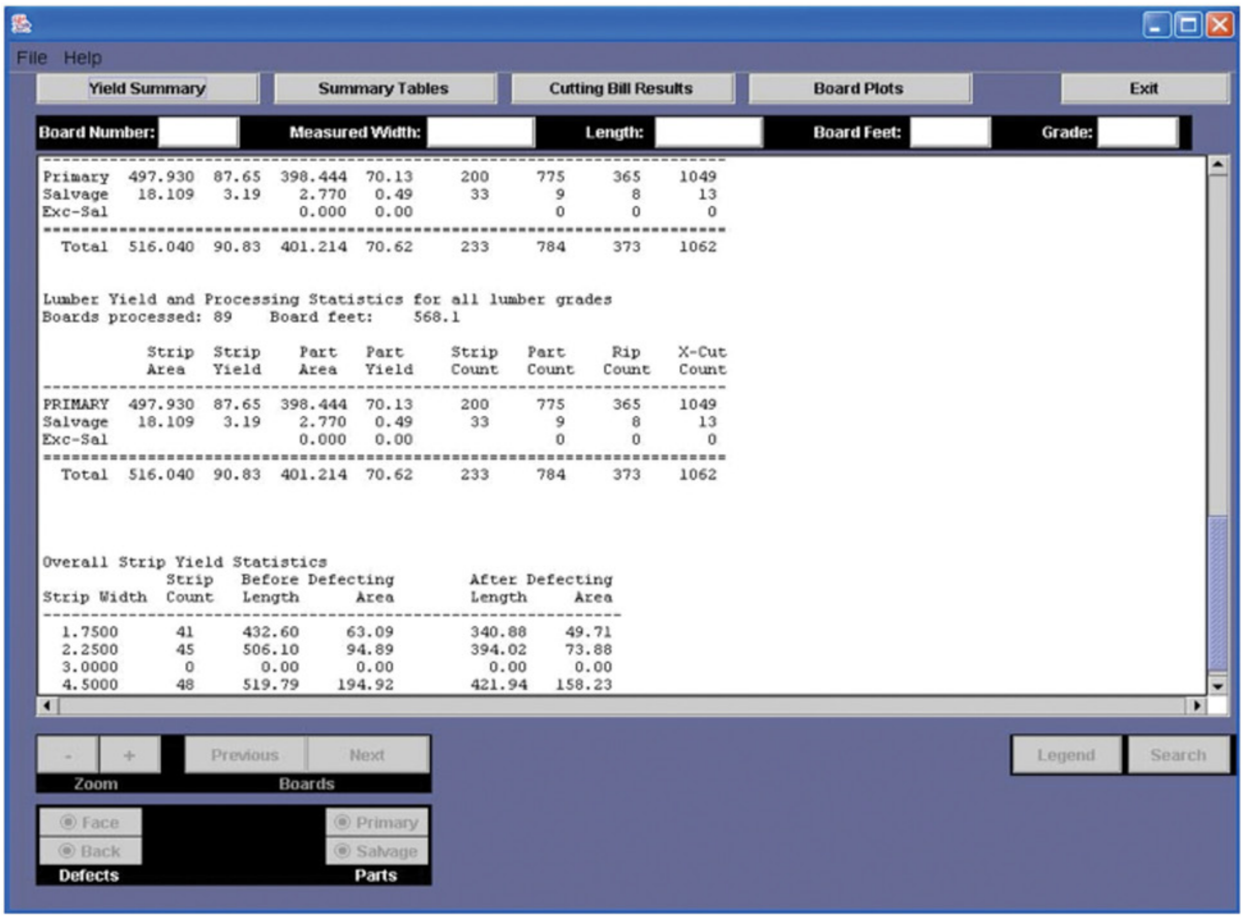
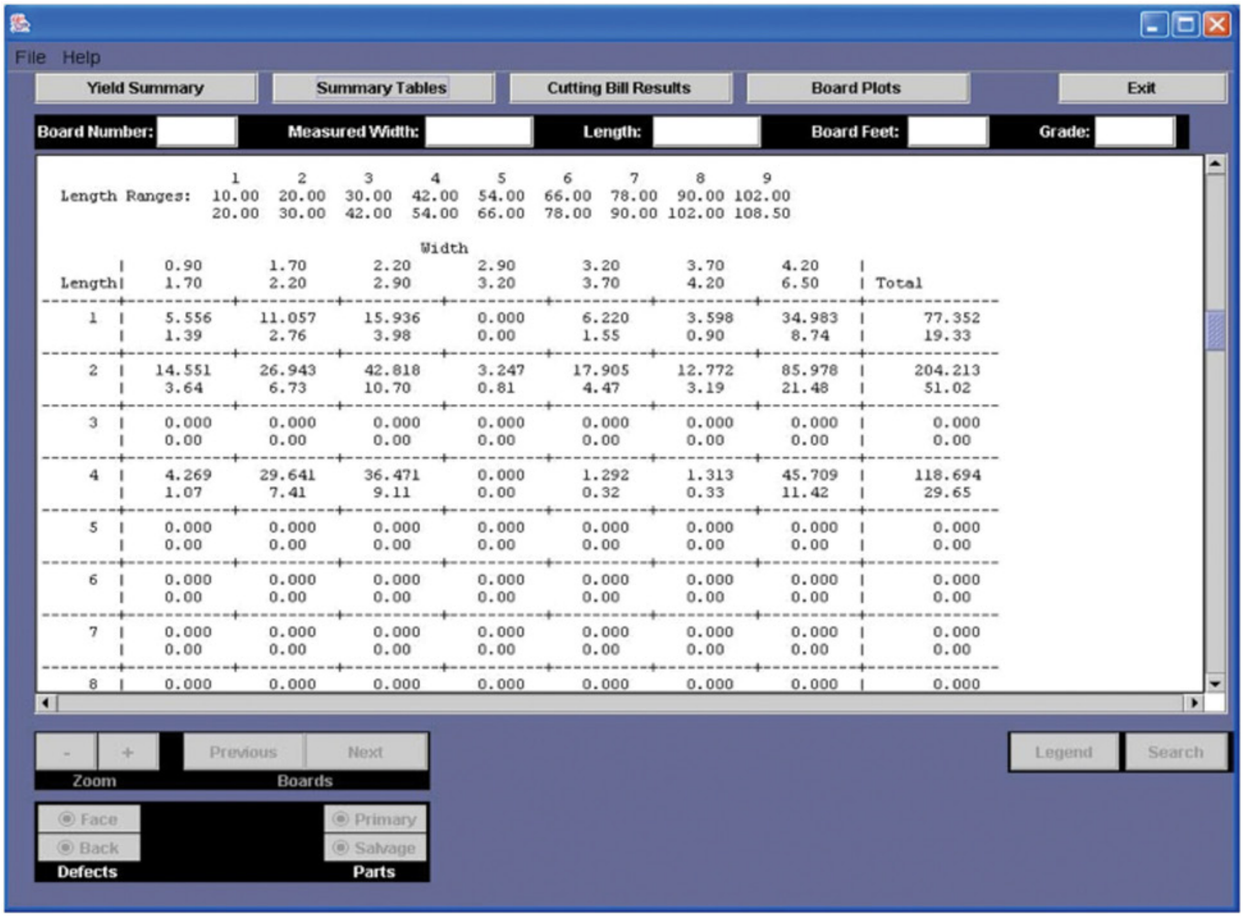


Figure 8.2.1.—Example Yield summary results.

For each grade processed and all grades combined, these tables list the yield and processing requirements (numbers of strips, parts, rips, and crosscuts) for primary, salvage, excess primary, and excess salvage yield categories.

8.3 Summary Table Results

Summary tables provide detailed information on parts and yield. They list the number of parts generated, surface area, and percentage of parts by user-defined width and length groupings. Select *Summary Tables* from the top of the viewer window (Fig. 8.1.1). The first part of the summary table report lists the processing options and yield summaries discussed in Section 8.1. Because summary tables can be large, you may want to print them for easier examination. Select *File* and then click *Print* to print summary table results (Fig. 8.1.1). All summary tables for an input file are placed in a single output file with the .sum extension. Six summary tables describe yield distributions. The first three tables give the distributions based on surface area, and the other summary tables give the distribution based on lumber grades used. A sample summary table is shown in Figure 8.3.1.



Length Ranges:	1	2	3	4	5	6	7	8	9
	10.00 20.00	20.00 30.00	30.00 42.00	42.00 54.00	54.00 66.00	66.00 78.00	78.00 90.00	90.00 102.00	102.00 108.50

Length	Width 0.90 1.70	1.70 2.20	2.20 2.90	2.90 3.20	3.20 3.70	3.70 4.20	4.20 6.50	Total
1	5.556 1.39	11.057 2.76	15.936 3.98	0.000 0.00	6.220 1.55	3.598 0.90	34.983 8.74	77.352 19.33
2	14.551 3.64	26.943 6.73	42.818 10.70	3.247 0.81	17.905 4.47	12.772 3.19	85.978 21.48	204.213 51.02
3	0.000 0.00	0.000 0.00	0.000 0.00	0.000 0.00	0.000 0.00	0.000 0.00	0.000 0.00	0.000 0.00
4	4.269 1.07	29.641 7.41	36.471 9.11	0.000 0.00	1.292 0.32	1.313 0.33	45.709 11.42	118.694 29.65
5	0.000 0.00	0.000 0.00	0.000 0.00	0.000 0.00	0.000 0.00	0.000 0.00	0.000 0.00	0.000 0.00
6	0.000 0.00	0.000 0.00	0.000 0.00	0.000 0.00	0.000 0.00	0.000 0.00	0.000 0.00	0.000 0.00
7	0.000 0.00	0.000 0.00	0.000 0.00	0.000 0.00	0.000 0.00	0.000 0.00	0.000 0.00	0.000 0.00
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Figure 8.3.1.—Example Summary Table results.

In each length-width cell, the upper number is the board feet of surface area and the lower number is the yield percentage. The percentages in all columns sum to 100. The first table is the distribution of total yield. The second and third tables contain the surface-area distributions for the primary and salvage cuttings. The last three tables are based on the number of parts produced. These tables are organized in the same manner as the first three tables. In each length-width cell, the upper number is the part quantity and the lower number is the percentage of total part quantity.

8.4 Cutting Bill Results

The information generated by ROMI 4.0 when processing lumber to meet a cutting bill allows you to analyze the lumber volume, grade mix, and processing required to satisfy cutting bill requirements. Select *Cutting Bill Results* to view or print this type of information. Like summary tables, the first part of the cutting bill results contains processing and yield information. See Section 8.1 for a complete description of this output. Figure 8.4.1 shows a portion of the Cutting Bill Overall Part Quantity Obtained report.

