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PROCEDURE AND COMPUTER PROGRAM TO CALCULATE MACHINE CONTRIBUTIO--ETC(U)
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United States
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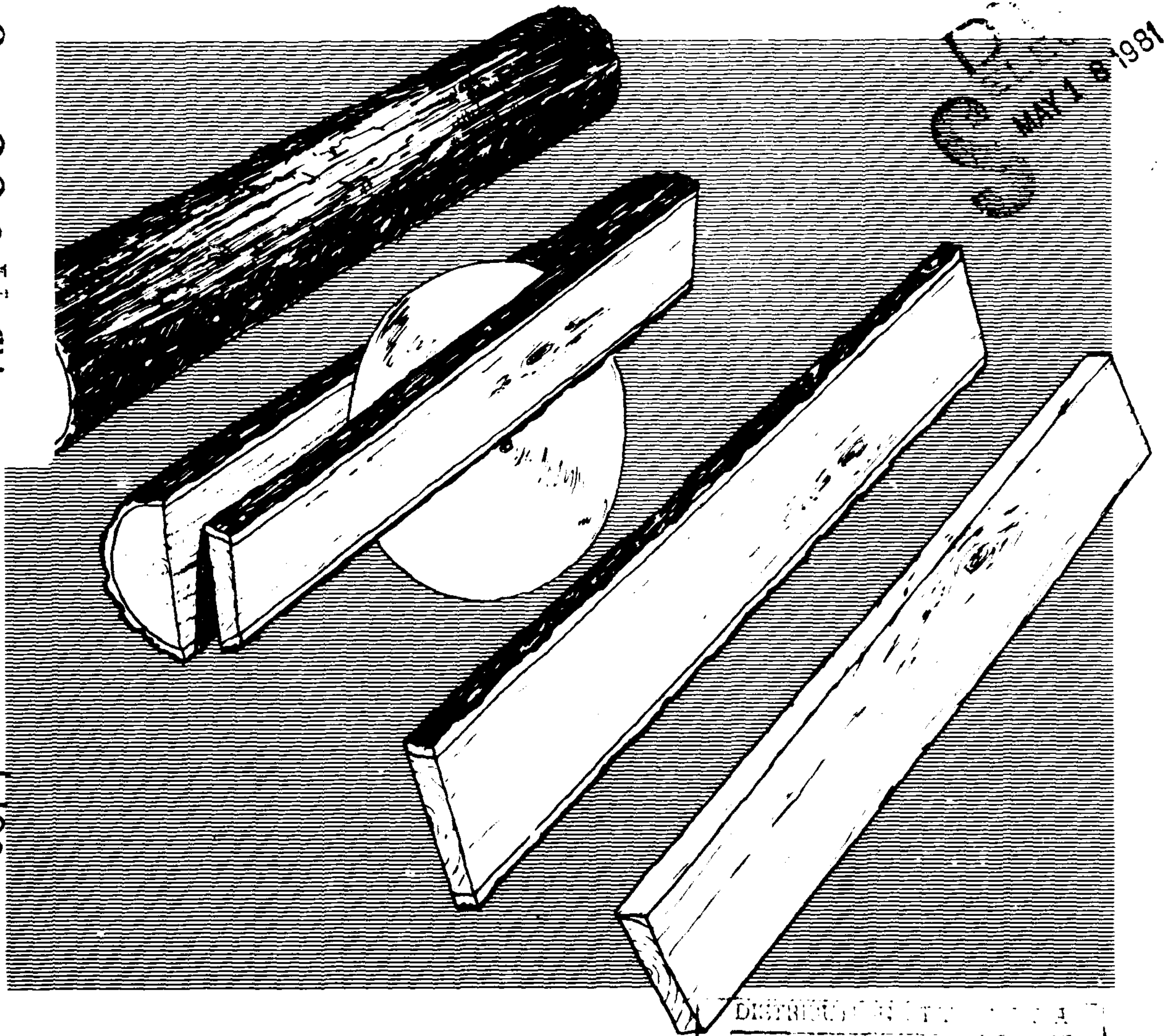
Forest Service

**Forest
Products
Laboratory**

Research
Paper
FPL 383

January 1981

Procedure and Computer Program to Calculate Machine Contribution to Sawmill Recovery



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ABSTRACT

The importance of considering individual machine contribution to total mill efficiency is discussed. A method for accurately calculating machine contribution is introduced, and an example is given using this method. A FORTRAN computer program to make *the necessary* complex calculations automatically is also presented with user instructions.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the contributions made by Stelios Pnevmaticos of Forintek Canada Corporation to the theoretical section of this publication. We are also indebted to Daniel Porter and Catherine Kubitschek for their work on the computer program.

