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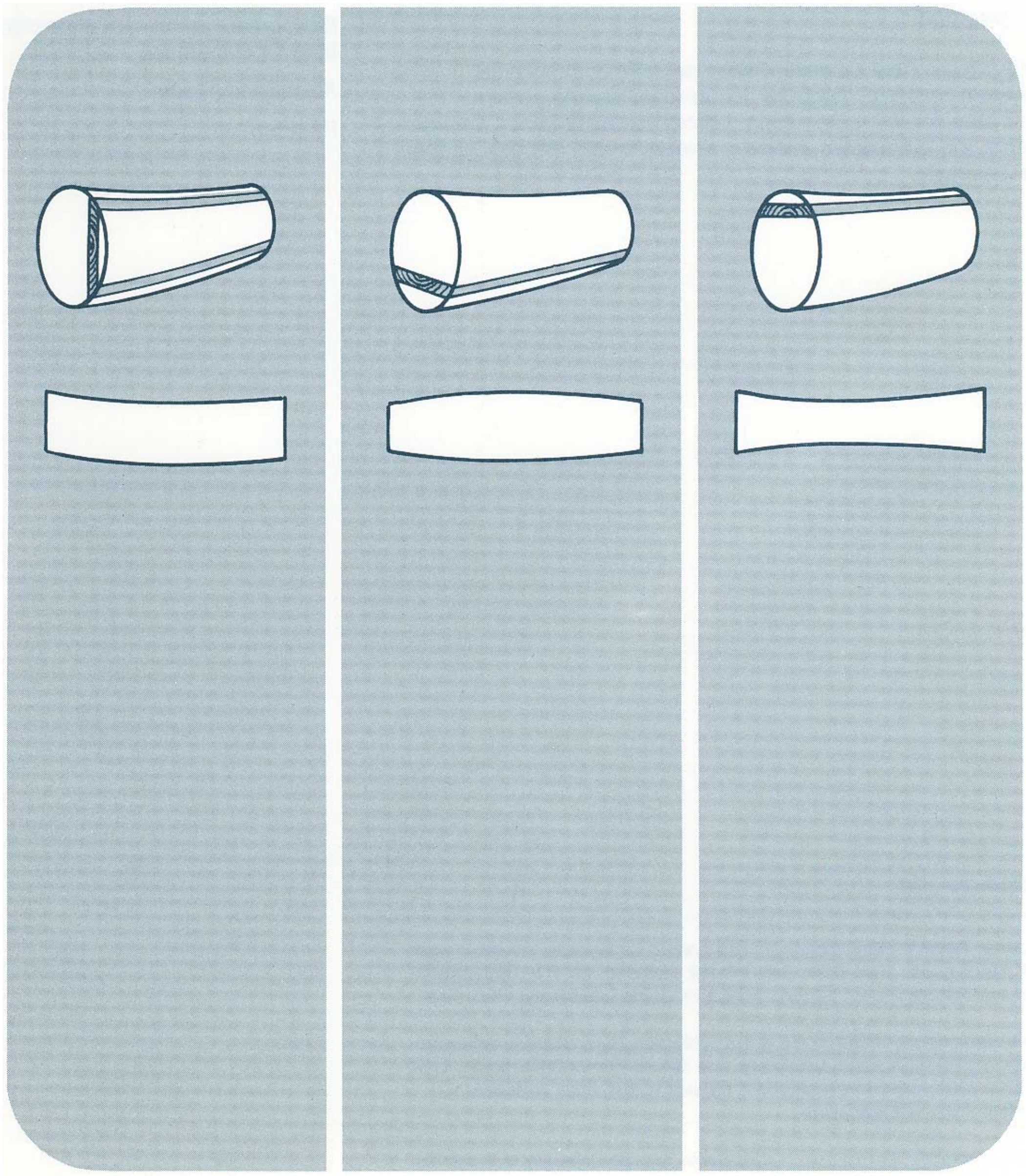
Best Opening Face System for Sweepy, Eccentric Logs

A User's Guide

David W. Lewis



Abstract

Log breakdown simulation models have gained rapid acceptance within the sawmill industry in the last 15 years. Although they have many advantages over traditional decisionmaking tools, the existing models do not calculate yield correctly when used to simulate the breakdown of eccentric, sweepy logs in North American sawmills producing softwood dimension lumber.

In an attempt to overcome these limitations, the Best Opening Face (BOF) model has been modified to simulate logs with sweep and elliptical cross sections. This paper discusses applications of the modified BOF model. These include quantifying lumber recovery losses resulting from elliptical shape and sweep and the generation of sawing solutions. The modifications made to the BOF model are described, and information on how to use the new features is provided.

Keywords: Best Opening Face; sawmilling; simulation; system analysis; computer techniques; sawing patterns; process control; automation; lumber recovery factor; lumber yield; log breakdown; models; sweep; crook; elliptical shape; eccentricity.

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David W. Lewis

Forest Products Laboratory, Madison, Wis.

Introduction

Log breakdown simulation models are used by many managers and technical people in the sawmill industry to increase lumber yield and improve management control. Although these models have gained rapid acceptance in the last 15 years and have many advantages over traditional decisionmaking methods, they have limitations when used to simulate the breakdown of eccentric, sweepy logs in North American sawmills producing softwood dimension lumber. In an attempt to overcome these limitations, the Best Opening Face sawmill simulation model (BOF) has been modified to simulate irregular logs with sweep and elliptical cross-sections. This paper discusses a history of log breakdown models, describes applications of the modified BOF, details the modifications made and provides information on how to use the new features.