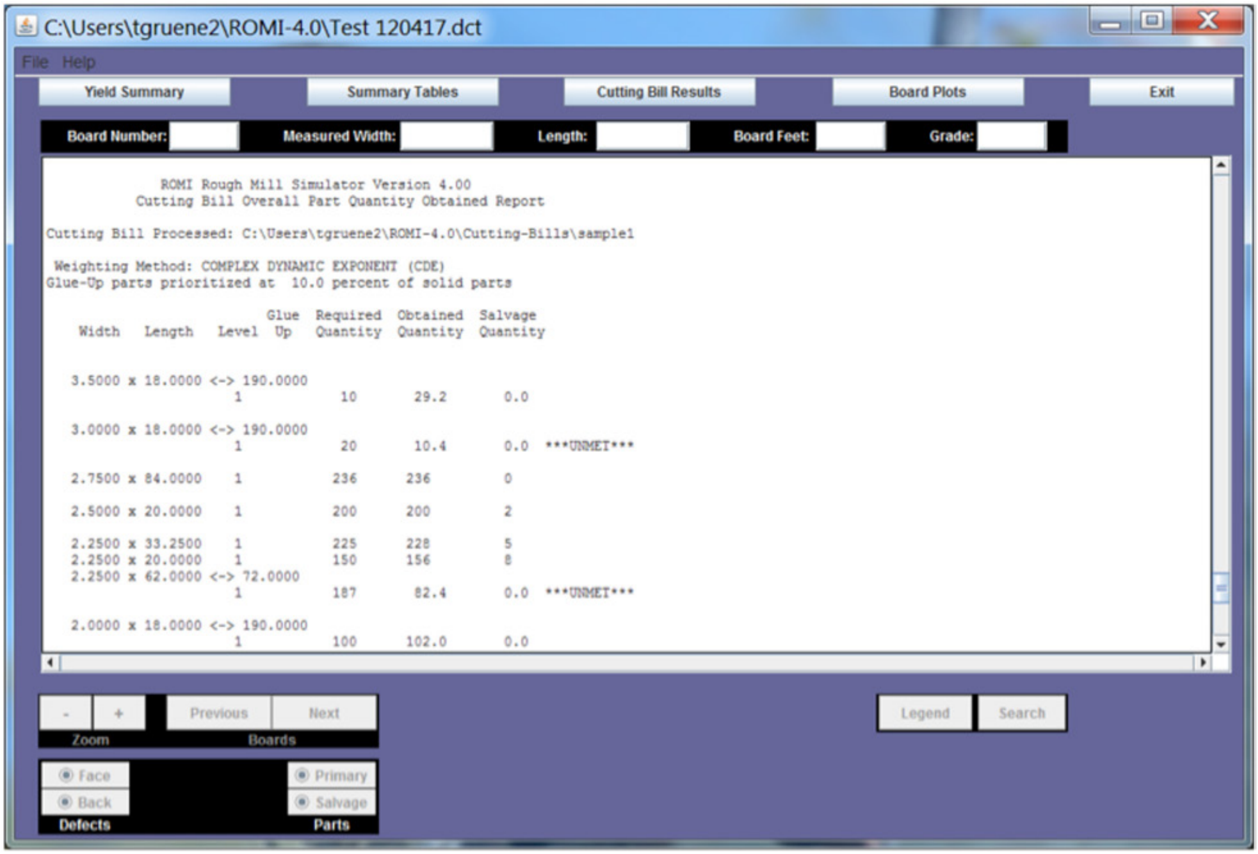


Figure 8.4.1.—Example Cutting Bill results.

The width and length of each part is shown at left of the part listing in Figure 8.4.1. For random-length parts, the minimum and maximum lengths are displayed to the right of the part's width on two lines. The Level column indicates the scheduling and replacement level number for that part. In the simulation performed to create Figure 8.4.1, no scheduling and replacement of parts was chosen, e.g., there are only Level 1 parts. The comment ***UNMET*** in the last column appears when the part quantity requirements of a given cutting bill were not met with the quantity of lumber allocated to this simulation run. In particular, either grade mix or board data input (number of selected board data files) was not large enough to meet all the cutting bill requirements.

8.5 Board Plots

ROMI 4.0 allows you to view or print plots of individual boards along with their parts, defects, and kerfs. The information used to generate board plots is maintained in output files with the extension .PLT. You can view board plots for an entire run or for a selected board. To do this, select *Board Plots* from the top of the viewer program. This brings up the board plot viewer window (Fig. 8.5.1).

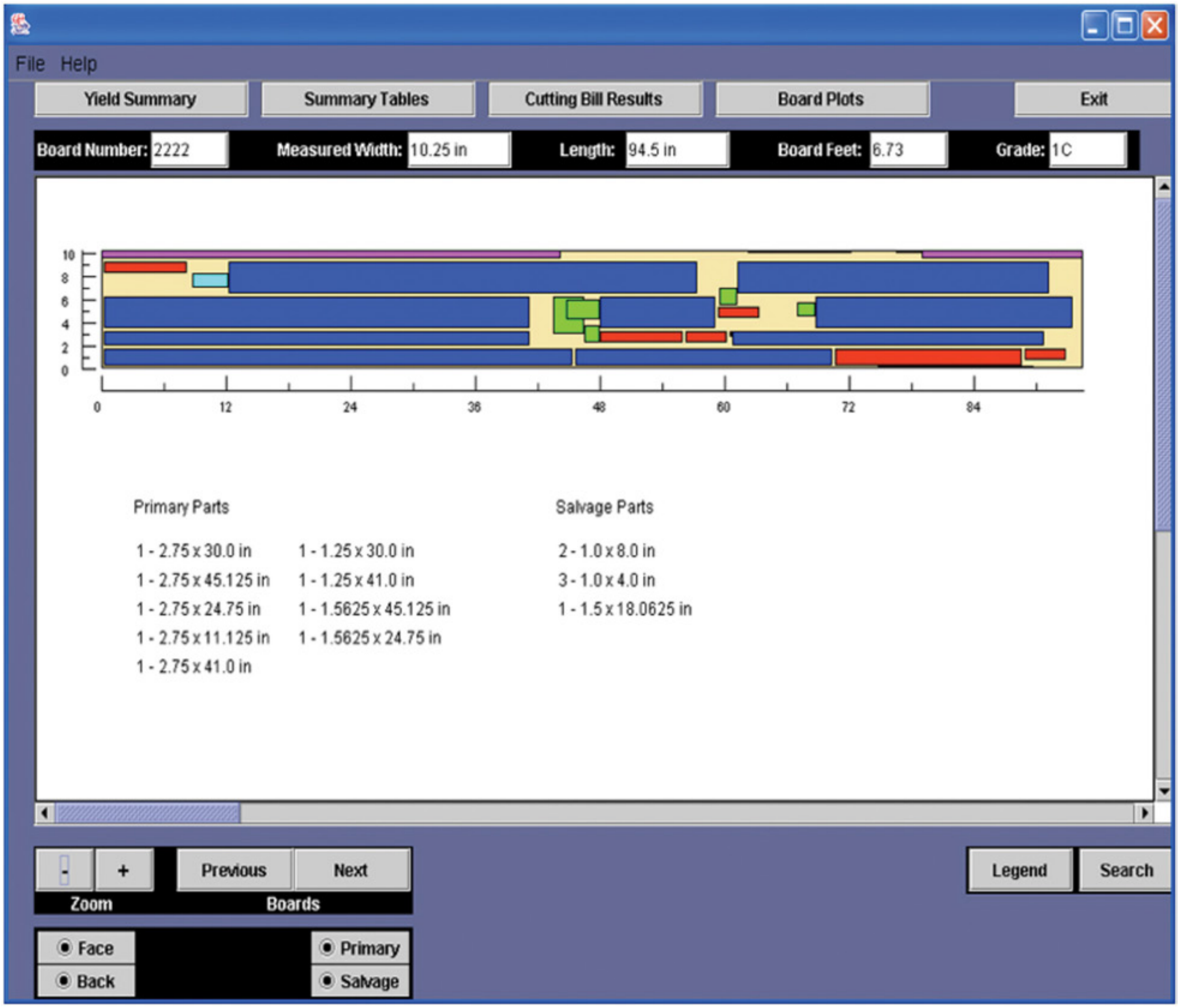


Figure 8.5.1.—Example Board Plots results.

By default, it shows the first board in the file, e.g., the first board processed. Click the *Search* button to choose a board for plotting boards by board number (Fig. 8.5.2).

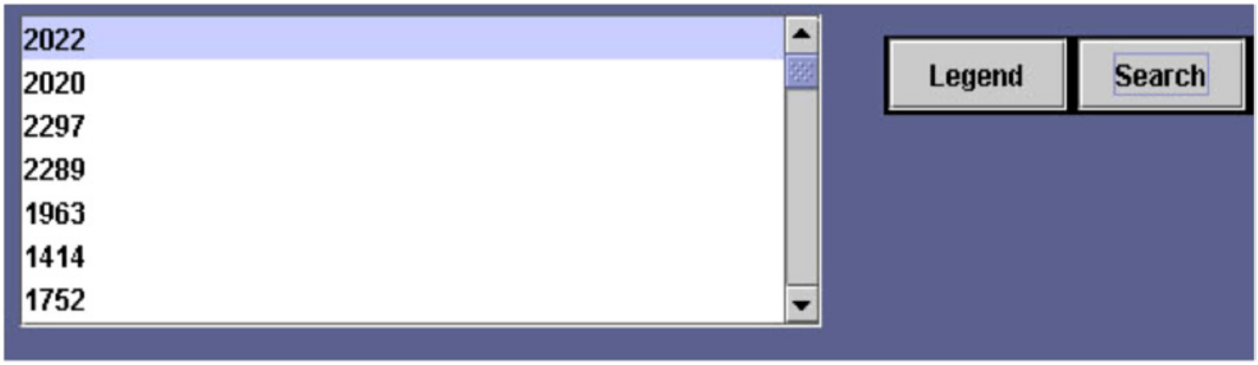


Figure 8.5.2.—Example Board search.

Boards are displayed as if they are transparent with color-coded defects from both sides visible at once. The toggle buttons at the bottom of the screen are to turn the defects for each side and the primary and salvage parts shown on and off. Click the *Legend* button at the bottom of the screen for an explanation of the different defect colors (Fig. 8.5.3).

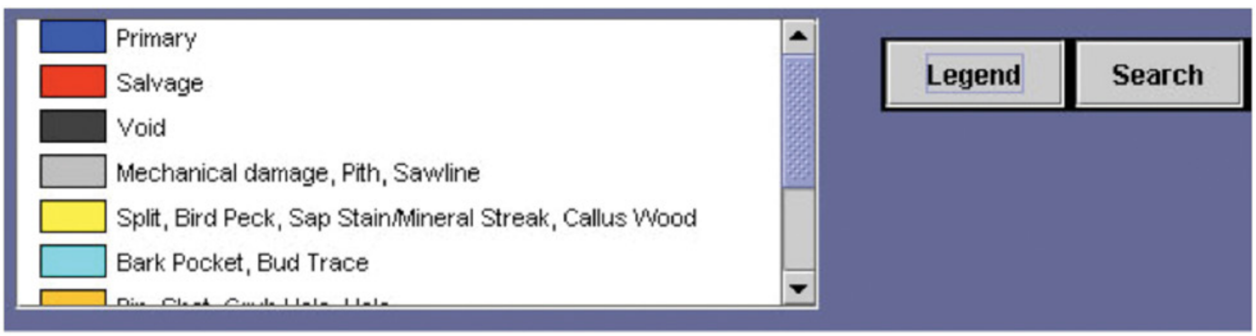


Figure 8.5.3.—Board Plot legend.

Use the plus (+) and minus (-) zoom buttons to reduce or increase the size of the board in the viewer (Fig. 8.5.1). Click the *Next* and *Previous* buttons to see the next or previously viewed board. You may print the current board by clicking *File* and then *Print*. Note that the viewer prints only what is shown in the window. To print an entire board, you must zoom out to make the whole board visible in the viewer. When you are finished, click the *Exit* button to close the viewer.

9 LEAST COST GRADE MIX

The least cost solution determined by ROMI uses the methodology developed by Zou et al. (2004) and Buehlmann et al. (2011). This method is a significant departure from previous methods (Lawson et al. 1996, Schumann 1971, Wodzinski et al. 1966) that assumed a linear relationship between cutting bill yields and lumber grades. As shown by Zou et al., the existence of a linear relationship cannot always be guaranteed. Thus, Zou et al. (2004) created a least cost grade mix calculator that does not rely on a linear relationship between cutting bill yields and lumber grades. The method used by ROMI 4.0 develops a series of yields that are based on the user's equipment settings, optimization settings, cutting bill demands, part grades, lumber costs, and processing costs. In this way, the least cost solution calculated by ROMI 4.0 is tailored to the user's situation.

