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User's Guide for LORCAT: The Log Recovery Analysis Tool, Version 4.00

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Abstract

The Log Recovery Analysis Tool (LORCAT) was developed to enable hardwood sawmill personnel, researchers, and other individuals interested in creating lumber and by-products from logs to examine the impacts of and the relationships among various factors that influence lumber recovery in hardwood mills. LORCAT is a spreadsheet-based tool that was developed for use with either Excel (Microsoft Inc., Redmond, Washington, USA) or LibreOffice (The Document Foundation, Berlin, Germany) spreadsheet applications. LORCAT allows users to interactively view the results from a single log or view trends by using hundreds of logs of various species, geometry, and quality. LORCAT requires users to specify the log lengths and grades, species, small- and large-end diameters, and various processing specifications, including opening face dimensions, cant size, board thickness, green allowance, sawing variation, kerf size, and taper sawing method. Additionally, cost data can be entered to allow estimates of total costs and profits for sawing a specific log or group of logs. After simulating sawing using those specifications, LORCAT reports the expected total number and volume of lumber and cants produced and the projected recovery by National Hardwood Lumber Association grades and gives estimates of cost and profit. Also, starting with LORCAT 4.00, users can select between novice and expert modes, with the novice mode offering less complexity and requiring less data input. For example, using expert mode, LORCAT 4.00 can estimate the volume and revenue of sawdust, chips, and bark generated, a feature that is not available in novice mode.

Keywords: sawmill, yield, recovery, application, simulation, hardwood

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Cover photo: Headrig sawing a yellow poplar log at the Turman Lumber sawmill (Hillsville, VA) on April 8, 2025. Courtesy photo by Urs Buehlmann/Virginia Tech.

Conversion table

English unit	Conversion factor	SI unit
board foot	2.359737×10^{-3}	cubic meter (m^3) (nominal)
cubic foot (ft^3)	2.831685×10^{-2}	cubic meter (m^3)
foot (ft)	3.048×10^{-1}	meter (m)
inch (in.)	2.54×10^{1}	millimeter (mm)
pound, mass (lb)	4.535924×10^{-1}	kilogram (kg)
ton (2,000 lb)	9.071847×10^{-1}	metric ton (t)

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1: Introduction

The interactions among log grades, log sizes, lumber thickness, kerf size, sawing variation, and other sawing specifications make running a hardwood sawmill a complex proposition. In fact, it is the interaction of these numerous variables that determine lumber recovery in hardwood sawmills (Steele 1984). Lin and others (2011) examined hardwood sawmills in West Virginia and found that log grade, species, diameter, and length in addition to sawmill parameters had statistically significant effects on lumber volume recovery. Most importantly, given the variability in processing parameters and methods combined with a varying log resource, these factors are rarely consistent from mill to mill (Steele 1984), and thus, any simulation must be sufficiently configurable to accurately model the variety of factors in a given mill.

Computer simulation of hardwood sawmill operation has evolved significantly since its beginning in the 1970s. One of the earliest computer tools for simulating hardwood sawmill operations was SOLVE developed by Adams (1972) to determine the maximum value of hardwood lumber that can be produced from a log sample given a mill's operational setup. SOLVE was followed by the Best Opening Face (BOF) program by Lewis and Hallock (1974), which determined the optimum placement of saw lines in a log that resulted in maximum recovery based on log size and quality characteristics. Adams followed with an updated version of SOLVE, SOLVE II, in 1977 (Adams and Dunmire 1977). SOLVE II allowed users to answer many questions related to everyday mill operations, such as identifying the break-even log, analyzing conversion costs by log grade and size, analyzing downtime, among other things. In 1996, Adams published SOLVE III, an easier-to-use and updated version of SOLVE II to help sawmill managers improve efficiency and solve common hardwood mill issues such as log size distribution, lumber grade yields, lumber recovery factors, overrun log costs and break-even log costs (Adams 1996). SOLVE III required users to conduct a comprehensive mill study and collect data related to various aspects of the mill's operation, such as operating costs, lumber grades, lumber thicknesses, lumber prices, and most importantly, log grades, log sizes, and the volumes of lumber recovered by National Hardwood Lumber Association (NHLA) grade. Because the hardwood industry found SOLVE III useful for their operations and it gained in popularity, Palmer and others (2009) updated and added functionality and ease of use to SOLVE III.

Before the Palmer and others (2009) update of SOLVE III, Govett and others (2005) created PROYIELD, a spreadsheet-based sawmill analysis tool that was designed to develop initial estimates of sawmill yields for planning and feasibility studies and to explore and test what-if questions related to processing. However, PROYIELD was not designed to optimize recovery and saw-line placement or to make opening face decisions for maximum value recovery because the program only returned summaries of lumber yield and residuals for specific scenarios.

Thomas and others (2021) developed the first version of the Log Recovery Analysis Tool (LORCAT). LORCAT is a spreadsheet-based log recovery estimation tool that was developed to permit sawmill operators and researchers the ability to determine potential outcomes in sawmill recovery based on changes of parameters in their operation. The objective was to create a simple-to-use analysis tool that required a minimum set of data input and then displayed the results of the analysis in a clear and easy-to-understand manner.

Since LORCAT's initial development, new versions have been released with each version including additional features. LORCAT 2.00 saw the addition of a cost-analysis module, which allowed users to estimate profit from sawing based on their operating costs. Version 2.00 also saw the addition of a method that simulated grade-sawing of lumber and a break-even analysis that indicated which log grades and sizes are likely to be sawn for a profit or loss. LORCAT 3.00 introduced features to make the user interface easier to use. This version was used for a validation study with three data sets collected from real world sawmilling (Thomas and others 2024). The authors found no significant difference between LORCAT's estimated recovery volumes and those observed at a mill. However, significant differences were found in the number of boards produced (Thomas and Buehlmann, in press).

Version 4.00 uses the validated sawing methods of version 3.00 and introduces features that extend the usefulness of the application. As more features have been added to LORCAT, the tool has become more complex to use. Hence, version 4.00 adds two different user modes, novice and expert, which can be chosen by the user. The novice mode simplifies the user interface and reduces the amount of data required for the simulation to run. The expert mode provides the full interface to all features and analysis results available. Also, LORCAT 4.00 now reports the volume and value of chips, sawdust, and bark when using the expert mode.

2: Methods

LORCAT processes logs that are represented using the geometric shape of a truncated cone. The user controls the shape of the log by specifying the log length and the diameters of the small and large ends of the truncated cone. LORCAT simulates the sawing of logs using one of five common sawing strategies (Fig. 2.1). The first strategy simulates grade sawing, where the log is rotated and boards are sawn from the highest-grade face until a user-specified cant thickness is achieved. The cant is then ripped into lumber by a simulated gang-resaw. (Fig. 2.1a). The second strategy simulates grade sawing with the production of a cant of a specified size that is not sawn into boards (Fig. 2.1b). The third strategy simulates using a gang-resaw to saw the cant that was produced from sawing the first two faces into lumber (Fig. 2.1c). The fourth method simulates sawing logs from opposite faces to a specified cant height and the resulting cant sawn into lumber (Fig. 2.1d). The fifth method simulates the European method of live or flitch sawing in which the log is sawn through-and-through (Fig. 2.1e). For all these sawing strategies, LORCAT users can select the method and all pertinent sawing parameters such as kerf size, green allowance, opening face size, sawing variation, and others to suit their operation and their analysis needs.

For all five sawing methods (Fig. 2.1), users can choose either split-taper or full-taper sawing (Malcolm 1961). In split-taper sawing, the taper of the log is split between opposite faces and the log is sawn parallel to its central axis (Hallock and others 1978). This sawing method has the potential to produce shorter boards, if the amount of taper is large enough, yet increase the recovery of lumber. Full-taper sawing saws the log parallel to the outside faces of the log (Hallock and others 1978). Thus, the grain will be parallel to the board surface in the resulting boards, making the lumber sawn stronger in general than split-taper sawn lumber.

The target thickness of each board sawn is the sum of the target lumber thickness, green allowance, and sawing variation (Young and others 2007). The within-board sawing variation allows LORCAT to model inaccuracies in the sawing process that are typically encountered in sawmills.

LORCAT uses the U.S. Department of Agriculture, Forest Service hardwood lumber yield tables (Hanks and others 1980, Hanks 1973) to estimate the lumber recovery by NHLA grade. These tables correlate the NHLA lumber grade recovery to the Forest Service log grades. LORCAT simulates the sawing of logs by using generic geometric models of logs that do not have crook or sweep. To simulate the processing of logs with crook and/or sweep or large defects, the scaling deduction (percentage) for that log using the Forest Service log grading rules (Rast and others 1973) must be determined and then applied to the recovery results from LORCAT.

The parameters that control the sawing process in LORCAT are user-specified. In the novice mode, users can change the species, log grade, log small- and large-end diameter, log length, cant height and width, lumber target thickness, green allowance for drying shrinkage, total sawing variation, saw kerf thickness, and cost inputs.

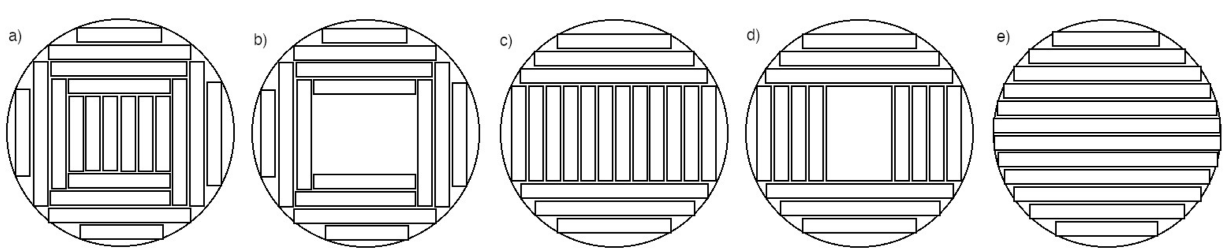


Figure 2.1—Sawing strategies used by LORCAT: (a) simulated grade sawing to a specified cant thickness, then completing sawing with a gang-resaw; (b) simulated grade sawing to a specified cant thickness; (c) sawing to specified cant thickness then completing sawing with a gang-resaw; (d) sawing to a specified cant size; (e) live sawing.

Expert mode introduces many more options that allow LORCAT to more closely simulate a variety of more complex sawmill process, including the following:

- Opening face width and length
- Separate setup for headrig and resaw kerf and sawing variation
- Full-taper sawing
- Sawing residue volumes and values
- Sawing residue weights, compaction, and expansion factors

However, the expert mode adds complexity to the user interface, requiring the user to be a true expert and making LORCAT more challenging to use, especially for beginners.

3: Using LORCAT

LORCAT is a spreadsheet-based hardwood log recovery analysis tool that was developed by the Forest Service and Virginia Tech. This computer tool is available free of charge from either of the following links:

https://www.fs.usda.gov/research/nrs/products/dataandtools/tools/lorcat-log-recovery-analysis-tool-hardwood-sawmill-efficiency

https://woodproducts.sbio.vt.edu/lorcat.html

The second link offers additional information about LORCAT, such as user manuals, videos explaining how to use LORCAT, and studies done with LORCAT.

3.1: Starting LORCAT

LORCAT is designed to be used with Excel (Microsoft, Inc., Redmond, Washington, USA) or LibreOffice Calc (The Document Foundation, Berlin, Germany). In both versions, LORCAT uses macros written in Visual Basic (Microsoft, Inc.) to simulate hardwood log sawing. Depending on your security settings in Excel or Calc, you may see a security warning such as the one shown in Figure 3.1.1, alerting you that macros will open in LORCAT when you open the spreadsheet. If you see that warning, macros from third parties will need to be allowed to run in the spreadsheet program. Click the “Enable Macros” button to allow the macros to execute on your computer.

If you are using LibreOffice Calc and see a warning that macros are disabled (Fig. 3.1.2), then spreadsheet preferences need to be updated to allow macros to be used. The contents of the message shown in Figure 3.1.2 instruct you how to set your LibreOffice Calc preferences to allow macros, which will vary depending on your version of LibreOffice and your operating system. Figure 3.1.3 shows the security section window in *Options* on the left and in *Macro Security* options on the right. In the *Macro Security* window, select “Medium” as shown and then click “OK”. You will need to exit and open LibreOffice Calc again for the change to take effect.

3.2: Expert and Novice Modes

After you have opened LORCAT and enabled the use of macros in your spreadsheet program, you are ready to start using LORCAT. As pointed out before, there are two ways of simulating mill operations in LORCAT, novice and expert. The *Setup* tab allows you to select which level of complexity you want to use (Fig. 3.2.1). Novice processing simplifies the user interfaces and makes it easier for you to perform analyses with less input. Novice mode is better for first-time or casual users. Expert mode processing, conversely, gives you full control over all parameters and modes available. Selecting novice or expert mode will cause the novice screen (Fig. 3.2.2) or the expert screen (Fig. 3.2.3) to appear as well as hide or show some parameters that control the sawing process.

3.3: Interactive and Batch Analyses

LORCAT offers two ways to perform analyses: interactive or batch. Interactive analyses allow you to examine the effects of sawing parameters on a single log with a size and grade of your choice. Figure 3.2.2 shows the *Interactive Sawing* tab for the novice mode. In contrast, batch analyses allow you to examine the effects of sawing parameters on two logs to as many as 1,000 logs. A random sample creation tool allows LORCAT to create a sample conforming to the log size and grade distribution specified by the user. Figure 3.3.1 shows the *Batch Sawing (Novice)* tab.

3.4: Common Concepts

Although LORCAT can perform interactive or batch analyses in either the novice or expert modes, there are concepts that are common to both modes. This section serves as an introduction to these common features. Please note that all measurements are in inches, except for log length, which is in feet.

3.4.1: Log Species

LORCAT allows you to select one of several common commercially used hardwood tree species. A pull-down menu with valid tree species will appear when you double-click the *Species* data cell (Fig. 3.4.1, Table 3.4.1). You have to select a single species as listed in Table 3.4.1. The species selection is used to determine the expected NHLA grade recovery based on the Forest Service hardwood yield tables (Hanks and others 1980). The last entry in the species list is “other”, which represents an average of all hardwood species. It approximates the sawing results of an unlisted hardwood species.

3.4.2: Log Grade

LORCAT users can choose either the Forest Service factory or construction log grades or a log grade based on the number of clear, defect-free faces. Figure 3.4.2 shows the drop-down menu of available log grade selections.

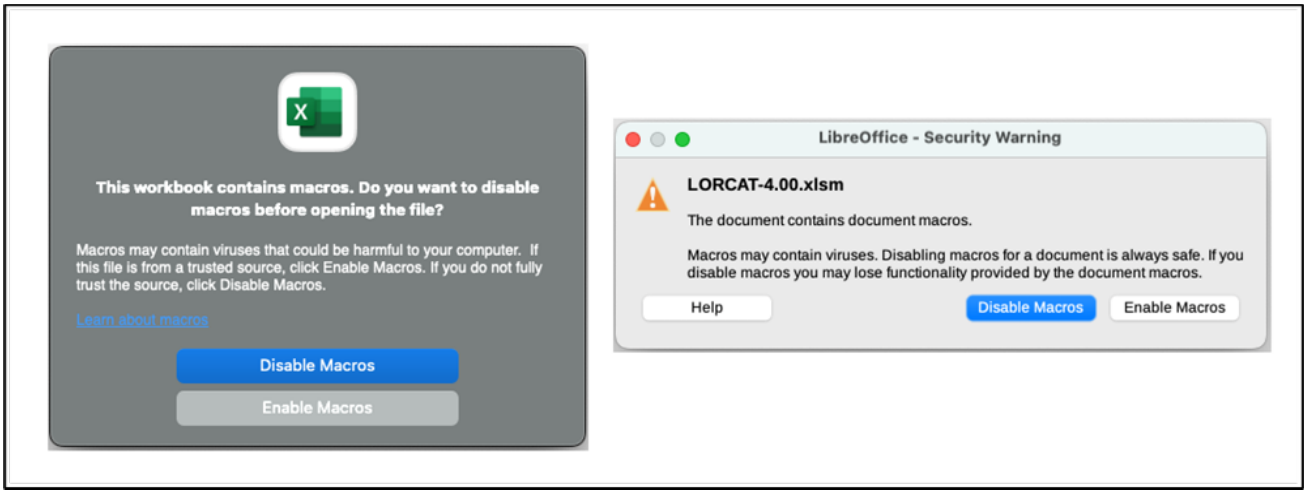


Figure 3.1.1—Sample security warnings from Microsoft Excel (left), and LibreOffice Calc (right).

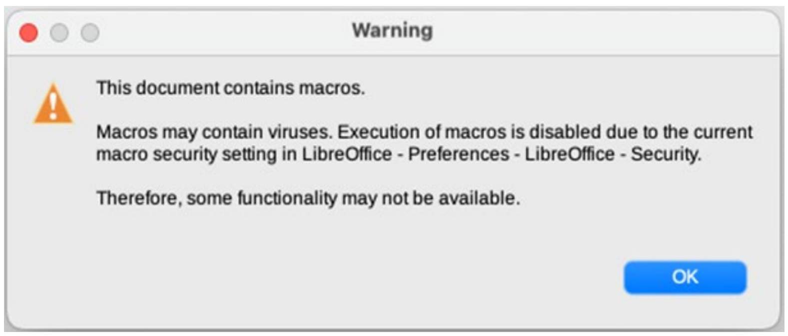


Figure 3.1.2—LibreOffice Calc message reporting that the execution of macros is disabled.

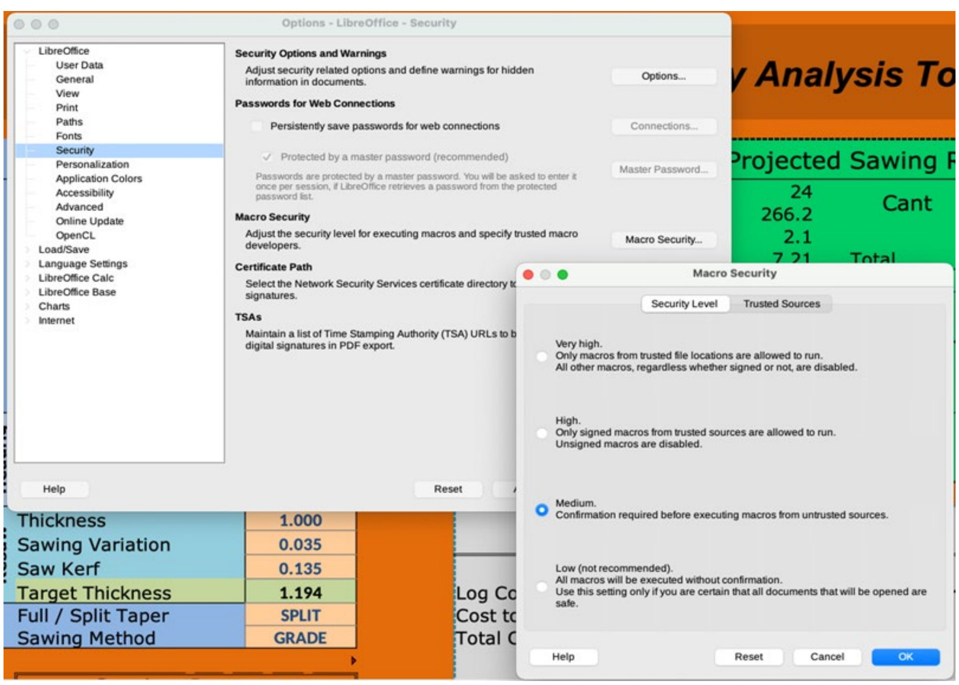


Figure 3.1.3—Updating security preferences in LibreOffice Calc to allow macro execution.

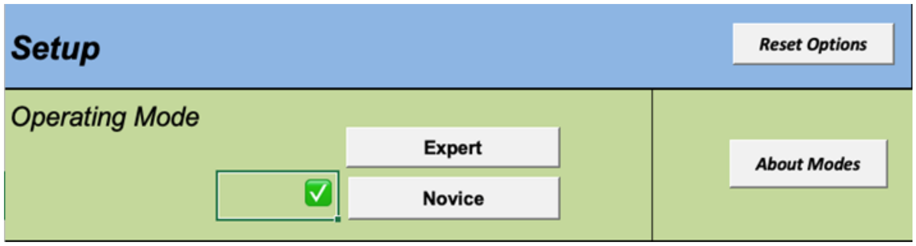


Figure 3.2.1—Setup tab showing the selection of novice mode.

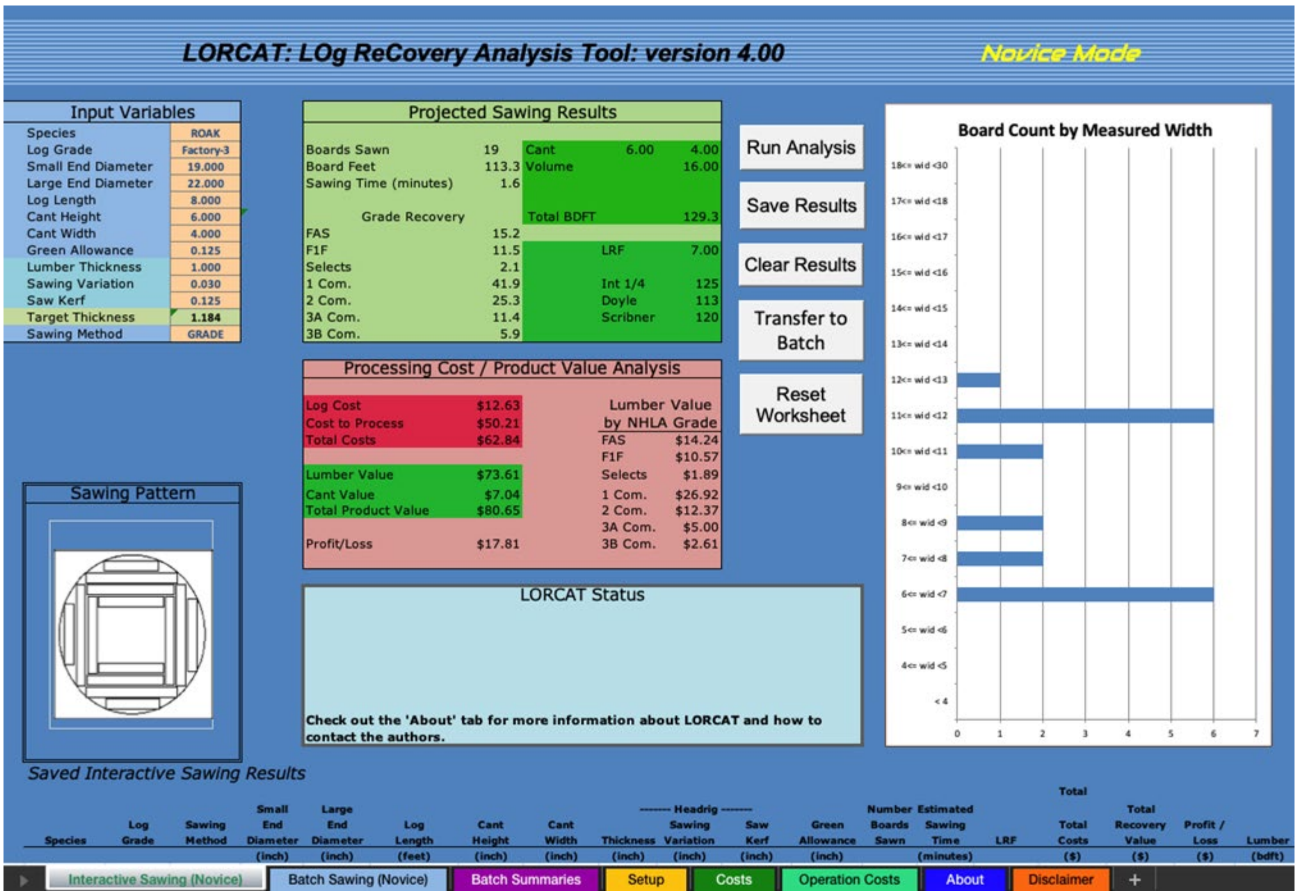


Figure 3.2.2—Novice mode: *Interactive Sawing (Novice)* tab.

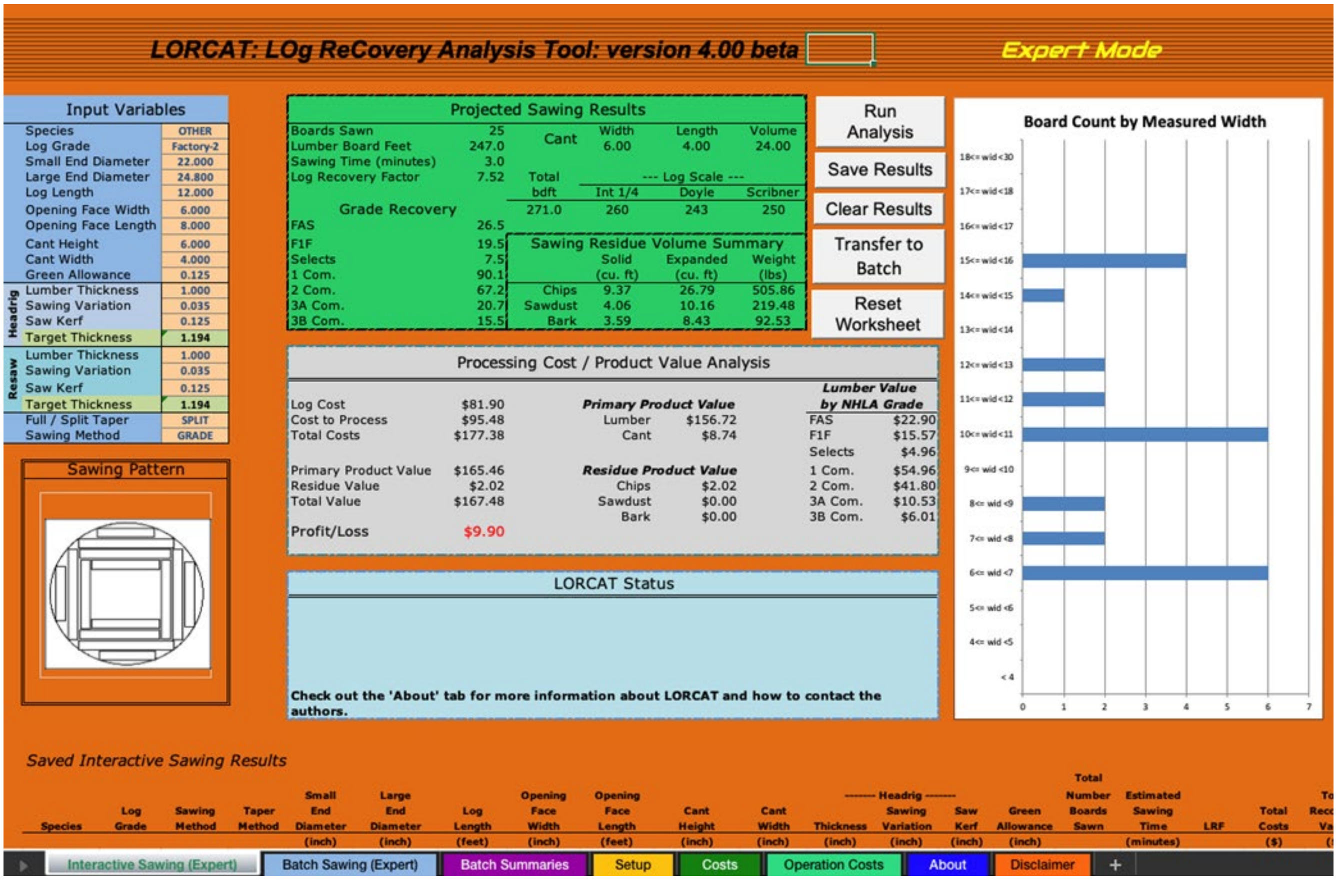


Figure 3.2.3—Expert mode: *Interactive Sawing (Expert)* tab.