This report assumes the reader has a working knowledge of BOF and knows how to use it. If not, the necessary information can be found in General Technical Report FPL-48, "Sawmill Simulation and the Best Opening Face System: A User's Guide" (Lewis 1985).

Background

To better understand the earlier models' limitations, it is helpful to trace the evolution of simulated log breakdown.

Increasing costs and recovery losses caused 'by decreasing log size and supply stimulated interest in the effect of sawing factors, such as lumber sizing and kerf width, on lumber yield. Most of the early work was done by diagramming logs, although Hallock (1962) examined the mathematical relationships. These early efforts provided some insight into the factors affecting lumber yield, but the diagrams were cumbersome to use and were not readily translated into practical information for a machine operator. The first computer-based simulation models for log breakdown were developed in the late 1960's (McAdoo 1969; Reynolds 1970; Sohn 1973; Tsolakides 1969) and, although they were much faster and more flexible than manual methods, they were designed to simulate either hardwood sawing (McAdoo 1969; Tsolakides 1969) or certain specific types of equipment for softwood breakdown–e.g., chipper-canters (Reynolds 1970) or stud mills (Sohn 1973).Since the usefulness of these models for simulating optimal sawing in random length softwood dimension mills was limited, the need for more general models became very apparent.

By the mid-1970s several additional models had been developed. Two of these (Airth and Calvert 1973; Pneumaticos et al. 1974) used a limited number of sawing patterns and could only simulate certain types of breakdown equipment. Two others, the Random Dimension model (Parnell et al. 1973) and the Best Opening Face (BOF) model (Hallock and Lewis 1971; Lewis 1978; 1985; Lewis and Hallock 1973), could simulate log breakdown in most softwood dimension sawmills.

Both models offer much flexibility in modeling North American sawing practices, but are limited by assuming the log is a truncated cone. Because these models simulate the breakdown of small second-growth timber, which is characteristically straight and has small sound knots and little rot, this assumption is reasonable even though some logs are not straight and most logs are not round. However, as environmental and economic pressures to improve lumber recovery increase, the need to model the actual log becomes more important.

Log breakdown models developed in Norway (Skjelmerud 1973), England (Maun 1977a; 1977b), and South Africa (Singmin 1978; Van Niekerk 1975) allow simulation of actual logs. Unfortunately their sawing patterns are limited, primarily modeling frame saws, and the models do not simulate North American sawing practice.

Applications of the Modified Best Opening Face Model

A log breakdown simulation model with flexibility in describing various log shapes, such as the modified BOF model, can be used to study problems earlier models could not.

Many sawmillers have advanced theories on the “best” way to recover the maximum lumber from elliptical logs. For instance, to get the highest yield, some claim elliptical logs should be sawn with the long axis up for the extra width in the side pieces and a potential extra piece in the cant, while others claim the short-axis-up orientation favors increased yield from wider cants or extra side pieces.

The conflicting theories are based on years of observations and, in some cases, mill studies. Since day-to-day changes in mill operation can make empirical data misleading and mill studies are often not repeatable, it has not been possible to resolve this conflict.

The modified BOF model offers a way of studying this problem without the confounding effects of uncontrollable variables. It is possible to determine the “best” way of orienting elliptical logs and to quantify the losses resulting from using “round log” solutions to saw these logs with automated log breakdown systems. For example, a 16-foot log with a small-end diameter of 12 inches and 2 inches of taper. The “round log” BOF solution for this log gives a yield of 157 board feet. If the log is actually elliptical in cross section with a 12-inch horizontal diameter and a 14-inch vertical diameter, the modified BOF model calculates the yield to be 187 board feet. Further, if the log has a 12-inch horizontal diameter and a 10-inch vertical diameter, the yield is only 132 board feet. These differences can be used to calculate the economic feasibility of changing current breakdownsystems.

Modifications to the Best Opening Face Model

Sweep presents a challenging problem as it complicates mechanical handling and decreases yield. Unfortunately, we have little definitive information on the magnitude of these decreases. In attempting to study this problem by sawing real logs, the inability to saw the same log several different ways makes clear answers hard to determine. Using a simulation model to quantify the losses in lumber yield due to sweep overcomes this handicap.

Previous log breakdown simulation models are being used to generate sawing patterns for use in log breakdown control systems. Although the use of modified BOF this way would increase yield, computer limitations prevent doing so.

Because a simulation model requires time to calculate the optimal sawing pattern and associated machine sets, these calculations are not usually done when the log is ready to be broken down. Instead, the model is used to calculate optimal sets for the entire range of logs expected in the mill, these sets are stored in the control system computer, and the best set for each log is "looked up" on the basis of scanner measurements and/or operator decisions.

With a simulation model that assumes logs are truncated cones, this procedure works reasonably well. With modified BOF, however, the number of different log shapes that can be simulated is very large, and using stored sawing patterns is not feasible. One possible solution to this problem would be development of an inexpensive, high-speed, parallel processing computer system.