Previous versions of ROMI's least cost grade mix solver were written using the SAS statistical package (SAS Institute 2002). The current least cost grade mix solution uses *R* statistical software, and all calculations are performed locally on the user's computer (Buck et al. 2010). With the installation of ROMI 4.0 on your computer, the *R* software is installed automatically. *R* does not require an Internet connection to perform the calculations.

9.1 Setup

Clicking the *Least Cost Grade Mix* button in the main ROMI 4.0 interface (Fig. 3.2.1) will open the window shown in Figure 9.1.1.

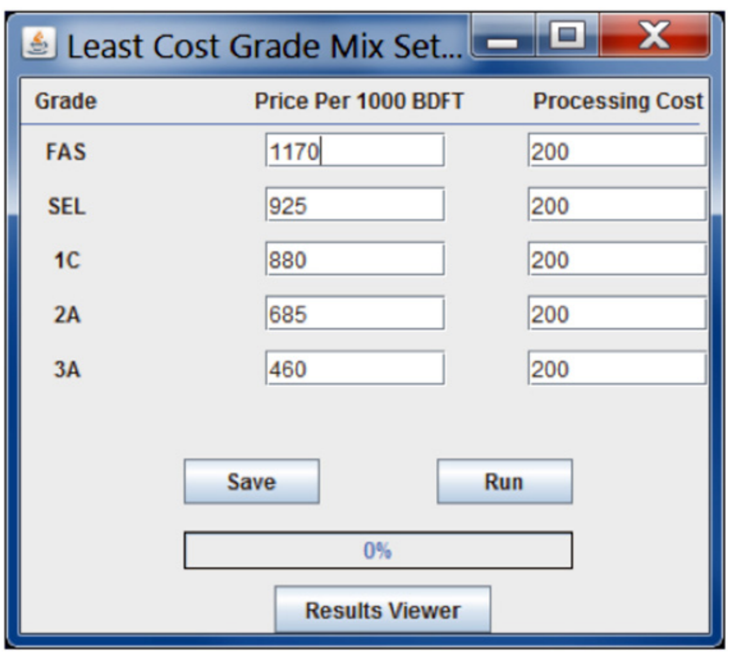


Figure 9.1.1.—Least Cost Grade Mix Setup.

In the Least Cost Grade Mix Setup menu, you may enter the cost of each board grade per 1,000 board feet and the cost to process 1,000 board feet of each grade. Clicking the *Save* button will store the information for later use. Clicking the *Run* button will cause ROMI 4.0 to run the Least Cost Grade Mix simulation. When the simulation is finished, the Least Cost Grade Mix Results window will appear.

9.2 Results

The Least Cost Grade Mix Results window (Fig. 9.2.1) shows the lowest cost grade mix based on the input data by the user.

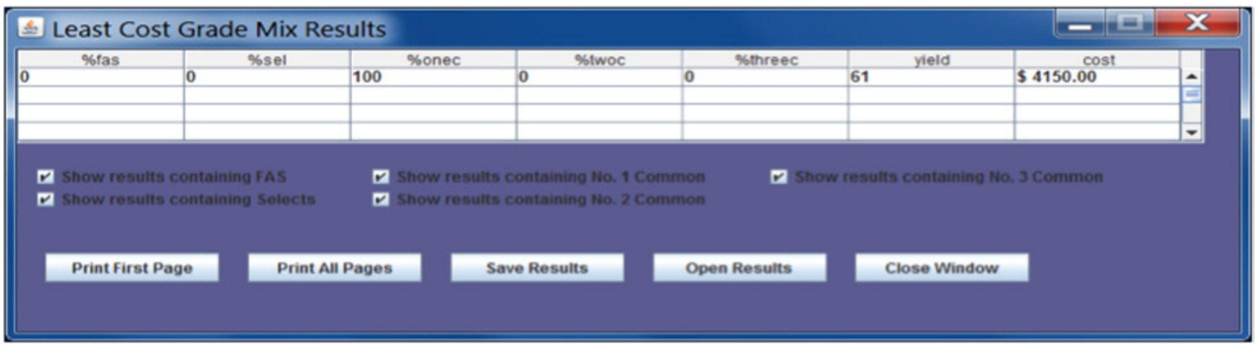


Figure 9.2.1.—Least Cost Grade Mix Results.

If a specific lumber grade is not desired in the results, then click the check box next to the grade and the window will update with the next higher quality grade mix. Save the results of a least cost grade mix for future reference by either clicking the *Save Results* button or clicking *File* and then *Save Results* (Fig. 9.2.2).

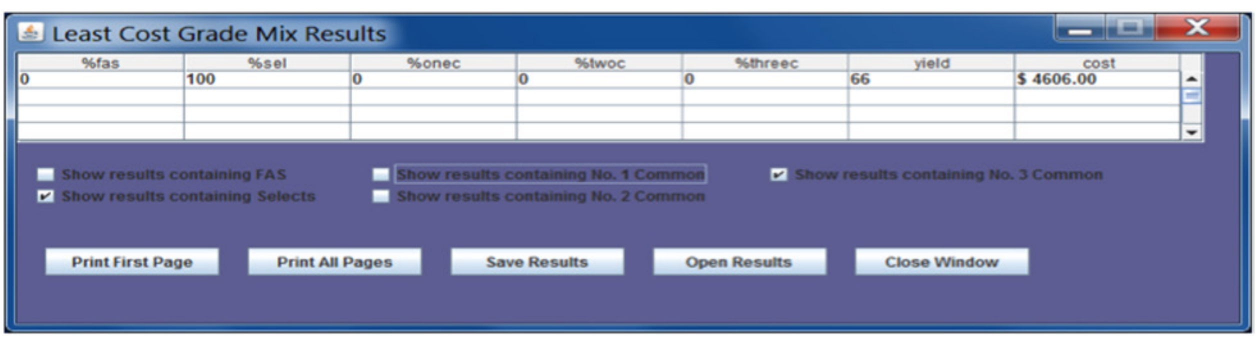


Figure 9.2.2.—Least Cost Grade Mix Results menu options.

The saved results file will be saved with the .lcr file extension. If results are saved, you may open the results viewer at any time and click the *Open* button and use the file selection to locate and open the results file. Clicking the *Print All Results* button or choosing it from the File menu will open a printer dialog and allow you to print the results. Note, the results files may be large and require several pages to print. Close the Least Cost Grade Mix Results window by clicking the *Close Window* button.

10 THE MECHANICS OF ROMI 4.0

This section describes in greater detail how ROMI 4.0 processes lumber to match the demands of a cutting bill. Understanding the elements discussed in this section will allow users to better configure ROMI 4.0, resulting in better simulations of rough mill and processing conditions. The elements of ROMI 4.0 covered in this section include gang-ripsaws, part prioritization, and salvage part processing.

10.1 Gang-Ripsaws

ROMI 4.0 simulates eight types of gang-ripsaws: (1) fixed arbor, (2) fixed arbor with movable outer blade, (3) fixed-blade-best-feed arbor, (4) simple fixed-blade-best-feed, (5) best-spacing-sequence, (6) best-spacing-sequence with movable-outer blade, (7) selective-rip arbor, and (8) all-blades-movable arbor. Unless otherwise specified, all arbors process the board from the right edge to the left edge, with the right edge against the fence (Fig. 10.1.1). When simulating a fixed-arbor saw, the spacings are specified so that the first spacing is closest to the rip fence. The ripsaw kerf is adjustable to 1⁄16 of an inch and the width to 3⁄8 of an inch.

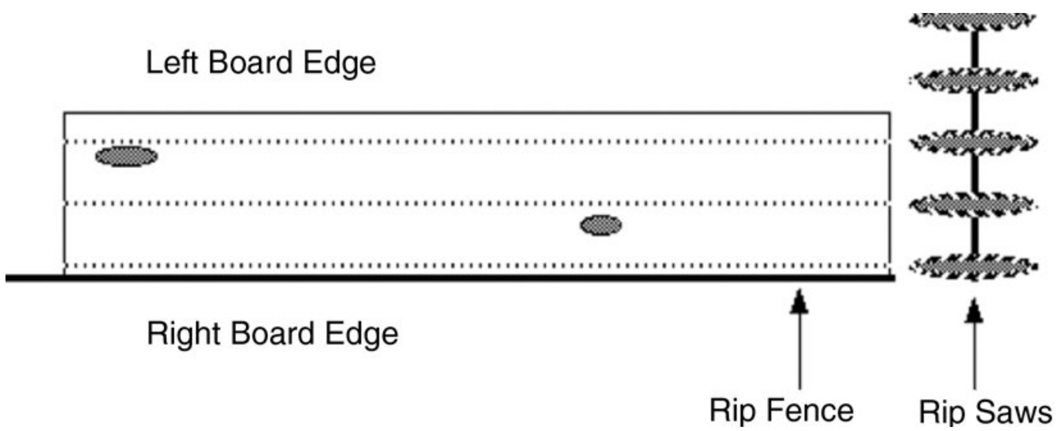


Figure 10.1.1—Rip-fence, board, and arbor relationship.

10.1.1 Fixed Blade Arbors

ROMI 4.0 has five different fixed-blade arbor types: fixed, fixed with movable-outer blade, simple fixed-blade-best-feed, fixed-blade-best-feed, and selective rip. The fixed-blade-best feed arbors simulate currently available optimizing lumber feeding systems. For all five fixed arbor configurations, users specify the saw spacing sequence by specifying as many as 15 spacings. Earlier versions of ROMI-RIP were limited with respect to the number of widths that could be placed on the arbor. ROMI 4.0 allows you to include additional widths not included in the cutting bill that allow optimizing for the productions of widths for panels.

The fixed blade and fixed blade with movable outer blades are the simplest arbors available in ROMI 4.0. These arbors perform no optimization and rip every board with its right edge against the fixed fence. This generates primary width strips and, normally, in the case of the fixed-blade arbor, an edging strip. The movable outer blade variant avoids generating narrow unusable edging strips. When using this arbor, ROMI 4.0 uses the minimum primary part width for making panels and uses that width in deciding when to move the outer saw blade. If the current spacings would generate an edging strip with less than the minimum acceptable primary width, the last blade is moved to the edge of the board and a single, wider, random-width strip is generated.

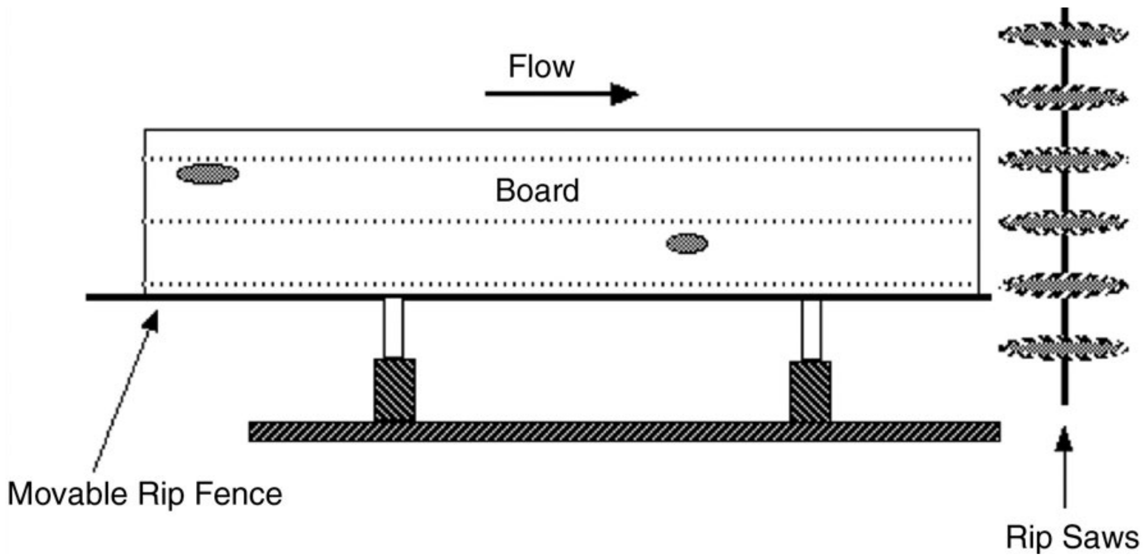


Figure 10.1.2.—Fixed-blade-best-feed arbor layout.