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Procedure and Computer Program to Calculate Machine Contribution to Sawmill Recovery

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FSRP-FPL-383

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Introduction

Quality control studies undertaken at a sawmill to determine machine efficiency are most often concerned with the relative amount of variation developed at each machine. This relative variation is then a gage used to determine whether or not the machine is performing at top efficiency.

A factor that can often be overlooked in this process is the contribution each machine makes to overall mill production. This factor may at times be as important as the determination of machine efficiency itself.

For example, when a machine is not operating at expected efficiency, mill management has three alternatives.

(1) The problem can be ignored.
(2) The machine can be fixed to perform as expected.
(3) The machine can be replaced.

The alternative selection is one that should involve cost/benefit analysis. The estimated increase in recovery should be weighed against the cost of action or inaction with respect to the machine. If the problem is ignored and no action taken, no direct expense is incurred to repair or replace the machine. On the other hand, there is an indirect cost involved in recovery lost at the machine. If the machine is repaired or replaced, there are immediate direct costs that should be outweighed and paid for by increased recovery.

The importance of consideration of machine contribution to total mill efficiency can be illustrated by an example from Stern[3] et al. Stern used computer solutions to determine the percentage increase in recovery attainable when sawing accuracy (defined as sawing variation produced by the machine plus oversizing) is improved. The particular example cited gives the predicted increase for improved sawing accuracy for a 1,000-board-foot sample composed of one log from each 1-inch-diameter class of from 5 to 20 inches.

Assuming that sawing accuracy on a machine with a 0.125-inch kerf can be improved from 0.2 to 0.1 inch, the study shows an increase in yield of 6.0 percent or 60 board feet for the sample in question.

Assuming this increased accuracy can be attained, there is still the question whether an investment made to obtain this increase would be a favorable one. Most sawmillers would probably agree that a 6 percent increase in recovery could easily pay for a moderate investment for machine repair or replacement. A detailed analysis of costs and returns should always replace intuition.

The choice among alternatives obtained from detailed analysis, however, may change depending on whether or not machine contribution is used in the calculations. If the machine is responsible for 90 percent of mill production, the increased recovery for the mill can be estimated at 5.4 percent (0.90 x 6 pct), still a respectable increase. If the machine is responsible for 10 percent of production, the increase becomes an estimated 0.6 percent (0.10 x 6 pct). At this rate the choice made on an intuitive basis seems to become less clearcut. Can any investment in machine improvement be justified in this case? The detailed analysis suggested above for justifying a choice of one of the three alternatives open to management becomes a more obvious need in this case.

Most mill managers can probably provide a seat-of-the-pants estimate of the contribution to total mill recovery made by each machine in their operation. This estimate may or

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[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[2] Member of State and Private Forestry staff located at the Forest Products Laboratory.

[3] Stern, A., H. Hallock, and D. W. Lewis. 1979. Improving sawing accuracy does help. USDA For. Serv. Res. Pap. FPL 320. For. Prod. Lab., Madison, Wis. 13 p.

may not be an adequate one. Factors involved in individual machine contribution to total mill recovery can be easily overlooked.

This paper discusses a methodology that can be used to accurately calculate individual machine contribution to recovery in a sawmill. A FORTRAN computer program to automatically calculate this contribution is also presented and its use explained.

Methodology

Gathering the Data

Development of percentage factors representing machine contribution to total mill recovery requires that a mill study be carried out. This study documents the flow of material through the sawmill by collecting data on the surface area and volume of lumber produced by each machine.