The BOF program is a computer simulation model of the breakdown of small straight logs into dimension lumber (Hallock and Lewis 1971; Lewis 1978; 1985; Lewis and Hallock 1973). It is based on the premise that the position of the first sawline on a log or cant establishes the position of all others. Because of the geometry of fitting specified sizes of rectangular lumber into varying sizes of essentially round logs, shifting the position of the first sawline across the face of the log can result in significant differences in the yield and value of lumber produced (Lewis and Hallock 1973).

The BOF model simulates the actual sawing process. For each log the sawing algorithm positions the initial opening face to produce the smallest acceptable piece from that log. Once the opening face is established, successive cuts are made, the resulting flitches and/or cant are edged and resawn, and the yield for the log is determined. Subsequently, the opening face is moved toward the center of the log and the sawing process repeated. This cycle continues until the resulting slab is thick enough to resaw. At this point, all reasonable possibilities have been tested and the best opening face determined.

Geometry of Logs and Pieces

The major limitation of the BOF model described in FPL-48 (Lewis 1985) is the assumption that the log is a truncated cone (fig. 1). To overcome this limitation, the modified BOF model simulates irregular logs with sweep and elliptical cross sections. This makes it possible to determine the "best" way of orienting elliptical logs and to quantify the losses resulting from using "round log" solutions to saw these logs with automated log breakdown systems.

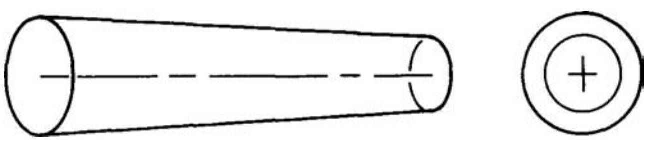

Figure 1.–Truncated cone log model. (ML84 5754)

Sweep

Sweep is assumed to be the smooth deflection of a log as measured at the mid-point of a straight line between the log ends (fig. 2). This measurement must be made either horizontally, simulating a sweepy log on its side, or vertically, simulating a sweepy log with the "horns" down. A log with sweep oriented in some other direction—i.e., not confined to either axis—can be simulated by measuring the sweep in both the horizontal and vertical directions.

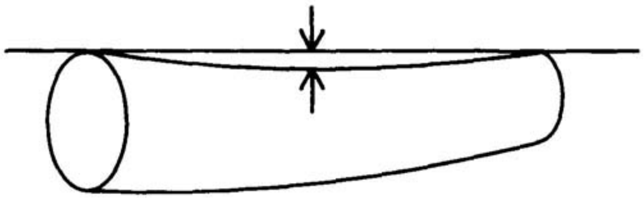

Figure 2.–Sweep and how it is measured. (ML84 5755)

Eccentricity

Most logs do not have round cross sections, so, although most logs are not truly elliptical either, the modified BOF model uses an elliptical shape because it provides a much closer approximation to the true cross-sectional shape. Such a model also has the advantage of being easy to define (using only two measurements per cross section) and takes very little additional computer time, as compared to a round log model.

The only constraint on the modified BOF model is that the axes of each ellipse must be oriented horizontally and vertically (fig. 3).

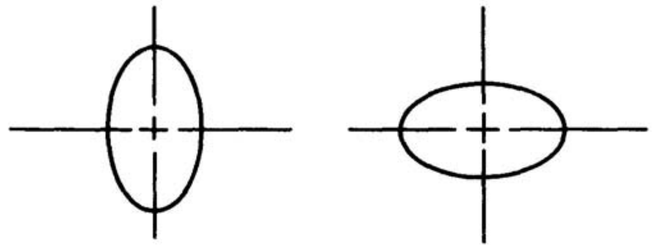

Figure 3.–Orientation of elliptical cross-sections. (ML84 5756)

Irregularity

The modified BOF model can simulate many different log shapes. The simplest non-conical log shape is one that is straight with constant taper and elliptical cross sections. In this case, the resulting pieces and cant look very much like those cut from a log the shape of a truncated cone. Somewhat more complicated is a log with uniform sweep and taper. In this case, some pieces are "crooked", some are "boat shaped", and some are "hour-glass shaped" (fig. 4).

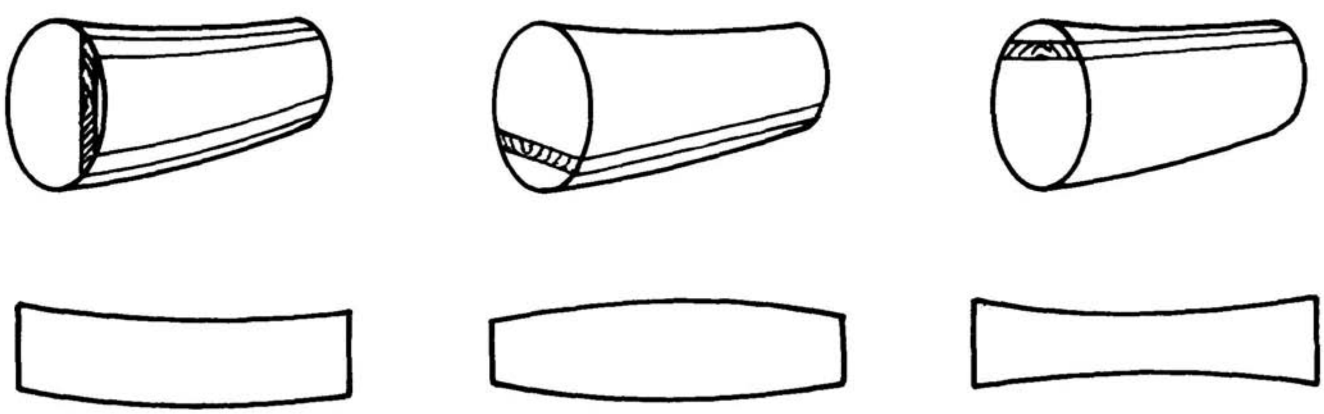

Figure 4.–Pieces cut from a log with uniform sweep and taper. (ML84 5757)

The logs previously discussed can be generated by the model with a minimum of information. However, since both axes and their offsets for each cross section can be defined, it is possible to simulate much more complex log shapes, including logs with twist and S-shaped logs. The pieces and cants theoretically cut from such logs could be of many different shapes and would be different for each log simulated.