The fixed-blade-best-feed arbors use a movable fence to optimize the placement of the board with respect to the saw blades on the arbor. Figure 10.1.2 shows the layout of the fixed-blade-best-feed arbors. The simple fixed-blade-best-feed arbor optimizes for the fitting of strip widths within each board to maximize the accumulated width of the strips and minimize the production of edgings. The regular fixed-blade-best-feed arbor optimizes for the production of strips that will generate the highest prioritized value of parts as required by the cutting bill. In general, the simple fixed-blade-best-feed arbor obtains lower yields and requires more board footage to satisfy cutting bill requirements than does the regular fixed-blade-best-feed arbor.

The selective-rip arbor models industrial selective-rip gang-ripsaws that are currently available. As with the other fixed-blade ripsaws, users specify the sequence of widths on the arbor. In addition, you select which saw blades are allowed to move on the arbor. There are two restrictions to the movement of saw blades: (1) movable saw blades cannot be adjacent, and (2) a movable saw blade can move no closer than 0.75 inch to another saw blade. The restriction in movement is due to the collars on the arbor that hold the saw blades. In general, the selective rip arbor achieves the highest yield of any of the fixed-blade arbor variants. However, the higher yield comes at the cost of greater optimization and increased simulation processing time.

10.1.2 Best-Spacing-Sequence Arbors

The best-spacing-sequence arbors optimize the sequence of the saw spacings. The spacings are selected so that widths with the greatest prioritized value of needed primary cuttings are generated. See Section 10.2 for information on how part priorities are determined and how they impact the parts selected to be cut from each board.

The optimal placement of the saw spacings along an arbor is determined by an exhaustive search. Every possible combination of spacings is examined for each board. The actual number of spacings used is determined by an interaction between the board width and the specified cutting widths.

The best-spacing-sequence arbor with movable-outer blade operates much like the best-spacing-sequence arbor discussed above. A movable-outer blade is added to minimize edging strips. This arbor assumes that random pieces are acceptable. An additional strip width, narrower than all the primary widths, is specified (see Section 4.2.6) and represents the minimum width acceptable for gluing into panels. After ROMI 4.0 determines the best-spacing sequence, the remainder of the board is examined. If the remainder meets or exceeds the additional narrow strip width, the processing continues. If it is narrower, the last specified width is not taken. Then the last saw blade is moved to the outer edge of the board and a wider random width strip is sawn.

10.1.3 All-Blades-Movable Arbor

The all-blades-movable arbor is uniquely different from all other arbors that have at least one fixed-saw spacing. Because there is no preset width, the saw spacings are usually set by the amount of the highest priority cuttings that can be obtained. These will usually be the widest and longest cuttings. In addition, a new “null” saw spacing is added to enable the saw to box in defects into narrow waste strips anywhere on the board face. For example, a board containing a large amount of pith and associated small knots along the middle of the board could use a null strip to box in the defects. The inclusion of null strips usually will result in wider strips that contain fewer defects. Null widths from 0.75 inch to 2.5 inches can be generated depending on the maximum yield of primary cuttings and board characteristics.

Simulating the all-blades-movable arbor is similar to the best-spacing-sequence arbors discussed in Section 10.1.2. The only difference is that spacer widths are added to the primary widths to allow for the creation of null spacings. Spacer widths determine the possible random width distances between the fixed width primary strips. Three space widths—0.75, 1, and 1.25 inch—are used to simulate all possible random width null spacings greater than 0.75 inch. To limit the number of combinations that have to be examined, the maximum null spacing is 2.5 inches and the minimum spacing between saws is 0.75 inch. The 0.75 inch minimum spacing is based on the fact that most currently available selective-rip gang-rip saws with movable-blade arbors can move saws no closer than 0.75 inch.

10.1.4 Optimizing Arbor Comparison

Each of the five optimizing arbors (best-spacing-sequence, fixed-blade-best-feed, simple fixed-blade-best-feed, selective-rip, and all-blades-movable) have different optimizing characteristics and give different yields. For the comparison, a 2A Common board (#3159 measuring 9 inches x 96.5 inches with 6 board feet) was sawn using the different arbors. Figure 10.1.3 shows the different gang-rip solutions for board 3159 given the different arbor types. Table 1 shows the cutting bill used for these examples. The CDE prioritization strategy was used to prioritize parts during processing. Table 2 summarizes the volumes of parts and percent yields obtained from the sample board for each optimizing arbor. Figure 10.1.3 shows the rip and chop solution for each of the optimizing arbors.

Table 1.—Cutting bill used to process sample board 3159 shown in Figure 10.1.3

Width	Length	Quantity
Inches	*Inches*	*Number*
4	58	200
4	18	400
4	14	100
4	8	50
2.75	52	200
2.75	41.5	150
2.75	34	100
2.75	22	125
2.75	20	150
2.75	18	50
2.75	14	150
2.75	8	100
12 (panel)	24	50
10 (panel)	20	50

Table 2.—Optimizing arbor part volume and yield comparison for 2AC board 3159

	Primary		Salvage		Total	
Arbor Type	Part volume	Yield	Part volume	Yield	Part volume	Yield
	Board feet	*Percent*	*Board feet*	*Percent*	*Board feet*	*Percent*
Best-Spacing-Sequence	3.65	60.83	0.23	3.83	3.88	64.67
Fixed-Blade-Best-Feed	4.11	68.50	0.00	0.00	4.11	68.50
SimpleFixed-Blade-Best-Feed	4.22	70.33	0.00	0.00	4.22	70.33
Selective-Rip	3.97	66.17	0.23	3.83	4.20	70.00
All-Blades-Movable	3.97	66.17	0.23	3.83	4.20	70.00

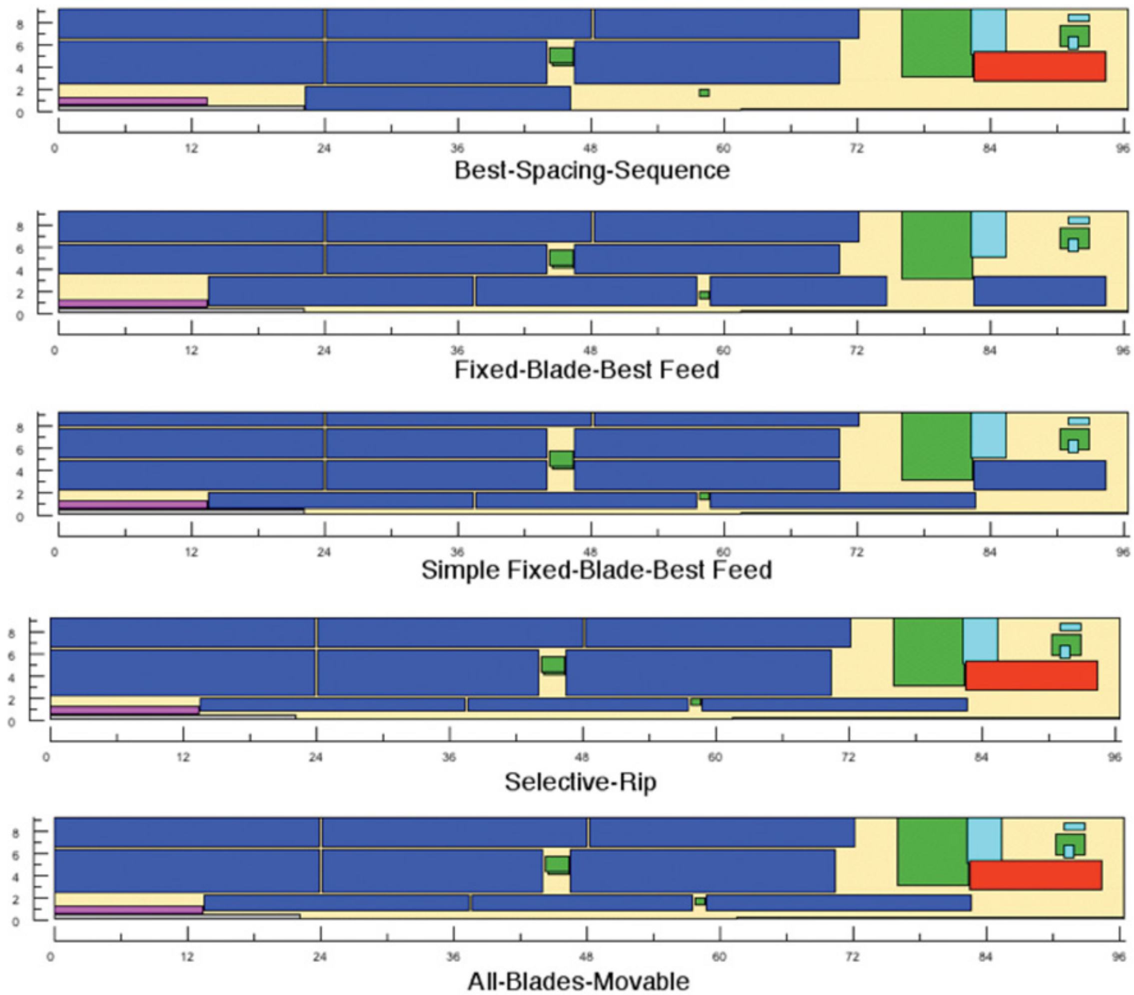


Figure 10.1.3.—Sample board sawn using, from top to bottom, the best-spacing-sequence,fixed-blade-best-feed, simple fixed-blade-best-feed, selective-rip, and all-blades-movable-arbors.

Overall, the best-spacing-sequence arbor obtained the lowest yield of all the optimizing arbors examined. However, like the movable blade arbors, the best-spacing-sequence arbor was able to obtain the wider 4.0-inch-wide parts. Because these wide parts can be difficult to obtain using 2A Common, this solution is desirable.

The fixed-blade-best-feed (FBBF) arbor obtained the second highest yield with the simple fixed-blade-best-feed (SFBBF) arbor achieving the highest yield. The simulated hardware of these two arbors are identical; the only difference is how the cutting solution is optimized. While the SFBBF arbor achieved higher yield, it does not consider cutting bill requirements when it makes its optimization decision it considers only optimizing the accumulated width of cuttings within the board. Therefore, toward the end of processing, when some widths are no longer required, the SFBBF arbor may have difficulties obtaining strip widths that are still needed. The FBBF arbor does not have this problem because it cuts according to remaining priorities.

The selective-rip arbor starts with the optimal spacing arrangement used by the FBBF and SFBBF arbors, but is allowed to move user-specified spacings to obtain difficult to obtain part sizes and to maximize yield and cutting opportunities. The all-blades-movable (ABM) arbor simply moves all blades and has the advantages of the selective-rip arbor but with greater flexibility. The selective-rip and ABM arbors are tied in achieving the third highest yield of all the optimizing arbors. The solutions from the two arbors are identical for this board due to similarities in the simulated hardware and optimizing methods. The solutions from both arbors returned wider, more valuable, and more difficult to obtain parts than did the FBBF and SFBBF arbors.