To insure that the percentage factors developed from the mill study are representative of typical mill operation, the variables of log input and product output should be controlled. That is, the log sample used for the mill study should be representative of the log mix the mill ordinarily processes; the product output should be representative as well. These data should be collected on a large enough log sample to insure reliability.

The real test of the adequacy of the log sample size must rest with the judgment of the individual responsible for the study. This individual should be satisfied that the number and mix of logs selected will give a good representation of typical mill operation as far as the percentage of each product processed at each machine is concerned. As a rough guideline, if the logs are selected on a mill run basis, the authors suggest that no less than 50 logs be used. This has proven to be adequate in actual sawmill studies.[4] In a large mill with several log breakdown machines, the sample should be larger.

Surface area/volume data are collected by stationing observers with different colored spray paints, crayons, or chalk at each machine center. When a sawn face that determines a final dimensioning cut is made by that machine center, the observer marks a colored line across the face approximately in the center of the piece. The following example illustrates how this procedure works.

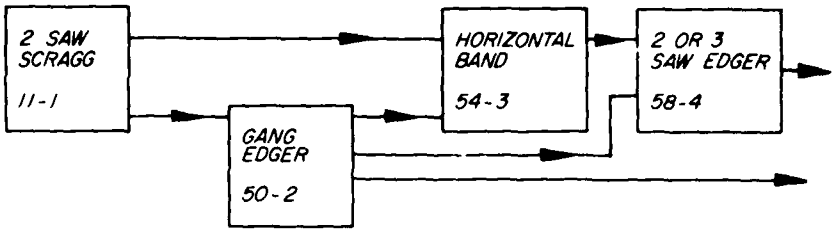

Figure 1.—Flow Chart of Hypothetical Sawmill

(M 149 038)

Suppose a hypothetical mill is composed of the machinery shown in figure 1.[5] The machine codes that appear under the machine names in the flow chart in this figure will be explained in the section covering the computer program.

Color codes are assigned to each machine responsible for a final dimensioning cut. In figure 1 the following codes apply:

Scragg Headsaw — Orange

Gang Edger — Blue

Horizontal Band—Green

Edger — Red

When the study logs enter the system, the observers stationed at the various machines begin marking the surface of each piece on which a final dimensioning cut has been made.

In this theoretical mill, the Scragg Headsaw produces a cant as shown in figure 2. Since the Scragg produces a final dimensioning cut on the cant, the observer marks one of these surfaces with an orange line midway from the ends of the cant as shown in figure 2.

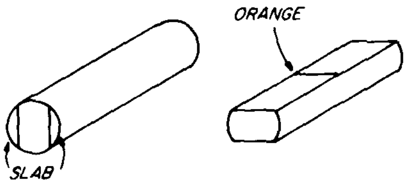

Figure 2.—Breakdown at the Scragg Headsaw

(M 149 042)

The cant produced on the Scragg moves to Gang Edger. Here the observer marks one surface of each of the pieces of lumber sawn from the cant with a blue line midway from the ends of each of four pieces as figure 3 indicates.

The two slabs produced by the Gang Edger, as well as those produced previously by the Scragg Headsaw, move to the Horizontal Band. These slabs are not marked as yet, since a final dimensioning cut has not been made on them at either the Gang Edger or Scragg Headsaw. As the slabs pass through the Horizontal

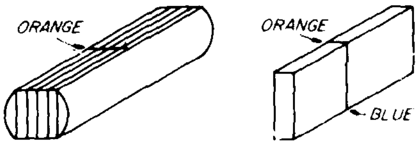

Figure 3.—Breakdown at the Gang Edger

(M 149 041)

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[4] Sawmill Improvement Program. 1979. Instructions for conducting a sawmill study, part II hardwood/random width option. Unpublished instructions. USDA For. Serv., National Sawmill Improvement Program, State and Private Forestry at Forest Products Laboratory, Madison, Wis. p. 16.

[5] The analysis is concerned only with machines that are responsible for variation in thickness and width. A machine is responsible for variation in either thickness or width when it is responsible for a final dimensioning cut. For this reason, only those machines responsible for a final dimensioning cut in thickness or width are shown in the flow chart above, trim saws have not been included.

Band, the observer there marks one of the surfaces with a green line midway from the ends of the flitch as in figure 4.