Wane

Unlike the original BOF model, the modified BOF no longer limits wane to 25 percent of the face and width. Other values, including a different one for each nominal size, can be used. As in the original model, allowable wane on a piece is calculated on the basis of the green finished size.

The Theoretical Sawing Process

Both BOF models simulate most common types of sawmill equipment used in North America. The major exceptions are chipper-canters, which chip the outside of the log into a fixed profile, and optimizing edgers, which may rip wide pieces into narrow widths based on value or grade.

Primary Log Breakdown

The placement of the opening faces and sawlines has not been changed from the original model. The log may be broken down either split taper, where the sawlines are parallel to a plane through the centers of both ends of the log, or full taper, where the saw lines are parallel to a plane touching the outside of the log ends on its convex side (fig.5).

All cross-section and saw-line placement is calculated relative to two reference planes (fig. 6). When split-taper sawing the log, the vertical reference plane is parallel to a plane through the centers of the log ends. In full taper sawing, the vertical reference plane is parallel to a plane touching the outside of the log ends. In sawing cants, a horizontal reference plane is used in the same manner as the vertical reference plane.

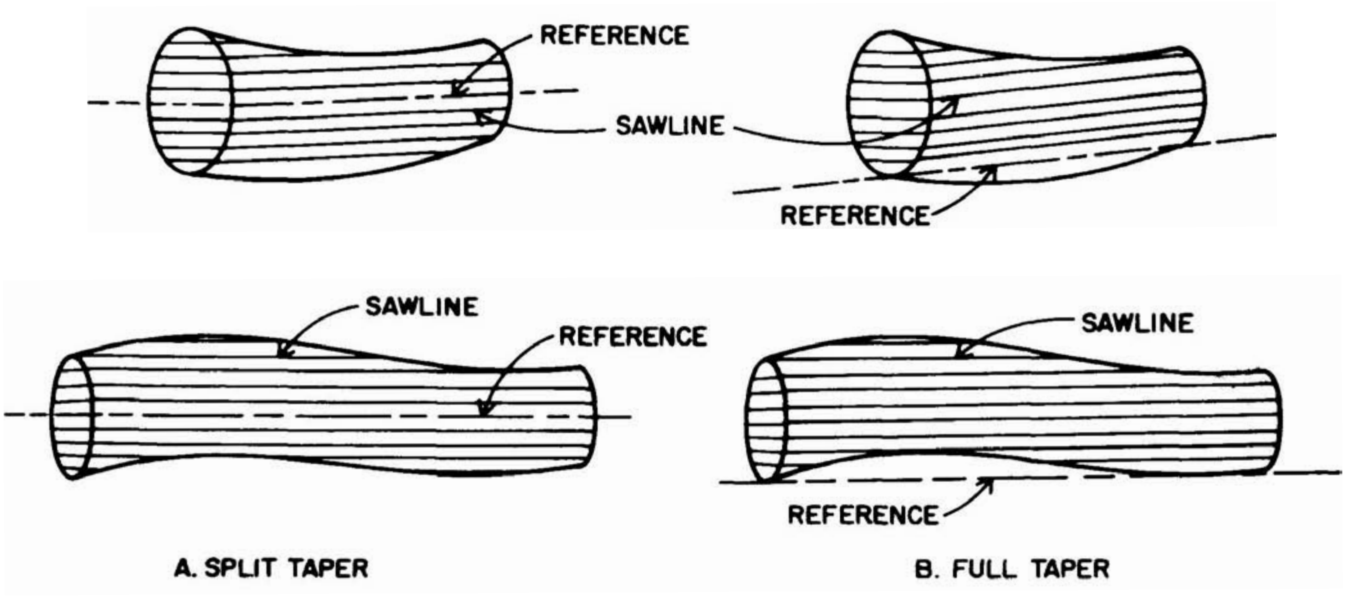

Figure 5.–Two methods of sawline orientation in sweepy and irregular logs. (ML84 5758)