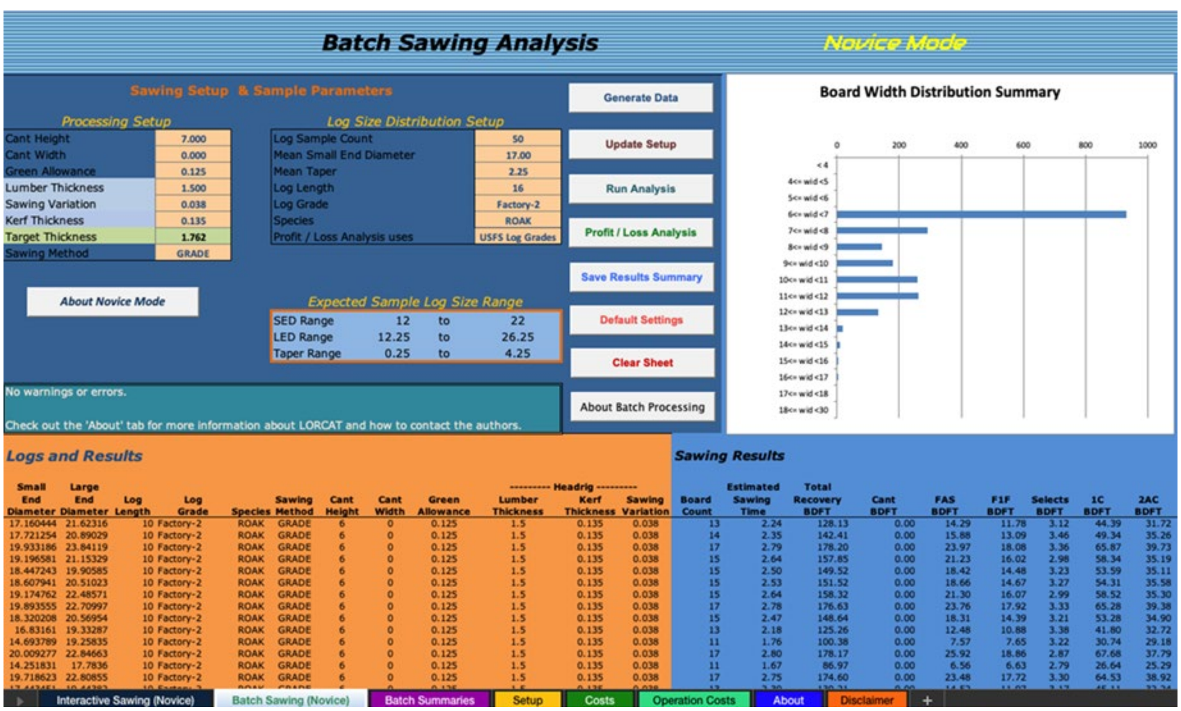


Figure 3.3.1—*Batch Sawing (Novice)* tab.

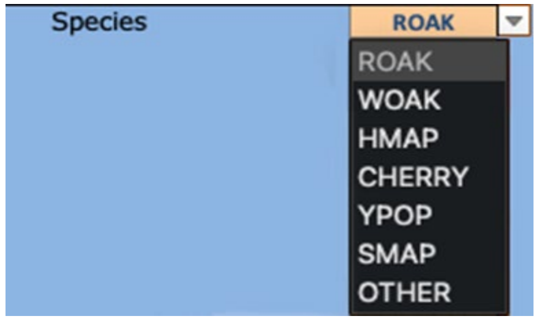


Figure 3.4.1—LORCAT species selection shown in a drop-down menu of all available species.

Table 3.4.1—Menu, common, and scientific names of species available in LORCAT

Menu name	Common name	Scientific name
ROAK	Red oak	*Quercus rubra*
WOAK	White oak	*Quercus alba*
HMAP	Hard maple	*Acer saccharum*
CHERRY	Black cherry	*Prunus serotina*
YPOP	Yellow-poplar	*Liriodendron tulipifera*
SMAP	Soft maple	*Acer rubrum*
OTHER	—	—

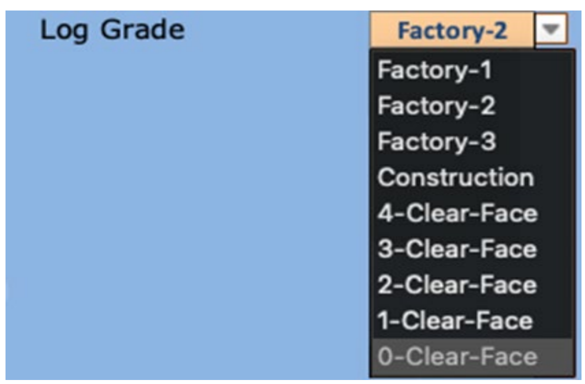


Figure 3.4.2—LORCAT log grade selection showing drop-down menu of all available grades.

Factory-1, Factory-2, Factory-3, and Construction are Forest Service log grades, with Factory-1 being the highest quality and Construction the lowest (Rast and others 1973). The Clear-Face log grades define quality by the number of clear, defect-free faces on the log surface (Cassens 2001, AHMI and AMC 2019). The Forest Service log grades are recognized as good predictors of NHLA recovery and lumber value (Hanks and others 1980). However, because of the complexity of the Forest Service log grades, clear-face log grades are often used.

3.4.3: Cant Size

Figure 3.4.3a shows a cant size data entry example in LORCAT with a cant height of 6 in. and a cant width of 4 in. To instruct LORCAT to produce a cant, simply enter the desired height and width of the cant. This will instruct LORCAT to saw a cant of the specified size and not resaw the cant into lumber. Entering any value for *Cant Height* and a zero for *Cant Width* will generate a cant of the specified height but with a width that will vary depending on the diameter of the log and the number of boards sawn (Fig. 3.4.3b). The resulting cant will then be sawn into lumber a)

Cant Height	6.000
Cant Width	4.000

b)

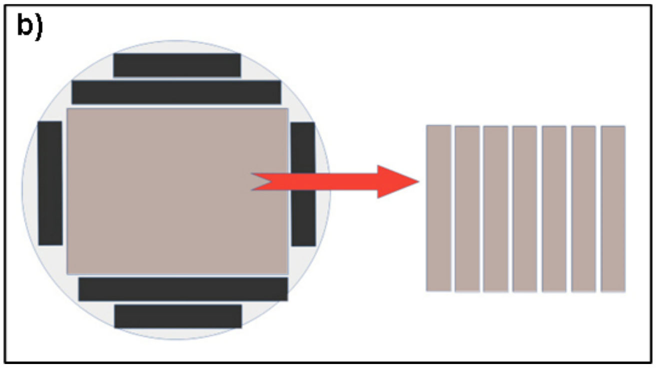


Figure 3.4.3—(a) Cant size specification data entry example; (b) fixed height cant sawn into boards.

using the specified lumber target thickness. If you use expert mode, the cant will be sawn into boards using the resaw sawing parameters. In novice mode, the cant will be sawn using the specified *Target Thickness* sawing parameters. Section 3.4.4: Lumber Thickness and Sawing Options gives more information on lumber thickness, headrig, and resaw sawing parameters. Finally, if a cant is not desired, simply enter zero for both *Cant Height* and *Cant Width*. Doing so is a precursor to setting up a simulation to perform live sawing. Section 3.4.5: Sawing Method gives more information about sawing modes and live sawing.

3.4.4: Lumber Thickness and Sawing Options

The specification of the target lumber size is an important factor in setting up a LORCAT analysis. Figure 3.4.4 shows the four user interfaces displayed depending on which combination of settings you choose, novice, expert, interactive, or batch. *Green Allowance* specifies the additional thickness to be sawn per inch such that when the board is dried (and hence shrinks), the final thickness is the specified or desired *Lumber Thickness*, i.e., the dried board at the end of the process. In novice mode, all sawing is performed on the headrig and a single set of sawing parameters can be entered, all of which pertain to the headrig sawing setup (Fig. 3.4.4a and b). In expert mode, sawing is simulated both on a headrig and, for the cant, on a resaw saw and sawing parameters are specified for each separately (Fig. 3.4.4c and d). Regardless of the analysis type, the first sawing parameter specified is *Lumber Thickness*, the desired thickness in inches of the lumber after drying. The second parameter is *Sawing Variation*, the measured total observed sawing variation. *Sawing Variation* is a combination of the within-board and the between-board sawing variations (Brown 2000). *Kerf Thickness* is the amount of wood removed by the saw during sawing. Based on the entered specifications for *Lumber Thickness*, *Green Allowance*, and *Sawing Variation*, *Target Thickness* is calculated using Brown's equation (Brown 2000):

Target thickness = (Lumber thickness + Green allowance) + Z × Sawing variation (1)

Where Z is the standard normal deviation, which is set at 1.97, allowing 2.5% of all lumber sawn to be undersized.

Thus, because *Target Thickness* is a calculated value, users cannot enter a value into that field.

3.4.5: Sawing Method

Sawing Method in LORCAT has three possible settings: *GRADE, SLAB*, or *LIVE* (Fig. 3.4.5). Your *Sawing Method* setting combined with your *Cant Width* and *Cant Height* settings affects what sawing pattern will be used. *GRADE* simulates the sawing of the log where the log is rotated during sawing and the highest-grade board is sawn at all times (Fig. 2.1a, b). *SLAB* sawing starts from two opposite

a) Novice Interactive

Green Allowance	0.125
Lumber Thickness	1.000
Sawing Variation	0.035
Saw Kerf	0.125
Target Thickness	1.194

b) Novice Batch

Green Allowance	0.125
Lumber Thickness	1.000
Sawing Variation	0.035
Kerf Thickness	0.125
Target Thickness	1.194

c) Expert Interactive

	Green Allowance	0.125
Headrig	Lumber Thickness	1.000
	Sawing Variation	0.035
	Saw Kerf	0.125
	Target Thickness	1.194
Resaw	Lumber Thickness	1.000
	Sawing Variation	0.035
	Saw Kerf	0.125
	Target Thickness	1.194

d) Expert Batch

Green Allowance	0.125	Headrig
Lumber Thickness	1.000	
Sawing Variation	0.035	
Kerf Thickness	0.125	
Target Thickness	1.194	
Lumber Thickness	1.000	Resaw
Sawing Variation	0.035	
Kerf Thickness	0.125	
Target Thickness	1.194	

Figure 3.4.4—Lumber target thickness for (a) novice interactive data entry, (b) novice batch sawing data entry, (c) expert interactive data entry, and (d) expert batch sawing data entry.

Figure 3.4.5—Sawing method selection showing drop-down menu selection.

faces until the specified cant size is achieved, then completes the sawing from the other two faces (Fig. 2.1c, d). *LIVE* sawing is the European method of sawing where the log is sawn through-and-through (Fig. 2.1e). Because NHLA grades (NHLA 2019) have limitations on the amount of wane permitted for each lumber grade, a measured width is determined for the board as if it had been edged. This measured width is then used as part of the criteria for assigning an NHLA grade.

4: Interactive Analyses

An interactive analysis allows you to experiment with sawing parameters on a single log. As such, a series of interactive analyses are quick and easy to conduct, and the differences among the different parameters entered are easy to observe. As previously discussed, there are two operating modes: novice and expert. Novice mode lacks several options, which makes LORCAT easier to operate. Overall, the key differences between novice mode and expert mode are that novice mode

- simulates only split-taper sawing,
- assumes a standard 6-in. by 8-ft minimum opening face board size,
- performs all sawing on the headrig, and
- does not provide residue volume or value estimates.

However, both novice and expert interactive analyses have much of the user interface and its operations in common. Section 4.3: Novice and Expert Interactive Analyses, Commonalities gives more information.

4.1: Novice Interactive Analyses

Figure 4.1.1 identifies the key areas of the *Interactive Sawing (Novice)* tab. The *Input Variables* box in the upper left corner is the only area in which data can be entered. Several components of *Input Variables* are common across all types of analyses. These are described in detail in Section 3.4: Common Concepts and are briefly mentioned in this section. *Projected Sawing Results* and *Processing Cost / Product Value Analysis* are specific to novice analyses. These are introduced in the remainder of this section. The remaining areas are common to both expert and novice interactive analyses. These areas in common are described in Section 5.3: Novice and Expert Batch Analyses, Commonalities.

4.1.1: Input Variables

Figure 4.1.2 shows the *Input Variables* area of the *Interactive Sawing (Novice)* tab. In this area, you enter the information about the log that you want to saw, specifically the *Species*, *Log Grade*, *Small End Diameter*, *Large End Diameter*, and *Log Length*. The available species and log grade options are discussed in Sections 3.4.1: Log Species and 3.4.2: Log Grade, respectively. The remaining entry items are required sawing parameters. The *Cant Height* and *Cant Width* settings control cant production and are detailed in Section 3.4.3: Cant Size. *Green Allowance, Thickness, Sawing Variation, Saw Kerf*, and *Target Thickness* parameters are detailed in Section 3.4.4: Lumber Thickness and Sawing Options. Below the *Target Thickness* is the *Sawing Method*, which controls the overall strategy for sawing and the sawing pattern. Section 3.4.5: Sawing Method gives more information.

4.1.2: Projected Sawing Results

Figure 4.1.3 shows the *Projected Sawing Results* area of the *Interactive Sawing (Novice)* tab. The left side of the *Projected Sawing Results* section reports the total number of boards sawn, the board footage of the sawn lumber, and an estimate of the sawing time in minutes. The sawing time shown in these results is based on the sawmill timing studies by Adams (1984) and can vary significantly from mill to mill. To tailor the sawing times to a specific mill, consult Section 6: Customizing LORCAT. Below *Sawing Time (minutes)* is the estimated recovery for each NHLA grade in board feet.

The right side of the *Projected Sawing Results* area reports the width, height, and volume of the sawn cant, if any. Below the cant information is the total board footage recovered (cant and lumber). Below the board footage recovered, the log recovery factor (LRF) is listed, followed by the board footage for International 1/4, Doyle, and Scribner log scales.

4.1.3: Processing Cost/Product Value Analysis

Figure 4.1.4 shows the *Processing Cost / Product Value Analysis* area. This area reports the estimated costs incurred and the estimated values created. The red highlighted area reports the log cost, cost to process, and total costs incurred for the log entered. Sections 7.1: Operating Costs and 7.1.4: Log Costs per Thousand Board Feet give more information on specifying log and processing costs. Below the cost section, the green highlighted area reports the sawn lumber, cant, and total values. At the bottom of the left side, the profit or loss associated with processing this log is reported.

The right side of this area reports the estimated value by NHLA grade for the lumber volumes reported in the *Projected Sawing Results* area, based on the market values specified in the *Costs* tab. Section 7.1.7: Green Lumber Prices gives information about entering lumber market values.

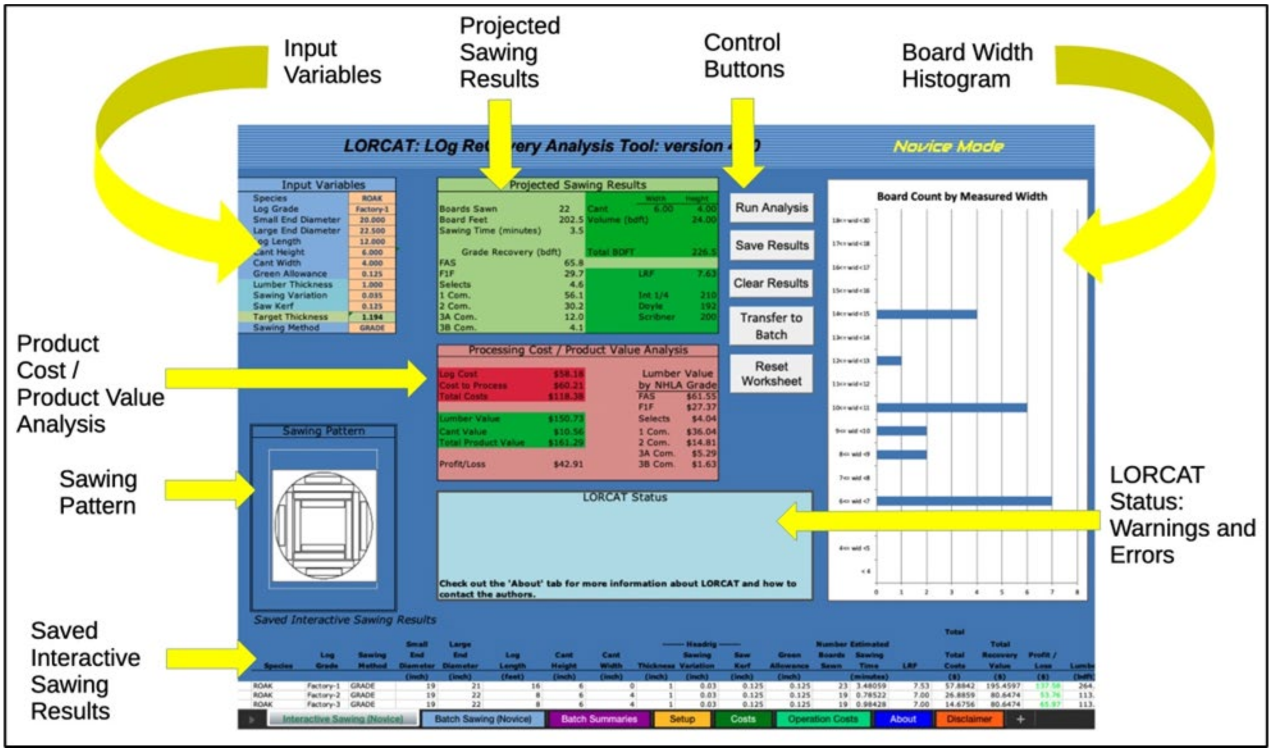


Figure 4.1.1—*Interactive Sawing (Novice)* tab with key areas identified.

Input Variables	
Species	ROAK
Log Grade	Factory-3
Small End Diameter	19.000
Large End Diameter	22.000
Log Length	8.000
Cant Height	6.000
Cant Width	4.000
Green Allowance	0.125
Lumber Thickness	1.000
Sawing Variation	0.030
Saw Kerf	0.125
Target Thickness	1.184
Sawing Method	GRADE

Figure 4.1.2—*Input Variables* for *Interactive Sawing (Novice)* analyses.

Projected Sawing Results				
Boards Sawn	19	Cant	6.00	4.00
Board Feet	113.3	Volume		16.00
Sawing Time (minutes)	1.6			
Grade Recovery		Total BDFT		129.3
FAS	15.2			
F1F	11.5		LRF	7.00
Selects	2.1			
1 Com.	41.9		Int 1/4	125
2 Com.	25.3		Doyle	113
3A Com.	11.4		Scribner	120
3B Com.	5.9			

Figure 4.1.3—*Projected Sawing Results* for *Interactive Sawing (Novice)* interactive analyses.

Processing Cost / Product Value Analysis			
		Lumber Value by NHLA Grade	
Log Cost	$12.63		
Cost to Process	$5.30		
Total Costs	$17.92	FAS	$14.24
		F1F	$10.57
Lumber Value	$73.61	Selects	$1.89
Cant Value	$7.04	1 Com.	$26.92
Total Product Value	$80.65	2 Com.	$12.37
		3A Com.	$5.00
Profit/Loss	$62.72	3B Com.	$2.61

Figure 4.1.4—*Processing Cost / Product Value Analysis* and *Profit/Loss* in the *Interactive Sawing (Novice)* tab.

4.2: Expert Interactive Analyses

Figure 4.2.1 shows the key areas of the *Interactive Sawing (Expert)* tab. Notice that this tab contains more parameters and reports more information than the *Interactive Sawing (Novice)* tab (Fig. 4.1.1). As in novice mode, the *Input Variables* box in the upper left corner is the only area in which you can enter data. The *Input Variables*, *Projected Sawing Results*, and *Processing Cost / Product Value Analysis* areas are specific to expert mode. These are introduced in the remainder of this section. The remaining areas (*Sawing Pattern*, *Saved Interactive Sawing Results*, control buttons, *LORCAT Status*, and *Board Count by Measured Width*) are common to both *Interactive Sawing (Expert)* and *Interactive Sawing (Novice)* analyses and are described in Section 4.3: Novice and Expert Interactive Analyses, Commonalities.

4.2.1: Input Variables

In the *Interactive Sawing (Expert)* tab *Input Variables* area, you enter the information about the log you want to saw, specifically the *Species*, *Log Grade*, *Small End Diameter*, *Large End Diameter*, and *Log Length*. The remaining entry items are for specifying the sawing parameters. The *Opening Face Width* and *Opening Face Length* define the target opening face, in other words, the size of the first board sawn from a face, in inches and feet, respectively. *Cant Height* and *Cant Width* control the sawing of the cant. Section 3.4.3: Cant Size gives detailed information. Next is the entry for *Green Allowance,* which specifies the additional thickness to be sawn per inch such that the board is of the specified thickness when dried.

In the *Interactive Sawing (Expert)* tab, headrig and resaw sawing parameters can be defined separately, which cannot be done in the *Interactive Sawing (Novice)* tab. Figure 4.2.2 shows the *Headrig* and *Resaw* section of the *Input Variables* area shown in Figure 4.2.1. Section 3.4.4: Lumber Thickness and Sawing Options gives more information about lumber thickness and sawing parameters. In the example shown in Figure 4.2.2, the same dried lumber thickness is the goal on both the headrig and the resaw. However, with different sawing variations between the headrig and the resaw, the target thickness sawn is slightly different between the two sawing methods.

You can instruct LORCAT to perform either split-taper or full-taper sawing as described in Section 2: Methods. Below the taper instructions, the last option shown is *Sawing Method,* which has three possible settings: GRADE, SLAB, or LIVE. Section 3.4.5: Sawing Method gives more information.

4.2.2: Projected Sawing Results

To the right of *Input Variables* is *Projected Sawing Results* (Fig. 4.2.1). The *Projected Sawing Results* from the *Interactive Sawing (Expert)* tab are shown in Figure 4.2.3. The left side of the *Projected Sawing Results* reports the total number of *Boards Sawn*, the *Lumber Board Feet* created, the *Sawing Time* used (based on timing studies by Adams (1984)), and the *Log Recovery Factor* achieved. Directly below the *Log Recovery Factor*, you will find the estimated recovery in board feet for each NHLA grade.

The right side of the *Projected Sawing Results* area (Fig. 4.2.3) reports the width, height, and volume of the cant sawn, if any. Below the cant information is the total board footage (*Total bdft*) recovered (cant and lumber board footage), followed by the board footage for International 1/4 (*Int 1/4*), *Doyle*, and *Scribner* log scales. In the lower right corner of the *Projected Sawing Results* area (Fig. 4.2.3) is the *Sawing Residue Volume Summary*. This section reports the estimated *Solid* and *Expanded* volume (cubic feet) and the estimated *Weight* (pounds) of the three types of residues produced: *Chips*, *Sawdust*, and *Bark*. The estimated volume and weight of the residues are based on standard conversion factors (Dobie and Wright 1975, FPL 2010). Section 6: Customizing LORCAT describes how to adjust these conversion factors to reflect specific conditions.

4.2.3: Processing Cost and Product Value Analysis

The gray area in the middle of the *Interactive Sawing (Expert)* tab (Fig. 4.2.1) is shown in Figure 4.2.4. This section reports the *Processing Cost / Product Value Analysis* of the processed log, i.e., the estimated costs and the estimated product values for the processed log. The left side of the *Processing Cost / Product Value Analysis* area (Fig. 4.2.4) summarizes the costs and the product values, and it reports the *Profit / Loss* for processing the current log. The center column of the *Processing Cost / Product Value Analysis* area reports the product values for the *Primary Product Value* of the *Lumber* and *Cant* and the *Residue Product Value* for *Chips*, *Sawdust*, and *Bark*. The right side of the *Processing Cost / Product Value Analysis* area reports the estimated *Lumber Value by NHLA Grade* for the lumber volumes reported in the *Projected Sawing Results* area, based on the market values specified in the *Costs* tab. Section 7.1.7: Green Lumber Prices gives information about entering the lumber market values.

Although most of the necessary data for sawing a log are entered into the *Interactive Sawing (Expert)* tab, the information about log and processing costs needs to be entered into the *Costs* and, if needed, the *Operation Costs* tab. Section 7: Operating Costs and Market Prices gives more information on specifying the log and processing costs as well the revenue generated from the products.

4.3: Novice and Expert Interactive Analyses, Commonalities

Novice and expert interactive analyses are very similar. Both process a log of a specific size and grade using a list of specified sawing operations, costs, and revenues and then summarize and report the results. As such, much of the user interface for the novice and expert interactive analyses are

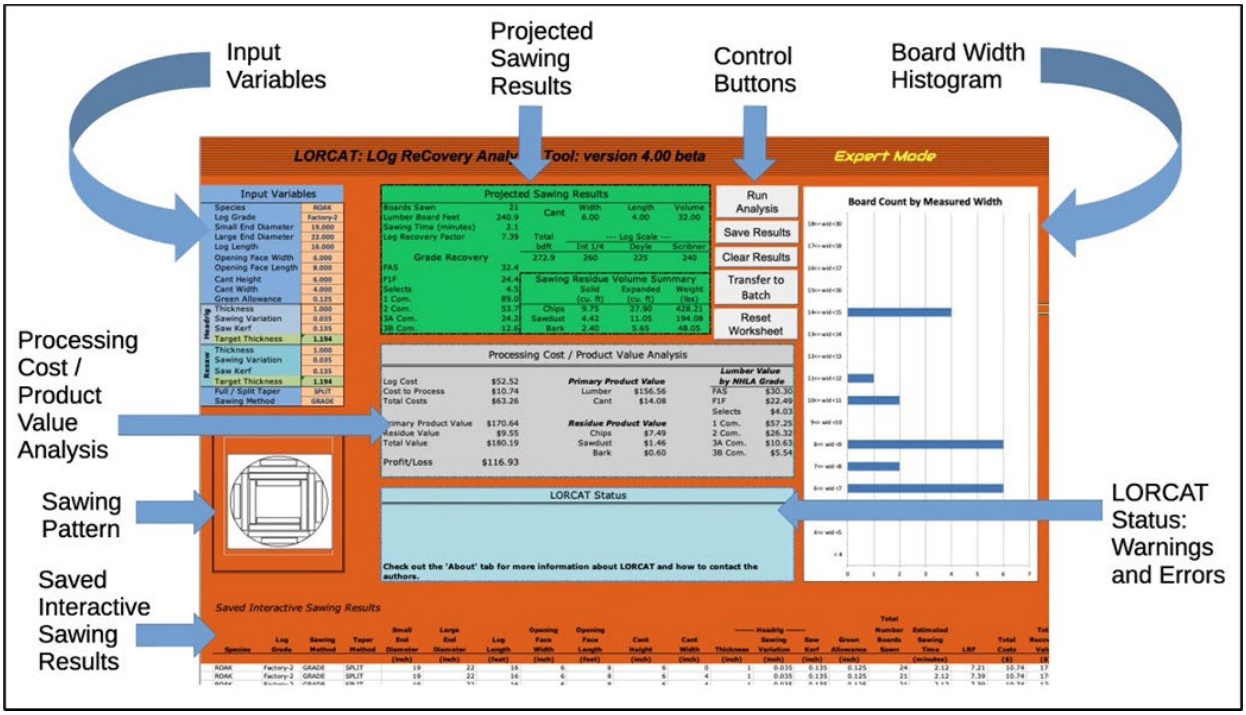


Figure 4.2.1—*Interactive Sawing (Expert)* tab with key areas identified.

Headrig	Lumber Thickness	1.000
	Sawing Variation	0.03
	Saw Kerf	0.135
	Target Thickness	1.184
Resaw	Lumber Thickness	1.000
	Sawing Variation	0.035
	Saw Kerf	0.125
	Target Thickness	1.194

Figure 4.2.2—Detail of the *Headrig* and *Resaw* sawing parameters section of the *Input Variables* setup in the *Interactive Sawing (Expert)* tab.

Projected Sawing Results					
Boards Sawn	21	Cant	Width	Length	Volume
Lumber Board Feet	241.5		6.00	4.00	32.00
Sawing Time (minutes)	2.1				
Log Recovery Factor	7.41	Total	--- Log Scale ---		
		bdft	Int 1/4	Doyle	Scribner
Grade Recovery		273.5	260	225	240
FAS	32.5				
F1F	24.5	Sawing Residue Volume Summary			
Selects	4.6		Solid	Expanded	Weight
1 Com.	89.3		(cu. ft)	(cu. ft)	(lbs)
2 Com.	53.8	Chips	10.02	28.67	440.08
3A Com.	24.2	Sawdust	4.10	10.26	180.09
3B Com.	12.6	Bark	2.40	5.65	48.05

Figure 4.2.3—*Projected Sawing Results* information area in the *Interactive Sawing (Expert)* tab.

Processing Cost / Product Value Analysis					
				Lumber Value by NHLA Grade	
Log Cost	$52.52	***Primary Product Value***			
Cost to Process	$11.02	Lumber	$156.94	FAS	$30.37
Total Costs	$63.54	Cant	$14.08	F1F	$22.55
				Selects	$4.04
Primary Product Value	$171.02	***Residue Product Value***		1 Com.	$57.39
Residue Value	$10.18	Chips	$7.64	2 Com.	$26.38
Total Value	$181.20	Sawdust	$2.13	3A Com.	$10.66
		Bark	$0.41	3B Com.	$5.56
Profit/Loss	$117.65				

Figure 4.2.4—*Processing Cost / Product Value Analysis* information area for expert interactive analyses.

identical. The remainder of this section describes the features common to both types of interactive analyses.