Figure 4.—Breakdown at the Horizontal Band

(M 149 039)

The four flitches that have now been produced by the Horizontal Band move to the Edger where they are cut to width. Figure 5 shows that the observer at the Edger marks one edge with a red line midway from the ends of each of the four pieces.

In some cases such as railroad crossties sawed at the Headsaw, all dimensions are determined by the Headsaw so the two adjacent faces would be marked with the same color.

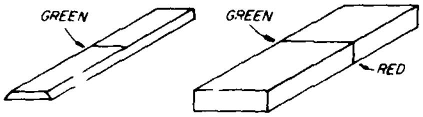
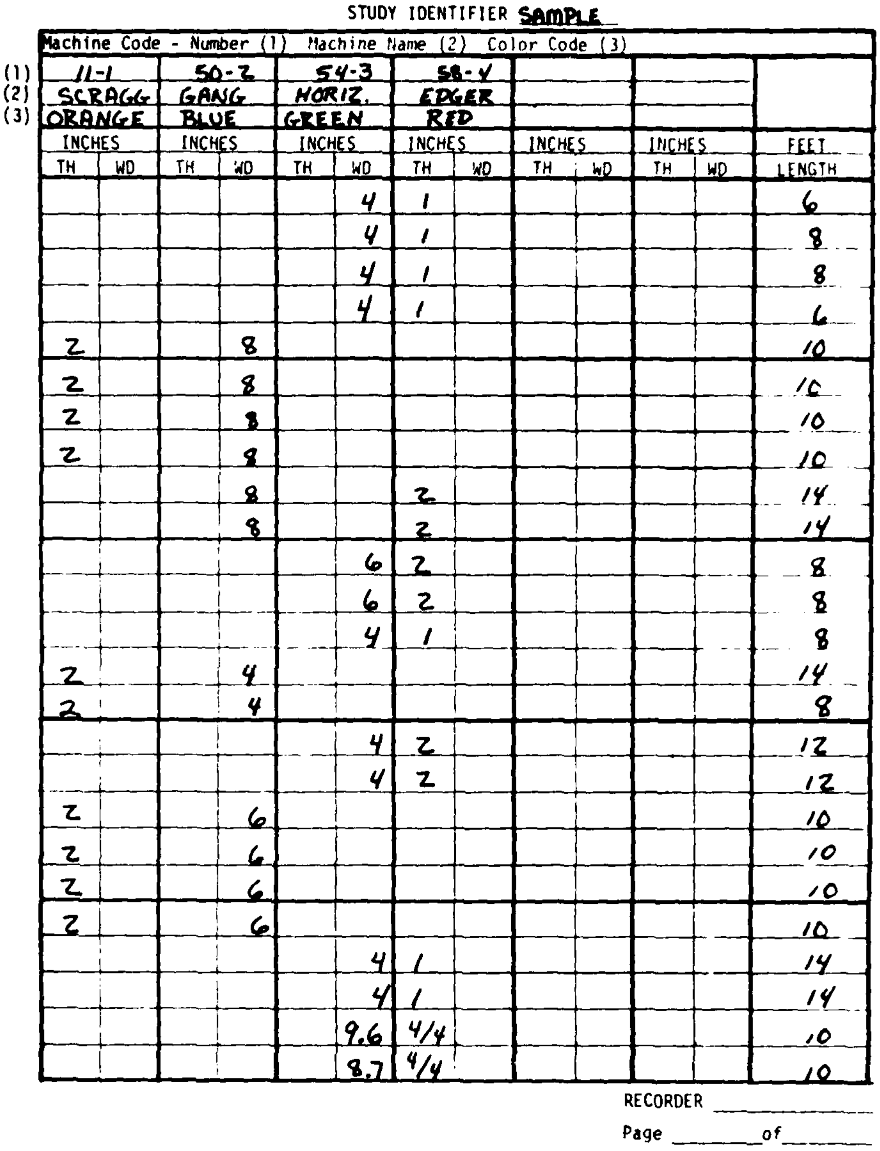


Figure 5.—Breakdown at the Edger

(M 149 040)

As the lumber marked at the various machine centers moves down the green chain, a final observer records the data necessary to compute machine contribution on the Machine Contribution Study Data Form (fig. 6). The data from this sample log have been recorded on this form as the observer would record it. The eight pieces produced are entered on the first eight lines of the form. The remainder of the form has been filled out with data from other study logs to complete the example.