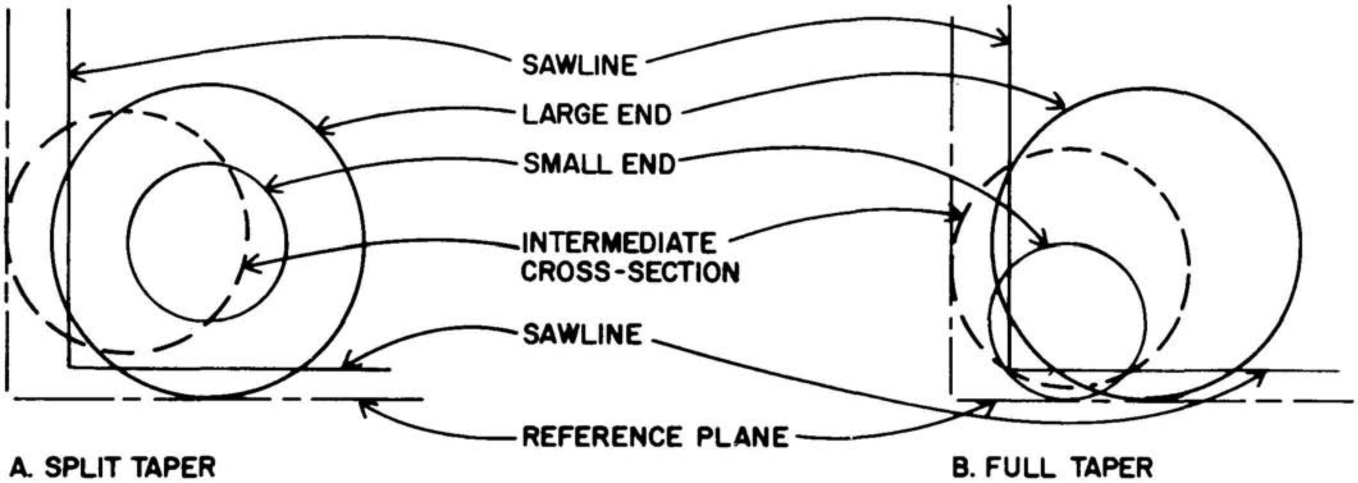

Figure 6.–Relation of sawlines and reference planes for irregular logs. (ML84 5759)

Edging and Trimming

Unlike Primary Log Breakdown, Edging and Trimming differs from that in original model. In the modified BOF model flitches are edged parallel to a line joining the wane edge at each end of the flitch (fig. 7a), unless this reference line crosses the wane edge somewhere in between. In this case, the end of the reference line outside the wane edge is moved inward until the whole reference line is inside or on the wane edge (fig. 7b). The sawlines are than placed parallel to this reference line.

The reference line is placed on the straight side of the flitch. If this is not possible, the reference line is placed on the convex side. If both sides are convex, the reference line is placed on the less convex side, while if both sides are concave, it is placed on the less concave side. If the flitch is crooked, the reference line is placed on the side that allows the greatest distance between the intersections of the line and the wane edge following the previously mentioned rules.

Like the original BOF model, the modified model uses one of two edging methods. Full-length edging simulates cutting the widest full-length piece of lumber possible as an edger operator might do. If the model cannot find a full-length piece, it reestablishes the reference line, and will try to fit a 2-foot shorter piece somewhere in the flitch. This process continues until a piece is found (fig. 8). Where possible, the model will remanufacture the remainder of the flitch into a piece of lumber.

Trim-back edging simulates an automated optimizing edger where only combinations based on the widest piece are cut. The combinations used in BOF edging are as follows:

Index	Nominal widths
1	3
2	4
3	6
4	8
5	10
6	12
7	4 + 10
8	4 + 12
9	6 + 12
10	8 + 12
11	10 + 12
12	12 + 12

As in full-length edging, the widest full length piece is found. Then the model reestablishes the reference line and tries to find the widest piece or combination of pieces 2 feet shorter. This process is continued until the shortest allowable length is tried and the best solution found (fig. 9). When two pieces fit in a flitch, the wider piece is always the longer.

As in the original model, allowable wane on a piece is calculated on the green finished size.

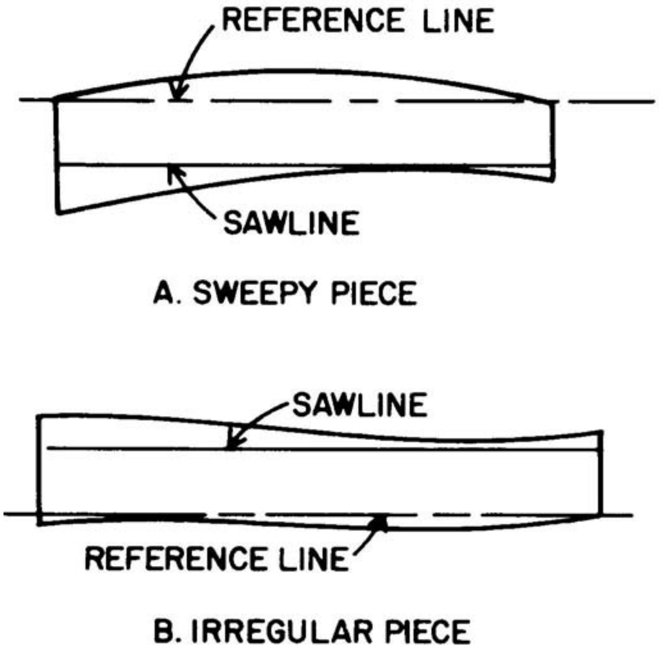

Figure 7.–Orientation of edging sawlines. (ML84 5760)