4.3.1: Control Buttons

The buttons in the novice and expert interactive analysis interface allow you to run an interactive analysis, manage results, and reset the worksheet. Figure 4.3.1 displays these control buttons, which are subsequently discussed in detail.

Run Analysis**:** After you have entered all the data (log specifications, sawing parameters, cost and revenue information), simply click the *Run Analysis* button to perform an interactive analysis. The analysis will complete in less than a second, and the *Projected Sawing Results*, *Processing Cost / Product Value Analysis*, and a graph showing the *Board Count by Measured Width*, i.e., a board width histogram plot, will be immediately updated with the new results.

Save Results**:** This button saves a summary of the current analysis in the *Saved Interactive Sawing Results* area at the bottom of the *Interactive Sawing* tab.

Clear Results**:** This button erases all of the saved sawing results stored in the *Saved Interactive Sawing Results* area at the bottom of the *Interactive Sawing* tab. LORCAT will prompt you to confirm this action.

Transfer to Batch**:** This button copies the current sawing setup to the *Batch Sawing* tab. This is helpful if you want to expand your current analysis done on a single log in the *Interactive Sawing* tab to a batch analysis in the *Batch Sawing* tab, where as many as 1,000 logs can be processed simultaneously. Because this action will overwrite the current batch sawing setup in the *Batch Sawing* tab, LORCAT will prompt you to confirm this action.

Reset Worksheet**:** This button will reset the worksheet to the original or default settings that were in place when you first downloaded LORCAT. As with other actions, LORCAT will prompt you to confirm this action.

4.3.2: Warnings and Errors

Located at the bottom center of the *Interactive Sawing* tab, the *LORCAT Status* area (Fig. 4.3.2) reports whether LORCAT detects any unusual values in the settings, such as a large-end diameter (LED) less than the small-end diameter (SED), a log that has excessive taper, a log diameter that is too small for the specified log grade, or live sawing with a cant size. Depending on the error, the window will also tell you how to correct it.

4.3.3: Sawing Pattern

The *Sawing Pattern* area in the *Interactive Sawing* tab (Fig. 4.3.3) shows a generic sawing pattern that will be used to saw the log based on your input in the sawing fields in the *Input Variables* area. Section 3.4.5: Sawing Method gives more information.

4.3.4: Board Width Histogram

The *Board Count by Measured Width* histogram, which is part of both interactive sawing tabs (novice and expert, Figs. 4.1.1 and 4.2.1), summarizes the widths of all the boards sawn by 1-in. width groupings. As such, it gives a quick way to visualize sawing results. Figure 4.3.4 shows a sample *Board Count by Measured Width* histogram for a log being sawn.

4.3.5: Saved Interactive Sawing Results

After you have your data entered and the analysis run, you can save the results in the *Saved Interactive Sawing Results* area (Fig. 4.3.5) after each changing of a sawing parameter(s). For every new saving, a new row is created containing all the information of this particular run; therefore, an almost unlimited number of results can be stored. This area allows you to do a side-by-side comparison of different sawing parameters on the same log or a comparison of different logs, sawing parameters, and sawing patterns. In expert mode, the saved results include the additional processing options as well as residue volume and value results.

5: Batch Analyses

The *Batch Sawing* tab allows you to simulate the processing of samples that contain up to 1,000 logs using their specified sawing parameters. As such, a series of interactive analyses are quick and easy to conduct and the differences among the analyses are easy to observe. As with the *Interactive Sawing* tab previously discussed, there are two distinct operating modes: novice and expert. However, a notable difference between interactive sawing and batch sawing, in both modes, novice and expert, is the amount of time to complete the analysis. An interactive sawing analysis usually takes less than a second. A batch sawing analysis can take several minutes depending on the number of logs being processed and the complexity of the sawing process. Thus, it is normally best to first determine what is desired in the simulation using the interactive sawing tab, then use the batch sawing tab to perform the analysis for a large sample of logs.

The *Batch Sawing* tab requires that you create a sample of logs to process, as opposed to the *Interactive Sawing* tab, in which you specifies only one log. LORCAT provides a means to create combinations of random distributions to match the log grades and sizes the user typically process.

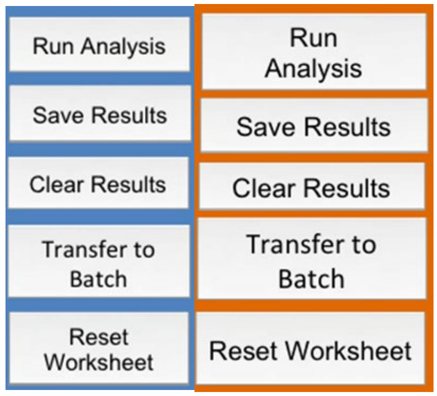


Figure 4.3.1—The same control buttons are used in the *Interactive Sawing (Novice)* (left) and the *Interactive Sawing (Expert)* (right) analysis.

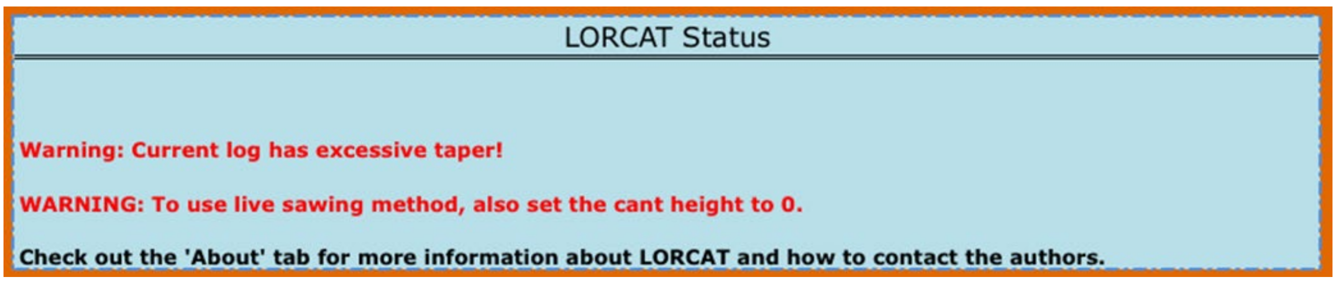


Figure 4.3.2—*LORCAT Status* area showing warning messages related to the setup of an analysis.

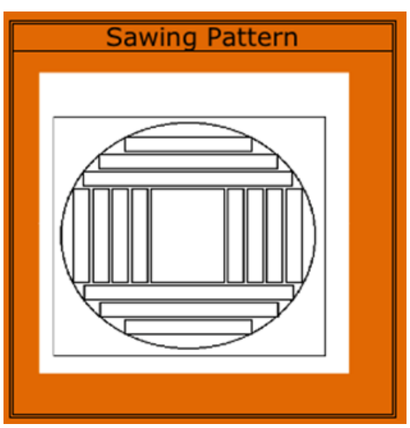


Figure 4.3.3—Generic sawing pattern to be used for this analysis based on input into the sawing fields in the *Input Variables* area.

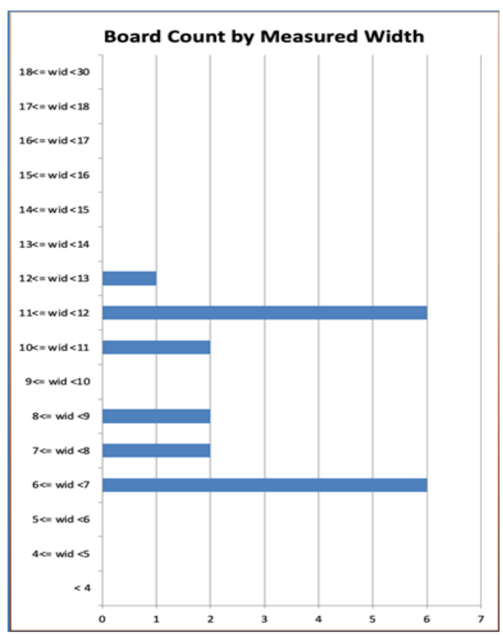


Figure 4.3.4—Histogram showing *Board Count by Measured Width*.

Saved Interactive Sawing Results

Species	Log Grade	Sawing Method	Taper Method	Small End Diameter (inch)	Large End Diameter (inch)	Log Length (feet)	Opening Face Width (inch)	Opening Face Length (feet)	Cant Height (inch)	Cant Width (inch)	------- Headrig ------- Thickness (inch)	Sawing Variation (inch)	Saw Kerf (inch)	Gre Allow (inc
ROAK	Factory-2	GRADE	SPLIT	19	22	16	6	8	6	4	1	0.035	0.135	

Figure 4.3.5—Left side of the *Saved Interactive Sawing Results* with one result saved.

5.1: Novice Batch Analyses

As with the interactive sawing analyses, LORCAT provides a simplified novice *Batch Sawing Analysis* interface (Fig. 5.1.1) to make it easier for novice users. Specifically, the batch sawing (novice) analysis interface has certain processing characteristics embedded:

- Simulates only split-taper sawing
- Assumes a standard 6-in. by 8-ft minimum opening face board size
- Performs all sawing on the headrig
- Does not provide residue volume or value estimates

For batch sawing (novice) analyses, some additional settings are simplified, especially with respect to sample creation:

- The small-end-diameter standard deviation is assumed to be 2.5 in.
- The taper standard deviation is assumed to be 1 in.
- LORCAT will automatically avoid creating logs with scaling diameters less than the minimum SED required for the current log grade

The SED and taper standard deviation assumptions for batch sawing (novice) analyses are based on a statistical analysis of the hardwood log data (Wood and others 2020) collected to establish the Forest Service log grading rules in the 1970s by Rast and others (1973) and the hardwood log grade yield prediction tables by Hanks and others (1980). Theoretically, the data by Wood and others (2020) provide the user with reliable log size distribution data, relieving the user of the need to collect and assess their own data.

The key differences between expert and novice batch sawing analyses are contained in the *Sawing Setup & Sample Parameters* section, which contains the *Processing Setup* and the *Log Size Distribution Setup* areas, as seen in Figure 5.1.1. Novice mode input parameters are discussed in Section 5.1.1: Novice Processing Setup and Section 5.1.2: Novice Log Sample Setup. Expert mode input parameters are discussed in Section 5.2.1: Expert Processing Setup and Section 5.2.2: Expert Log Sample Setup. Other aspects of batch analysis, i.e., control buttons, board width histogram, *Warnings or Errors!*, and *Logs and Results* are common to both novice and expert batch analyses and are discussed in Section 5.3: Novice and Expert Batch Analyses, Commonalities.

5.1.1: Novice Processing Setup

The first step in creating a batch analysis is to enter the variables that define the processing setup (Fig. 5.1.1). If you have created processing settings in the *Interactive Sawing (Novice)* tab that you would like to use for a batch analysis, click the *Transfer to Batch* button in the *Interactive Sawing (Novice)* tab shown in Figure 4.1.1. This will copy your settings in the *Interactive Sawing (Novice)* tab *Input Variables* (*Cant Height*, *Cant Width*, *Lumber Thickness*, *Saw Kerf*, *Sawing Variation*, *Green Allowance*, and *Sawing Method*) to the *Batch Sawing (Novice)* tab. These settings common to all analyses are discussed in Section 3.4: Common Concepts.

5.1.2: Novice Log Sample Setup

Defining the log sample that will be used for the analysis starts with entering the *Log Sample Count* (Fig. 5.1.1), where a sample size of 50 logs has been set by default. LORCAT can process sample sizes of 1 to 1,000 logs. However, depending on your computer and sawing parameters, it can take several minutes to process large log samples. Next, the *Mean Small End Diameter*, also known as the average scaling diameter, is specified. The *Mean Taper,* also known as average taper, parameter describes the average overall difference between SED and LED for the specified log lengths. Based on the *Mean Small End Diameter* and the *Mean Taper*, LORCAT calculates the minimum and maximum SED, LED, and taper for each log and reports these ranges in the light blue box labeled *Expected Sample Log Size Range* just below the *Log Size Distribution Setup* box (Fig. 5.1.1). The information in this box is used as a guide to creating a distribution of log diameters and taper that match the diameters and taper of the logs normally sawn.

After you have the diameter ranges set up, pick the *Log Length,* in feet, that you want for your sample. The next parameter is *Log Grade.* You can choose either a Forest Service factory log grade or a log grade based on the number of clear, defect-free faces. Then, you will have to select the *Species* to be sawn by using the pull-down menu that appears when you click the *Species* cell. After all your entries have been made, click the *Generate Data* button (Figs. 5.1.1 and 5.1.2) and the sample will be added to the *Log and Results* section at the bottom of the tab. To create a sample that includes more than a single log length, enter the *Log Length* for the next sample and make any adjustments to the diameter or taper settings. When you are done adjusting the settings, click the *Generate Data* button (Figs. 5.1.1 and 5.1.2) to add logs matching your settings to the log sample. Using this method, you can create samples consisting of up to 1,000 logs.

To perform a *Profit / Loss Analysis,* you must select the log grading system to be used for the analysis. For profit/loss analyses, only the *Log Length* and *Species* need to be specified. LORCAT automatically creates a diameter distribution that allows you to fully explore the impact of log diameter on profitability.

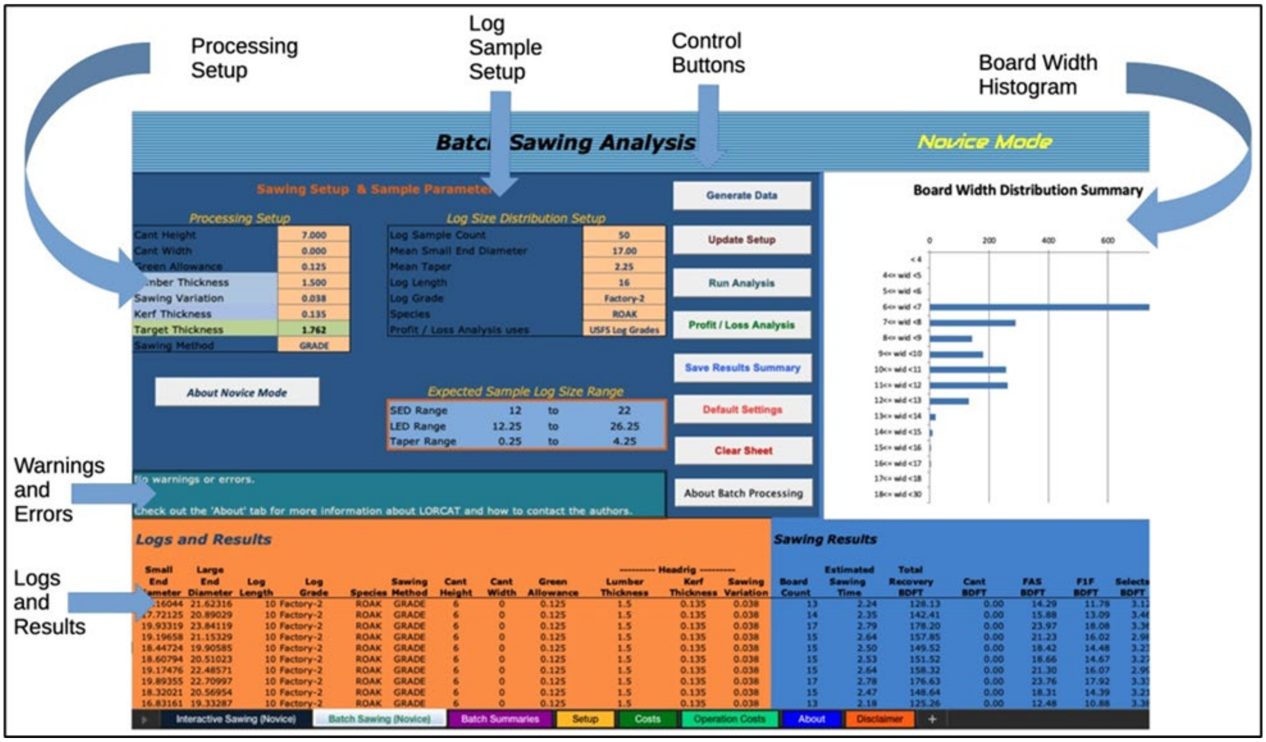


Figure 5.1.1—*Batch Sawing (Novice)* tab with key areas identified.

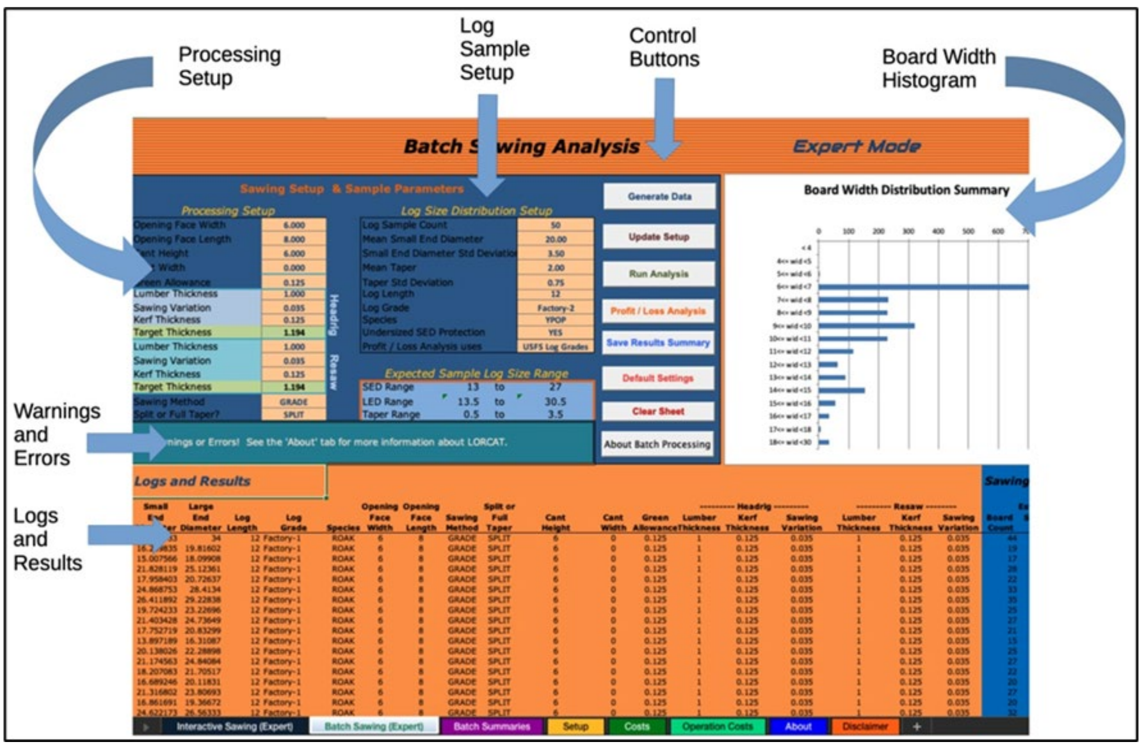


Figure 5.1.2—*Batch Sawing (Expert)* tab with key areas identified.

5.2: Expert Batch Analyses

Expert batch analyses give users access to all features and options that LORCAT provides, including

- Opening face and width settings
- Separate resaw configuration
- Split or full-taper sawing
- Volume, weight, and values for chips, sawdust, and bark residues
- Full control over log sample generation statistics

Although these features make LORCAT simulations more complex to set up, they do make it possible to more closely emulate a real-world mill and obtain more meaningful results.

The major areas of the *Batch Sawing (Expert)* tab are shown in Figure 5.1.2. First, you enter the data that define the sawing process into the *Processing Setup* area. This is discussed in more detail in Section 5.2.1: Expert Processing Setup. The *Log Size Distribution Setup* area is where you enter the specifications that define the log samples to be processed. This is discussed in more detail in Section 5.2.2: Expert Log Sample Setup. The remaining areas shown in Figure 5.1.2, e.g., control buttons, board width histogram, *Warnings and Errors!*, and *Logs and Results,* are common to both novice and expert batch analyses and are discussed in Section 5.3: Novice and Expert Batch Analyses, Commonalities.

5.2.1: Expert Processing Setup

The first step in creating a batch analysis is to enter the variables that define the *Processing Setup* (Fig. 5.1.2). You either enter all the variables here into the appropriate cells of the *Batch Sawing (Expert)* tab or if you have processing settings that were created in the *Interactive Sawing* tab, they can be transferred to the *Batch Sawing* tab by clicking on the *Transfer to Batch* button in the *Interactive Sawing* tab (Fig. 4.2.1).

In the *Processing Setup* area of the *Batch Sawing (Expert)* tab, you must enter the *Opening Face Width* (in inches) and the *Opening Face Length* (in feet) to specify the minimum acceptable width and length of the opening board face. *Cant Height* and *Cant Width* control the dimensions, in inches, of the cant produced. Section 3.4.3: Cant Size gives a full description of the cant height and cant width parameters. Also, in expert mode analyses, lumber thickness, kerf thickness, and sawing variation are specified for the headrig and resaw separately (Fig. 5.1.2). Section 3.4.4: Lumber Thickness and Sawing Options gives a complete description of these parameters and *Green Allowance*. Section 3.4.5: Sawing Method provides information about sawing methods. The last item in the *Processing Setup* area in the *Batch Sawing (Expert)* tab is selecting how to deal with taper (*Split or Full Taper?*) More details about split or full taper sawing can be found in Section 2: Methods.

5.2.2: Expert Log Sample Setup

The next step is to define the log sample that will be used for the analysis. First, enter the *Log Sample Count*, which is the number of logs to be sawn. In Figure 5.1.2, a sample size of 40 logs is specified. LORCAT can process total sample sizes of up to 1,000 logs. However, depending on your computer, it can take several minutes to process samples larger than several hundred logs. Next, the *Mean Small End Diameter*, also known as the average scaling diameter, is specified. The SED range of the logs is controlled by the *Small End Diameter Std Deviation* (SED-STD), where the SED will always be SED ± 2 × SED-STD.

The *Mean Taper* (average taper) parameter describes the average overall difference between SED and LED for the specified log length. Based on the mean SED and mean taper, LORCAT calculates the minimum and maximum *SED Range*, *LED Range*, and *Taper Range* and reports these ranges in the light blue box called *Expected Sample Log Size Range* just below the *Log Size Distribution Setup* box (Fig. 5.1.2). This box can be used as a guide to creating a distribution of log sizes that matches the diameters of the logs you normally saw.

After you have the diameter ranges set up, pick the *Log Length,* in feet, for the specific sample. The next parameter is *Log Grade.* You can choose either a Forest Service factory log grade or a log grade based on the number of clear, defect-free faces. Section 3.4.2: Log Grade contains more information. The remaining required selection to enter is *Species.* A pull-down menu with valid tree species will appear when you click the *Species* cell. Section 3.4.1: Log Species provides a complete description of all species available.

5.3: Novice and Expert Batch Analyses, Commonalities

The differences between novice and expert batch analysis are concentrated in the design and setup of the processing options, the log sample creation, residue calculations, and the processing cost and product value analyses. However, the fundamental aspects of sawing lumber are identical. The remainder of this section discusses the operating aspects that are common to both types (novice and expert) of analyses.

5.3.1: Control Buttons, Creating Sample Sets, and Running Analyses

After you have created your processing options and log size distribution, you are ready to create a sample log set and run an analysis. The control buttons for novice analyses (Fig. 5.1.1) and expert analyses (Fig. 5.1.2) allow you to perform these actions. At a minimum, you will need to click *Generate Data* to create the log sample and *Run Analysis* to perform the sawing simulation. The actions of all the control buttons found in the *Batch Sawing* tab are described here:

***Generate Data*:** This button creates a log sample according to the specifications in the *Log Size Distribution Setup* window and stores them after the last log listed at the bottom of the page in *Logs and Results*. You can use this feature to create log samples that consist of multiple lengths, diameters, tapers, and log grades. LORCAT can process a maximum sample size of 1,000 logs. To create a log sample with only the current sample specification in the *Log Size Distribution Setup* area, click the *Clear Sheet* button first.

***Update Setup*:** If you make changes to the *Processing Setup* but want to keep the same logs, click *Update Setup*. This will replace the processing settings for all the logs stored in the *Logs and Results* section with the updated settings in the *Processing Setup* box. This allows you to make comparisons among different processing setups without any differences in log samples.

***Run Analysis*:** This button commands LORCAT to process all the logs listed at the bottom of the screen and write the results of each log processed. Section 5.3.5: Logs and Results gives information to help you understand the results of your analyses.

***Profit/Loss Analysis*:** This button will start an analysis that allows you to determine which log sizes and grades can be processed profitably, given the processing setup, log costs, processing costs, and lumber and residue market prices. Section 5.5: Profit and Loss Analyses gives more information about this topic.

***Save Results Summary*:** This button will create a summary in the *Batch Summaries* tab for all the logs and results processed with their results shown in the *Logs and Results* section of the *Batch Sawing (Expert)* tab. LORCAT will ask for a descriptive name for this summary. Section 5.4: Batch Analysis Summaries gives more information about these summaries.

***Default Settings*:** This button resets the *Processing Setup* and *Log Size Distribution Setup* parameters to the original LORCAT default settings.

***Clear Sheet*:** This button erases all logs and processing results stored in the *Logs and Results* section of the *Batch Sawing* tab.

***About Batch Processing*:** This button displays a pop-up box with information about batch processing.

5.3.2: Log Sample Creation

The simplest use of the batch interfaces is the creation of a log sample that consists of a single length or single log grade. However, LORCAT allows you to create log samples that include multiple lengths, multiple grades, and different diameter distributions within each grade or length. In short, LORCAT is capable of replicating almost any diameter, length, and log grade that could be encountered in a log yard.

To create a log sample consisting of multiple lengths or grades, you must build the sample by creating each length–grade combination separately. After you specify the distribution for each length–grade combination and click the *Generate Data* button, the logs are added to any logs already listed in the *Logs and Results* section (Fig. 28). To start a new log sample, click the *Clear Sheet* button first to delete all *Logs and Results* from the tab. Section 8.3: Novice Batch leads you through a novice batch analysis that creates samples containing 10-, 12-, and 16-ft-long logs.

5.3.3: Warnings and Errors

Located between the *Sawing Setup & Sample Parameters* and the *Logs and Results* section, the LORCAT status area (Warnings or Errors!) reports if it detects any unusual values in the settings. This include such problems as an LED less than the SED, a log diameter that is too small for the specified log grade, and live sawing with a cant size. Depending on the error, the window may provide instructions on how to correct it.

5.3.4: Board Width Histogram

The *Board Width Distribution Summary* histogram summarizes the population of the widths of the boards sawn by 1-in. width groupings. As such, it gives a quick way to visualize sawing results without regard to length. Figure 5.3.1 shows a sample *Board Width Distribution Summary* histogram from an analysis that processed 100 logs.