The first step in filling in the data form is to record an identifying name of up to six characters in the Identifier space. If more than one study is contemplated, this will help identify the data and subsequent computations.



STUDY IDENTIFIER SAMPLE

Machine Code - Number (1) Machine Name (2) Color Code (3)

(1)	11-1		50-2		54-3		58-4						
(2)	SCRAGG		GANG		HORIZ.		EDGER						
(3)	ORANGE		BLUE		GREEN		RED						
	INCHES		INCHES		INCHES		INCHES		INCHES		INCHES		FEET
	TH	WD	TH	WD	TH	WD	TH	WD	TH	WD	TH	WD	LENGTH
						4	1						6
						4	1						8
						4	1						8
						4	1						6
	2			8									10
	2			8									10
	2			8									10
	2			8									10
				8			2						14
				8			2						14
						6	2						8
						6	2						8
						4	1						8
	2			4									14
	2			4									8
						4	2						12
						4	2						12
	2			6									10
	2			6									10
	2			6									10
	2			6									10
						4	1						14
						4	1						14
						9.6	4/4						10
						8.7	4/4						10

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Figure 6.—Machine Contribution Study Data Form

A machine code and number separated by a dash are to be entered on line 1 of the data form. This information is necessary when a computer is used to process the data. Machine codes and numbers for this entry will be explained in the section covering use of the computer program. Enter the machine name on line 2. The color to be entered on line 3 is taken from those assigned to each machine at the beginning of the study.

Each machine column on the data form has thickness and width columns. If both faces of a product are produced on the same machine, an entry should be made in each of these columns. If a product is produced on two machines, the appropriate entry is made under the machine name responsible.

Data for products produced to specified widths are entered as the nominal dimension. For example, a 2 x 4 would have a 2 entered in one column and a 4 in another.

Except for the last two boards, all lumber on the data form are of specified sizes. These last two boards are 4/4 random width grade lumber. When random width lumber is produced, the thickness designation is entered by the quarter system—4/4, 5/4, 8/4, etc. The width of grade lumber is measured to the nearest 0.1 inch and entered in inches on the data form.

The different methods for designating specified and random width lumber are necessary for computer processing of the data. Since random width lumber possesses assignable variation in only one dimension, it is processed differently than are specified widths where variation can be attributed to two dimensions.

The Need for Weighting Factors

Before discussing analysis of the data, it is necessary to discuss just what is being measured. The gathering of surface area/volume data is used to measure the importance of variation from each machine in the sawmill. Consider two sample boards processed on two different machines with scant sawing variations[6] of 0.075 and 0.125 respectively. The first produces a 10-foot 2 x 4 and the second a 10-foot 2 x 12. To simplify the explanation, assume that the pieces can be brought to proper final size if planed to remove only the scant sawing variation and that any additional planing allowance or shrinkage are not factors.

Consider first the importance of variation in the 2-inch thickness on these boards. The end view of two pieces of lumber in figure 7 shows a way of measuring this importance.

The ALS standard for nominal 2-inch dry dressed dimension lumber is 1.50 inches. In order for this lumber to plane skip-free, added thickness equal to 0.075 and 0.125 inch respectively is needed. This extra thickness is shown as a rectangle in dashed lines on the right side of each piece. (This rectangle has been exaggerated in size as compared to the size of the lumber. Its purpose is to show the relative magnitude of the differing variations and is not intended to show how true variation appears on a piece.)