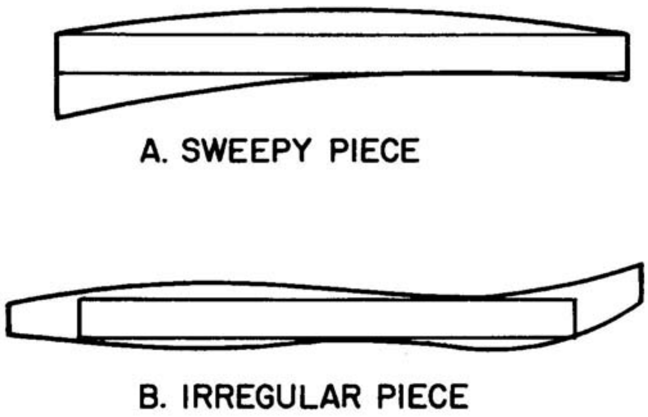

Figure 8.–Full-length edging. (ML84 5761)

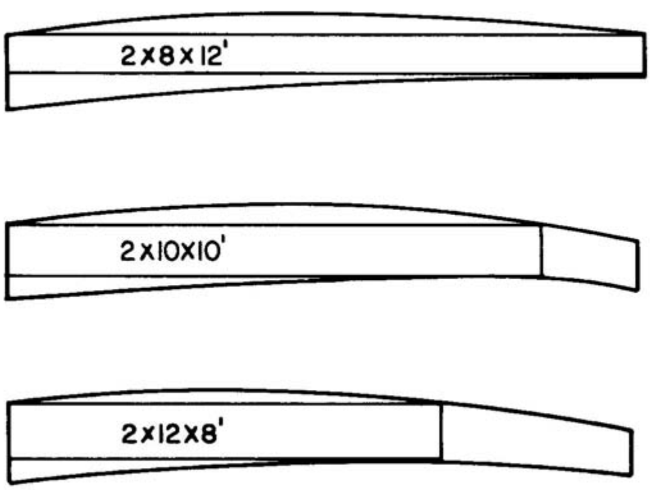

Figure 9.–Trim-back edging. (ML84 5762)

Using the Modified Best Opening Face Program

Many different sawmill configurations can be simulated by BOF. A particular configuration is defined by data describing the mill and options that control program flow.

The outline in table 1 summarizes the information required and the options available when using modified BOF. The necessary data cards are illustrated in figure 10. The first two cards allow selection of various processing options and also contain the information describing a particular sawmill's equipment and raw material. Except as noted in figure 10, the information may be entered as decimal numbers anywhere within the indicated fields. Those values requiring right justification are indicated by the letters RJ appearing in the field shown in figure 10.

The discussion in this section is limited to information related to the modifications made to BOF. For a discussion of the other required information and options see FPL-48 (Lewis 1985).

Required Information

Although information defining the sawmill is required for each simulation, that defining the log distribution is only needed when the program generates the log data (Option 23 not set).

Minimum and Maximum Log Diameter
These define the range of minor axes for the small end of the logs being simulated. See also FPL-48 (Lewis 1985).

Axes Differential and Orientation
This defines the difference between the major and minor axes and their orientation. The program calculates the size of the major axis of the small log end by adding the absolute value of this number to the minor axis of the small end. The major and minor axes at all other points along the log are calculated using the axes at the small end and the taper. A positive (+) value indicates the major axis is vertical and a negative (–) indicates it is horizontal. For example, +1.5 would indicate a vertical major axis 1.5 inches greater than the minor axis, while –2.1 would indicate a horizontal major axis 2.1 inches greater than the minor axis.

Sweep
This is the deflection of a log as measured at the mid-point of a straight line between the ends of a 16-foot log (fig. 2). Sweep is calculated for logs shorter or longer than a 16-foot log as if these logs were sections or extensions of the 16-foot log (fig. 11). Two sweep values are required; one in the vertical direction and one in the horizontal direction (fig.12).

Cant Breakdown Kerf
This is the kerf of the saw or saws used to break down the cant. The sawlines in the cant are perpendicular to the sawlines in the log and are generally considered to be horizontal. If more than one saw is used, the weighted average of the kerfs should be entered. This will introduce a small amount of error, but should be less than if only one kerf value was used. See also FPL-48 (Lewis 1985).

Edger Kerf
This is the kerf of the saw or saws used to edge flitches. If more than one saw is used, their kerfs should be pro-rated.

Program Control Options

BOF can be made to simulate a particular sawmill by specifying various options and entering supplementary information where necessary. These options are set by entering values in the appropriate columns of the first card. If an option is not set, either a blank or a *0* (zero) may be entered. Options should be set by entering a *1* unless otherwise specified. The options described below are either added to or changed from those in the original BOF.

Option 15. Shrinkage (used only for dry sizes–i.e., Option 3 not set)

Not Set: A shrinkage value of 5 percent will be used in calculating rough green lumber sizes.

Set: Enter *1.* The shrinkage from green to rough dry at the time of planing is used. The value as a percent is entered—e.g., 3.8 percent is entered as 3.8, not 0.038.

Enter *2.* The percent moisture content of the dry lumber and oven dry shrinkage are entered. The program will calculate the percent shrinkage.