5.3.5: Logs and Results

Information about the logs sawn and the results obtained (*Logs and Results*) is contained below the *Sawing Setup & Sample Parameters* and the *Board Width Distribution Summary* in the *Batch Sawing* tab in multiple columns and is color-coded to make it easier to focus on specific information (Fig. 5.3.2). Each row contains all the data and results for a single log. Figure 5.3.2a shows a complete set of columns included in the *Log and Results* section in the *Batch Sawing (Expert)* tab. The leftmost orange columns contain all the log sample data and processing settings that were generated when you clicked the *Generate Data* button in the *Sawing Setup & Sample Parameters* section. Because this section records the log and processing variables, it is populated before the analysis is run. The blue columns contain information about the lumber and cants recovered and the sawing time for each log. The yellow columns present information about the residues generated; hence, there will not be yellow columns when LORCAT is run in novice mode. The green columns labeled *Revenue Cost Analysis* contain all financial information from the run, including profit or loss for a given log sawn. The light blue columns labeled *Over-run Analysis* contain information about over-runs, followed by a gray area that displays the *LRF Statistics*. The purple area contains information about

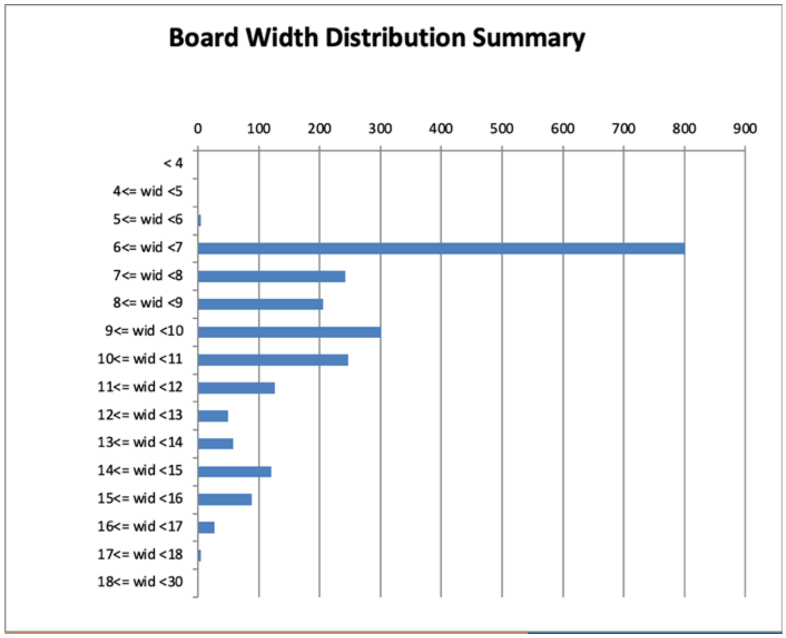
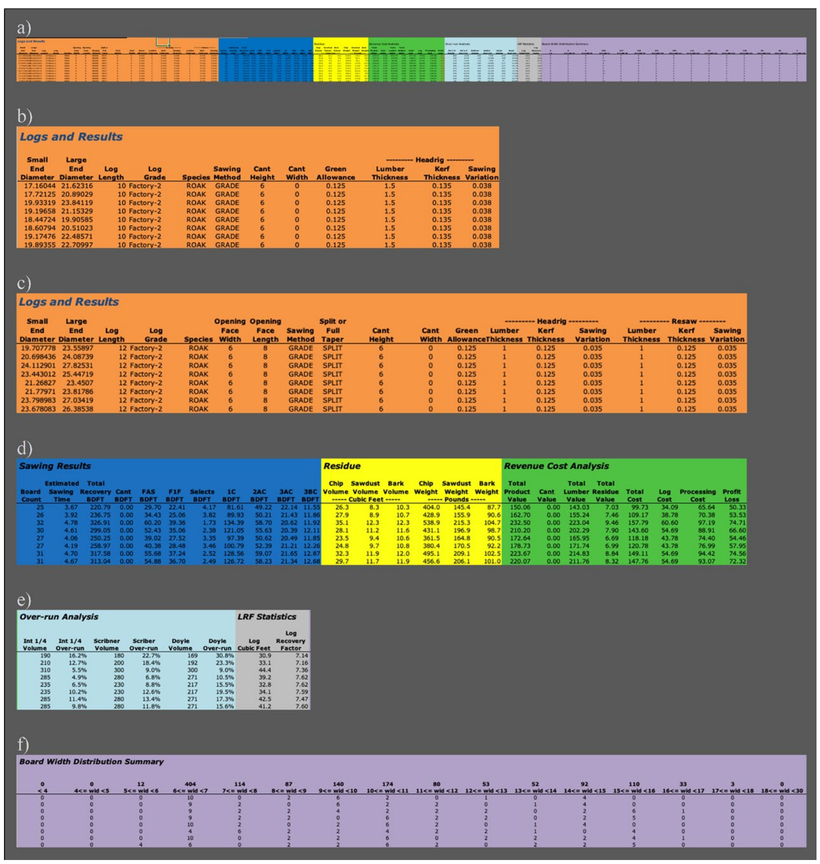


Figure 5.3.1—Sample board width distribution histogram from a batch analysis.



a)

b)

Logs and Results

Small End Diameter	Large End Diameter	Log Length	Log Grade	Species	Sawing Method	Cant Height	Cant Width	Green Allowance	Headrig Lumber Thickness	Headrig Kerf Thickness	Headrig Sawing Variation
17.16044	21.62316	10	Factory-2	ROAK	GRADE	6	0	0.125	1.5	0.135	0.038
17.72125	20.89029	10	Factory-2	ROAK	GRADE	6	0	0.125	1.5	0.135	0.038
19.93319	23.84119	10	Factory-2	ROAK	GRADE	6	0	0.125	1.5	0.135	0.038
19.19658	21.15329	10	Factory-2	ROAK	GRADE	6	0	0.125	1.5	0.135	0.038
18.44724	19.90585	10	Factory-2	ROAK	GRADE	6	0	0.125	1.5	0.135	0.038
18.60794	20.51023	10	Factory-2	ROAK	GRADE	6	0	0.125	1.5	0.135	0.038
19.17476	22.48571	10	Factory-2	ROAK	GRADE	6	0	0.125	1.5	0.135	0.038
19.89355	22.70997	10	Factory-2	ROAK	GRADE	6	0	0.125	1.5	0.135	0.038

c)

Logs and Results

Small End Diameter	Large End Diameter	Log Length	Log Grade	Species	Opening Face Width	Opening Face Length	Sawing Method	Split or Full Taper	Cant Height	Cant Width	Green Allowance	Headrig Lumber Thickness	Headrig Kerf Thickness	Headrig Sawing Variation	Resaw Lumber Thickness	Resaw Kerf Thickness	Resaw Sawing Variation
19.707778	23.55897	12	Factory-2	ROAK	6	8	GRADE	SPLIT	6	0	0.125	1	0.125	0.035	1	0.125	0.035
20.698436	24.08739	12	Factory-2	ROAK	6	8	GRADE	SPLIT	6	0	0.125	1	0.125	0.035	1	0.125	0.035
24.112901	27.82531	12	Factory-2	ROAK	6	8	GRADE	SPLIT	6	0	0.125	1	0.125	0.035	1	0.125	0.035
23.443012	25.44719	12	Factory-2	ROAK	6	8	GRADE	SPLIT	6	0	0.125	1	0.125	0.035	1	0.125	0.035
21.26827	23.4507	12	Factory-2	ROAK	6	8	GRADE	SPLIT	6	0	0.125	1	0.125	0.035	1	0.125	0.035
21.77971	23.81786	12	Factory-2	ROAK	6	8	GRADE	SPLIT	6	0	0.125	1	0.125	0.035	1	0.125	0.035
23.798983	27.03419	12	Factory-2	ROAK	6	8	GRADE	SPLIT	6	0	0.125	1	0.125	0.035	1	0.125	0.035
23.678083	26.38538	12	Factory-2	ROAK	6	8	GRADE	SPLIT	6	0	0.125	1	0.125	0.035	1	0.125	0.035

d)

Sawing Results

Board Count	Estimated Sawing Time	Total Recovery BDFT	Cant BDFT	FAS BDFT	F1F BDFT	Selects BDFT	1C BDFT	2AC BDFT	3AC BDFT	3BC BDFT
25	3.67	220.79	0.00	29.70	22.41	4.17	81.61	49.22	22.14	11.55
26	3.92	236.75	0.00	34.43	25.06	3.82	89.93	50.21	21.43	11.86
32	4.78	326.91	0.00	60.20	39.36	1.73	134.39	58.70	20.62	11.92
30	4.61	299.05	0.00	52.43	35.06	2.38	121.05	55.63	20.39	12.11
27	4.06	250.25	0.00	39.02	27.52	3.35	97.39	50.62	20.49	11.85
27	4.19	258.97	0.00	40.38	28.48	3.46	100.79	52.39	21.21	12.26
31	4.70	317.58	0.00	55.68	37.24	2.52	128.56	59.07	21.65	12.87
31	4.67	313.04	0.00	54.88	36.70	2.49	126.72	58.23	21.34	12.68

Residue

Chip Volume (Cubic Feet)	Sawdust Volume (Cubic Feet)	Bark Volume (Cubic Feet)	Chip Weight (Pounds)	Sawdust Weight (Pounds)	Bark Weight (Pounds)
26.3	8.3	10.3	404.0	145.4	87.7
27.9	8.9	10.7	428.9	155.9	90.6
35.1	12.3	12.3	538.9	215.3	104.7
28.1	11.2	11.6	431.1	196.9	98.7
23.5	9.4	10.6	361.5	164.8	90.5
24.8	9.7	10.8	380.4	170.5	92.2
32.3	11.9	12.0	495.1	209.1	102.5
29.7	11.7	11.9	456.6	206.1	101.0

Revenue Cost Analysis

Total Product Value	Cant Value	Total Lumber Value	Total Residue Value	Total Cost	Log Cost	Processing Cost	Profit Loss
150.06	0.00	143.03	7.03	99.73	34.09	65.64	50.33
162.70	0.00	155.24	7.46	109.17	38.78	70.38	53.53
232.50	0.00	223.04	9.46	157.79	60.60	97.19	74.71
210.20	0.00	202.29	7.90	143.60	54.69	88.91	66.60
172.64	0.00	165.95	6.69	118.18	43.78	74.40	54.46
178.73	0.00	171.74	6.99	120.78	43.78	76.99	57.95
223.67	0.00	214.83	8.84	149.11	54.69	94.42	74.56
220.07	0.00	211.76	8.32	147.76	54.69	93.07	72.32

e)

Over-run Analysis: Int 1/4 Volume	Int 1/4 Over-run	Scribner Volume	Scriber Over-run	Doyle Volume	Doyle Over-run	LRF Statistics: Log Cubic Feet	Log Recovery Factor
190	16.2%	180	22.7%	169	30.8%	30.9	7.14
210	12.7%	200	18.4%	192	23.3%	33.1	7.16
310	5.5%	300	9.0%	300	9.0%	44.4	7.36
285	4.9%	280	6.8%	271	10.5%	39.2	7.62
235	6.5%	230	8.8%	217	15.5%	32.8	7.62
235	10.2%	230	12.6%	217	19.5%	34.1	7.59
285	11.4%	280	13.4%	271	17.3%	42.5	7.47
285	9.8%	280	11.8%	271	15.6%	41.2	7.60

f)

Board Width Distribution Summary

< 4	4<= wid <5	5<= wid <6	6<= wid <7	7<= wid <8	8<= wid <9	9<= wid <10	10<= wid <11	11<= wid <12	12<= wid <13	13<= wid <14	14<= wid <15	15<= wid <16	16<= wid <17	17<= wid <18	18<= wid <30
0	0	12	404	114	87	140	174	80	53	52	92	110	33	3	0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Figure 5.3.2—Simulation data and results: (a) complete set of log, processing, and results columns as presented in LORCAT; (b) novice log information and processing settings; (c) expert log information and processing settings; (d) NHLA grade recovery, residue volumes, and value by product; (e) log scale and log recovery factor; (f) board counts by width category.

the *Board Width Distribution Summary*, which is used to generate the *Board Width Distribution Summary* histogram.

Figure 5.3.2b shows the columns for novice analyses, whereas Figure 5.3.2c shows the columns for expert analyses. The key difference between Figures 5.3.2b and 5.3.2c is that 5.3.2c contains the extra processing options that can only be entered in expert mode. The blue columns shown in Figure 5.3.2d report estimated processing time, total recovery, and recovery by NHLA grade (NHLA 2019). Expert analyses will include the yellow columns that report residue product volumes and weight (Fig. 5.3.2d). The green columns (Fig. 5.3.2d) report the values of the different products, processing costs, log cost, and most importantly, profit or loss. If processing the log resulted in a loss, the value is displayed in red. The light blue columns (Fig. 5.3.2e) show log scale volumes and over-run percentage. If an under-run occurred, the value is reported as a negative. The gray columns (Fig. 5.3.2e) contain the cubic footage of the log calculated using Smalian's equation (Haygreen and Bowyer 1996) and the LRF. The purple columns in Figure 5.3.2f count the numbers of boards sawn by board width. The data in these columns are used to create the *Board Width Distribution Summary* (Fig. 5.3.1).

5.4: Batch Analysis Summaries

Batch analysis summaries are used to compare results and trends across different analyses. For example, if you want to determine the impact of a potential reduction in kerf thickness, make two batch analyses, one for each kerf thickness, and save summaries for each. The *Batch Summaries* tab (Fig. 5.4.1) shows the overview for both kerf thicknesses (Fig. 5.4.1a). You can easily compare the differences in recovery (Fig. 5.4.1b); residue or waste (Fig. 5.4.1c); product value, operating cost, and profit (Fig. 5.4.1c); log scale over/under run (Fig. 5.4.1c); and width distribution of sawn lumber (Fig. 5.4.1d).

When the results from a batch analysis are analyzed, there are several important factors to check to make sure that the analysis is valid and reflects your operation as accurately as possible. Such checks and comparisons include the following questions:

- Is the total sawing time as expected?
- Is the LRF too low or too high?
- Was a profit expected but a loss or very low profit realized?
- Was the processing cost (much) higher than expected?

These checks are simple ones that can help identify a mistake in your setup. Solutions for these common issues are presented in Section 9: Troubleshooting Simulations.

5.5: Profit and Loss Analyses

The profit and loss analysis is designed to make it easy for you to determine which log diameters of specific grades, given your processing setup and costs and revenues, result in a loss or a minimal profit when sawn. Identifying logs that will lose money, and ideally keeping them out of the mill, will boost the mill's profitability. The only difference between expert and novice profit and loss analyses is that the expert mode analysis includes the expenses and profit related to handling and selling residue products. Because the key goal of both analyses is determining the profitability trends of logs with respect to diameter and grade, expert and novice profit and loss analyses are discussed together.

The analysis can take as much as 40 minutes to run and will overwrite any information currently in the *Logs and Results* area. Because of this, LORCAT will ask if you really want to run the analysis. You have the option of performing the analysis using Forest Service log grades or clear-face log grades. The log grading system preference can be set using the pull-down menu in *Profit/Loss Analysis Uses* in the *Log Size Distribution Setup* area. Most importantly, to perform this analysis, you must have your costs and market prices entered into LORCAT. Section 7: Operating Costs and Market Prices gives information about specifying costs and market prices.

When you click the *Profit / Loss Analysis* button, LORCAT first generates a log sample to use with the analysis. The sample will include logs of every log grade. If you are using Forest Service log grades, there will be three log groups: Factory 1, Factory 2, and Factory 3. If you are using clear-face log grades, there will be five log groups: 4 clear faces, 3 clear faces, 2 clear faces, 1 clear face, and no clear face. Within each log grade grouping, a sample of logs will be created ranging from the minimum SED for the log grade to the maximum SED normally observed by 0.1-in. increments. The LED is then estimated using the hardwood log taper distribution documented by Wood and others (2020). Thus, 10 logs are created for each inch diameter class. Figure 7.1 shows a portion of the log data and results from a profit and loss analysis. The leftmost orange columns show information about the log processed; the green columns report the different product values and costs, as well as *Profit Loss* in the rightmost column. This sample is from a novice analysis that excludes residue value. Section 8.5: Batch Sawing (Novice) Profit / Loss Analyses presents an example that performs a novice profit/loss analysis.

6: Customizing LORCAT

LORCAT includes some customization options to tailor the operation of the simulation, the logs sawn, and the results to your preferences and operations.

6.1: Novice and Expert Mode

The ability to switch operating modes between novice and expert is a key customization feature of LORCAT (Fig. 6.1.1). Novice mode (Fig. 6.1.1a) simplifies the setup

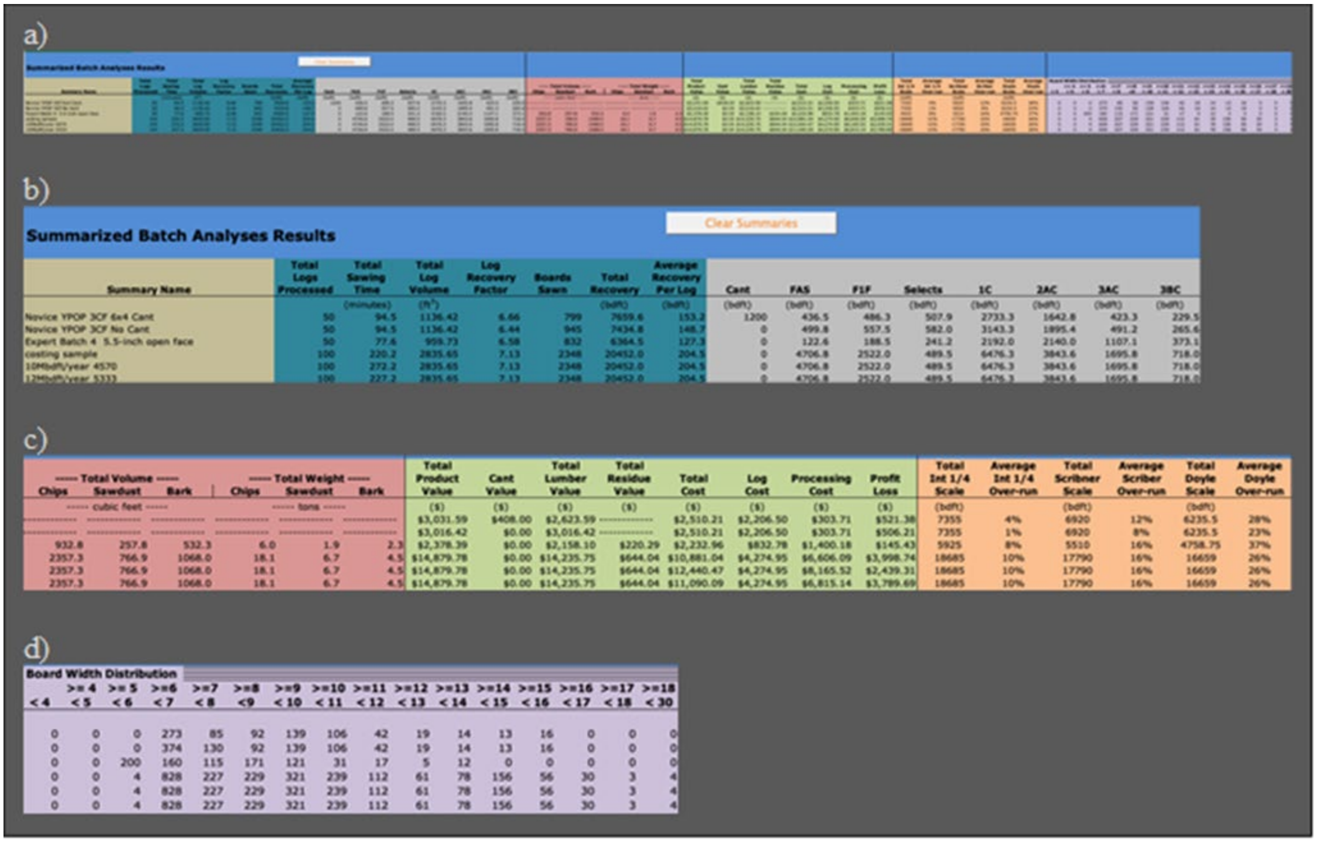
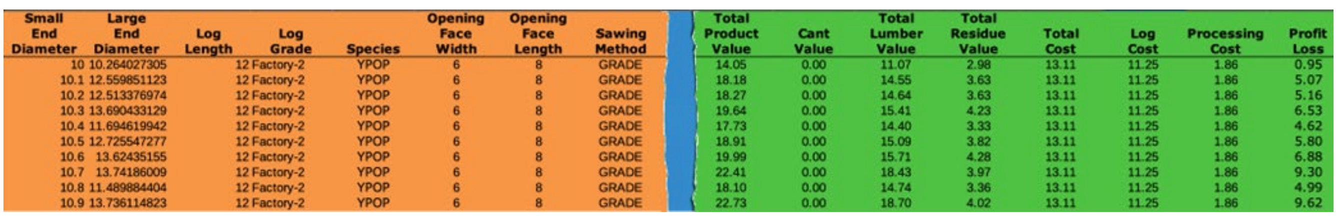


Figure 5.4.1—Batch analysis summary tab screenshot: (a) complete set of *Summarized Batch Analyses Results* columns; (b) leftmost columns with description, log sample summary, and recovery by NHLA Grade; (c) middle columns with residue volumes, values, and log scales; (d) rightmost columns with *Board Width Distribution* data.



Small End Diameter	Large End Diameter	Log Length	Log Grade	Species	Opening Face Width	Opening Face Length	Sawing Method	Total Product Value	Cant Value	Total Lumber Value	Total Residue Value	Total Cost	Log Cost	Processing Cost	Profit Loss
10	10.264027305	12	Factory-2	YPOP	6	8	GRADE	14.05	0.00	11.07	2.98	13.11	11.25	1.86	0.95
10.1	12.559851123	12	Factory-2	YPOP	6	8	GRADE	18.18	0.00	14.55	3.63	13.11	11.25	1.86	5.07
10.2	12.513376974	12	Factory-2	YPOP	6	8	GRADE	18.27	0.00	14.64	3.63	13.11	11.25	1.86	5.16
10.3	13.690433129	12	Factory-2	YPOP	6	8	GRADE	19.64	0.00	15.41	4.23	13.11	11.25	1.86	6.53
10.4	11.694619942	12	Factory-2	YPOP	6	8	GRADE	17.73	0.00	14.40	3.33	13.11	11.25	1.86	4.62
10.5	12.725547277	12	Factory-2	YPOP	6	8	GRADE	18.91	0.00	15.09	3.82	13.11	11.25	1.86	5.80
10.6	13.62435155	12	Factory-2	YPOP	6	8	GRADE	19.99	0.00	15.71	4.28	13.11	11.25	1.86	6.88
10.7	13.74186009	12	Factory-2	YPOP	6	8	GRADE	22.41	0.00	18.43	3.97	13.11	11.25	1.86	9.30
10.8	11.489884404	12	Factory-2	YPOP	6	8	GRADE	18.10	0.00	14.74	3.36	13.11	11.25	1.86	4.99
10.9	13.736114823	12	Factory-2	YPOP	6	8	GRADE	22.73	0.00	18.70	4.02	13.11	11.25	1.86	9.62

Figure 5.5.1—Profit and loss analysis sample showing profitability of a segment of the log sample.

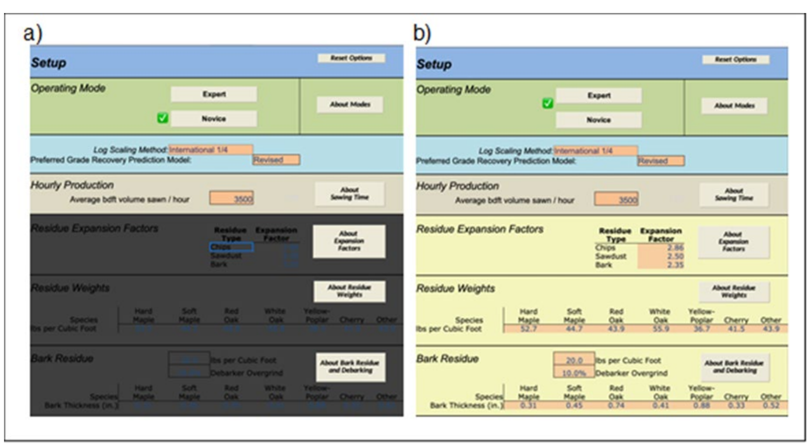


Figure 6.1.1—LORCAT *Setup* tab: (a) novice mode view; (b) expert mode view.

parameters that you have to enter to perform an interactive or batch analysis by making assumptions about the operation being simulated. Sections 4: Interactive Analyses and 5.1: Novice Batch Analyses give more information about these assumptions. Conversely, expert mode requires that you enter a complete set of specifications for their operation. Additionally, expert mode enables the volume and weight estimation of residue products (Fig. 6.1.1b).

6.2: Log Scale

To account for the log volume and costs being processed, LORCAT can use International 1/4, Scribner, or Doyle log scaling (Fig. 6.1.1). The selected log scale is then used for determining the log volume and cost (Section 7: Operating Costs and Market Prices).

6.3: Log Grade Recovery

To determine the NHLA grade recovery from sawing, LORCAT uses data from Hanks and others (1980) to estimate grade recovery. The Hanks and others (1980) recovery data are based on the sawing of nearly 10,000 logs. Two estimation methods are based on this data: *Original* and *Revised* (Fig. 6.1.1). The *Original* grade recovery prediction method uses the data as published by the Forest Service (Hanks and others 1980). However, the Hanks data have gaps and do not cover all diameters for all species. Thus, logs not included in the original Forest Service data will not have a projected grade recovery. Another problem with the grade recovery tables is that the number of logs for some species and diameter combinations is based on a single log. Thus, the prediction table can yield inconsistent and biased predictions for some logs. With the original grade recovery data that Wood and others (2020) collected to establish the NHLA grade recovery tables (Hanks and others 1980, Hanks 1973), a series of grade recovery prediction models were developed to predict NHLA grade yields for all species and diameters. Selecting the *Revised* method will enable LORCAT to use the newer revised recovery prediction model (Thomas and Buehlmann, in press).

6.4: Estimated Sawing Times

The estimated sawing times in LORCAT are based on the hardwood log sawing data collected by Adams as part of the DESIM (Adams 1984) and PC SOLVE (Adams 1996) projects. Enter your mill's average board feet volume sawn per hour into the *Hourly Production* section of the *Setup* tab (Fig. 6.1.1). LORCAT uses the volume you enter as a factor into a model that estimates the time required to saw a log. The model is based on the scaling diameter, log length, and grade. The estimated board feet per hour will vary slightly depending on log grade, scaling diameter, and length.

6.5: Expert Mode Residue Volume and Weight Options

Figure 6.1.1b shows the expert mode version of the *Setup* tab with the residue configuration automatically enabled. When logs are sawn, three types of residues are generated: chips, sawdust, and bark. When these products are generated in the mill, they are produced as particulates, ranging from small particles such as sawdust to larger particles such as bark chunks and slabs that are typically converted into chips. LORCAT calculates the volumes of these residues not as particles but as a solid volume (Fig. 6.5.1). The log volume is calculated using Smalian's equation (Haygreen and Bowyer 1996) using the LED and SED measured inside the bark. Bark volume is then calculated based on the bark thickness added to the diameter-inside-bark measurements (Dobie and Wright 1975). Figure 6.5.1 shows what areas of the log are used to estimate residual volumes.

6.5.1: Expansion Factors

To convert these solid volumes into expanded or particulate volumes, an expansion factor is required. Figure 6.1.1b shows the default expansion factors for the three residue types as determined by Dobie and Wright (1975). Thus, based on the default expansion factors, 1 ft^3 of solid wood when chipped becomes 2.5 ft^3 of chips.

6.5.2: Residue Weights

The *Residue Weights* section allows you to specify the weight in pounds of a cubic foot of solid wood by hardwood species (Fig. 6.1.1b). The default weights included in LORCAT were calculated using the average green moisture content and species weights from the Wood Handbook (FPL 2021).

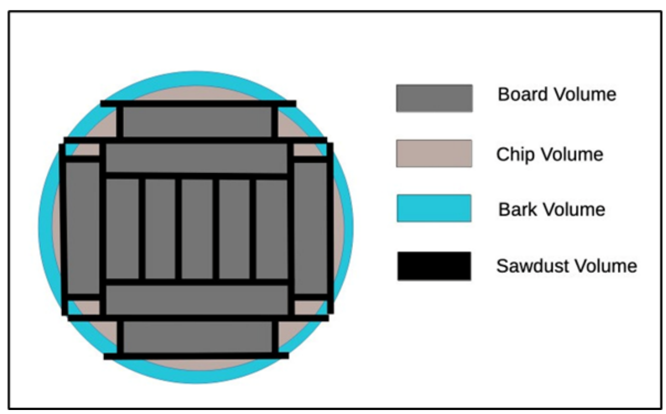


Figure 6.5.1—Schematic drawing of a log showing lumber and residue volumes.

6.5.3: Bark Residue

LORCAT uses an average weight per cubic foot of bark (Dobie and Wright 1975) to estimate the total weight of the bark residue based on the average bark thickness specific to each species. The default bark thicknesses were calculated using the methods defined by Haygreen and Bowyer (1996). It is normal for some solid wood to be removed from the logs during the debarking process. Depending on the operator and the logs being debarked, this amount of 'overgrind' will vary. A *Debarker Overgrind* variable was added to account for this extra material being torn away from the log (Fig. 6.1.1b).

7: Operating Costs and Market Prices

The costs worksheet collects information about the costs of doing business and allows entry of the revenue expected from selling the products. Figure 7.1 shows an overview of the costs worksheet in LORCAT 4.00. The *Costs* tab starts with the *Operating Costs* at the top, followed by the *Log Costs per Thousand bdft*, then the *Cant Prices* on the left side and the *Residues Prices* on the right side, and finally the *Green Lumber Prices* at the bottom. Each of these sections is subsequently discussed.

7.1: Operating Costs

LORCAT 4.00 offers three ways to account for operating costs: *Sawing Time-Based Costing*, *Sawn Lumber Volume-Based Costing*, and *Input Log Volume-Based Costing*. Only the selected costing method can be seen and configured. The unselected methods are shaded and unavailable. To pick a costing method, simply click the button associated with the method.