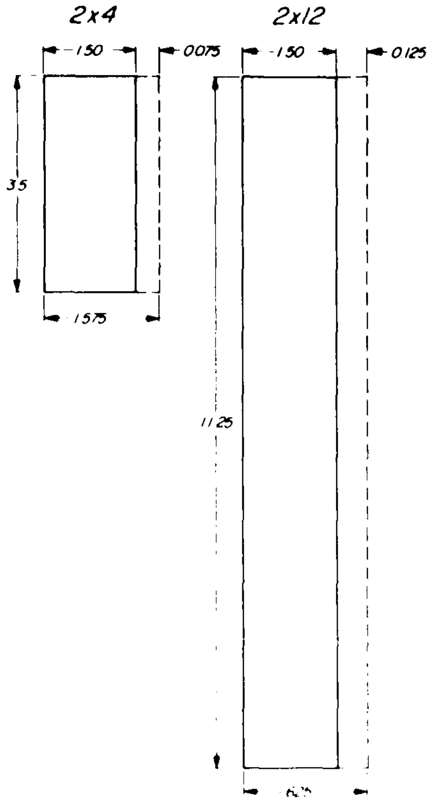

Figure 7.—End View of Two Pieces of Lumber Illustrating the Importance of Variation as Measured by Surface Area

(M 149 043)

It can be seen in figure 7 that the variation in the 2-inch nominal thickness for each piece occurs on the adjacent face. That is, the variation for the 2 x 4, 2-inch dimension occurs over the surface area of the nominal 4-inch face.

It can be seen then, that the importance of variation in a given dimension is defined by the surface area of the adjacent face. Furthermore, the variation in a given dimension is caused by machinery that saws the face adjacent to that dimension.

The widths of the two pieces in this example are 3.5 and 11.25 respectively. If the variations of the two were identical, the relative importance of the variation on the two pieces would be a ratio of 11.25 to 3.5. (This assumes that board lengths are equal as in this example.) Consideration of the relative importance of the variations in the 2-inch dimension alone, without consideration of the surface area over which this variation occurs, gives a ratio of 1.66667 (0.125 ÷ 0.075 = 1.66667).

Using the actual variation figures from the example, it can be calculated that the importance of the variation on the 2 x 12 is much larger. The importance is equal to the ratios of the two rectangular solids defined by the actual widths of the lumber, the amount of variation in the 2-inch dimension and the lumber lengths. Since lengths are the same in this case, the relative importance can be calculated without its inclusion as follows:

2 x 4

$3.5 \times 0.075 = 0.26250$

2 x 12

$11.25 \times 0.125 = 1.40625$

The relative importance of the variation on the 2 x 12 as compared to that on the 2 x 4 then becomes 1.40625 ÷ 0.26250 = 5.35714. Consideration of surface area rather than variation alone leads to an increased estimate of the relative importance of the variation on the 2 x 12 of our example from 1.66667 (variation alone) to 5.35714 (surface area considered). This illustrates the need to include surface area in the calculations.

The same calculations can be made to ascertain the importance of variation and surface area on the 4-and 12-inch dimensions of the example lumber.

A weighting factor, in addition to surface area, is needed to calculate machine contribution. This is a volume factor and is calculated from the same data used to obtain surface area from the study data form.

This factor is needed because the surface area calculation gives only a relative measure of the importance of variation on a dimension processed at a single machine. To derive the importance to total mill production, the volume of the product on which the variation occurs must be considered.

For example, it may be determined from the surface area calculations that Machine A is responsible for 90 percent of the variation and Machine B for 10 percent of the variation in the 2-inch dimension of the 2 x 12's produced at a mill.

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[6] Scant sawing variation is the variation on the negative side of the board measurement data distribution. This value is the distance from the average board thickness to an appropriate probability (1-α) level in the left tail of the distribution. This value is the amount of extra thickness needed on a piece of lumber to allow skips on α percent of the lumber processed

If 2 percent of the mill's volume production is 2 x 12's, the importance of the variation on the 2-inch dimension of the 2 x 12 on Machine A relative to total mill production will be 0.90 x 0.02 = 0.018; or on Machine B will be 0.10 x 0.02 = 0.002.

In order to obtain meaningful figures from the tally on the data form, each product must be identified so that its volume factor and resultant importance to variation contribution can be calculated. In the preceding example, 2 x 12's must be identified as a product, the volume produced determined, and the volume factor calculated. This factor is then multiplied by the surface area calculation for each dimension of each product. That is, both the 2- and 12-inch dimensions of a 2 x 12 contain variation. The percent of each dimension produced on each machine must be known.