Table 1.–Summary of Best Opening Face system data[1]

Options	Action	
	Not set	Set
1. Processing control	BOF solutions	*1* = tables only *9* = end of control set
2 Sawing method	Cant	Live
3. Lumber sizes	Dry	Green
4. Maximization	Value[2]	Volume
5. Cant sawing maximization method	Uses selected cant size	*1* = largest cant when maximizing value *5* = tries all cant sizes
6. Cant breakdown method	Split taper	Full taper[3,4]
7. Cant breakdown fence	Fixed	*1* = variable fence *2-9* = 2-9 fence positions only
8. Edging method	Trim back	Full length
9. Piece count	Not printed	*1* = offset, sequence printed *2* = all tables printed
10. Narrowest piece allowed (in.)[5]	4	*1* = 3-in. *2* = stud mill with 4-in. *3* = stud mill with 3-in.
11. Shortest piece allowed (ft.)[5]	8	(Must enter)
12. Minimum and maximum log length (ft.)	8 to 16	(Must enter)
13. Log diameter increment (in.)	0.1	(Must enter)
14. Log and cant face opening increments (in.)	0.050 to 0.050	(Must enter)
15. Shrinkage (pct)	5.0	(Must enter)
16. Minimum log required for cant	Cant contains at least two 2 x 4's, two 2 x 6's, three 2 x 8's, three 2 x 10's, or three 2 x 12's	*1* = normal log breakdown6 *2,4,6,* or *8* = only 2 side pieces on log[6] 9 = no side pieces6
17. Offset positions	Variable	*1* = selected positions only[7] *2* = 4-in. cant centered
18. Lumber dimensions	ALS	(Must enter)
19. Log breakdown method	Split taper	*1* = full taper *2* = both split and full taper
20. Jacket board thickness	(Must be set)	*1* = all 1-in. lumber *2* = all 2-in. lumber *3* = 2-in. with 1-in. jacket board
21. Wane allowance (pct)	25	(Must enter)
22. Target sizes (in.)	Program calculates target sizes	(Must enter)
23. Log data	Program generates log data	*1* = irregular logs[8] *2* = logs with smooth sweep[9]

[1] Generally required information: Jacket board thickness (in.), minimum and maximum log diameter (in.), taper (in. per 16 ft). saw setting increment (in.), head saw kerf (in.), cant breakdown kerf (in.), dressing allowance (in.), and sawing variation (in.).
[2] If *not* set, must provide price table.
[3] If set, must provide initial fence setting.
[4] For Option 6 (when jacket board thickness in 1 in.):
1 = 1 x 4 on fence side of cant, 1 or 2 in. on back.
2 = 2-in. piece on fence side of cant, 1 or 2 in. on back.
3 = 1 x 4 on few side of cant, 2 in. on back.
4 = 2-in. piece on both sides of cant.
[5] See text for limits
[6] Enter minimum log diameter for cant sizes on card 2.
[7] If set, must provide number of positions; also log face opening increment is used as offset increment.
[8] Must provide log length; information on each 1-foot cross section.
[9] Must provide log length: Information on each log end; sweep.