10.1.5 Optimizing Fixed-Blade Saw Spacing Sequences

One industry expert is quoted as saying that, “There are thousands of ways to arrange a few different saw spacings. Most are poor and unrealistic…” (Gatchell 1996, p.37). Successfully optimizing the sequence of fixed-blade saw spacings requires that you know the width distribution of the lumber to be processed and the volume of finished parts required in each part width. In addition, you need to recognize that an arbor is not just a sequence of spacings, but a sequence of combinations that overlap and interact (Gatchell 1996). The publication Designing a Fixed-Blade Gang Ripsaw Arbor with a Pencil (Gatchell 1996) explains how to easily design arbors that are near optimal, if not optimal.

The fixed-blade arbor optimization tool included with ROMI 4.0 automates the method designed by Gatchell (1996). ROMI 4.0 makes a single optimization run with the user-specified cutting bill and lumber data using the best-spacing-sequence arbor. Recall that this arbor generates for each board the optimal fixed-blade saw spacing sequence. As ROMI 4.0 processes boards, it remembers the set of saw spacing sequences. The sequences not only show the optimal solution for each board, but also represent the interaction between board widths and cutting bill width requirements. For example, part widths that have higher requirements are used more often and appear in the set of sequences more frequently.

ROMI 4.0 sorts and summarizes the set of saw spacing sequences and begins building the arbor with the saw spacing sequence that is used most often. The optimizer adds sequences to the arbor such that the interaction between the spacings provides the most optimal combination and does not repeat any existing combination. For more information on how to run the ROMI 4.0 arbor optimizer, see Section 4.2.5.

10.2 Part Prioritization

Interactions among length, width, and quality of boards and parts are critical to efficient processing. The goal is to cut only needed parts from as little lumber as possible, while minimizing the production of “orphan” parts. Longer and wider parts are more difficult to obtain from the lower grades. Also, lumber quality varies from board to board within a lumber grade. To solve these problems, a method is needed to prioritize the parts so that the simulator can make a decision on which part size to cut.

ROMI 4.0 allows you to select one of several part-prioritizing strategies based on area, dollar value, or automatically assigned parts values using one of ROMI 4.0's dynamic strategies. The goal of these strategies is to meet all of a cutting bill's required cuttings while using the least amount of lumber. Value-based and area-based strategies are included because they are widely used and might still simulate some rough mills. Although these methods are static in nature (the first and last pieces cut for a part size have the same priority), we have included a simple modifier for each that will make them somewhat dynamic. However, the recommended strategy is the dynamic exponent method.

10.2.1 Value-based Part Prioritizing

ROMI 4.0 contains two value-based part-prioritization strategies: *Part Value* and *Dynamic Part Value*. *Part Value* is similar to strategies used in earlier rough mill simulations such as CORY (Brunner et al. 1987). With part valuing, each part size is assigned a value. The decision, which parts get a higher dynamic part value, is determined by the user. Normally, parts that are needed more are given a higher value. Smaller part sizes are given a lower value. Obviously, very different results can be obtained by using different part values. In reality, the values assigned to the different part sizes may or may not reflect the actual value of the part. The simulation is dependent on your assumptions about parts' values.

Most dollar valuation systems cannot consider the part quantities needed. If a part is valued high at the beginning of processing, it will have the same high value at the end of processing even if the required number of cuttings is met shortly after processing begins. A better solution is to decrease the value of the part as its requirements are met (DYNAMIC PART VALUE). This shifts emphasis from quantity requirements for parts that are nearly satisfied to those that are not being met. If the required quantity for a part size is **N**, the value of the part is reduced **1/N** each time a part is cut. For example, if you value a part size at $1.00 and require 50 of them, cutting one part of this size will reduce the value of the next part to $0.98.

10.2.2 Area-Based Part Prioritizing

ROMI 4.0 contains three part-prioritization strategies based on part area: AREA, L2W, and L2W x NEED. AREA part prioritization equally prioritizes the width and length of parts and is the true yield optimization prioritization mode. Thus, the highest overall yield can be expected when using this method. However, because it places no emphasis on wider or longer parts, it is likely to prioritize parts inconsistent with the demands of the cutting bill. The L2W strategy is the same formula found in Thomas' YIELD program (Thomas 1962), Brunner's CORY (Brunner et al. 1987), and the Forest Products Lab's YIELD program (Wodzinski and Hahm 1966). L2W builds in a preference for longer cuttings and is more likely to correspond to cutting bill requirements. It does not, however, consider part quantity.

Cutting bills where the numbers of different parts vary greatly are difficult to analyze. A simple improvement to the L2W formula is L2W x NEED (Thomas 1996). L2W multiplied by NEED, the current number of parts required for a particular part size, results in a L2W strategy that is sensitive to quantity demands. Overall performance is improved. As a part is cut, the need for that part size is decreased by one. The L2W x NEED strategy can be regarded as a simple dynamic strategy.

10.2.3 Dynamic Part Prioritizing

Dynamic part-prioritizing strategies seek to overcome many of the problems associated with dollar-based or area-based strategies. Dynamic strategies are distinguished from others by the ability to reduce priorities as part requirements are met. Rather than depend on part size alone or on an operator's judgment about which values to assign to different part sizes, dynamic strategies assign each part size a priority based on its size and quantity needed. This allows cutting preference to shift from parts with low quantities to those that require a higher quantity.

ROMI 4.0's dynamic strategies calculate exponential weighing factors that are based on the needed quantity of a part size. These exponential factors typically range in value from 1.0 to 3.2, depending on the needed quantity of the part size. ROMI 4.0 allows you to pick from one of two exponential part-prioritizing strategies: Simple Dynamic Exponent (SDE) or Complex Dynamic Exponent (CDE). As the name implies, CDE considers more information about the cutting bill's current requirements than SDE when assigning part priorities. For example, CDE is sensitive not only to how many parts are currently needed for each size, but also to how many have been cut. This sensitivity is useful when a cutting bill contains large parts with relatively small quantities needed. Because large parts will be harder to obtain, using only a quantity-based exponential weighting factor, these parts may not be given high enough priority to be obtained opportunistically. CDE increases the priority of such parts so that they can be obtained at earlier, more opportune times in processing.

CDE and SDE should not be confused with dynamic variants of the value-based and area-based strategies. The simplistic dynamic value and area strategies mentioned earlier reduce their priorities linearly; CDE and SDE reductions are exponential. A major drawback to linear reductions is that the priority of a part is reduced much more rapidly than with the exponential method (Fig. 10.2.1). The key advantage of the CDE and SDE strategies is that they maintain priority levels until most of the required cuttings for the part have been obtained. Figure 10.2.1 shows a comparison between the linear dynamic area strategy and the exponential CDE strategy. A full discussion of the evolution of the dynamic prioritizing strategies is found in Prioritizing Parts from Cutting Bills when Gang Ripping First (Thomas 1996).

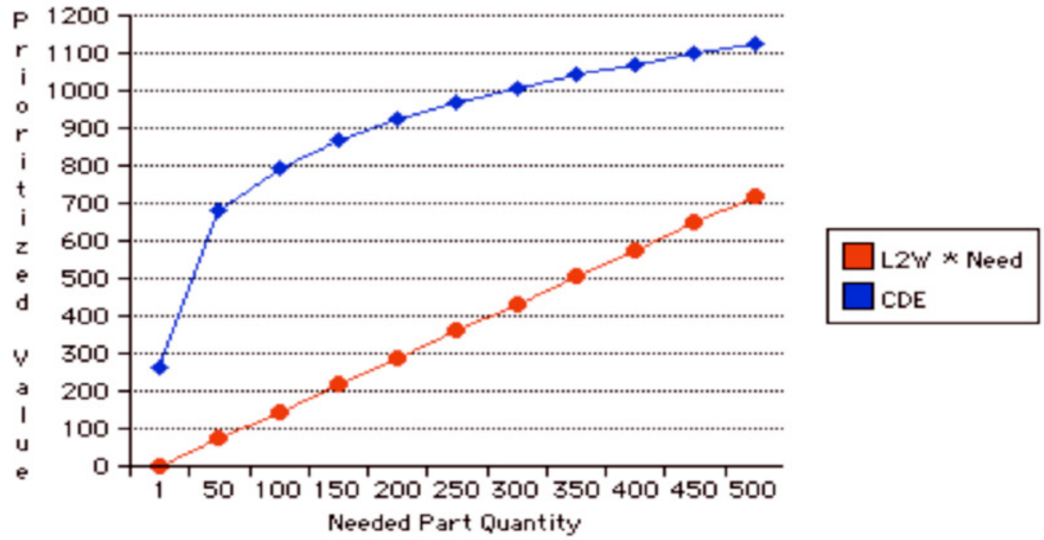


Figure 10.2.1.—L2W x Need and CDE prioritizing comparison for a 2 x 48-inch part.

10.2.4 Selecting a Part-Prioritizing Strategy

ROMI 4.0's default part-prioritizing strategy is CDE. CDE prioritizes parts so they can be obtained from the least amount of lumber most of the time. However, this level of efficiency may be too high for some users. If chop saws are being run on a longest-length-first basis, the L2W or L2W x Need strategies might predict yield better.

10.2.5 Processing Salvage Parts

Clear areas of a strip section that do not contain primary parts but that can contain salvage parts are called salvage areas. When the available clear area for a salvage part is identified, several options can be used to determine which part size to cut from the clear area. The simplest option takes the full width of the area to generate a random width part. For this method, you need to specify the minimum acceptable salvage width. A second method rips the area to the widest possible specified primary-part width. The third method rips the area to the widest possible salvage-part width. Salvage-part widths are specified by the user separately from the primary widths and used only for salvage.

Three different methods can be used to determine which salvage-part length to cut. The simplest method takes the longest random length possible with respect to the minimum and maximum primary-part lengths. The second method takes the longest primary-part length that will fit. The third method takes the longest salvage-part length. Salvage specific part lengths are specified separately from the primary lengths. After the first salvage part has been cut, the remaining area is examined. Cuttings are removed until there is no area large enough for the smallest salvage cutting.

10.2.6 Smart Salvage

If specified, ROMI 4.0 will attempt to cut a part from salvage that is needed by the cutting bill (see Section 4.2.7 for more information about configuring ROMI 4.0 to do this). ROMI 4.0 first determines the widest possible primary part that will fit in the clear salvage area. Next, a check is made to see that there is a need for a part length that will fit in the clear area. If any are needed, the most desirable (depending on part-prioritization strategy) primary-size part is cut. If there is no need for that size, the largest primary part that fits the clear area is cut.

The benefits of salvaging according to the cutting bill are maximized when primary operations are prevented from cutting orphan or excess parts. This allows the salvage operations to look at larger areas and potentially cut larger parts that are needed by the cutting bill. This approximates the re-saw or re-rip operations found in rough mills. Re-saw involves re-ripping a strip to a width that will yield a part needed by the cutting bill. This operation will be referred to as “smart salvage.”

Figure 10.2.2 shows a strip where all possible primary parts have been cut from the full-width clear area and one salvage part from the right end. In this example, only the leftmost parts are actually needed by the cutting bill. The remaining primary part is an excess or orphan part. Figure 10.2.3 shows the same strip processed when the primary operations cut only needed parts. This yielded two needed parts and one needed primary-size salvage part.