7.1.1: Sawing Time-Based Costing

Mills that know how many board feet of logs can be sawn in a given time period (typically an hour) will want to select *Use Sawing Time-Based Costing* for their calculations. This costing method bases the operating cost on the estimated amount of time needed to saw a log. Sawing time is estimated using the scaling diameters, lengths, and grades of the logs to be processed based on mill timing studies by Adams (1984). This estimated time for processing logs may not reflect the true value for a given mill; hence, this estimated sawing time can be adjusted in the *Setup* tab. Section 6.4: Estimated Sawing Times gives more information about configuring sawing time. You can either enter the operating cost of the mill in U.S. dollars per hour directly or use the *Operating Costs* sheet to calculate costs in U.S. dollars per hour for a given utilization rate of the mill. This feature can be turned on or off by choosing yes or no in the field adjacent to the *Use operating cost from "Operations Costs" sheet?* question. Figure 7.1.1 shows the setup of sawing time-based costing without the use of LORCAT's *Operation Costs* feature, meaning that you must enter the operating cost in U.S. dollars per hour in the field adjacent to *Operating cost, directly specified*.

7.1.2: Sawn Lumber-Based Costing

Mills that know how many board feet of lumber can be sawn in a given time period (typically an hour) will want to select *Use Sawn Lumber Volume-Based Costing* for their calculations. This costing method bases the operating cost on the estimated average sawn volume of lumber per hour. You can either enter the operating cost of the mill in U.S. dollars per hour directly or use the *Operating Costs* sheet to calculate costs in U.S. dollars per hour for a given utilization rate of the mill. This feature can be turned on or off by choosing yes or no in the field adjacent to the *Use operating cost from "Operations Costs" sheet?* question. Figure 7.1.2 shows the setup of lumber volume-based costing using LORCAT's *Operating Costs* feature, meaning that you must enter cost data into the costs worksheet.

7.1.3: Input Log Volume-Based Costing

Mills that know the average volume (International 1/4, Scribner, or Doyle) of logs sawn per hour will want to select *Use Input Log Volume-Based Costing* for their calculations. This costing method bases the operating cost on the estimated *Input log volume at utilization rate / hour Scale (bdft)*. As in the two prior methods, you can either enter the mill operating cost in U.S. dollars per hour directly or use the *Operating Costs* sheet to calculate costs in U.S. dollars per hour for a given utilization rate of the mill. Figure 7.1.3 shows the setup of log volume-based costing using LORCAT's *Operation Costs, directly specified* feature, meaning that you must enter cost data into the field indicated.

7.1.4: Log Costs per Thousand Board Feet

The actual cost of logs processed by LORCAT depends on which log scale is being used, International 1/4, Scribner, or Doyle. To change the log scaling method, go to the *Setup* tab. The log costs section of the *Costs* tab (Fig. 7.1.4) displays the log scaling method that is currently selected in the *Setup* tab. In this log costs section, you can enter log costs per thousand board feet of scale volume for *USFS Log Grades* (left) and for *Trimmed Clear Face Log Grades* (right).

7.1.5: Cant Prices

Figure 7.1.5 displays the *Cant Prices (prices per thousand bdft)* table in the *Costs* tab where cant prices can be entered for LORCAT to use to calculate the value of the sawn products. Cant prices can be entered per thousand board feet for red oak (*ROAK*), white oak (*WOAK*), yellow poplar (*YPOP*), hard maple (*HMAP*), soft maple (*SMAP*), cherry (*CHERR*Y), and other species (*OTHER*).

7.1.6: Residue Prices

Residues Prices can be entered per ton (2,000 lb) for *Chips*, *Sawdust*, and *Bark*. Figure 7.1.6 shows the window from the

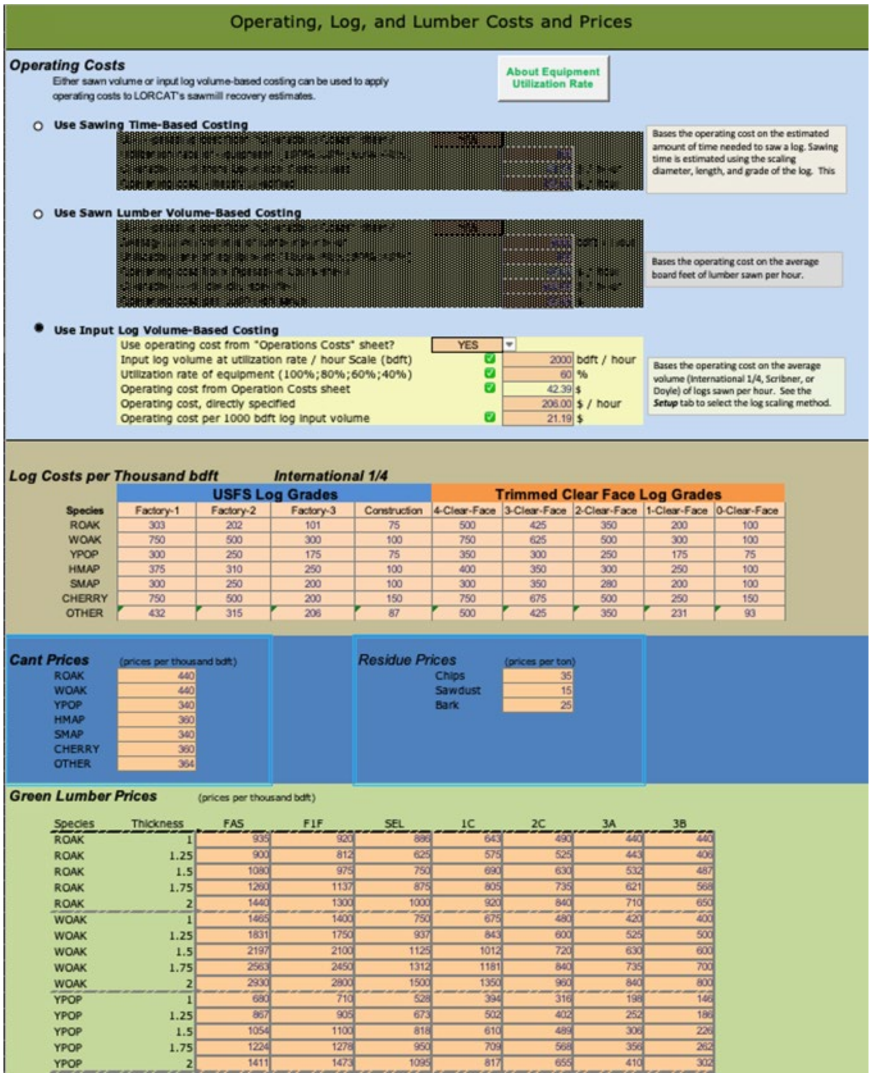


Figure 7.1—*Costs* tab showing operating, log, and lumber costs and prices.

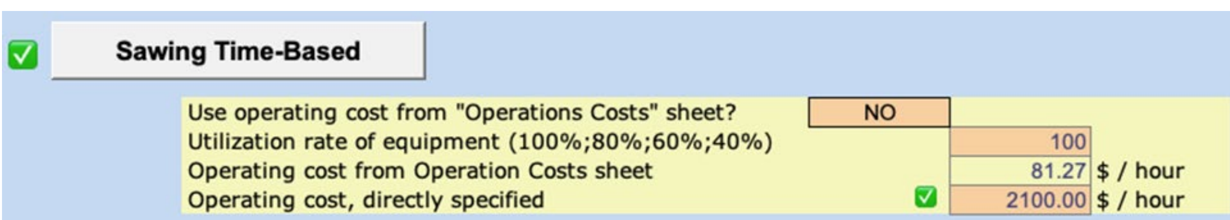


Figure 7.1.1—The *Use Sawing Time-Based Costing* area from the *Costs* tab.

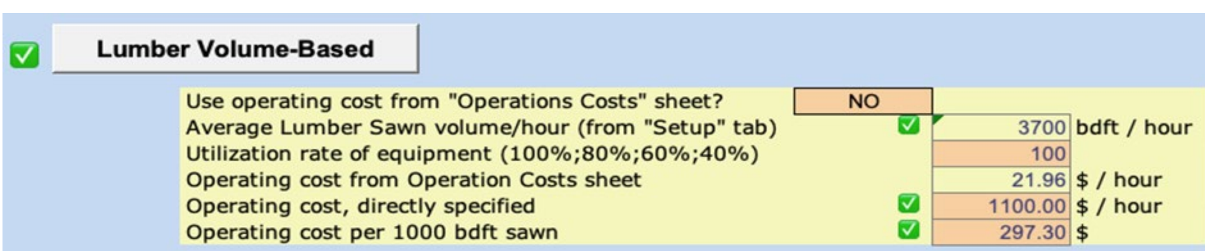


Figure 7.1.2—The *Use Sawn Lumber Volume-Based Costing* area from the *Costs* tab.

Log Volume-Based

Use operating cost from "Operations Costs" sheet?	YES		
Input log volume at utilization rate / hour Scale (bdft)	✓	2000	bdft / hour
Utilization rate of equipment (100%;80%;60%;40%)	✓	60	%
Operating cost from Operation Costs sheet	✓	42.39	$
Operating cost, directly specified		206.00	$ / hour
Operating cost per 1000 bdft log input volume	✓	21.19	$

Figure 7.1.3—The *Use Input Log Volume-Based Costing* area from the *Costs* tab.

Log Costs per Thousand bdft ***International 1/4***

	USFS Log Grades				Trimmed Clear Face Log Grades				
Species	Factory-1	Factory-2	Factory-3	Construction	4-Clear-Face	3-Clear-Face	2-Clear-Face	1-Clear-Face	0-Clear-Face
ROAK	303	202	101	75	500	425	350	200	100
WOAK	750	500	300	100	750	625	500	300	100
YPOP	300	250	175	75	350	300	250	175	75
HMAP	375	310	250	100	400	350	300	250	100
SMAP	300	250	200	100	300	350	280	200	100
CHERRY	750	500	200	150	750	675	500	250	150
OTHER	432	315	206	87	500	425	350	231	93

Figure 7.1.4—The *Log Costs per Thousand bdft* table from the *Costs* tab.

Cant Prices (prices per thousand bdft)

ROAK	440
WOAK	440
YPOP	340
HMAP	360
SMAP	340
CHERRY	360
OTHER	364

Figure 7.1.5—The *Cant Prices (prices per thousand bdft)* table from the *Costs* tab.

Residue Prices (prices per ton)

Chips	25
Sawdust	17
Bark	17

Figure 7.1.6—The *Residue Prices (prices per ton)* table from the *Costs* tab.

Costs tab in LORCAT where *Residue Prices (prices per ton)* can be entered. Transportation costs, if applicable and which may be different for each mill, can be subtracted from the quoted prices if needed.

7.1.7: Green Lumber Prices

Green Lumber Prices (prices per thousand bdft) are entered into the table below the cant and residue prices in the *Costs* tab (Fig. 7.1.7). Prices for *FAS, F1F, SEL, 1C, 2C, 3A*, and *3B* lumber grades according to the National Hardwood Lumber Association's grading rules (NHLA 2019) for lumber thicknesses of 1, 1.25, 1.5, 1.75, and 2 in. can be entered. Thus, if the mill gets a premium price for thicker lumber, this pricing structure can be replicated.

7.2: Operation Costs

The *Operation Costs* tab (Fig. 7.2.1) allows you to calculate the cost of the products manufactured using either sawing time-based costing, sawn lumber volume-based costing, or input log volume-based costing as selected in the *Costs* tab. Following traditional cost accounting methods, the *Operation Costs* tab calculates the annual fixed and variable labor and overhead costs for a sawmill per hour at 100%, 80%, 60%, and 40% utilization. The *Operation Costs* tab can be used for sawmills of any size. Larger sawmills may have their own costing tools and can use their data directly in the *Costs* tab without involving the *Operation Costs* tab. However, the cost accounting in the *Operation Costs* tab allows you to estimate your own costs for producing your products. LORCAT 4.00 then shows you whether the revenues can offset these costs.

Green Lumber Prices (prices per thousand bdft)

Species	Thickness	FAS	F1F	SEL	1C	2C	3A	3B
ROAK	1	935	920	886	643	490	440	400
ROAK	1.25	935	920	886	643	490	440	400
ROAK	1.5	935	920	886	643	490	440	400
ROAK	1.75	935	920	886	643	490	440	400
ROAK	2	935	920	886	643	490	440	400
WOAK	1	1465	1400	750	675	480	420	400
WOAK	1.25	1465	1400	750	675	480	420	400
WOAK	1.5	1465	1400	750	675	480	420	400
WOAK	1.75	1465	1400	750	675	480	420	400
WOAK	2	1465	1400	750	675	480	420	400
YPOP	1	860	850	817	420	285	200	150
YPOP	1.25	860	850	817	420	285	200	150
YPOP	1.5	860	850	817	420	285	200	150
YPOP	1.75	860	850	817	420	285	200	150
YPOP	2	860	850	817	420	285	200	150
HMAP	1	1430	1364	1252	1060	688	512	410
HMAP	1.25	1430	1364	1252	1060	688	512	410
HMAP	1.5	1430	1364	1252	1060	688	512	410
HMAP	1.75	1430	1364	1252	1060	688	512	410
HMAP	2	1430	1364	1252	1060	688	512	410
SMAP	1	1122	1070	982	832	540	402	322
SMAP	1.25	1122	1070	982	832	540	402	322
SMAP	1.5	1122	1070	982	832	540	402	322
SMAP	1.75	1122	1070	982	832	540	402	322
SMAP	2	1122	1070	982	832	540	402	322
CHERRY	1	1175	1165	700	650	380	300	225
CHERRY	1.25	1175	1165	700	650	380	300	225
CHERRY	1.5	1175	1165	700	650	380	300	225
CHERRY	1.75	1175	1165	700	650	380	300	225
CHERRY	2	1175	1165	700	650	380	300	225
OTHER	1	864	800	662	610	622	508	388
OTHER	1.25	864	800	662	610	622	508	388
OTHER	1.5	864	800	662	610	622	508	388
OTHER	1.75	864	800	662	610	622	508	388
OTHER	2	864	800	662	610	622	508	388

Figure 7.1.7—The *Green Lumber Prices (prices per thousand bdft)* table from the *Costs* tab.

Calculating the labor and overhead costs of the product in the *Operation Costs* tab first involves entering some basic numbers from the specific operation under *Input Data* (Row 1), *Labor Requirements* (Row 12), *Labor Costs* (Row 16), and *Investment* (Row 23). Based on this information, LORCAT 4.00 then calculates fixed and variable *Operating Cost: Labor per Year* (Row 27), *Operating Cost per Year* (Row 32), *Capital Cost per Year* (Row 39), and *Overhead and Miscellaneous Cost per Year* (Row 43). These costs then are allocated to *Total fixed cost per year* (Row 48) and *Total variable cost per year* (Row 49) under the heading *Cost Allocation* (Row 47). This information then is used to give the *Equipment Operating Cost per Hour* (Row 50) by *variable cost* (Row 51) and by *fixed cost at % utilization* (Rows 52–56). The sum of variable costs and fixed costs at a given utilization level yields the *Total Equipment Cost per Working Hour* (Row 57).

Only cells highlighted orange in the *Operation Costs* tab allow you to enter data (Fig. 7.2.2). The input expected from you is described in Column B, and Column C either gives further explanations or shows the equation from which the result in Columns D or E or both are being derived.

8: Examples

This section presents different sawmill processing questions for novice and expert interactive and batch analyses. Questions related to expected grade recovery, opening face width, kerf size, and sawing variation will be examined. Although we treat each of these questions as a single question, the approaches and solutions may be used to address a wider range of questions. At the end of this section, we perform a novice profit/loss analysis. This example will use the novice user interface, but the same analysis steps can be used to perform an expert analysis.

When you are performing the batch examples, novice or expert, or the profit/loss analysis, it is important to remember that LORCAT uses a random distribution function to create log samples that meet the required distributions of log diameters and tapers. Thus, even if you follow the examples directly, the resulting log samples will

Average machine cost calculations - per hour with varying utilization rates

Load Default Costs

#	B	C	D	E
1	**Input Data**	**Source of Calculation or Formula**	**Unit**	
2	space requirement	layout	sqft	0
3	cost of space per year per sqft	company accounting	$/sqft per year	$0.00
4	machine energy consumption per hour	users' manual, company information	kWh, gal, t	1
5	cost of energy per hour	market prices	$ / kWh, gal, t	$4.00
6	fixed energy cost as % of total energy costs	company accounting	%	10
7	depreciation period (straight line depreciation)	IRS	years	10
8	assumed interest rate	company information	%	5
9	estimation of start-up and training costs	percentage of purchase price incl. installation	%	5
10	estimated labor overhead costs (benefits)	percentage of total labor costs	%	50
11	total working hours per year	company information	hours	1801
12	**Labor Requirements**			
13	# of skilled operators (employee)	company information	person(s)	1
14	# of unskilled operators (employee)	company information	person(s)	1
15	# of supervising employees	company information	person(s)	0
16	**Labor Costs**			
17	labor cost skilled employee	company accounting	$ / year	$50,000.00
18	cost benefits skilled employee	=#17x(#10/100)	$ / year	$25,000.00
19	labor cost unskilled employee	company accounting	$ / year	$35,000.00
20	cost benefits unskilled employee	=#19x(#10/100)	$ / year	$17,500.00
21	supervisor cost	company accounting	$ / year	$65,000.00
22	cost benefits supervisor	=#21x(#10/100)	$ / year	$32,500.00
23	**Investment**			
24	purchase price incl. transport and installation	final invoice	$	$55,000.00
25	cost of start-up and training	=#9 x#24	$	$2,750.00
26	**Total investment**	=#24+#25	**$**	**$57,750.00**
			Cost Type	
27	**Operating Cost: Labor per Year**		Fixed	Variable
28	total skilled employee cost	=#13*(#17+#18)		$75,000.00
29	total unskilled employee cost	=#14*(#19+#20)		$52,500.00
30	total supervisor cost	=#15*(#21+#22)		$0.00
31	**Total labor cost**	=#28+#29+#30	**$0.00**	**$127,500.00**
32	**Operating Cost per Year**			
33	tools, blades, and jigs	estimation	$0.00	$2,400.00
34	space cost	=#2x#3	$0.00	
35	fixed energy cost	=#4x#5x(#6/100)x#11	$720.40	
36	variable energy cost	=#4x#5x(1-(#6/100)x#11		$6,483.60
37	maintenance cost	estimation	$100.00	$500.00
38	**Total operating cost**	=#33+#34+#35+#36+#37	**$820.40**	**$9,383.60**
39	**Capital Cost per Year**			
40	depreciation	=#26x(1/#7)	$5,775.00	
41	interest	=#26x(#8/100)	$2,887.50	
42	**Total capital cost**	=#40+#41	**$8,662.50**	
43	**Overhead and Miscellaneous Cost per Year**			
44	production overhead	estimation	$0.00	$0.00
45	miscellaneous cost	estimation	$0.00	$0.00
46	**Total overhead and miscellaneous cost**	=#44+#45	**$0.00**	**$0.00**
47	**Cost Allocation**			
48	**Total fixed cost per year**	=#31+#38+#42+#46	**$9,482.90**	
49	**Total variable cost per year**	=#31+#38+#42+#46		**$136,883.60**
50	**Equipment Operating Cost per Hour**			
51	variable cost (quantity-dependent)	=#49/#11		**$76.00**
52	fixed cost (time-dependent) at % utilization			
53	100% utilization level	=#48/#11	**$5.27**	
54	80% utilization level	=#48/(#11x0.8)	**$6.58**	
55	60% utilization level	=#48/(#11x0.6)	**$8.78**	
56	40% utilization level	=#48/(#11x0.4)	**$13.16**	
57	**Total Equipment Cost per Working Hour**			
58	**100% utilization level**	=#51+#53	**$81.27**	
59	**80% utilization level**	=#51+#54	**$82.59**	
60	**60% utilization level**	=#51+#55	**$84.78**	
61	**40% utilization level**	=#51+#56	**$89.17**	

Figure 7.2.1—The _Operation Costs_ tab in LORCAT 4.00.

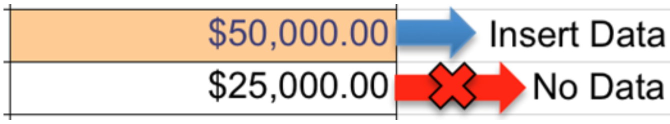


Figure 7.2.2—Orange highlighted cells in Columns D and E accept entry of data; cells that are not highlighted orange do not accept entry of data.

be slightly different from the ones created in this example, leading to slightly different results. However, the results of the analysis and overall trends in comparisons between analyses of different sawing setups should be similar.

8.1: Interactive Sawing (Novice)

In this analysis, we wanted to know the expected NHLA grade recovery for a specific log and a set of sawing parameters and the recovery for a Factory 2 red oak log that is 12 ft long with an SED of 20.00 in. and an LED of 22.5 in. We used a grade-sawing approach to produce a dried lumber thickness of 1 in. with a standard green allowance of 0.125 in. We used a saw blade with a kerf of 0.125 in. In addition, we estimated our total sawing variation to be 0.035 in. Lastly, we sawed to produce a cant that is 6 by 4 in. When this log information and these sawing parameters are entered into LORCAT, the *Input Variables* section of the novice interactive interface will look like that in Figure 8.1.1.

After these variables are entered, click the *Run Analysis* button to perform the simulation and see the *Projected Sawing Results* (Fig. 8.1.2). The sample analysis shows that a total of 226.5 bdft (lumber and cant combined) should be expected from sawing this log with these sawing variables.

Input Variables	
Species	ROAK
Log Grade	Factory-2
Small End Diameter	20.000
Large End Diameter	22.500
Log Length	12.000
Cant Height	6.000
Cant Width	4.000
Green Allowance	0.125
Lumber Thickness	1.000
Sawing Variation	0.035
Saw Kerf	0.125
Target Thickness	1.194
Sawing Method	GRADE

Figure 8.1.1—*Input Variables* for the interactive example (novice) discussed.

Projected Sawing Results				
Boards Sawn	22	Cant	6.00	4.00
Board Feet	202.5	Volume		24.00
Sawing Time (minutes)	2.4			
Grade Recovery		Total BDFT		226.5
FAS	29.5			
F1F	21.4		LRF	7.63
Selects	3.3			
1 Com.	76.9		Int 1/4	210
2 Com.	43.0		Doyle	192
3A Com.	18.3		Scribner	200
3B Com.	10.1			

Figure 8.1.2—*Projected Sawing Results* for the interactive example (novice).

The NHLA grade recovery is shown on the left side under *Grade Recovery* in Figure 8.1.2.

8.2: Interactive Sawing (Expert)

LORCAT's *Interactive Sawing (Expert)* tab can be used to conduct a more in-depth analysis in which we are interested in determining the NHLA grade recovery for a log, along with the projected profit or loss associated with sawing it. For this analysis, we wanted to know the recovery for a Factory 2 red oak log that is 16 ft long with an SED of 18.00 in. and an LED of 21.5 in. For sawing, we used a standard opening face size of 6 in. wide by 8 ft long. We sawed to produce a random-width cant that is 6 in. high (as indicated by setting the *Cant Width* at 0.000). We had a standard 0.125-in. green thickness allowance and were sawing to a 1-in. dry thickness on both the headrig and resaw. On the headrig, we had a kerf thickness of 0.135 in. with a total sawing variation of 0.030 in., giving a *Target Thickness* of 1.184 in. For the resaw, we had a kerf thickness of 0.130 in. with a total sawing variation of 0.035 in., giving a *Target Thickness* of 1.194 in. We used a split-taper grade sawing method to saw the log. After entering this information, the *Input Variables* window on the *Interactive Sawing (Expert)* tab looks like that shown in Figure 8.2.1.

In this example, we are interested in knowing the profitability related to sawing this log. Hence, we needed to enter the costs associated with buying the log and its processing in our sawmill. To assign log costs, we needed to specify the log scaling method. For our example, we scaled logs using the International 1/4 scale (Fig. 8.2.2). Let's say

Input Variables		
	Species	ROAK
	Log Grade	Factory-2
	Small End Diameter	18.000
	Large End Diameter	21.500
	Log Length	16.000
	Opening Face Width	6.000
	Opening Face Length	8.000
	Cant Height	6.000
	Cant Width	0.000
	Green Allowance	0.125
Headrig	Lumber Thickness	1.000
Headrig	Sawing Variation	0.03
Headrig	Saw Kerf	0.135
Headrig	Target Thickness	1.184
Resaw	Lumber Thickness	1.000
Resaw	Sawing Variation	0.035
Resaw	Saw Kerf	0.125
Resaw	Target Thickness	1.194
	Full / Split Taper	SPLIT
	Sawing Method	GRADE

Figure 8.2.1—*Input Variables* for the *Interactive Sawing (Expert)* example.

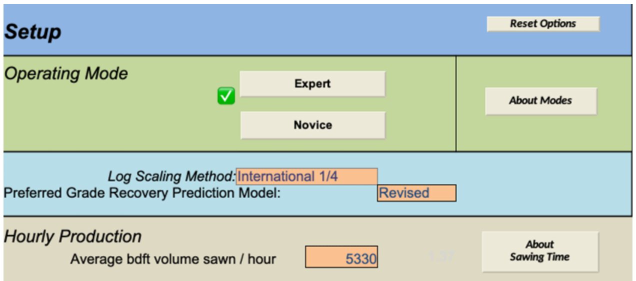


Figure 8.2.2—*Setup* tab showing *Operating Mode*, *Log Scaling Method*, and *Hourly Production* settings.

that the mill we are analyzing saws approximately 12 million board feet (Mbdft) per year and operates 2,250 h per year. Thus, our *Hourly Production* is about 5,330 bdft, which we entered into our *Setup* tab (Fig. 8.2.2).

For our operating cost (hourly wages and mill operating costs combined), we directly specified an operating cost of $1,800.00 per hour (Fig. 8.2.3). We used Forest Service factory log grades with a specified cost of $202 per 1,000 bdft (International 1/4 scale; Fig. 8.2.4). For residue prices, we specified that the price of chips, sawdust, and bark were $25, $17, and $17 per ton, respectively (Fig. 8.2.5). The market prices of 1-in.-thick green red oak lumber in this example were $935, $920, $886, $643, $490, $440, and $400 for FAS, F1F, SEL, 1C, 2C, 3A, and 3B per thousand board feet, respectively (Fig. 8.2.6). In addition, we used the default residue expansion factors as shown in Figure 8.27. Section 6.5.3: Bark Residue gives a complete description of expansion factors.

When all the input variables (log information, operation settings, costs) have been entered into LORCAT as shown in Figures 8.2.1 through 8.2.5, you are ready to proceed. Click the *Run Analysis* button on the *Interactive Sawing (Expert)* tab to process the log. The results will then appear in the *Projected Sawing Results* and *Processing Cost / Product Value Analysis* areas on the *Interactive Sawing (Expert)* tab as shown in Figures 8.2.8 and 8.2.9. The left side of Figure 8.2.8 reports the number of boards and total board footage sawn along with the NHLA grade recovery and the number of minutes it took to saw the log into lumber. The right side of Figure 8.2.8 shows the scale volume for each log scale as well as a summary of the volume and weight of residue produced. We did not saw a solid cant; therefore, cant width, height, and volume are all 0.00.

Figure 8.2.9 reports the profit or loss associated with sawing the log in the *Processing Cost / Product Value Analysis* section of the *Interactive Sawing (Expert)* tab. The rightmost column in Figure 8.2.9 reports the value of the lumber sawn by NHLA grade. The center column reports the total value of the lumber sawn, the cant, and the residues generated during sawing. The leftmost column provides a summary of the costs, values, and, most importantly, the overall estimated *Profit/Loss* from sawing this log (Fig. 8.2.9).

8.3: Batch Sawing (Novice)

For the novice example, we performed a *Batch Sawing (Novice)* analysis. Figure 8.3.1 shows the *Processing Setup* that was used for this example. We sawed to a 6-in.-high, random-width cant that will then be sawn into lumber. To do this, we entered 6.0 for the *Cant Height* and 0 for the *Cant Width*. We also used the standard *Green Allowance* of 0.125 in. (Fig. 8.3.1). In this example, we produced 6/4, or 1.5-in.-thick, lumber. The mill we are simulating has a total *Sawing Variation* of 0.038 in. and uses a saw that has a *Kerf Thickness* of 0.135 in. Lastly, we sawed the logs using *GRADE* sawing. When all these settings are entered in the *Processing Setup* area of the *Batch Sawing (Novice)* tab, the *Processing Setup* should look like that shown in Figure 8.3.1.