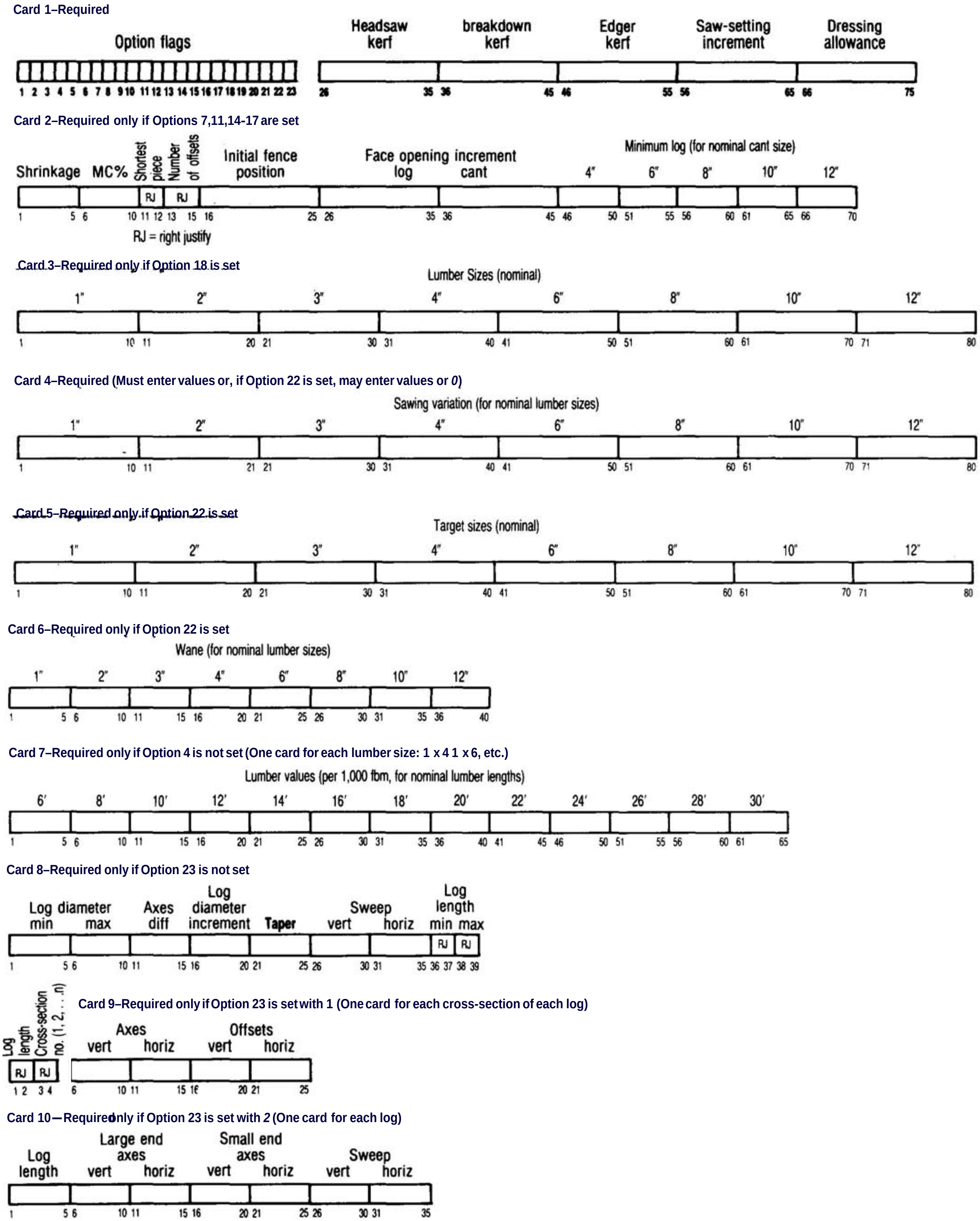

Figure 10.–Modified Best Opening Face System (Version 05). Except as noted, information may be entered as decimal numbers anywhere within the indicated field limits. Those values requiring right justification are indicated by the letters RJ appearing in the field.

Option 21. Wane Allowance

Not Set: A wane allowance of 25 percent of each thickness and width is used.

Set: The user may enter the wane allowance for each thickness and width.

Option 22. Target Sizes

Not Set: Program calculates rough green lumber sizes (target sizes) using dressed sizes, dressing allowance, shrinkage and sawing variations.

Set: The user may enter the target sizes desired. In this case only two of the following are needed: dressing allowance, shrinkage, and sawing variation. If all three are given, the program ignores dressing allowance.

Option 23. Log Data

Not Set: Log data are generated by the program from information given.

Set: Enter *1.* Individual log data are entered. Data must include log length and information about each cross section at 1-foot intervals along the log. Each cross section is defined by values for the major and minor axes and displacement (offset) from each reference plane (fig. 12). When measuring offsets for a log, the measurements should be ≥ 0 and should be made from a line parallel to a straight line between the ends of the log (fig. 13).

Enter *2.* Individual log data are entered. Data must include log length, major and minor axes of each log end, and sweep, if any (see p. 8).

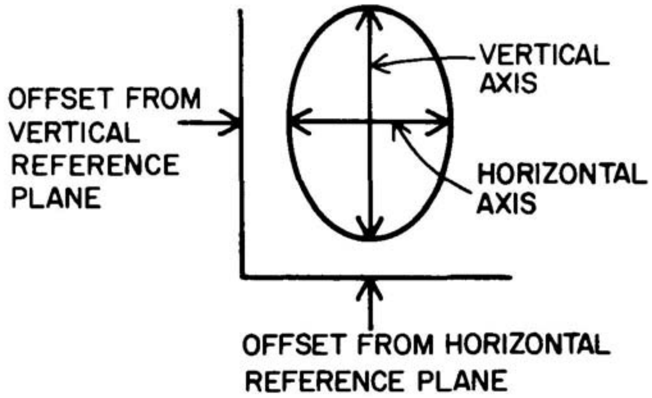

Figure 12.–Definition of size and location of each cross-section. (ML84 5764)

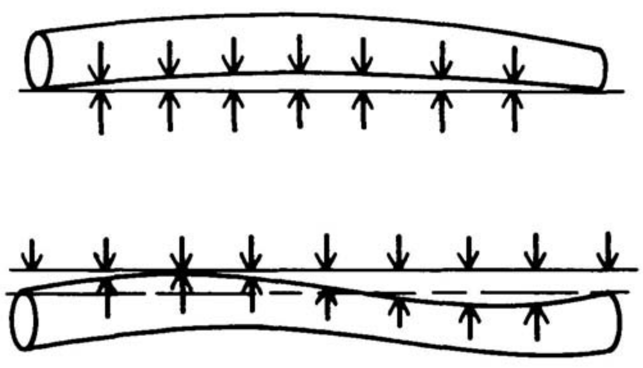

Figure 13.–Suggested method of measuring cross-section offsets. (ML84 5765)

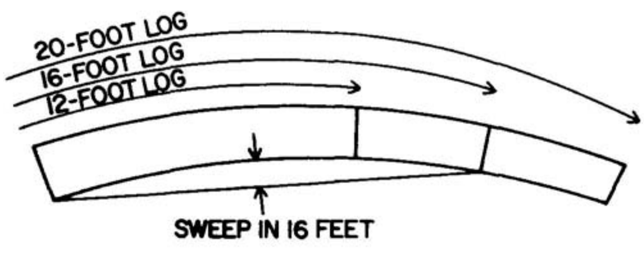

Figure 11.–Relation of sweep in 16-foot logs to other-length logs. (ML84 5763)

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Program

The FORTRAN source for the BOF program/Version 05 for sweepy, eccentric logs is available in electronically readable form from:

U.S. Department of Agriculture, Forest Service
State and Private Forestry
One Gifford Pinchot Drive
Madison, WI 53705-2398

It is titled "FORTRAN Listing of the Best Opening Face System for Sweepy, Eccentric Logs."

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