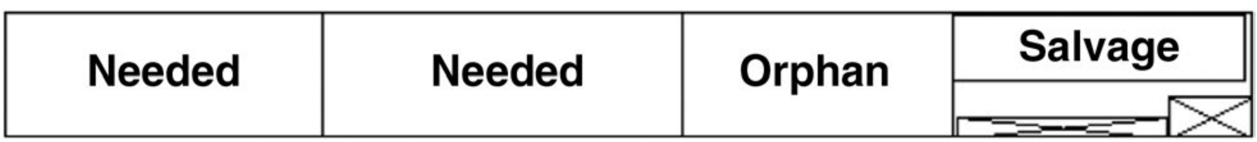


Figure 10.2.2.—Conventional primary operation.

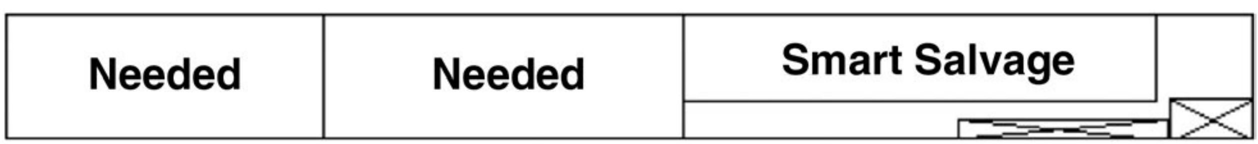


Figure 10.2.3.—Smart salvage operation.

Although smart salvage reduces salvage yield, it has the potential to reduce the amount of lumber required to meet a cutting bill. ROMI 4.0 simulations, comparing yields between smart salvage and standard operations across several cutting bills and lumber grades, show a reduction of 0.4 to 2.2 percent in the total amount of lumber required to meet a given cutting bill. Several factors can influence this reduction. Obviously, if the cutting bill is well matched to the lumber, few orphans, and acceptable yield, the benefits from using smart salvage will be lower. Sawing wider strips increases smart salvage chances of finding required cuttings.

11 USER INFORMATION FEATURES

11.1 Cutting Bill Information

One of the big changes in ROMI 4.0 is improved usability for the novice user. The core functions and routines remain similar to the previous version for practiced users. To improve the usability and auditability of the run simulation, ROMI 4.0 tracks information about the cutting bill in a file menu creating a file property sheet. A file property is a set of information that helps to identify your file (cutting bill and simulation) either now or later. For example, the title of your document is a property, as are the author and date of creation or the date the file was modified. Monitoring of file properties is important to track changes and to know the latest version of a file or when a modification or update took place.

In ROMI 4.0 the Cutting Bill information is displayed on the main user interface and includes the most important information such as User name, Simulation date, Grade Mix used, Order comments, and the modification parameter check boxes *Enable Cutting Bill* and *Display on Output*. Figure 11.1.1 shows the Cutting Bill Information window at the bottom right field within the main user interface.

Figure 11.1.1.—Cutting Bill Information feature on the main user interface of ROMI 4.0.

Clicking the button labeled *Edit Cutting Bill Info* will cause ROMI 4.0 to open the Cutting Bill Information window and collect information (such as user name, simulation date, grade mix used, and other comments regarding the cutting bill file) from the current cutting bill and send it to the main user interface and, after a simulation, to the output file. Figure 11.1.2 shows the Cutting Bill Information window. Within the Cutting Bill Information window the user can specify details about the simulation and the cutting bill used. Also, the configuration of the output file properties for the cutting bill information is possible here. To close the window, click on the *Okay* button.

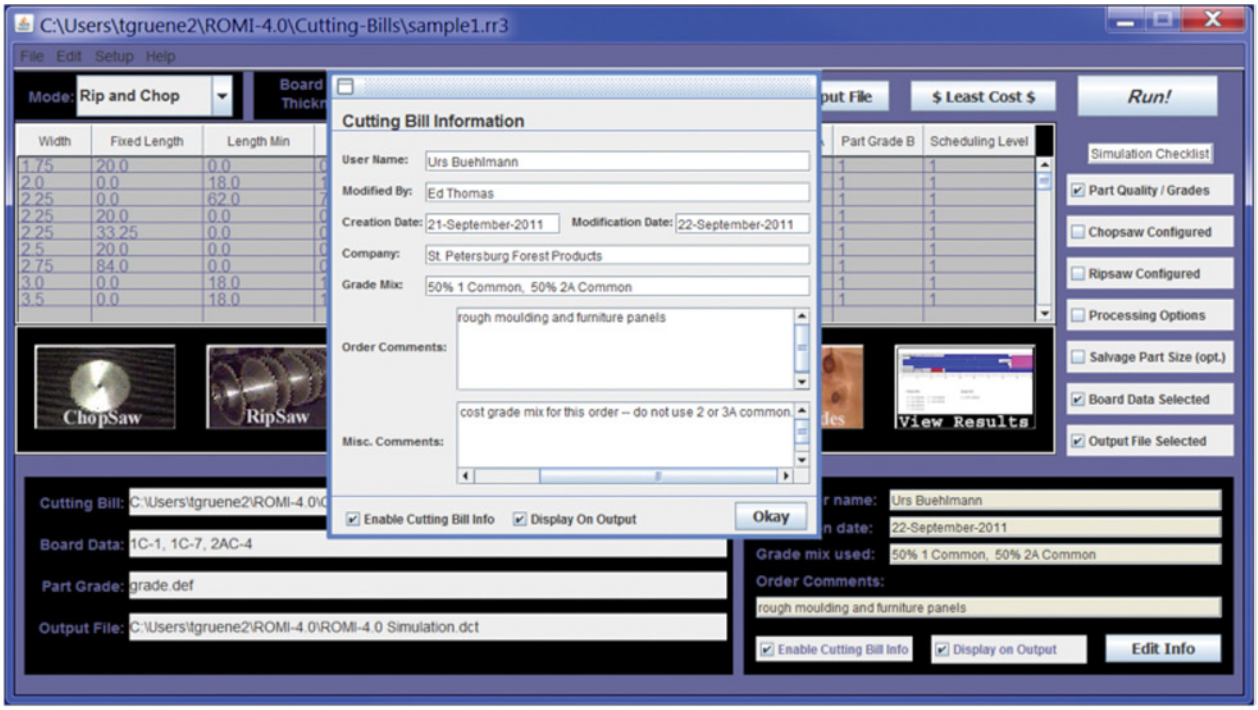


Figure 11.1.2.—Cutting Bill Information feature information window; stores the most important information about the processed cutting bill.

11.2 Help

ROMI 4.0 offers the user help, if necessary. In the task line of ROMI 4.0 (Fig. 3.2.1) the user can click on Help and a window will open (Fig. 11.2.1). The *Help function* includes a Help Menu (see Section 11.2.1), the Users Manual, and About (including contact information and the link to the ROMI 4.0 homepage for updates and news).

In addition to the *Help function* on ROMI 4.0, there are 27 related publications on the installation CD. These are included to give the user a more detailed understanding of the ROMI program and the simulation of rough mill processes.

Width	Fixed Length	Length Min	Length Max	Random Y/N	Quantity	Value	Panel Y/N	Part Grade A	Part Grade B	Scheduling Level
1.75	20.0	0.0	0.0		250	0		1	1	1
2.0	0.0	18.0	190.0	✔	100	0		1	1	1
2.25	0.0	62.0	72.0	✔	187	0		1	1	1
2.25	20.0	0.0	0.0		150	0		1	1	1
2.25	33.25	0.0	0.0		225	0		1	1	1
2.5	20.0	0.0	0.0		200	0		1	1	1
2.75	84.0	0.0	0.0		236	0		1	1	1
3.0	0.0	18.0	190.0	✔	180	0		1	1	1
3.5	0.0	18.0	190.0	✔	200	0		1	1	1

Figure 11.2.1.—ROMI 4.0 Help function.

11.2.1 Help Menu

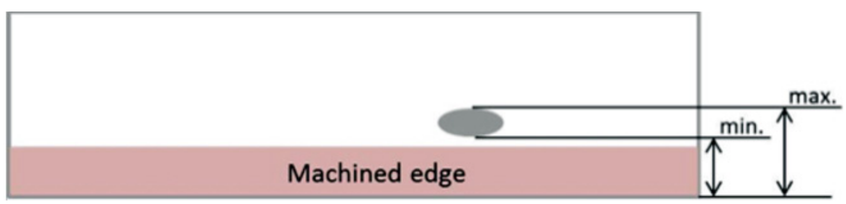
For terms used in ROMI 4.0 (The number in brackets behind some terms refers to digitized defect code used in ROMI 4.0).

1998 Data Bank for Kiln-Dried Red Oak Lumber	The representation of red oak boards used for simulations in ROMI. Gatchell et al.'s (1998) database contains 3,487 boards with a total of 20,021 board feet 4/4 kiln-dried red oak boards graded using **NHLA Grading Rules FAS, F1F, Select, No.1 Common, No.2 Common, and No.3A Common.**
Adventitious buds	Adventitious buds are subnormal buds and can be found at any points along the stem. They arise from latent or dormant buds in the leaf axils (angle between the branch and the stem) of the young stem and persist for an indefinite number of years within the cortical-cambial zone. They retain connection back to the pith by means of a stele, e.g., a bundle of water-conducting tissues also known as a **bud trace**.
Arbor	Arbors are the axis on which the saw blades that rip the boards into smaller strips are fixed on.
Arbor, All-blades-Movable	An arbor on which all blades are allowed to move to generate specified or random-width strips that best match the characteristics of the board and the demands of a given cutting bill.
Arbor, Best-Spacing-Sequence	The best fixed blade saw spacing arrangement is generated for each board by moving the rip fence onto which the board's edge is pressed into the most preferred position relative to the saw blades.
Arbor, Fixed	The saw spacing arrangement specified by the user and used for all boards. Each board is ripped with one edge against the edge of the fixed fence.
Arbor, Fixed-Blade-Best-Feed	The saw spacing arrangement specified by the user and used for all boards. Each board is positioned automatically with respect to the saw spacings such that the strips generated best match the characteristics of the board and the demands of the cutting bill.
Arbor, Movable-Outer-Blade	An arbor on which the last blade can be moved out to the edge of the board. The blade is moved out if an edging strip less than the minimum primary width would be generated. This produces a single, wider random-width strip, or a strip of the widest width possible.
Arbor, Selective-Rip	This arbor consists of fixed and movable blades. The user specifies the distance between the blades (the strip widths) and indicates which blades are allowed to move. In addition, the user specifies the distance the movable blades are allowed to move, thus allowing the simulator to position the board and move blades such that the strips generated best match board characteristics and cutting bill demands.
Bark	Bark is the outermost layer of a living tree. It serves to protect the tree from insect, bacterial, and animal attack.
Bark pocket [10]	A space between annual growth rings that contains bark. Bark pockets appear different in the anatomical directions of the cut: as dark streaks on radial surfaces and as rounded areas on tangential surfaces.
Bird peck [23]	A small hole or patch of distorted grain resulting from birds pecking through the growing cells in the tree. The shape of bird peck usually resembles a carpet tack with the point toward the **bark**. Bird peck is usually accompanied with **discoloration** extending for considerable distance along the **grain** and to a much lesser extent across the grain.
Board	Lumber that is less than 38 mm standard (2 foot nominal) thickness and greater than 38 mm standard (2 inch nominal) width. Boards less than 140 mm standard (6 inch nominal) width are sometimes called strips.