The next step is to create the log sample to analyze with the given information in the *Processing Setup*. For this part of the example, the assumption is that we typically process red oak Forest Service Factory Grade 2 logs in 10-, 12-, and 16-ft lengths and that there is no significant difference in the numbers of logs processed among these lengths. For all logs, the *Mean Small End Diameter* is 17 in. and the overall *Mean Taper* is 2.25 in. We built a sample that contains 50 logs for each length (10, 12, and 16 ft) and matches our diameter and taper distribution. Figure 8.3.2 shows these values entered into the *Log Size Distribution Setup* for the 10-ft-long logs. After you enter the data for the 10-ft logs, click the *Generate Data* button (Fig. 5.1.1). This will populate the *Logs and Results* area with the processing setup and the sample of 10-ft-long logs. To create the 12-ft-long log part of the sample, enter 12 for the *Log Length* and click the *Generate Data* button (Fig. 5.1.1). This step can be repeated for the 16-ft-long logs. LORCAT allows users to create samples containing multiple lengths (and any other log characteristics) using this method, although the total sample size must be less than 1,000 logs.

Before we started the analysis, we specified the operating costs, log costs, and market prices for our lumber. For our operating costs (hourly wages and mill operating costs combined), we used *Lumber Volume-Based* costing with an *Operating cost, directly specified* of $1,500.00 per hour (Fig. 8.3.3). Our *Average Lumber Sawn volume/hour* is 4,000 bdft, as shown in Figure 8.3.3. This amount should not be entered into the *Average Lumber Sawn volume/hour* field in the *Costs* tab but instead should be entered into the *Average bdft volume sawn / hour* field in the *Setup* tab (Fig. 8.2.2). LORCAT will automatically calculate the *Operating cost per 1000 bdft sawn* (Fig. 8.3.3). We are using Forest Service factory log grades with a specified cost of $202 per 1,000 bdft (International 1/4 scale; Fig. 8.2.4). The market prices (*Green Lumber Prices*; Fig. 8.3.4) of 1.5-in.-thick,

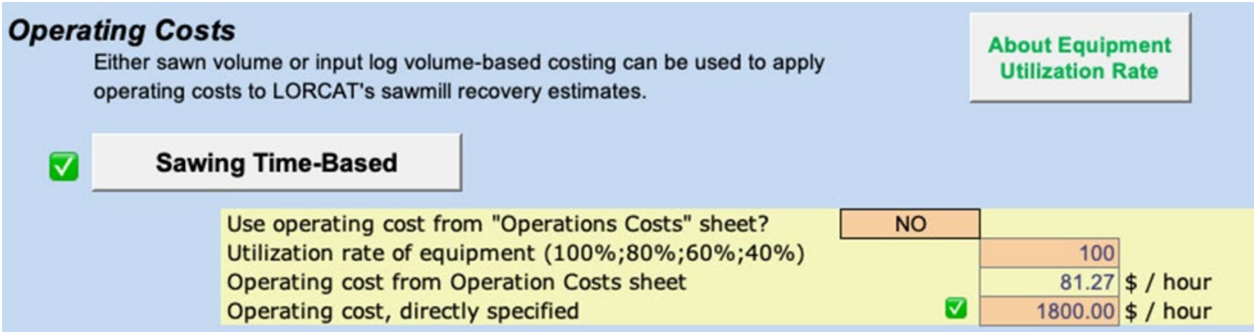


Figure 8.2.3—Specification of hourly operating cost into the *Costs* tab.

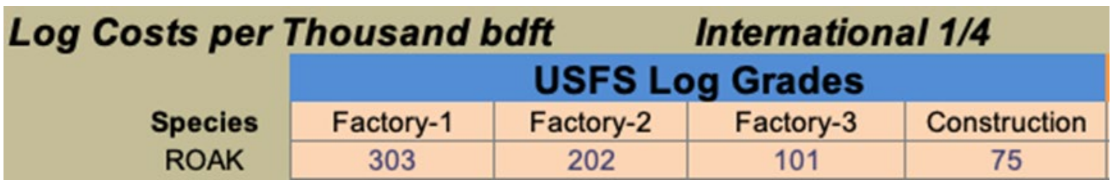


Figure 8.2.4—Specification of Factory 2 red oak log costs into the *Costs* tab.

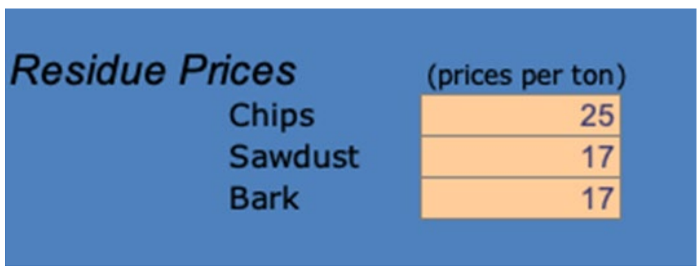


Figure 8.2.5—Market prices of chips, sawdust, and bark into the *Costs* tab.

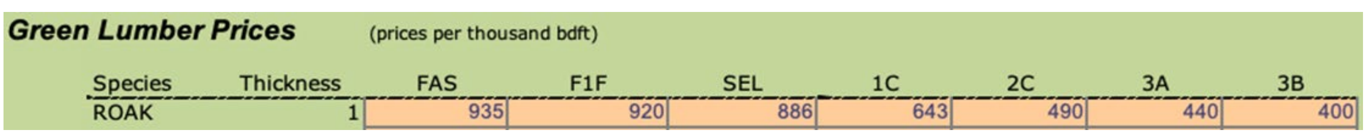


Figure 8.2.6—Market prices of 1-in.-thick green red oak lumber into the *Costs* tab.

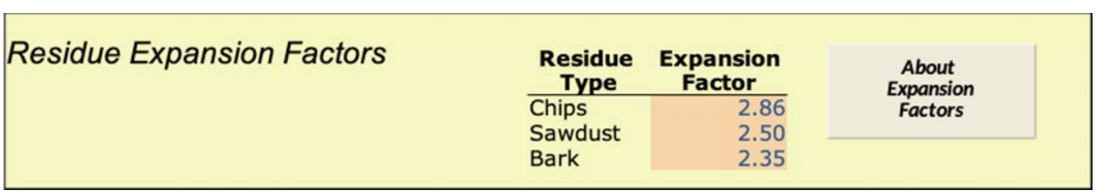


Figure 8.2.7—Default *Residue Expansion Factors* used by LORCAT as a default in the *Costs* tab.

Projected Sawing Results

Boards Sawn	23	Cant	Width	Height	Volume
Lumber Board Feet	248.3		0.00	0.00	0.00
Sawing Time (minutes)	2.8				
Log Recovery Factor	7.23	Total	--- Log Scale ---		
		bdft	Int 1/4	Doyle	Scribner
Grade Recovery		248.3	230	196	220
FAS	30.6				

		Sawing Residue Volume Summary			
F1F	24.0		Solid	Expanded	Weight
Selects	5.4		(cu. ft)	(cu. ft)	(lbs)
1 Com.	89.0				
2 Com.	58.3	Chips	9.64	27.56	423.00
3A Com.	27.6	Sawdust	4.02	10.06	176.59
3B Com.	13.4	Bark	5.83	13.70	116.59

Figure 8.2.8—*Projected Sawing Results* as shown on the *Interactive Sawing (Expert)* tab.

Processing Cost / Product Value Analysis

				Lumber Value by NHLA Grade	
Log Cost	$46.46	***Primary Product Value***			
Cost to Process	$89.66	Lumber	$158.78	FAS	$28.60
Total Costs	$136.12	Cant	$0.00	F1F	$22.12
				Selects	$4.75
Primary Product Value	$158.78	***Residue Product Value***		1 Com.	$57.23
Residue Value	$7.78	Chips	$5.29	2 Com.	$28.57
Total Value	$166.56	Sawdust	$1.50	3A Com.	$12.15
		Bark	$0.99	3B Com.	$5.36
Profit/Loss	$30.44				

Figure 8.2.9—Estimated *Processing Cost / Product Value Analysis* as shown on the *Interactive Sawing (Expert)* tab for the example discussed.

Processing Setup	
Cant Height	6.000
Cant Width	0.000
Green Allowance	0.125
Lumber Thickness	1.500
Sawing Variation	0.038
Kerf Thickness	0.135
Target Thickness	1.762
Sawing Method	GRADE

Figure 8.3.1—*Processing Setup* with sawing variables used for the *Batch Sawing (Novice)* example analysis.

Log Size Distribution Setup	
Log Sample Count	50
Mean Small End Diameter	17.00
Mean Taper	2.25
Log Length	10
Log Grade	Factory-2
Species	ROAK
Profit / Loss Analysis uses	USFS Log Grades

Figure 8.3.2—*Log Size Distribution Setup* in the *Batch Sawing (Novice)* tab showing the setup for 10-ft-long logs.

Lumber Volume-Based

Use operating cost from "Operations Costs" sheet?	NO		
Average Lumber Sawn volume/hour (from "Setup" tab)	✓	4000	bdft / hour
Utilization rate of equipment (100%;80%;60%;40%)		100	
Operating cost from Operation Costs sheet		20.32	$ / hour
Operating cost, directly specified	✓	1500.00	$ / hour
Operating cost per 1000 bdft sawn	✓	375.00	$

Figure 8.3.3—*Costs* tab showing *Lumber Volume-Based* operating costs for the example.

Green Lumber Prices (prices per thousand bdft)

Species	Thickness	FAS	F1F	SEL	1C	2C	3A	3B
ROAK	1	935	920	886	643	490	440	400
ROAK	1.25	944	929	895	649	495	444	404
ROAK	1.5	953	938	904	655	500	448	408

Figure 8.3.4—*Costs* tab showing *Green Lumber Prices* of 1.5-in.-thick green red oak lumber.

green red oak lumber in this example were $953, $938, $904, $665, $500, $448, and $408 per thousand board feet for FAS, F1F, SEL, 1C, 2C, 3A, and 3B, respectively.

After you have the *Processing Setup* entered, the log sample created, the *Lumber Volume-Based* operating costs set up, and the log and lumber prices entered, you are ready to click the *Run Analysis* button to start the analysis (Fig. 5.1.1). Depending on your computer and software, it may take anywhere from a few seconds to several minutes for LORCAT to perform the analysis. When the analysis is complete, LORCAT will display a completion pop-up window (Fig. 8.3.5). Clicking *OK* will return you to the *Batch Sawing (Novice)* tab (Fig. 5.1.1) where the results may be examined in the *Logs and Results* section at the bottom of the screen.

Information of key interest when performing these analyses is the profit or loss related to processing each log and the results for the sample of logs as a whole. In the *Logs and Results* section, the green-shaded columns contain information about the different costs and the value of the lumber and cant produced (Fig. 8.3.6). LORCAT shows the results of all logs sawn individually. For the green columns, simply scroll down in the *Logs and Results section* to view results for all logs. You can also create a summary of the results for the entire analysis. To do this, click the *Save Results Summary* button on the *Batch Sawing (Novice)* tab (Fig. 5.1.1) and enter a description for the results summary. For our example analysis, we entered *150 Log Novice Test* for the description.

As we look at the results from this batch simulation, it is important to know that when you create a log sample with LORCAT, it generates a random sample of logs that matches the specified diameter distribution. Thus, although the sample is representative of the logs that are normally encountered in your log yard, it is extremely likely that repeating the analysis will result in a slightly different yet statistically representative sample. In addition, it is also likely that the results presented here will be slightly different than the ones you receive in your simulation. However, the overall trends will be the same.

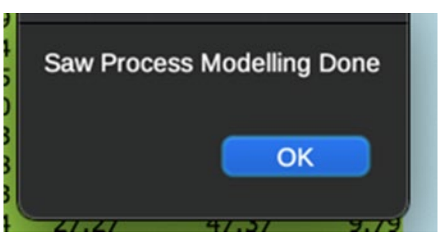


Figure 8.3.5—LORCAT batch analysis completion notification window.

Revenue Cost Analysis

Total Product Value	Cant Value	Total Lumber Value	Total Costs	Log Cost	Processing Cost	Profit Loss
54.58	0.00	54.58	51.13	17.17	33.96	3.45
91.53	0.00	91.53	79.67	25.25	54.42	11.86
74.83	0.00	74.83	67.36	22.22	45.14	7.47
103.00	0.00	103.00	91.95	32.32	59.63	11.06
64.88	0.00	64.88	58.93	19.19	39.74	5.95
117.88	0.00	117.88	102.77	35.35	67.42	15.12
83.04	0.00	83.04	74.62	25.25	49.37	8.41
80.97	0.00	80.97	73.40	25.25	48.15	7.58
122.55	0.00	122.55	105.44	35.35	70.09	17.12
96.05	0.00	96.05	84.61	28.28	56.33	11.44

Figure 8.3.6—First 10 rows of the *Revenue Cost Analysis* columns of the *Logs and Results* section.

Figure 8.3.7 shows the *Batch Summaries* tab with saved results from the example analysis and the description we used. In Figure 8.3.7, we see that the sawing of the 150 logs produced a total of 2,177 boards with a *Total Recovery* of 26,726.8 bdft with an *Average Recovery per Log* of 178.2 bdft. Scrolling the tab to the right several rows will show the costs, lumber value, and profit/loss columns with a green background (Fig. 8.3.8). In Figure 8.3.8, we see that we have a *Total Lumber Value* of $17,024.41 with a total cost of $15,037.20, which gives a profit of $1,987.22.

In the sample analysis, we used a *Kerf Thickness* of 0.135 in., as shown in Figure 8.3.1, to estimate the total recovery and profit related to the 150-log sample. However, it might be interesting to learn whether reducing the kerf to 0.125 in. would improve recovery or profit. The first step is to change the *Kerf Thickness* setting in *Processing Setup* in the *Batch Sawing (Novice)* tab (Fig. 8.3.1) to 0.125 in. When the processing settings are updated (or for that matter, any setting pertaining to the simulation run), the settings in *Logs and Results* are not automatically updated. Click the *Update Setup* button (Fig. 5.1.1) to update the settings in the *Logs and Results* section of the *Batch Sawing (Novice)* tab for the entered changes to be used in the next analysis. Notice that now, the log sample in Figure 8.3.9 shows the new *Kerf Thickness* of 0.125 in.

Next, click the *Run Analysis* button (Fig. 5.1.1) to rerun the analysis with the new kerf thickness. To make comparing results using the two kerf sizes easy, click *Save Results Summary* and enter *.125 Kerf Analyses* for the description. Figures 8.3.10 (sawing information) and 8.3.11 (cost and revenue information) show the summarized results for the two analyses. The first row shows the results for the first analysis with the 0.135-in. kerf, whereas the second row shows the results for the second analysis using a 0.125-in. kerf. Comparing *Total Recovery* shows that we gained 205.7 (26,932.5 − 26,726.8) bdft, an increase in the *Average Recovery Per Log* of 1.4 bdft (Fig. 8.3.10). The decrease in kerf thickness resulted in an increase in *Total Lumber Value* of $129.90 ($17,154.31 − $17,024.41) (Fig. 8.3.11).

An increase of $129.90 in *Total Lumber Value* (Fig. 8.3.11) for a sample of 150 logs is not a very large gain. If we look at *Boards Sawn* (Fig. 8.3.10), which is the number of boards sawn in each analysis, we see that the smaller kerf allows us to saw 14 additional boards, or 0.6% more boards. One reason for such a small increase is that we are sawing 1.5-in.-thick boards, which results in approximately 50% less kerfs in the log compared with cutting 1-in.-thick lumber. Accordingly, if we were sawing thicker lumber, such as 2.0-in.-thick boards, we would expect less of a difference in total recovery caused by the decrease in kerf thickness. Repeating the example with a lumber thickness of 1.0 in. should confirm that a greater recovery difference will be achieved with thinner lumber and more kerfs.

8.4: Batch Sawing (Expert)

In the expert example, we present a *Batch Sawing (Expert)* analysis of sawing low-grade yellow-poplar logs. Logs were sawn using a 6-in.-wide by 8-ft-long opening face (Fig. 8.4.1). All logs were sawn to a 6-in.-high, random-width cant that was then sawn into lumber. To do this, we entered 6.0 for the *Cant Height* and 0 for the *Cant Width* (Fig. 8.4.1). We also used the standard *Green Allowance* of 0.125-in. (this should be checked to ensure that it is set correctly) (Fig. 8.4.1). We produced 4/4 or 1-in.-thick lumber at the headrig. Also at the headrig, the saw kerf was 0.135-in. and total sawing variation was 0.035-in. The random width cants were sawn to 6/4 or 1.5-in.-thick lumber at resaw. The total *Sawing Variation* at the resaw was 0.030 in., and a saw with a *Kerf Thickness* of 0.125 in. was used. Lastly, we sawed the logs using *GRADE* sawing. When all these settings are entered in *Processing Setup* of the expert batch tab, the *Processing Setup* should look like that shown in Figure 8.4.1.

The next step is to create the log sample to analyze given the *Processing Setup*. For this example, we processed a low-grade sample of 50, one-clear-face, yellow-poplar logs. For all logs, the *Mean Small End Diameter* was 15 in. with a standard deviation of 2.0 in. In addition, the *Mean Taper* of the logs was 2.0 in. with a standard deviation of 0.75 in. The logs in this sample were all 12 ft long. Figure 8.4.2 shows these values entered into the *Log Size Distribution Setup* area of LORCAT. This sample setup will create a sample of logs with SEDs ranging from 11 to 19 in. and LEDs ranging from 11.5 to 22.5 in. When you have all the setup variables entered, click the *Generate Data* button (Fig. 5.1.2) to populate the *Logs and Results* section with the log sample and processing options used in the analyses (Fig. 8.4.3).

Before the analysis can be started, the average hourly sawmill production volume, operating costs, log costs, and the market prices for the lumber must be specified. In the expert example, we used the Doyle log scale for determining log volume (Fig. 8.4.4). The average volume sawn per hour in our example was 5,000 bdft, as entered into the *Setup* tab (Fig. 8.4.4).

For the operating cost in this example (hourly wages and mill operating costs combined), we used *Lumber Volume-Based* costing with a directly specified operating cost of $1,000.00 per hour. The *Average lumber sawn volume/hour* was 5,000 bdft (Fig. 8.4.5), as previously entered into the *Setup* tab (Fig. 8.4.4). LORCAT will automatically calculate the *Operating cost per 1000 bdft sawn* (Fig. 8.4.5). We used trimmed clear-face grades, in which one-clear-face logs have a cost of $175 per 1,000 bdft (Doyle scale; Fig. 8.4.6). The prices of residue, chips, sawdust, and bark are specified per ton. For this example, we specified $25, $17, and $17 for the price per ton of chips, sawdust, and bark, respectively (Fig. 8.4.7). The market prices of our green

Summarized Batch Analyses Results

Summary Name	Total Logs Processed	Total Sawing Time (minutes)	Total Log Volume (ft³)	Log Recovery Factor	Boards Sawn	Total Recovery (bdft)	Average Recovery Per Log (bdft)
150 Log Novice Test	150	459.7	3926.94	6.75	2177	26726.8	178.2

Figure 8.3.7—*Batch Summaries* tab showing the saved summary for the example *Batch Sawing (Novice)* analysis.

Total Product Value ($)	Cant Value ($)	Total Lumber Value ($)	Total Residue Value ($)	Total Cost ($)	Log Cost ($)	Processing Cost ($)	Profit Loss ($)
$17,024.41	$0.00	$17,024.41	---------	$15,037.20	$5,014.65	$10,022.55	$1,987.22

Figure 8.3.8—*Batch Summaries* tab showing the saved summary for cost and revenue for the example *Batch Sawing (Novice)* analysis.

Logs and Results

Small End Diameter	Large End Diameter	Log Length	Log Grade	Species	Sawing Method	Cant Height	Cant Width	Green Allowance	Headrig: Lumber Thickness	Headrig: Kerf Thickness	Headrig: Sawing Variation
14.70	17.88	10	Factory-2	ROAK	GRADE	6	0	0.125	1.5	0.125	0.038
17.91	21.70	10	Factory-2	ROAK	GRADE	6	0	0.125	1.5	0.125	0.038
16.23	19.35	10	Factory-2	ROAK	GRADE	6	0	0.125	1.5	0.125	0.038
19.25	22.40	10	Factory-2	ROAK	GRADE	6	0	0.125	1.5	0.125	0.038
15.59	18.37	10	Factory-2	ROAK	GRADE	6	0	0.125	1.5	0.125	0.038
20.08	23.65	10	Factory-2	ROAK	GRADE	6	0	0.125	1.5	0.125	0.038
17.62	19.96	10	Factory-2	ROAK	GRADE	6	0	0.125	1.5	0.125	0.038
17.21	20.19	10	Factory-2	ROAK	GRADE	6	0	0.125	1.5	0.125	0.038
20.69	23.31	10	Factory-2	ROAK	GRADE	6	0	0.125	1.5	0.125	0.038
18.39	22.19	10	Factory-2	ROAK	GRADE	6	0	0.125	1.5	0.125	0.038

Figure 8.3.9—*Logs and Results* section showing updated *Kerf Thickness* of 0.125 in.

Summarized Batch Analyses Results

Summary Name	Total Logs Processed	Total Sawing Time (minutes)	Total Log Volume (ft³)	Log Recovery Factor	Boards Sawn	Total Recovery (bdft)	Average Recovery Per Log (bdft)
150 Log Novice Test	150	459.7	3926.94	6.75	2177	26726.8	178.2
.125 Kerf Analyses	150	459.7	3926.94	6.81	2191	26932.5	179.6

Figure 8.3.10—*Summarized Batch Analyses Results* for the sawing information with the two kerf sizes selected.

Total Product Value ($)	Cant Value ($)	Total Lumber Value ($)	Total Residue Value ($)	Total Cost ($)	Log Cost ($)	Processing Cost ($)	Profit Loss ($)
$17,024.41	$0.00	$17,024.41	---------	$15,037.20	$5,014.65	$10,022.55	$1,987.22
$17,154.31	$0.00	$17,154.31	---------	$15,114.35	$5,014.65	$10,099.70	$2,039.96

Figure 8.3.11—*Summarized Batch Analysis Results* for cost and revenue with the two kerf sizes selected.

Processing Setup		
Opening Face Width	6.000	
Opening Face Length	8.000	
Cant Height	6.000	
Cant Width	0.000	
Green Allowance	0.125	
Lumber Thickness	1.000	Headrig
Sawing Variation	0.035	Headrig
Kerf Thickness	0.125	Headrig
Target Thickness	1.194	Headrig
Lumber Thickness	1.000	Resaw
Sawing Variation	0.035	Resaw
Kerf Thickness	0.125	Resaw
Target Thickness	1.194	Resaw
Sawing Method	GRADE	
Split or Full Taper?	SPLIT	

Figure 8.4.1—*Processing Setup* for the *Batch Sawing (Expert)* analysis example.

Log Size Distribution Setup	
Log Sample Count	50
Mean Small End Diameter	15.00
Small End Diameter Std Deviatio	2.00
Mean Taper	2.00
Taper Std Deviation	0.75
Log Length	12
Log Grade	1-Clear-Face
Species	YPOP
Undersized SED Protection	YES
Profit / Loss Analysis uses	USFS Log Grades

Expected Sample Log Size Range			
SED Range	11	to	19
LED Range	11.5	to	22.5
Taper Range	0.5	to	3.5

Figure 8.4.2—*Log Size Distribution Setup* showing sample setup for *Batch Sawing (Expert)* example.

Logs and Results

												--------- Headrig ---------				--------- Resaw --------		
Small End Diameter	Large End Diameter	Log Length	Log Grade	Species	Opening Face Width	Opening Face Length	Sawing Method	Split or Full Taper	Cant Height	Cant Width	Green Allowance	Lumber Thickness	Kerf Thickness	Sawing Variation	Lumber Thickness	Kerf Thickness	Sawing Variation
14.60906	18.56726	12	1-Clear-Face	YPOP	6	8	GRADE	SPLIT	6	0	0.125	1	0.125	0.035	1	0.125	0.035
16.614964	20.93659	12	1-Clear-Face	YPOP	6	8	GRADE	SPLIT	6	0	0.125	1	0.125	0.035	1	0.125	0.035
14.091852	14.7381	12	1-Clear-Face	YPOP	6	8	GRADE	SPLIT	6	0	0.125	1	0.125	0.035	1	0.125	0.035
13.988339	15.96915	12	1-Clear-Face	YPOP	6	8	GRADE	SPLIT	6	0	0.125	1	0.125	0.035	1	0.125	0.035
18.388482	21.27078	12	1-Clear-Face	YPOP	6	8	GRADE	SPLIT	6	0	0.125	1	0.125	0.035	1	0.125	0.035
15.597246	18.3464	12	1-Clear-Face	YPOP	6	8	GRADE	SPLIT	6	0	0.125	1	0.125	0.035	1	0.125	0.035
14.073221	17.11159	12	1-Clear-Face	YPOP	6	8	GRADE	SPLIT	6	0	0.125	1	0.125	0.035	1	0.125	0.035
11.888539	13.51294	12	1-Clear-Face	YPOP	6	8	GRADE	SPLIT	6	0	0.125	1	0.125	0.035	1	0.125	0.035
15.479063	17.70136	12	1-Clear-Face	YPOP	6	8	GRADE	SPLIT	6	0	0.125	1	0.125	0.035	1	0.125	0.035
15.64239	18.55685	12	1-Clear-Face	YPOP	6	8	GRADE	SPLIT	6	0	0.125	1	0.125	0.035	1	0.125	0.035
18.549035	20.69221	12	1-Clear-Face	YPOP	6	8	GRADE	SPLIT	6	0	0.125	1	0.125	0.035	1	0.125	0.035
14.242877	15.32304	12	1-Clear-Face	YPOP	6	8	GRADE	SPLIT	6	0	0.125	1	0.125	0.035	1	0.125	0.035
17.044535	20.90081	12	1-Clear-Face	YPOP	6	8	GRADE	SPLIT	6	0	0.125	1	0.125	0.035	1	0.125	0.035
13.091315	14.83861	12	1-Clear-Face	YPOP	6	8	GRADE	SPLIT	6	0	0.125	1	0.125	0.035	1	0.125	0.035

Figure 8.4.3—*Logs and Results* section showing the first 14 rows of the sample and processing setup.

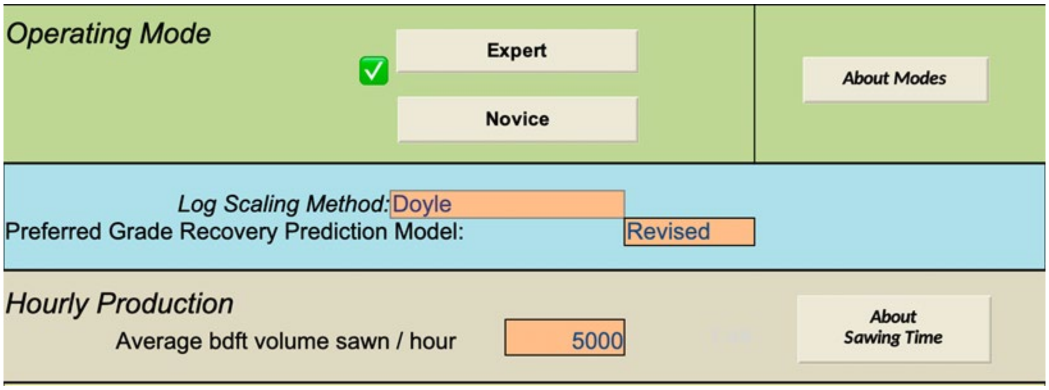


Figure 8.4.4—*Setup* tab showing settings used for the *Batch Sawing (Expert)* example.