Board foot (BF)	A board foot (BF) is the unit of measurement used for hardwood lumber in the United States. A board foot is a volume of lumber 1 foot long x 1 foot wide x 1 inch thick (1 foot = 0.305m, 1 inch = 25.4 mm). The formula for determining board feet in a board is: $$(BF) = \frac{\textit{(Width in inch x Length in feet x Thickness in inch)}}{12}$$ The percentage of clear wood required for each grade, based on **NHLA Grading Rules**, are based on this 12 foot unit of measure.
Board Segment	Used in cross-cut first operations. A full-width section of a board produced by crosscutting the board to a specified part length. Board segments are ripped to produce one or more primary parts.
Bud Trace with Bark / Check [20]	See **Adventitious buds**.
Burl [13]	Bulges and irregular growth that form on the trunks and roots of trees. Burls are highly sought after for the aesthetically appealing veneer they yield, but have to be considered as defects in regular rough mill operations when occurring as small artifacts in **boards**.
Callus wood [21]	Callus wood grows around a correct pruning cut and seals the cut. This callus wood later becomes woundwood and can be up to 40 percent stronger than the original wood. Also, callus wood has a slightly altered chemical makeup because its composition is designed to fight any kind of pathogens.
Check	A lengthwise separation of the wood that usually extends across the rings of annual growth and commonly results from stresses building up in wood during seasoning (drying).
Check, Surface [14]	**Checks** are small splits on the surfaces of lumber that are no longer than 2 inches and do not completely penetrate the board. **Checks** can either be caused by mechanical means or occur naturally. **Checks** occur on board surfaces after or during drying and processing.
Chip [16]	(Machine) chip or **torn grain** results from mechanical forces, caused by machines, through the wood structure. Chip refers to a smaller area (normally only fiber bundles or local spots) of torn-out wooden material. (See also **Snipe** / **Tear out**).
Crook	A lumber defect where an edgewise **warp** affects the straightness of the board, thereby affecting board quality and yield.
Cutting bill	A specified list of part sizes and quantities. (See also **Dynamic Prioritization Methods** and **Static Prioritization Methods**).
Cutting stage	A single ripping or crosscut operation. For example, crosscutting a board into primary part length board sections is a cutting stage. The production of primary parts requires two stages: crosscutting and ripping or vice versa.
Decay [4]	Refers to the decomposition of wood substance by fungi (basidiomycetes, such as white or brown rot).
Decay, Advanced or common	The more advanced stages of decay in which the destruction of the wood substance is readily recognized as the wood has become punky, soft and spongy, stringy, ringshaked, pitted, or crumbled. Also, advanced **discoloration** or bleaching of the wood occurs at this stage.
Decay, Incipient [18]	The early stage of decay that has not yet softened or otherwise perceptibly impaired the hardness of the wood. Incipient decay is usually accompanied by a slight **discoloration** of the wood.
Dimension component	As defined by the **Wood Components Manufacturers Association** (WCMA), dimension components are hardwood and softwood parts, normally kiln-dried, which have been processed to a point where the maximum waste is left at the dimension mill, and the maximum utility is delivered to the user. The components are categorized in quantity and quality, such as dimensions, surface quality, raw material, and part grades.

Dimension component, Part grade	See **Part grade, Dimension component** and **Table 3**.
Dimensional lumber	See **Lumber**
Discoloration	The act of (wood) changing its original color (of a material or substance) to a different color or shade. Also, **discoloration** due to an external action or act, e.g., attack by micro-organism, chemical reactions.
Excess Part	See **Part, Orphan**
Excess Primary Part	Part produced using only the two original cutting stages (e.g., no salvage operation) for which there is no requirement in the cutting bill, but whose size (width and length) are found in the cutting bill.
Excess Salvage Part	Parts produced in three or more cutting stages (e.g., the two primary cutting stages plus additional salvage cutting stages) for which there is no requirement in the cutting bill.
FAS	A quality classification of hardwood lumber according to **NHLA Grading Rules.** (See Hardwood grades and Table 4).
F1F	A quality classification of hardwood lumber according to **NHLA Grading Rules.** (See Hardwood grades and Table 4).
Grain	The direction, size, arrangement, appearance, or quality of the fibers in wood or lumber. To have a specific meaning, the term must be specified, such as close-grained (fine-grained), cross-grained, or edge-grained wood.
Grading rules	A set of criteria by which to judge various pieces of lumber or panels in terms of appearance, strength, and suitability for various uses. Regional grading agencies draw up rules for grading based on the voluntary product standards issued by the U.S. Bureau of Standards. ROMI uses the most widely followed standards issued by **NHLA**. (See **NHLA Grading Rules**.)
Grub hole [11]	Grub holes resulting as pre-stage result of wood destroying beetles. Typically grub holes are 0.25 inch in diameter or larger (depending on the species).
Hardwood grades	Hardwood lumber is usually graded (according to the **NHLA Grading Rules**, see **National Hardwood Lumber Association**) on the basis of the size and number of cuttings (pieces) that can be obtained from a **board** when cut up. Hardwood grades are used in the manufacture of a hardwood product. The upper grades, **including FAS, FAS-One-Face (F1F)** and **Selects**, are most suitable for long clear cuttings (such as mouldings and joinery products). The common grades, primarily No.1 Common (No.1C) and No.2A Common (No.2AC), are likely to be the most suitable for smaller cuttings (such as kitchen cabinet and furniture parts). Worth noting is the fact that once resawn, the cuttings obtained from the Common grades will be of the same clear wood as the upper grades, but smaller (shorter and/or narrower) cuttings will have been obtained. **Table 4** gives an overview of the characteristics of each hardwood grade class.
Kerf	The amount of wood removed by a saw blade. Common kerf thicknesses simulated by ROMI 4.0 are 0.125 and 0.1875 of an inch. (See saw **kerf**.)
Knot	The portion of a branch or limb that has been surrounded by subsequent growth of the stem. The shape of the knot as it appears on a cut surface depends on the anatomical direction and on the angle of the cut relative to the axis of the knot. For determining the quality of the wood, further determination of the knot's size and health are necessary. It is necessary to evaluate if knots are **sound knots** or **unsound / loose knots**.
Knot, pin	A **knot** that does not exceed 0.25 inch in average diameter in its sound portion or ⅛ inch in average diameter in its unsound portion.
Knot, sound [15]	A **knot** that is solid across its face, at least as hard as the surrounding wood, and shows no indication of decay.
Knot, unsound (loose) [12]	A **knot** that is not held firmly in place by growth or position and that cannot be relied upon to remain in place. Refers also to a knot that is decayed or that shows decay.

Length (of a board)	The length of a board is defined as the length of the piece in axial (grain) direction, expressed in feet.
Lumber	The product of the saw and planing mill for which manufacturing is limited to sawing, resawing, passing lengthwise through a standard planing machine, crosscutting to length, and matching. Lumber may be from either softwood or hardwood.
Mechanical damage [1]	Refers to artificial damage to lumber or dimension components that occurs along the product's value chain, e.g. holes from moisture meters, hooks, nicks, grooves, or other damages from a foreign object.
Mineral streak [25]	Normally an olive to greenish-black or brown **discoloration** caused in hardwoods due to the storage and incorporation of minerals in the wood structure during tree growth.
National Lumber Hardwood Association (NHLA)	The purpose of the NHLA is to establish, maintain, and apply a uniform system for the inspection, measurement, and grading of hardwood lumber; to establish and maintain training schools and instructional courses and to publish books and literature applicable to the study of the NHLA grading standards and their applications; to conduct conferences, seminars, and other educational activities on subjects of importance to the hardwood trade; to encourage research in hardwood timber management and utilization, and to disseminate information to the industry; to promote the welfare and protect the interests of the hardwood trade.
(NHLA) Grading Rules	**NHLA** Grading Rules provide both the buyer and seller with a consistent language to use in specifying hardwood lumber transactions. Knowledge of the NHLA Grading Rules is essential for buyers on a global scale to understand the terms of the trade.
No. 1 Common	A quality classification of hardwood lumber according to **NHLA Grading Rules.** (See **Hardwood grades** and **Table 4**).
No. 2 Common	A quality classification of hardwood lumber according to **NHLA Grading Rules.** (See **Hardwood grades** and **Table 4**).
No. 3A Common	A quality classification of hardwood lumber according to **NHLA Grading Rules.** (See **Hardwood grades** and **Table 4**).
Panel	A panel is made up of two or more edge-glued wood pieces of specified length and width. Typically, panels are produced to approximate sizes and later cut to specific parts.
Part grade, Dimension component	Classification dimension components based on quality according to rules established by the **Wood Component Manufacturers Association (WCMA)**. In rough or semi-machined dimension parts, for any grade, those blemishes that will be removed in planing or machining to finished sizes are permitted. Three face grades for hardwood dimension components are specified: "A" Face – Material that is acceptable for prominent surfaces such as tops, doors, and drawers. "B" Face – Material that is acceptable for surface of intermediate visibility such as exteriors of most end panels; the interior of end panels on an open case, shelves, and the inside of drawer fronts. "C" Face – Material that is acceptable for low visibility parts where strength and smoothness is the deciding factor – such as back edges of rails, or the underside portion of any table that is susceptible to touch and feel. (See **Table 3**.)
Part, Orphan	A primary part that is cut but is not needed; that is, the required numbers of parts of this particular size have been met already. An "extra" piece.
Part, Primary	Parts produced by ripping board sections to primary part widths.
Pith [3]	The small, soft inner core of a tree trunk, branch, twig, or log.
Pith fleck(s)	A narrow streak, resembling pith on the surface of a piece, resulting from burrowing of larvae in the growing tissues of the tree. (See **Callus cells**).
Pith related tear or split [6]	Tear or split induced by inner tension related to dimensional change and/or shrinkage beginning at the pith of a tree trunk, branch, twig, or log.
Primary Part Length	Any length specified in a cutting bill is a primary part length. Primary part lengths are the lengths that are crosscut from the board (cross-cutting first) or the strip (rip-first).

Primary Part Width	The part widths used when ripping board segments to specified part sizes. Any part width listed in a cutting bill is a primary part width.
Primary Part Width Minimum	The minimum primary width that is specified when processing random width part sizes.
Prioritization Methods	With a proper part prioritization and scheduling strategy, cutting bill requirements can be met using less board footage compared to no or sub-optimal prioritizing strategies. Essentially makes some part sizes more preferred than others at any given point in the cut-up cycle. Optimized lumber cut-up (e.g., lumber cut-up using prioritization methods) results in lower lumber requirements, less lumber handling and processing, higher production capacity, and lower numbers of unneeded parts (orphan and excess salvage parts).
Prioritization, Dynamic Method	A method of prioritizing parts required in a cutting bill so that the part priorities change as parts are produced. Dynamic methods generally require less board footage than static methods to meet a given cutting bill. (See **Cutting Bill** and **Static Prioritization Methods**.)
Prioritization, Static Method	A method of prioritizing cutting bill parts. The priority assigned to a cutting bill part at the start of a lumber processing cycle is the same priority that is used at the end of the processing cycle. Numbers or dollar values are good examples of a static prioritization strategy. Static prioritization generally is less efficient than dynamic strategies. (See **Cutting Bill** and **Dynamic Prioritization Methods**.)
Proximity rule	The Proximity rule is useful for moulding and millwork parts where defects are acceptable in areas where no machining takes place. The rule has to be defined from both edges, respectively, the minimum and maximum distance from the machined edge. The definition of proximity rules will help to improve yield when defects are acceptable in certain areas. 
Rough (sawn) lumber	Lumber that has not been dressed (surfaced) but has been sawn, edged, and trimmed.
Salvage	Parts that are obtained involving at least one additional cutting operation beyond the two original cuts (rip-first and cross-cut first or vice versa). The additional cut makes these parts more expensive to produce and, therefore, less desirable. Unlike excess salvage, salvage parts are required by the cutting bill.
Saw kerf	(1) Grooves or notches made in cutting with a saw. (2) That portion of a log, timber, or other piece of wood removed by the saw in parting the material into two pieces.
Saw line [9]	Special case of **mechanical damage**, e.g., a partial cut through the board either axial or across the board from an earlier processing stage (logging, sawmill, etc.).
Saw Space Sequence	The sequence or arrangement of widths on the arbor. It is important that this sequence be developed in consideration of the width distribution of the lumber and the surface area required for each part width as described by the cutting bill.
Selects	A quality classification of hardwood lumber according to NHLA grading rules. (See **Hardwood grades** and **Table 4**.)
Shake	A separation of the wood structure along the grain, the greater part of which occurs between the rings of a tree's annual growth. Usually considered to have occurred on the standing tree or during felling.
Snipe [17]	(Machine) Snipe or **Tear out** as result of a medium to exert major mechanical force through the wood structure, refers to a bigger area being affected compared to (Machine) **Chip** or **Torn** grain.

Split [24]	An axis-wise separation of the wood. Induced by internal or external forces to irreversibly tear apart the wood cells.
Split, Machine made [7]	Major splitting that may happen during the machining process of wood, also called **tear out** or **torn** grain depending on the size of the damage. Machine made split usually occurs in planning or molding operations, but may also happen with other machines featuring rotating knives.
Stain	A **discoloration** in wood that may be caused by such diverse agencies as micro-organisms, environmental influences, chemicals, metals, and /or combinations of the above. The term is also used for materials that are used to impart die onto wood. (See **Stain, sap**.)
Stain, sap [22]	A **discoloration** of a tree's sapwood caused by the growth of certain fungi mainly on the surface but also in the interior of the wood. Stain discolors the wood but does not lead to a reduction of the material's mechanical properties. However, conditions allowing stains to grow also favor the growth of other (wood destroying) fungi.
Stain, sticker [19]	A brown or blue stain that develops when seasoning lumber where the lumber surface has been in contact with the **stickers**.
Sticker(s)	A .75 to 1 inch wood strip that is inserted between stacks of green lumber and spaced between 16 to 24 inches to allow air to flow through the stack to ensure proper drying.
Strip	A narrow, board-length piece of wood produced by the gang-ripsaw using rip-first processing.
(Standard) Thickness	Standard thickness (based on **NHLA grading rules**) for rough sawn lumber is expressed in quarters of an inch, e.g., 1 inch= $\frac{4}{4}$. The majority of U.S. hardwood lumber production is sawn between 1 inch and 2 inch, although other thicknesses are available in more limited quantities. The NHLA Grading Rules include a list of standard thicknesses for **rough (sawn) lumber**. Standard thicknesses (according to NHLA grading rules) for rough lumber are: ⅜, ½, ⅝, ¾, 1, 1-¼, 1-½, 1-¾, 2, 2-½, 3, 3-½, 4, 4-½, 5, 5-½, and 6 inch. One inch and thicker may also be expressed in quarter inches as follows: $\frac{4}{4}$, $\frac{5}{4}$, $\frac{6}{4}$, $\frac{7}{4}$, $\frac{8}{4}$, $\frac{10}{4}$, $\frac{12}{4}$, $\frac{14}{4}$, $\frac{16}{4}$, $\frac{18}{4}$, $\frac{20}{4}$, $\frac{22}{4}$, and $\frac{24}{4}$.
(Standard) Length	Standard lengths (according to **NHLA Grading rules**) are 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, and 16 feet.
Surface measure (SM)	Surface measure (SM) is the surface area of a board in square feet. To determine surface measure, multiply the width of the board in inches by the length of the board in feet and divide the sum by 12 (rounding up or down to the nearest number). The percentage of clear wood for each grade is based on the surface measure, not the board feet measure. Thus, all boards, no matter what their (**standard**) **thickness**, are graded in the same way.
Surfaced lumber	**Lumber** that is dressed by running it through a planer.
Tear out	See **Snipe**.
Torn Grain	See **Chip**.
Void [2]	Unfilled or unoccupied space within the wood structure. Due to the lack of material and the associated lower mechanical properties of a piece this needs to be considered a defect. This lack of material poses problems in material handling in advanced processing. Also, void has an undesirable impact on the appearance of the wood (product).
Wane [8]	**Bark** or lack of wood from any cause on the edge or corner of lumber or a component except for eased edges.
Warp	Warp is any variation from a plane surface. Warp generally includes bow, crook, cup, and twist, or any combination thereof.
Wood Components Manufacturers Association (WCMA)	The basic goals of the Wood Components Manufacturers Association (WCMA) are to establish and maintain specifications and commercial standards for the hardwood dimension manufacturing industry.
Worm hole(s)	Holes and channels cut in wood by insects.

Worm hole(s), Pin [211]	One spot worm hole not over 1⁄16 inch in diameter.
Worm hole(s), Spot [111]	One spot worm hole over 1⁄16 inch but not more than 1⁄8 inch in diameter.
Worm hole(s), Shot	One spot worm hole over 1⁄8 inch but less than 1⁄4 inch in diameter.
Yield	Yield is defined as the ratio of aggregate part surface area output to aggregate **lumber** surface area input.

Table 3.—Summary of dimension component part specifications per Face Grade according to the Wood Component Manufacturers Association (WCMA 2007, adapted)

"A" Face – Material that is acceptable for prominent surfaces such as tops, doors and drawer fronts.	
Will admit:	Small sound knot specks
	Small dark mineral streaks or pitch pockets not over 1/16 inch x 1 inch (1.6 mm x 25.4 mm)
	Light discoloration
	Size of strips (staves): 1 inch (25.4 mm) min., 5 inch (127 mm) max., narrow strips (staves) to be well scattered
Will not admit:	Birds eye
	Any knots other than small specks
	Splits, checks, or shake
	Holes, gouges, or other open areas deeper than 1/32 inch (0.8 mm)
	Bark or wane
	Mineral streaks larger than 1/16 inch x 1 inch (1.6 mm x 25.4 mm)
	Large dark discolored areas
	Punky or unsound wood
"B" Face – Material that is acceptable for surface of intermediate visibility such as the exterior of most end panels, the interior of end panels on an open case, shelves, and the inside of drawer fronts.	
Will admit:	Occasional pin knots and small sound knots not over ⅛ inch (3.2 mm)
	Occasional mineral streak not over ¼ inch x 2 ¼ inch (6.4 mm x 63.5 mm)
	Moderate discoloration
	Occasional birdseye
	Size of strips (staves): ¾ inch (19.1 mm) min., 5 inch (127 mm) max., narrow strips (staves) to be well scattered.
Will not admit:	Any knots over ⅛ inch (3.2 mm)
	Splits, checks or shake
	Holes, gouges or other open areas deeper than 1/32 inch (0.8 mm)
	Bark or wane
	Punky or unsound wood
	Mineral streaks over ¼ inch x 2 ½ inch (6.4 mm x 63.5 mm)
	Large dark discolored areas
"C" Face – Material which is acceptable for low visibility parts where strength and smoothness is the deciding factor – such as back edges of rails, underside portion of any table that is susceptible to touch and feel.	
Will admit:	Unlimited discoloration or mineral streaks
	Solid knots up to ½ inch (12.7 mm) diameter
	Surface checks
	Open defects up to ⅛ inch x 1 inch (3.2 mm x 25.4 mm) or ¼ inch (6.4 mm) diameter
	Unlimited birdseye
	Small areas of punky or unsound wood
	Boards of any width up to 5 inch (63.5 mm)
Will not admit:	Large open knots
	Wane
	Large areas of punky or unsound wood

Table 4.—Summary of grade classes and particular requirements per class according to the National Hardwood Lumber Association (NHLA 2011, adapted)

Grade	Board length	Board width	Minimum	Clear area	Allowable cuts to obtain Part dimensions	
	Minimum	Minimum	Part size		Part length	Cuts
	Feet	*Inches*		*Percent*	*Feet*	
FAS	8	6	4 in x5 ft or 3 in x 7 ft	83 ⅓	4-7 8-11 12-15 ≥16	1 2 3 4
SEL	6	4	4 inch x 5 ft or 3 in x7 ft	66 ⅔	better side same as FAS reverse side better than 1 Com.	
1 Com.	4	3	4 in x2 ft or 3 in x7 ft	66 ⅔	3-4 5-7 8-10 11-13 ≥14	1 2 3 4 5
2A Com.	4	3	3 in x 2 ft	50	2-3 4-5 6-7 8-9 10-11 12-13 ≥14	1 2 3 4 5 6 7
3A Com.	4	3	3 in x 2 ft	33 ⅓	no limit to number of cuts	
3B Com.	4	3	1 ½ in x2 ft	25	no limit to number of cuts	

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APPENDIX I

System Limitations

Current specifications and limitations of the ROMI 4.0 simulator:

Board width:	48 inches (1.219 meters)
Board length:	Unlimited
Cutting bill	
Maximum individual part quantity:	32,000
Maximum individual part value:	32,000
Maximum number of part sizes:	400
Board data files processed at once:	10
Length ranges:	10
Width ranges:	15
Lengths	
Primary:	30 or random
Salvage:	15 or random
Widths	
Primary:	20 or random
Salvage:	15 or random
Gang-ripsaw arbor	
Width	48
Number of spacings	15

APPENDIX II

Board Data Bank Description

This appendix describes the contents of the board data files (Gatchell et al. 1998) included with ROMI 4.0. All data files have an eight letter primary file name followed by a .DAT extension. All of the boards in each data file are one of six grades. The grade of lumber in a particular data file is determined by looking at the file name.

If the file name begins with	The grade is
FAS	FAS
F1F	FAS one Face
SEL	Select
1C	No. 1 Common
2AC	No. 2A Common
3AC	No. 3A Common

The boards supplied with ROMI 4.0 are from the 1998 Data Bank for Red Oak Lumber by Gatchell et al. (1998). The following tables show the total number of boards in each of the six grades. The boards in each grade are randomly sorted into subsets containing approximately the same number of boards. Data files ending with a letter contain boards that are mirror images of their corresponding files with number endings. For example, 1C-A contains boards that are mirror images of the boards in 1C-1, 2AC-3 mirrors boards in 2AC-3, and so on. MIX files contain all boards, both normal and mirrored, for the grade.

Lumber grade	Total boards	Board footage	Number of subsets
FAS	659	5,134	10
FAS one Face	348	2,552	5
Selects	279	1,052	2
No. 1 Common	1,039	5,887	11
No. 2A Common	922	4,737	9
No. 3A Common	240	1,012	2

In addition, a small cherry lumber database is available. These data file names all begin with “Cherry-“ and are stored with the red oak lumber data. The small number of boards available in the cherry databank prevents ROMI from being able to create random datasets from the cherry data. The cherry databank consists of the following:

Lumber grade	Total boards	Board footage
FAS one Face	3	28
Selects	1	5
No. 1 Common	34	242
No. 2A Common	72	556
No. 3A Common	148	965
Total	258	1,796

Thomas, R. Edward; Grueneberg, Timo; Buehlmann, Urs. 2015. **ROMI 4.0: Rough mill simulator 4.0 users manual.** Gen. Tech. Rep. NRS-143. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 82 p.

The Rough MIll simulator (ROMI Version 4.0) is a computer software package for personal computers (PCs) that simulates current industrial practices for rip-first, chop-first, and rip and chop-first lumber processing. This guide shows how to set up the software; design, implement, and execute simulations; and examine the results. ROMI 4.0 accepts cutting bills with as many as 600 solid and/or panel part sizes. Plots of boards processed are easily viewed or printed as are detailed summaries of processing data (number of rips and crosscuts) and yields for each grade. ROMI 4.0 optimization algorithms are based on a red oak database containing 3,500 boards of all common National Hardwood Lumber Association grades. Even though ROMI is based on red oak, the digitized board information can be adapted and modified to several other common hardwood species. It is an updated version of ROMI 3: Rough Mill Simulator Version 3.0: User's Guide, General Technical Report NE-328.

KEY WORDS: rough mill, cutting bill, simulation, hardware lumber

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