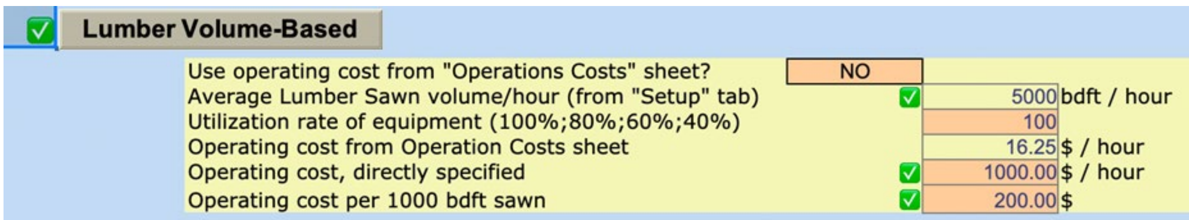
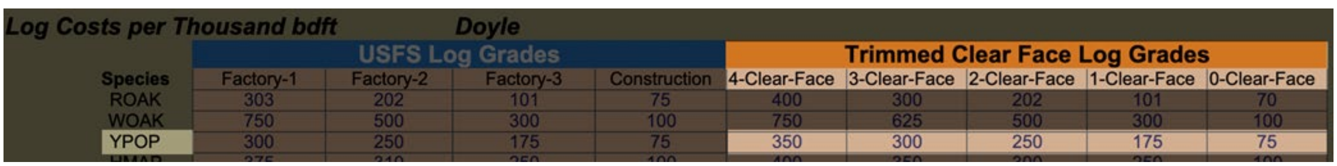
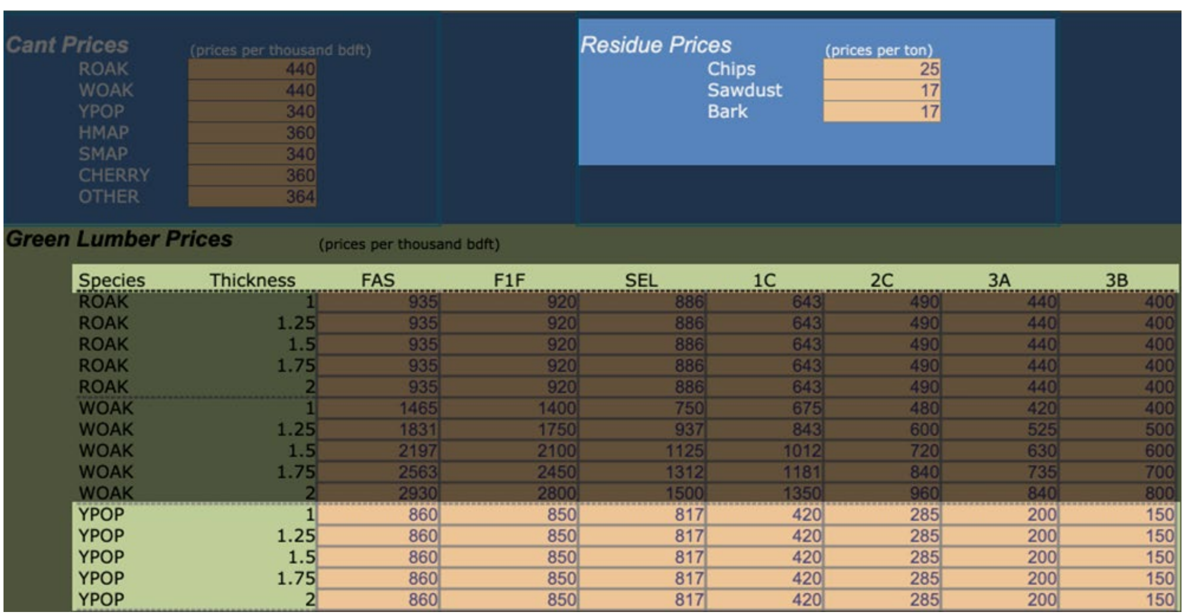


Figure 8.4.5—*Costs* tab showing the selection of *Lumber Volume-Based* costing.


Log Costs per Thousand bdft — Doyle

Species	USFS Log Grades: Factory-1	Factory-2	Factory-3	Construction	Trimmed Clear Face Log Grades: 4-Clear-Face	3-Clear-Face	2-Clear-Face	1-Clear-Face	0-Clear-Face
ROAK	303	202	101	75	400	300	202	101	70
WOAK	750	500	300	100	750	625	500	300	100
YPOP	300	250	175	75	350	300	250	175	75

Figure 8.4.6—*Log Costs per Thousand bdft* section of *Costs* tab with yellow-poplar trimmed clear-face log prices highlighted.


Cant Prices (prices per thousand bdft)

Species	Price
ROAK	440
WOAK	440
YPOP	340
HMAP	360
SMAP	340
CHERRY	360
OTHER	364

Residue Prices (prices per ton)

Residue	Price
Chips	25
Sawdust	17
Bark	17

Green Lumber Prices (prices per thousand bdft)

Species	Thickness	FAS	F1F	SEL	1C	2C	3A	3B
ROAK	1	935	920	886	643	490	440	400
ROAK	1.25	935	920	886	643	490	440	400
ROAK	1.5	935	920	886	643	490	440	400
ROAK	1.75	935	920	886	643	490	440	400
ROAK	2	935	920	886	643	490	440	400
WOAK	1	1465	1400	750	675	480	420	400
WOAK	1.25	1831	1750	937	843	600	525	500
WOAK	1.5	2197	2100	1125	1012	720	630	600
WOAK	1.75	2563	2450	1312	1181	840	735	700
WOAK	2	2930	2800	1500	1350	960	840	800
YPOP	1	860	850	817	420	285	200	150
YPOP	1.25	860	850	817	420	285	200	150
YPOP	1.5	860	850	817	420	285	200	150
YPOP	1.75	860	850	817	420	285	200	150
YPOP	2	860	850	817	420	285	200	150

Figure 8.4.7—*Green Lumber Prices* and *Residue Prices* sections of the *Costs* tab with yellow-poplar lumber and residue prices highlighted.

yellow-poplar lumber, regardless of thickness, in this example were $860, $850, $817, $420, $285, $200, and $250 for FAS, F1F, SEL, 1C, 2C, 3A, and 3B per thousand board feet, respectively (Fig. 8.4.7).

After you enter the *Processing Setup* (Fig. 8.4.1), create the sample logs (Figs. 8.4.2 and 8.4.3), and set up the operating, log, and lumber costs and prices (Figs. 8.4.4 to 8.4.7), you are ready to click the *Run Analysis* button to start the analysis (Fig. 5.1.2). Depending on your computer and software, it may take anywhere from a few seconds to several minutes for LORCAT to perform the analysis. When the analysis is complete, LORCAT will display a pop-up window (Fig. 8.4.8). Click *OK* to return to the *Batch Sawing (Expert)* tab and examine the results in the *Logs and Results* section at the bottom of the tab as shown for another simulation in Figure 5.1.2.

You can view the results for each individual log in the *Logs and Results* section of the *Batch Sawing (Expert)* tab. The blue columns report the *Board Count*, *Estimated Sawing Time*, *Total Recovery*, and the NHLA grade recovery for each grade for each log sawn (Fig. 8.4.9). The yellow columns report the volumes and weights of the chip, sawdust, and bark residue generated from each log sawn (Fig. 8.4.10). The green columns (Fig. 8.4.11) contain information about the different costs and values of the lumber produced. A summary of the results for the entire analysis can also be created. To do this, click the *Save Results Summary* button on the *Batch Sawing (Novice)* tab (Fig. 5.1.2) and enter a description for the results summary. For the example, we entered *Low Grade Yellow-Poplar, 6x8 OF, 6-inch cant* for the description. The more descriptive the example, the easier it is to refer back to past analyses if needed.

Figure 8.4.12 shows the description and overview of the *Summarized Batch Analyses Results* for our example analysis. The results show that we produced a total of 6,209.2 bdft from the 50 logs with a total sawing time of 91.0 min and an *Average Recovery per Log* of 124.2 bdft. Figure 8.4.13 shows the overall values and costs associated with sawing the 50 yellow-poplar logs. In this case, lumber with a total value of $2,190.12 and residues with a total value of $208.16 were produced. A total processing cost of $1,241.82 was incurred with a log cost of $795.90, giving a total cost of $2,147.14. Overall, the simulation estimated a total profit of $360.53. Given that it took 91.0 min, (1.52 h) to saw the logs, an overall mill profit of $237.19 ($360.53/1.52) per hour of operation was realized.

In the example analysis, a sample of 50 low-grade, small-diameter, yellow-poplar logs were sawn. For the example, we used a standard opening face width of 6 in. For small-diameter logs, the wider the opening face, the thicker the slab cut and the greater the proportion of residue with respect to log volume. In addition, because we were sawing

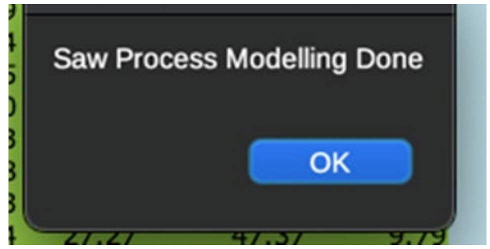


Figure 8.4.8—LORCAT batch analysis completion notification window.

low-grade logs, the odds of getting an FAS jacket board were low for each opening face cut. Thus, we could have explored the option of using a narrower opening face width, such as 5.5 in. Entering 5.5 for the *Opening Face Width* as shown in Figure 8.4.14 reveals the potential impact of a narrower opening face width. After entering the new opening face width, click *Update Setup* to change the settings in the *Log and Results* section. Next, click *Run Analysis* to repeat the simulation with the narrower opening face width. To make comparisons with the earlier analysis, click *Save Results Summary* and enter *Low Grade Yellow-Poplar, 5.5x8 OF, 6-inch cant* as the description.

Figure 8.4.15 shows the summaries for the 6.0- and 5.5-in. opening face analyses. Using the narrower opening face allowed us to produce an additional 92.1 bdft (6301.3 – 6209.2) from the 50 logs. This raised the *Average Recovery per Log* to 126.0 bdft. As expected, the increase in sawn lumber volume resulted in a decrease of chip volume and weight and a slight increase, 3.5 ft^3, in sawdust volume (Fig. 8.4.16). Overall, the reduction in opening face resulted in a profit increase of $36.73 ($397.56 – $360.53; Fig. 8.4.17). It is interesting to note the decrease in *Total Residue Value* caused by the reduction in chip volume/weight, as well as the increase in processing cost caused by the extra boards sawn (Fig. 8.4.17).

8.5: Batch Sawing (Novice) Profit/Loss Analyses

LORCAT's *Profit / Loss Analysis*, whether in novice or expert mode, operates by creating a set of logs that cover a wide range of diameter classes within each log grade, from the minimum diameter allowed for the log grade to the maximum normally observed, typically 30 in. For each diameter class, LORCAT creates 10 logs for each inch, with SEDs separated by 0.1-in. increments, e.g., 10.1, 10.2, 10.3, etc. The LED is determined using the observed taper distribution for that diameter class, log grade, and tree species using the data collected to develop the Forest Service log grades (Wood and others 2020). Figure 8.5.1 shows the beginning of the *Logs and Results* section, specifically the first 13 logs of a *Profit / Loss Analysis* for Forest Service log grades. For analysis with Forest Service log grades, LORCAT creates a 470-log sample, whereas clear-face log grade analyses use a 730-log sample. Given

Sawing Results

Board Count	Estimated Sawing Time	Total Recovery BDFT	Cant BDFT	FAS BDFT	F1F BDFT	Selects BDFT	1C BDFT	2AC BDFT	3AC BDFT	3BC BDFT
17	1.64	115.49	0.00	1.82	3.26	4.17	38.87	39.28	20.79	7.31
20	1.85	158.42	0.00	7.25	12.81	13.53	63.01	43.78	11.51	6.53
14	1.74	93.93	0.00	0.49	1.86	1.03	22.93	30.91	27.86	8.85
15	1.71	100.62	0.00	0.43	1.61	0.94	21.29	32.34	34.04	9.96
22	2.40	186.21	0.00	4.73	5.05	8.35	71.23	63.52	25.26	8.08
18	1.84	125.35	0.00	2.28	3.52	4.82	43.80	42.84	21.14	6.95
15	1.53	102.11	0.00	1.61	2.88	3.69	34.36	34.73	18.38	6.46
11	1.09	65.82	0.00	0.55	1.86	1.90	19.34	21.71	14.09	6.38
17	1.82	122.57	0.00	2.23	3.44	4.71	42.83	41.89	20.67	6.79
18	2.05	126.12	0.00	0.75	2.89	1.58	34.45	42.36	32.77	11.31
22	2.43	178.78	0.00	4.54	4.85	8.01	68.38	60.98	24.25	7.76
15	1.77	102.06	0.00	0.53	2.02	1.12	24.92	33.58	30.27	9.61
21	1.93	159.72	0.00	8.52	12.68	13.35	65.01	42.79	11.19	6.17
13	1.34	86.45	0.00	1.14	2.44	2.91	27.91	29.18	16.55	6.30

Figure 8.4.9—First 14 rows of the sawing results (*Board Count*, *Estimated Sawing Time*, *Total Recovery*, and the NHLA grade recovery) in the *Logs and Results* section of the *Batch Sawing (Expert)* tab.

Residue

Chip Volume	Sawdust Volume	Bark Volume	Chip Weight	Sawdust Weight	Bark Weight
----- Cubic Feet -----			----- Pounds -----		
19.8	4.3	9.6	254.4	63.6	81.4
22.4	5.9	10.8	287.4	87.2	91.6
12.5	3.5	8.4	161.0	51.7	71.3
13.9	3.8	8.7	178.9	55.4	73.9
21.7	7.0	11.3	278.7	102.5	96.5
19.1	4.7	9.8	245.0	69.0	83.2
17.3	3.8	9.0	221.8	56.2	76.8
11.8	2.5	7.4	152.0	36.2	63.3
17.3	4.6	9.6	222.6	67.5	81.4
19.7	4.7	9.8	253.2	69.4	83.8
22.1	6.7	11.2	283.5	98.4	95.5
12.3	3.8	8.6	158.0	56.2	73.0
23.2	6.0	10.9	298.3	87.9	92.5
12.4	3.2	8.1	158.9	47.6	69.2

Figure 8.4.10—First 14 rows of the *Residue* area in the *Logs and Results* section of the *Batch Sawing (Expert)* tab.

Revenue Cost Analysis

Total Product Value	Cant Value	Total Lumber Value	Total Residue Value	Total Cost	Log Cost	Processing Cost	Profit Loss
44.92	0.00	40.51	4.41	36.22	13.13	23.10	8.70
75.51	0.00	70.40	5.11	50.58	18.90	31.68	24.93
31.25	0.00	28.19	3.06	31.91	13.13	18.79	-0.67
32.31	0.00	28.97	3.33	30.76	10.63	20.12	1.55
74.64	0.00	69.46	5.18	62.97	25.73	37.24	11.67
49.12	0.00	44.76	4.36	40.95	15.88	25.07	8.17
39.72	0.00	35.82	3.90	33.55	13.13	20.42	6.17
24.43	0.00	21.68	2.75	19.60	6.43	13.16	4.83
47.82	0.00	43.77	4.05	40.39	15.88	24.51	7.42
43.66	0.00	39.19	4.47	41.11	15.88	25.22	2.55
71.88	0.00	66.69	5.19	61.48	25.73	35.76	10.40
33.70	0.00	30.63	3.07	33.54	13.13	20.41	0.16
76.94	0.00	71.68	5.26	54.13	22.18	31.94	22.82
32.72	0.00	29.74	2.98	27.92	10.63	17.29	4.80

Figure 8.4.11—First 14 rows of the *Revenue Cost Analysis* section showing product values, costs, and profit in the *Logs and Results* section of the *Batch Sawing (Expert)* tab.

Summarized Batch Analyses Results							
Summary Name	Total Logs Processed	Total Sawing Time	Total Log Volume	Log Recovery Factor	Boards Sawn	Total Recovery	Average Recovery Per Log
		(minutes)	(ft^3)			(bdft)	(bdft)
Low Grade Yellow-Poplar, 6x8 OF, 6-inch cant	50	91.0	925.55	6.65	860	6209.2	124.2

Figure 8.4.12—Overview of batch summaries entry for the low grade yellow-poplar analysis.

Total Product Value	Cant Value	Total Lumber Value	Total Residue Value	Total Cost	Log Cost	Processing Cost	Profit Loss
($)	($)	($)	($)	($)	($)	($)	($)
$2,398.27	$0.00	$2,190.12	$208.16	$2,037.74	$795.90	$1,241.84	$360.53

Figure 8.4.13—Product value and costs summary with overall profit/loss for the analysis in the *Batch Summaries* tab.

Processing Setup		
Opening Face Width	5.500	
Opening Face Length	8.000	
Cant Height	6.000	
Cant Width	0.000	
Green Allowance	0.125	
Lumber Thickness	1.000	Headrig
Sawing Variation	0.035	Headrig
Kerf Thickness	0.125	Headrig
Target Thickness	1.194	Headrig
Lumber Thickness	1.000	Resaw
Sawing Variation	0.035	Resaw
Kerf Thickness	0.125	Resaw
Target Thickness	1.194	Resaw
Sawing Method	GRADE	
Split or Full Taper?	SPLIT	

Figure 8.4.14—*Processing Setup* for an analysis using a narrower opening face width.

Summarized Batch Analyses Results							
Summary Name	Total Logs Processed	Total Sawing Time	Total Log Volume	Log Recovery Factor	Boards Sawn	Total Recovery	Average Recovery Per Log
		(minutes)	(ft^3)			(bdft)	(bdft)
Low Grade Yellow-Poplar, 6x8 OF, 6-inch cant	50	91.0	925.55	6.65	860	6209.2	124.2
Low Grade Yellow-Poplar, 5.5x8 OF, 6-inch Cant	50	90.0	925.55	6.75	876	6301.3	126.0

Figure 8.4.15—Left-end of the *Batch Summaries* entry for the low-grade yellow-poplar analysis with either a 6-in. opening face (top) or 5.5-in. opening face (bottom).

----- Total Volume -----			----- Total Weight -----		
Chips	Sawdust	Bark	Chips	Sawdust	Bark
----- cubic feet -----			----- tons -----		
900.6	232.8	479.0	5.8	1.7	2.0
874.7	236.3	479.0	5.6	1.7	2.0

Figure 8.4.16—Summary of residuals for the analysis of the two simulation runs (6-in. opening face (top) and 5.5-in. opening face (bottom)) in the *Batch Summaries* tab.

Total Product Value	Cant Value	Total Lumber Value	Total Residue Value	Total Cost	Log Cost	Processing Cost	Profit Loss
($)	($)	($)	($)	($)	($)	($)	($)
$2,398.27	$0.00	$2,190.12	$208.16	$2,037.74	$795.90	$1,241.84	$360.53
$2,454.12	$0.00	$2,249.69	$204.44	$2,056.16	$795.90	$1,260.26	$397.96

Figure 8.4.17—Product value and costs summary with overall profit/loss for the analysis of the two simulation runs (6-in. opening face (top) and 5.5-in. opening face (bottom)) in the *Batch Summaries* tab.

Small End Diameter	Large End Diameter	Log Length	Log Grade	Species
13.00	13.30	12	Factory-1	ROAK
13.10	16.21	12	Factory-1	ROAK
13.20	16.12	12	Factory-1	ROAK
13.30	17.60	12	Factory-1	ROAK
13.40	15.02	12	Factory-1	ROAK
13.50	16.31	12	Factory-1	ROAK
13.60	17.43	12	Factory-1	ROAK
13.70	17.55	12	Factory-1	ROAK
13.80	14.64	12	Factory-1	ROAK
13.90	17.49	12	Factory-1	ROAK
14.00	18.95	12	Factory-1	ROAK
14.10	18.71	12	Factory-1	ROAK
14.20	16.98	12	Factory-1	ROAK

Figure 8.5.1—Segment of the log sample created by LORCAT for a *Batch Sawing (Novice)* profit/loss analysis.

the size of these log samples, a *Profit / Loss Analysis* can take several minutes to complete.

The replication of logs within each diameter class was designed to allow users to see if all, none, or some within a diameter class were likely to make a profit. Users then can gauge their own risk for a particular log grade–diameter combination. For example, if most of the logs within a diameter class for a given log grade were sawn at a loss, then the likelihood of making a profit on those logs in your sawmill is low.

The first step in performing a *Profit / Loss Analysis* is to enter the *Processing Setup* of the mill. For this example, we preferred novice mode for the *Profit / Loss Analysis;* therefore, we enabled novice mode in the *Setup* tab (Fig. 8.5.2).

We used the same settings that were used for our novice interactive analysis (Section 8.1: Interactive Sawing (Novice)) with the exception that we are not going to saw the 6- by 4-in. cants, but we will saw a cant that is 6 in high and allow the width to vary by entering a width of 0 to produce 1-in.-thick lumber. As before, we used a grade-sawing approach to produce a dried lumber thickness of 1 in. with a standard green allowance of 0.125 in. We used a saw blade with a kerf of 0.125 in. and 0.035 in. of total sawing variation. When these processing variables are entered into LORCAT, the *Processing Setup* section of the *Batch Sawing (Novice)* tab will look like that shown in Figure 8.5.3.

The next step is to specify the operating cost, log cost, and market prices for the lumber to be sold based on NHLA lumber grades. For this example, we used the *Lumber Volume-Based* costing approach (Fig. 8.5.4). Our mill produces 3,500 bdft of lumber per hour, on average, based on the fact that our mill produces approximately 8 Mbdft of lumber per year (8 Mbdft/2,250 h/year; Fig. 8.5.2). Based on our accounting, we specified an hourly operating cost of $1,500. LORCAT then calculated the *Operating cost per 1000 bdft sawn* as $428.57. We sawed red oak, and we used Forest Service factory log grades with a specified cost of $303, $202, and $101 per 1,000 bdft (International 1/4 scale) for Factory 1, Factory 2, and Factory 3, respectively (Fig. 8.5.5). The market prices of 1-in.-thick, green red oak lumber in this example were $935, $920, $886, $643, $490, $440, and $400 for FAS, F1F, SEL, 1C, 2C, 3A, and 3B per thousand board feet, respectively (Fig. 8.5.6).

A *Profit / Loss Analysis* is always performed for a single log length (up to a maximum of 16 ft), as shown in Figure 8.5.7 where we used 12 ft. Restricting the analysis to one length requires 470 logs and 730 logs for Forest Service log grades and clear-face log grades, respectively. When multiple lengths are allowed for the *Profit / Loss Analysis*, the

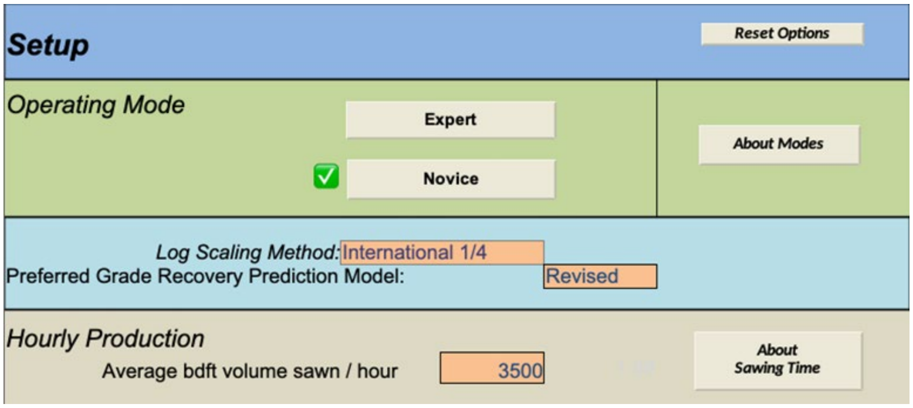


Figure 8.5.2—*Setup* tab showing selection of novice mode.

Processing Setup	
Cant Height	6.000
Cant Width	0.000
Green Allowance	0.125
Lumber Thickness	1.000
Sawing Variation	0.035
Kerf Thickness	0.125
Target Thickness	1.194
Sawing Method	GRADE

Figure 8.5.3—*Processing setup* used for the example in the *Batch Sawing (Novice)* tab for a profit/loss analysis.

Lumber Volume-Based			
Use operating cost from "Operations Costs" sheet?	NO		
Average Lumber Sawn volume/hour (from "Setup" tab)	✓	3500	bdft / hour
Utilization rate of equipment (100%;80%;60%;40%)		100	
Operating cost from Operation Costs sheet		23.22	$ / hour
Operating cost, directly specified	✓	1500.00	$ / hour
Operating cost per 1000 bdft sawn	✓	428.57	$

Figure 8.5.4—Segment of *Setup* tab showing the specification of *Lumber Volume-Based* operating cost.

Log Costs per Thousand bdft	International 1/4			
	USFS Log Grades			
Species	Factory-1	Factory-2	Factory-3	Construction
ROAK	303	202	101	75

Figure 8.5.5—Specification of red oak log costs in the *Costs* tab.

Green Lumber Prices (prices per thousand bdft)

Species	Thickness	FAS	F1F	SEL	1C	2C	3A	3B
ROAK	1	935	920	886	643	490	440	400

Figure 8.5.6—Market prices of 1-in.-thick green red oak lumber as entered into the *Costs* tab.

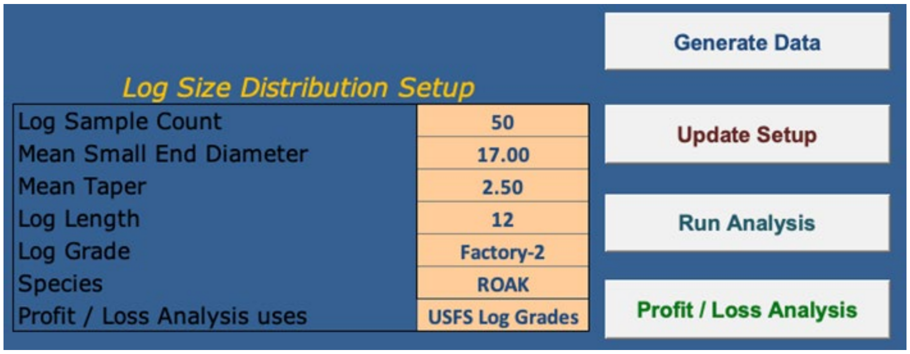


Figure 8.5.7—Setup options chosen for our *Profit / Loss Analysis* as entered into the *Log Size Distribution Setup* matrix of the *Batch Sawing (Novice)* tab.

number of samples to be processed gets too large. Running the analysis over all log lengths would require 2,250 logs for Forest Service log grades and 3,650 logs for clear-face log grades, which would exceed the maximum sample size of 1,000 logs per simulation that LORCAT can perform. To examine multiple log lengths, a separate *Profit / Loss Analysis* needs to be conducted for each log length.

After selecting the length of the logs to be processed, the *Log Grade*, species, and log grading system, either Forest Service log grades or clear-face grades, to be used in the analysis must be selected. In our example, we used *USFS Log Grades* as shown in Figure 8.5.7. All the other input data into the *Log Size Distribution Setup* matrix of the *Batch Sawing (Novice)* tab (e.g., *Log Sample Count*, *Mean Small End Diameter*, *Mean Taper*, and *Log Grade*) do not need to be updated because the *Profit / Loss Analysis* does not use these data from the matrix but instead uses its own specifications.

When the *Processing Setup* (Fig. 8.5.3), operating costs (Fig. 8.5.4), *Log Costs* (Fig. 8.5.5), *Green Lumber Prices* (Fig. 8.5.6), and *Log Size Distribution Setup* (Fig. 8.5.7) have been configured as shown, you are ready to click the *Profit / Loss Analysis* button from the *Batch Sawing* tab (Fig. 8.5.7). To perform the *Profit / Loss Analysis*, LORCAT needs to clear all data from the Logs and Results section in the *Batch Sawing (Novice)* tab. Before clearing the data, LORCAT will ask if this is okay. After this is accepted, the run starts, which can last several minutes. This will not only block spreadsheet programs but the computer may also respond sluggishly to any other command.

Figure 8.5.8 shows the *Logs and Results* section from the *Profit / Loss analysis* without the *Board Width Distribution Summary*. The results are in the same format as those from the batch analyses (Sections 8.3: Novice Batch and 8.5: Batch Sawing (Novice) Profit/Loss Analyses). For a *Profit / Loss Analysis*, two sections are important: the orange section that lists the log diameters and grades and the green section that reports the costs, revenue, and profit for each log. Figure 8.5.9 shows these sections for the 10- through 12-in. SED Factory 2 logs. *Profit Loss* in the *Revenue Cost Analysis* section in the *Batch Sawing (Novice)* tab (the green column in Fig. 8.5.9) is the difference between total revenue and total costs. The results should be examined for logs that resulted in a loss or a minimal, unacceptable profit after sawing. For example, for the 10-in.-diameter class logs, every log resulted in a loss of $3.79 or more. For the 11-in.-diameter class logs, only the 11.9-in.-diameter log resulted in a profit ($0.61; Fig. 8.5.9). Thus, if the goal is to maximize profit for the sawmill, these grade–diameter class combinations should be avoided. Instead, the grade and diameter class combinations that resulted in higher profits should be maximized.

8.6: Defining Operation Costs

Some mills know their operating costs as a *Sawing Time-Based*, *Lumber Volume-Based*, or *Log Volume-Based* cost from their own calculations. However, some operations may not have much information about their cost structure. For this reason, LORCAT allows users to calculate their operating costs on the *Operation Costs* tab. This example explains the default values contained in LORCAT 4.00 that mimic a two-person mobile bandsaw operation.

Figure 7.2.1 shows the *Operation Costs* tab in LORCAT 4.00, starting with *Input Data* on Row 1. Figure 8.6.1 shows the *Input Data* section (Rows 1 to 11) of the *Operation Costs* tab. Column B lists the input data description, starting with *space requirement* for your operation. A mobile bandsaw operator might not need a space for his or her operation that is owned or rented; therefore, such an operation may have no square footage to enter and also may not have anything to enter into Row 3, *cost of space per year per sqft*. The next row (Row 4) is where the amount of energy the operation consumes per hour is entered. In our case, we estimated that we used 1 gallon of diesel fuel per hour under normal operating conditions. Row 5 asks for the price paid per unit of energy. For our example, we entered about $4.00 per gallon. You also have to enter how the usage of energy fluctuates with the capacity utilization of the machines (Row 6), e.g., when the machine is idle or not

Logs and Results

Small End Diameter	Large End Diameter	Log Length	Log Grade	Species	Sawing Method	Cant Height	Cant Width	Green Allowance	Lumber Thickness	Headrig Kerf Thickness	Headrig Sawing Variation
13.00	13.40	16	Factory-1	ROAK	GRADE	6	0	0.125	1.5	0.125	0.038
13.10	17.24	16	Factory-1	ROAK	GRADE	6	0	0.125	1.5	0.125	0.038
13.20	17.09	16	Factory-1	ROAK	GRADE	6	0	0.125	1.5	0.125	0.038
13.30	19.03	16	Factory-1	ROAK	GRADE	6	0	0.125	1.5	0.125	0.038
13.40	15.56	16	Factory-1	ROAK	GRADE	6	0	0.125	1.5	0.125	0.038
13.50	17.24	16	Factory-1	ROAK	GRADE	6	0	0.125	1.5	0.125	0.038
13.60	18.70	16	Factory-1	ROAK	GRADE	6	0	0.125	1.5	0.125	0.038

Small End Diameter	Board Count	Estimated Sawing Time	Total Recovery BDFT	Cant BDFT	FAS BDFT	F1F BDFT	Selects BDFT	1C BDFT	2AC BDFT	3AC BDFT	3BC BDFT
13.00	9	2.74	88.72	0.00	18.47	13.98	4.25	21.32	21.00	8.85	0.85
13.10	11	2.78	128.47	0.00	26.75	20.24	6.15	30.88	30.41	12.82	1.27
13.20	11	2.81	129.83	0.00	27.03	20.45	6.21	31.20	30.73	12.95	1.24
13.30	11	2.85	125.71	0.00	26.17	19.80	6.02	30.21	29.76	12.54	1.21
13.40	9	2.88	102.91	0.00	21.43	16.21	4.92	24.73	24.36	10.27	0.99
13.50	11	2.92	132.70	0.00	27.63	20.91	6.35	31.89	31.41	13.24	1.27
13.60	11	2.95	130.15	0.00	27.10	20.50	6.23	31.28	30.81	12.99	1.25

Small End Diameter	Revenue Cost Analysis: Total Product Value	Cant Value	Total Lumber Value	Total Costs	Log Cost	Processing Cost	Profit Loss
13.00	62.13	0.00	62.13	72.87	34.85	38.02	-10.74
13.10	89.96	0.00	89.96	89.90	34.85	55.06	0.06
13.20	90.91	0.00	90.91	90.49	34.85	55.64	0.43
13.30	88.03	0.00	88.03	88.72	34.85	53.88	-0.69
13.40	73.07	0.00	73.07	79.95	34.85	44.11	-6.88
13.50	92.92	0.00	92.92	91.71	34.85	56.87	1.21
13.60	91.14	0.00	91.14	90.62	34.85	55.78	0.52

Small End Diameter	Over-run Analysis: Int 1/4 Volume	Int 1/4 Over-run	Scribner Volume	Scribner Over-run	Doyle Volume	Doyle Over-run	LRF Statistics: Log Cubic Feet	Log Recovery Factor
13.00	115	-22.8%	100	-11.3%	81	9.5%	15.2	5.83
13.10	115	11.7%	100	28.5%	81	58.6%	20.5	6.27
13.20	115	12.9%	100	29.8%	81	60.3%	20.4	6.37
13.30	115	9.3%	100	25.7%	81	55.2%	23.5	5.34
13.40	115	-10.5%	100	2.9%	81	27.1%	18.4	5.59
13.50	115	15.4%	100	32.7%	81	63.8%	21.0	6.33
13.60	115	13.2%	100	30.2%	81	60.7%	23.4	5.57

Figure 8.5.8—Partial overview of the *Logs and Results* section from our *Profit / Loss Analysis* in the *Batch Sawing (Novice)* tab.

Logs and Results / **Revenue Cost Analysis**

Small End Diameter	Large End Diameter	Log Length	Log Grade	Species	Total Product Value	Cant Value	Total Lumber Value	Total Costs	Log Cost	Processing Cost	Profit Loss
10.00	10.35	16	Factory-2	ROAK	22.67	0.00	22.67	30.37	13.13	17.24	-7.70
10.10	13.38	16	Factory-2	ROAK	34.89	0.00	34.89	39.66	13.13	26.53	-4.77
10.20	13.28	16	Factory-2	ROAK	34.90	0.00	34.90	39.66	13.13	26.53	-4.76
10.30	14.82	16	Factory-2	ROAK	38.08	0.00	38.08	42.08	13.13	28.95	-4.00
10.40	12.13	16	Factory-2	ROAK	32.86	0.00	32.86	38.12	13.13	24.99	-5.25
10.50	13.47	16	Factory-2	ROAK	35.85	0.00	35.85	40.38	13.13	27.25	-4.54
10.60	14.63	16	Factory-2	ROAK	38.30	0.00	38.30	42.25	13.13	29.12	-3.95
10.70	14.76	16	Factory-2	ROAK	38.73	0.00	38.73	42.57	13.13	29.44	-3.85
10.80	11.72	16	Factory-2	ROAK	32.85	0.00	32.85	38.10	13.13	24.97	-5.26
10.90	14.68	16	Factory-2	ROAK	38.97	0.00	38.97	42.76	13.13	29.63	-3.79
11.00	16.66	16	Factory-2	ROAK	55.98	0.00	55.98	58.00	16.16	41.84	-2.02
11.10	16.36	16	Factory-2	ROAK	57.10	0.00	57.10	58.84	16.16	42.68	-1.74
11.20	14.31	16	Factory-2	ROAK	39.50	0.00	39.50	45.68	16.16	29.52	-6.18
11.30	13.12	16	Factory-2	ROAK	37.37	0.00	37.37	44.09	16.16	27.93	-6.72
11.40	13.93	16	Factory-2	ROAK	39.15	0.00	39.15	45.42	16.16	29.26	-6.27
11.50	14.73	16	Factory-2	ROAK	50.33	0.00	50.33	53.78	16.16	37.62	-3.44
11.60	18.28	16	Factory-2	ROAK	62.53	0.00	62.53	62.90	16.16	46.74	-0.36
11.70	13.79	16	Factory-2	ROAK	39.46	0.00	39.46	45.65	16.16	29.49	-6.19
11.80	15.89	16	Factory-2	ROAK	61.63	0.00	61.63	62.22	16.16	46.06	-0.59
11.90	17.21	16	Factory-2	ROAK	66.37	0.00	66.37	65.76	16.16	49.60	0.61
12.00	16.40	16	Factory-2	ROAK	62.94	0.00	62.94	65.44	19.19	46.25	-2.50
12.10	14.70	16	Factory-2	ROAK	53.05	0.00	53.05	58.17	19.19	38.98	-5.12
12.20	22.23	16	Factory-2	ROAK	80.83	0.00	80.83	78.59	19.19	59.40	2.24
12.30	23.29	16	Factory-2	ROAK	104.68	0.00	104.68	96.11	19.19	76.92	8.57
12.40	13.62	16	Factory-2	ROAK	50.26	0.00	50.26	56.12	19.19	36.93	-5.86
12.50	15.88	16	Factory-2	ROAK	66.45	0.00	66.45	68.02	19.19	48.83	-1.57
12.60	14.51	16	Factory-2	ROAK	54.06	0.00	54.06	58.91	19.19	39.72	-4.86
12.70	14.00	16	Factory-2	ROAK	52.72	0.00	52.72	57.93	19.19	38.74	-5.21
12.80	18.65	16	Factory-2	ROAK	70.78	0.00	70.78	71.20	19.19	52.01	-0.42
12.90	17.29	16	Factory-2	ROAK	73.63	0.00	73.63	73.30	19.19	54.11	0.33

Figure 8.5.9—Detail of the *Profit /Loss Analysis* results from the *Batch Sawing (Novice)* tab.

A	B	C	D	E
1	**Input Data**	**Source of Calculation or Formula**	**Unit**	
2	space requirement	layout	sqft	0
3	cost of space per year per sqft	company accounting	$/sqft	$0.00
4	machine energy consumption per hour	users' manual, company information	kWh, gal, t	1
5	cost of energy per hour	market prices	$ / kWh, gal, t	$4.00
6	fixed energy cost as % of total energy costs	company accounting	%	10
7	depreciation period (straight line depreciation)	IRS	years	10
8	assumed interest rate	company information	%	5
9	estimation of start-up and training costs	percentage of purchase price incl. installation	%	5
10	estimated labor overhead costs (benefits)	percentage of total labor costs	%	50
11	total working hours per year	company information	hours	1801

Figure 8.6.1—*Input Data* (Rows 1 to 11) in the *Operation Costs* tab.

fully used because of low-capacity utilization. Row 7 asks for the depreciation period of the machine(s), which can be according to the IRS or based on your own estimate. LORCAT then will use straight-line depreciation for your investment in equipment. Row 8 asks for *assumed interest rate*, Row 9 asks for estimation of start-up and training costs as a percentage of purchase price and installation, and Row 10 asks for *estimated labor overhead costs*, e.g., what is added to the base pay of worker's pay, which should, at a minimum, include benefits. Finally, Row 11 asks for total number of hours the operation is running per year.

In *Labor Requirements* (Fig. 8.6.2; Rows 12 to 15), you are asked to enter the total number of employees (including yourself) working in the operation. For ease of use, LORCAT distinguishes only between skilled, unskilled, and supervising employees. Part-time employees can be entered

12	**Labor Requirements**			
13	# of skilled operators (employee)	company information	person(s)	1
14	# of unskilled operators (employee)	company information	person(s)	1
15	# of supervising employees	company information	person(s)	0

Figure 8.6.2—*Labor Requirements* (Rows 12 to 15) in the *Operation Costs* tab.

as fractions. Our example operation employed two persons, the owner and one employee.

In the next section, *Labor Costs* (Fig. 8.6.3; Rows 17 to 22), employee costs and cost benefits are entered (skilled, unskilled, and supervisor). In our example, the owner was listed as a skilled operator and the helper was listed as an unskilled operator. If there is more than one person in any position (skilled, unskilled, or supervisor), their salaries should be averaged and this average should be entered in the orange cells on Rows 17, 19, and 22 in Column E. The benefits of all the employees are calculated automatically from the input in Row 10 (*estimated labor overhead costs (benefits)*; Fig. 8.6.1).

Rows 23 to 26 deal with *Investment* as shown in Figure 8.6.4. In Row 24, you can enter the total investment costs of your equipment, i.e., the total sum of all investments into all your equipment including transport and installation. LORCAT will then automatically add your start-up and training costs that were entered into Row 9 (*estimation of start-up and training costs*).

Figure 8.6.5 shows, starting with Row 27, the *Operation Cost: Labor per Year*. These costs are calculated based on the input previously given but are divided into *Fixed* and *Variable* costs. Fixed costs are any expenses that stay the same no matter how much the company produces, whereas variable costs are any expenses that change with the amount of products that a company produces. For example, labor costs are typically viewed as variable costs because an employee can be laid off, whereas depreciation of assets are *Fixed* because depreciation accumulates whether a product is being produced or not. For the example, we assumed that the owner (skilled) and the helper (unskilled) will forgo their pay if no work is being conducted. Hence, LORCAT 4.00 enters the *Operating Cost: Labor per Year* into the *Cost Type Variable* in Rows 28 to 30 with the total being shown in *Total labor cost* on Row 31.

Operating Cost per Year is assembled in Rows 32 to 38 (Fig. 8.6.6). We estimated annual expenses for *tools, blades, and jigs* to be $2,400 as a variable cost because those costs only occur if the mill is indeed producing products. One could also argue that part of the variable costs for tools, blades, and jigs could be fixed costs because some of those tools, blades, and jigs are being used whether products are being produced or not. This example shows that judgment must be used to make these calls depending on the situation. Energy costs were divided based on our original assumption in Row 6 that fixed energy makes up 10% of total energy costs, and the respective amounts were entered into Rows 35 (fixed) and 36 (variable) in Figure 8.6.6.

Figure 8.6.7, showing Rows 39 to 42, deals with the *Capital Cost per Year* of the operation. Row 40 calculates the annual *depreciation*, and Row 41 calculates the annual *interest* of any investments. The sum of the operation's *Total capital cost* in shown in Row 42.

Rows 43 to 46 (Fig. 8.6.8) calculate the *Overhead and Miscellaneous Cost per Year*. *Production overhead* costs (Row 44) are manufacturing overhead costs that cannot be directly attributed to an individual cost object or product such as costs for auxiliary materials, auxiliary wages, auxiliary materials, or other costs. *Miscellaneous cost* (Row 45) are any costs that your operation incurs that are not attributable to any other cost listed in this *Operation Costs* tab. For the example, we decided to forgo any estimation of *production overhead* or *miscellaneous cost*, fixed and variable. Hence, the *Total overhead and miscellaneous cost* is zero (Row 46).

Figure 8.6.9 shows the sum of the mill's *Cost Allocation*, both fixed (Row 48) and variable (Row 49). According to these numbers, this mill incurred $9,482.90 fixed costs and $136,883.60 variable costs per year, of which $127,500.00 were labor costs.

Figure 8.6.10 shows the *Equipment Operating Cost per Hour* and the *Total Equipment Cost per Working Hour* (Rows 50 to 61). Row 51 shows that the variable cost was $76.00 per hour. Our *fixed cost* was dependent on the utilization of the mill and was $5.27 per hour when the mill was being fully utilized (100%; Row 53) and was $13.16 per hour when the mill was only 40% utilized (Row 56). Rows 57 to 61 give the total cost of using the mill at a specific utilization level. In our example, values ranged from $81.27 for the *100% utilization level* (Row 58) to $89.17 for the *40% utilization level* (Row 41).

9: Troubleshooting Simulations

Some of the benefits of using simulation are that it can help identify potential issues in the operation as well as opportunities for improvement. For example, if the LRF is lower than expected on some or all logs in the simulation, there are several potential reasons ranging from a typo in the sawing parameters in the simulation to an inefficient process. Identifying and correcting such issues outside of normal processing will lead to an improved understanding

16	**Labor Costs**			
17	labor cost skilled employee	company accounting	$ / year	$50,000.00
18	cost benefits skilled employee	=#17x(#10/100)	$ / year	$25,000.00
19	labor cost unskilled employee	company accounting	$ / year	$35,000.00
20	cost benefits unskilled employee	=#19x(#10/100)	$ / year	$17,500.00
21	supervisor cost	company accounting	$ / year	$65,000.00
22	cost benefits supervisor	=#21x(#10/100)	$ / year	$32,500.00

Figure 8.6.3—*Labor Costs* (Rows 16 to 22) in the *Operation Costs* tab.

23	**Investment**			
24	purchase price incl. transport and installation	final invoice	$	$55,000.00
25	cost of start-up and training	=#9 x#24	$	$2,750.00
26	**Total investment**	=#24+#25	***$***	**$57,750.00**

Figure 8.6.4—*Investment* (Rows 23 to 26) in the *Operation Costs* tab.

			Cost Type	
27	**Operating Cost: Labor per Year**		Fixed	Variable
28	total skilled employee cost	=#13*(#17+#18)		$75,000.00
29	total unskilled employee cost	=#14*(#19+#20)		$52,500.00
30	total supervisor cost	=#15*(#21+#22)		$0.00
31	**Total labor cost**	=#28+#29+#30	**$0.00**	**$127,500.00**

Figure 8.6.5—*Operating Cost: Labor per Year* (Rows 27 to 31) in the *Operation Costs* tab.

32	**Operating Cost per Year**			
33	tools, blades, and jigs	estimation	$0.00	$2,400.00
34	space cost	=#2x#3	$0.00	
35	fixed energy cost	=#4x#5x(#6/100)x#11	$720.40	
36	variable energy cost	=#4x#5x(1-(#6/100)x#11		$6,483.60
37	maintenance cost	estimation	$100.00	$500.00
38	**Total operating cost**	=#33+#34+#35+#36+#37	**$820.40**	**$9,383.60**

Figure 8.6.6—*Operating Cost per Year* (Rows 32 to 38) in the *Operation Costs* tab.

39	**Capital Cost per Year**			
40	depreciation	=#26x(1/#7)	$5,775.00	
41	interest	=#26x(#8/100)	$2,887.50	
42	**Total capital cost**	=#40+#41	**$8,662.50**	

Figure 8.6.7—*Capital Cost per Year* (Rows 39 to 42) in the *Operation Costs* tab.

43	**Overhead and Miscellaneous Cost per Year**			
44	production overhead	estimation	$0.00	$0.00
45	miscellaneous cost	estimation	$0.00	$0.00
46	**Total overhead and miscellaneous cost**	=#44+#45	**$0.00**	**$0.00**

Figure 8.6.8—*Overhead and Miscellaneous Costs per Year* (Rows 43 to 46) in the *Operation Costs* tab.

47	**Cost Allocation**			
48	**Total fixed cost per year**	=#31+#38+#42+#46	**$9,482.90**	
49	**Total variable cost per year**	=#31+#38+#42+#46		**$136,883.60**

Figure 8.6.9—*Cost Allocation* (Rows 47 to 49) in the *Operation Costs* tab.

50	**Equipment Operating Cost per Hour**			
51	variable cost (quantity-dependent)	=#49/#11		**$76.00**
52	fixed cost (time-dependent) at % utilization			
53	100% utilization level	=#48/#11	**$5.27**	
54	80% utilization level	=#48/(#11x0.8)	**$6.58**	
55	60% utilization level	=#48/(#11x0.6)	**$8.78**	
56	40% utilization level	=#48/(#11x0.4)	**$13.16**	
57	**Total Equipment Cost per Working Hour**			
58	**100% utilization level**	=#51+#53	**$81.27**	
59	**80% utilization level**	=#51+#54	**$82.59**	
60	**60% utilization level**	=#51+#55	**$84.78**	
61	**40% utilization level**	=#51+#56	**$89.17**	

Figure 8.6.10—*Equipment Operating Cost per Hour* (Rows 50 to 56) and *Total Equipment Cost per Working Hour* (Rows 57 to 61) in the *Operation Costs* tab.

of the processing methods and an improvement in mill efficiency and profitability.

The following are several common problems that may be apparent when performing interactive or batch simulation analyses in LORCAT 4.00. For each problem, we offer potential causes that depend on the particular setup.

- LRF lower than expected
  - An oversized opening face width or an opening face too wide for a log with a small SED
  - Long opening face length on a short log or a log with a high degree of taper
  - An above average kerf thickness or an error in the specification, e.g., 1.25 instead of 0.125
  - An above average sawing variation or an error in the specification, e.g., 0.30 instead of 0.030
- A loss or very low profit
  - Can be related to a low LRF (see potential causes for low LRF)
  - Incorrect (low) prices for lumber
  - Incorrect (high) prices for logs
  - Incorrect (high) processing cost (See potential causes for high processing cost)
  - If a sawing time-based processing cost was used and the sawing time per log is high, then hourly throughput will be lower and the associated cost per log will be high. To correct, examine and adjust sawing time. Section 6: Customizing LORCAT gives more information.
- No cant was sawn
  - Cant dimensions were too large for the log diameter
  - Log diameter coupled with board thickness or an oversized opening face width does not leave enough log area after slabbing and boards to produce cant
  - Cant height or cant width is 0
- No recovery or value by NHLA grade
  - Ensure that the length and SED of the log meets the minimum size requirements for the grade (check the LORCAT status window for a warning or error message)
  - Grade recovery can only be projected for logs up to 16 ft long
  - The original grade recovery prediction method uses the data as published by the Forest Service (Hanks and others 1980). These data have gaps and do not cover all diameters for all species. Thus, logs not included in the original Forest Service data will not have projected grade recovery. The revised method includes projected grade yields for all diameters. Section 6: Customizing LORCAT gives more information.
- Processing cost(s) for analyses higher than expected
  - Verify that the correct operating cost method and the correct costs and values were entered on the *Costs* tab
  - If sawing time-based or lumber volume-based costing was used, verify that the hourly production: average board feet volume sawn per hour is correct on the *Setup* tab.
- Warning message: "Log diameter is less than minimum diameter for the log grade"
  - The Forest Service log grades have minimum SED requirements to make each grade. These requirements are shown in Table 9.1.
- Warning message: "Current log has excessive taper"
  - LORCAT shows this warning whenever there are 6 in. or more of taper present in the log being processed. Although LORCAT will process this log without any issues, this amount of taper is uncommon and should be verified.

Table 9.1—Minimum small-end diameters (SED) for Forest Service log grades

Forest Service log grade	Minimum SED (in.)
Factory 1	13
Factory 2	10
Factory 3	8

10: Glossary

1 Common: Quality grade for lumber as specified by NHLA. A grade for medium quality, standard hardwood lumber that is widely used in the manufacture of furniture and kitchen cabinet parts (NHLA 2019, AHEC 2017).

2A Common: Quality grade for lumber as specified by NHLA. A lower quality, standard hardwood lumber grade that is often referred to as the economy grade because of its price and suitability for a wide range of furniture parts. It is also the grade of choice for the U.S. hardwood flooring industry (NHLA 2019, AHEC 2017). Must yield 50% of its surface area in clear cuttings.

3A Common: Quality grade for lumber as specified by NHLA. A standard hardwood lumber grade that has 33.3% of its surface area in clear cuttings (NHLA 2019). A lower quality, economically priced lumber grade commonly used for utility products such as crates, palettes, fences, etc.

3B Common: Quality grade for lumber as specified by NHLA. A standard hardwood lumber grade that has 25% of its surface area in clear cuttings (NHLA 2019). A lower quality, economically priced lumber grade commonly used for utility products such as crates, palettes, fences, etc.

Bark: The outer protective covering of trees. A byproduct or residue of sawmills. Often sold to specialized processors, burned for biofuel, or used for landscaping.

Cant: In LORCAT, it is the center section of a log, sawn on at least two faces. A cant can be produced to a dimensional size, such as 4 by 6 in., or to a thickness, such as 6 in. and a variable width. In LORCAT, variable width cants are resawn into lumber according to the specified sawing parameters.

Chips: Small pieces of wood formed by cutting or chipping slabs or edgings. In LORCAT, these are produced from slabs and edgings. Woodchips may be used for biofuel or for producing wood pulp.

Diameter Class: Categorification of logs by scaling or small-end diameter, typically by 1-in. groups, e.g., a 12-in. diameter class would include all logs with diameters from 12.0 to 12.99 in.

Doyle: The most widely used log scaling rule, especially in the eastern United States. This log rule was first published in 1837. Doyle is considered to be the least accurate at the small-to-medium range of diameters because of a deduction for waste that is excessive in small logs (Cassens 2001).

Equipment Utilization Rate: Expresses the ratio of total hours used to total hours available as a percentage. Used to adjust fixed costs, i.e., costs that do not change regardless of the sales or production volume of the business.

Expansion Factor: A multiplication factor that is used to calculate the volume of chips or sawdust that would be produced if a solid block of wood was converted to these products. For example, an expansion factor of 2.86 means that if 1 ft^3 of solid wood was chipped, it would produce 2.86 ft^3 of chips.

F1F (FAS One Face): Quality grade for lumber as specified by NHLA. The better face must meet all FAS requirements, whereas the poorer face must meet all the requirements of 1 Common grade, thus ensuring the buyer with at least one FAS face (AHEC 2017). A standard hardwood lumber grade (NHLA 2019).

Face: During log grading and sawing, the log surface is divided into four equal segments referred to as a face (Fig. 10.1) (Rast and others 1973).

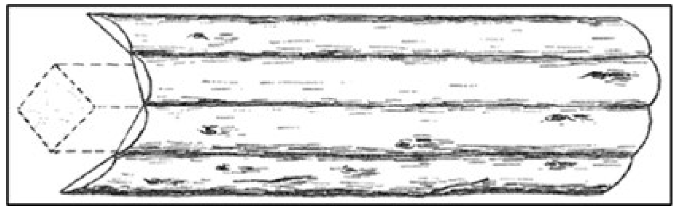


Figure 10.1—The four equal segments referred to as faces that are sawn off a log during processing.

FAS: Quality grade for lumber as specified by NHLA. The highest quality standard hardwood lumber grade. The name comes from the previous NHLA grades "Firsts and Seconds" (NHLA 2019). This grade is best suited for high quality furniture, interior joinery, and solid wood mouldings. The minimum board size is 6 in. and wider and 8 ft and longer (AHEC 2017).

Fixed Cost: Cost that the business incurs irrespective of the sales or production of the business.

Green Allowance: Specifies the additional thickness to be sawn per inch such that when the board is dried (and hence shrinks), the final thickness is the desired thickness.

Head Rig: The main saw in the sawmill that saws logs into lumber and cants. Head rigs can use either a bandsaw or a circular saw.

International ¼: A log rule that was developed in 1900 by Judson Clark (Cassens 2001). It is considered to be one of the more accurate of the current log rules. However, it is also one of the least used rules.

Log Volume-Based: Bases the operating cost on the average volume (International 1/4, Scribner, or Doyle) of logs sawn per hour.

Lumber Volume-Based: Bases the operating cost on the average board feet of lumber sawn per hour.

Opening Face Length: Specifies the target length of the first board that is sawn from a log face. Typically, the opening face length is 8 ft. On lower quality log faces that are unlikely to make a FAS board, the opening face length is sometimes shortened to 6 ft.

Opening Face Width: Specifies the target width of the first board that is sawn from a log face. An opening face that is too wide for the log diameter will result in a thick slab and lower lumber recovery. Too narrow an opening face width will often result in high quality lumber that is too narrow to make the higher NHLA grades.

Operating Cost: The cost of running a sawmill to produce lumber and other products. Operating cost can be based on sawing time, lumber volume, or log volume.

Residue: Typically, the materials that remain when a log has been sawn into lumber at the sawmill. In the context of LORCAT, residues are bark, sawdust, slabs, and edgings. LORCAT further simulates the chipping of slabs and edgings into chips. In some mills, these are used for bioenergy, and in other mills, these are sold to specialized processors.

Saw Kerf: The thickness of wood removed by the saw blade during the sawing process.

Sawdust: The wood dust created by the saw blade during the sawing process. This type of residue is commercially sold by the ton.

Sawing Time-Based: Bases the operating cost on the estimated amount of time needed to saw a log. Sawing time is estimated using the scaling diameter, length, and grade of the log. This method is based on mill timing studies by Adams (1984).

Sawing Variation: The degree of deviation from a specified target lumber thickness incurred during the sawing process (Brown 2000). Two measurements of sawing variation exist: within-board and between-board variation. The two together combine to report total sawing variation, commonly referred to simply as sawing variation.

Scribner: A log rule first published in 1846. Scribner Decimal C is the most prevalent form of the rule. The rule rounds the predicted volume to the nearest 10 bdft (Cassens 2001).

Selects: Quality grade for lumber as specified by NHLA (2019). This grade is virtually the same as F1F except for the minimum board size required. Selects allows boards 4 in. and wider and 6 ft and longer (AHEC 2017).

Taper, Full: Sawing method in which logs are sawn parallel to the outside faces of the log (Hallock and others 1978). Thus, the grain is parallel to the board surface in the resulting boards, making the lumber stronger in general than split-taper sawn lumber.

Taper, Split: Sawing method in which the taper of the log is split between opposite faces and the log is sawn parallel to its central axis (Hallock and others 1978). This sawing method has the potential to produce shorter boards, if the amount of taper is large enough, yet increase the recovery of lumber.

Target Thickness: Green sawn lumber thickness that is the sum of the desired final lumber thickness, green allowance, and sawing variation. The target thickness is calculated to account for shrinkage caused by drying and for variation in sawn thickness such that the number of scant boards produced is minimized.

Variable Cost: Cost that the business incurs based on the number or volume of goods produced.

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