In the example, the calculations made addressed the 2-inch dimension of the 2 x 12's. This will be denoted throughout the remainder of the paper as simply 2 x 12 -2. The variation in the nominal 12- inch dimension of the 2 x 12 would be designated as 2 x 12 -12 and the surface area and volume calculations applied as in the example for the nominal 2-inch dimension.

Returning to the sample data in figure 6, it can be seen that the purpose is to obtain information to calculate both a surface area factor and volume factor. Multiplied together, these give a measure of the relative importance of the variation found on each dimension of each product produced. The methods to calculate the surface area and volume factors follow.

Calculating the Surface Area Factor

An example of calculating the surface area factor for the data recorded on the field form in figure 6 will be shown. In order to more easily calculate the surface area for each dimension as is necessary, it is helpful to summarize the data on surface area by product first (1 x 4, 2 x 8, etc.). The surface area calculations for each dimension (1 x 4 - 1, 1 x 4 - 2, 2 x 8 - 2, 2 x 8 - 8, etc.) of the product summarized are then made separately. In the example, the summary of surface area for 2 x 8's is given first. Remember that the machine which produced the surface area of a given face is responsible for the dimensional variation of the adjoining face.

For the sample data this means that the variation in the 8-inch dimension of the 2 x 8's is caused by the Scragg or Edger. The surface area of the 2-inch face produced by the Scragg or Edger gives a measure of the importance of the variation found in the 8-inch dimension.

To help reduce the confusion possible here, the machine responsible for the variation in a given dimension is listed in parentheses above it in the summary of surface area table. This can then be read to mean that the variation produced by the Scragg, in parentheses, in the 8-inch dimension is measured by the surface area of the 2-inch faces listed under the Scragg, not in parentheses.

As an example of calculating the surface area factor for one dimension, look at the first four boards in the summary of surface area for 2 x 8's. It can be seen that the variation in the nominal 8-inch dimension was caused by the Scragg since this appears in parentheses. These four pieces are the total production of 2 x 8 - 8's manufactured by the Scragg. The surface area of the 2-inch face (length x width or 2 x 10 = 20), under the Scragg heading without parentheses, is summed (20 + 20 + 20 + 20 = 80) to obtain the measure of surface area to attribute to the variation in the nominal 8-inch dimension.

The percentage that this surface area, for 2 x 8 - 8's manufactured on the Scragg, represents as a percent of the total surface area of 2 x 8's (680) is calculated (80 ÷ 680 = 0.12) to give the surface area factor. The surface area factor is calculated in this way for each dimension of each product tallied as follows.

2 x 8 - Summary of Surface Area

Scragg	Gang	Horizontal Band	Edger	Length
(Gang)	(Scragg)			
2	8			10
2	8			10
2	8			10
2	8			10
	(Edger)		(Gang)	
	8		2	14
	8		2	14

2 x 8 - Total Surface Area Calculation

2 x 8 - 8

Scragg = (2 x 10) + (2 x 10) + (2 x 10) + (2 x 10) = 80

Edger = (2 x 14) + (2 x 14) = 56

2 x 8 - 2

Gang = (8 x 10) + (8 x 10) + (8 x 10) + (8 x 10)
+ (8 x 14) + (8 x 14) = 544

Total = 680

2 x 8 - Surface Area Factor Calculation

2 x 8 - 8

Scragg = 80/680 = 0.12

Edger = 56/680 = .08

2 x 8 - 2

Gang = 544/680 = 0.80

2 x 6 · Summary of Surface Area

Scragg	Gang	Horizontal Band	Edger	Length
		(Edger)	(Horizontal Band)	
		6	2	8
		6	2	8
(Gang)	(Scragg)			
2	6			10
2	6			10
2	6			10
2	6			10

2 x 6 · Total Surface Area Calculation

2 x 6 · 6

Edger = (2 x 8) + (2 x 8) = 32

Scragg = (2 x 10) + (2 x 10) + (2 x 10) + (2 x 10) = 80

2 x 6 · 2

H. Band = (6 x 8) + (6 x 8) = 96

Gang = (6 x 10) + (6 x 10) + (6 x 10) + (6 x 10) = 240

Total = 448

2 x 6 · Surface Area Factor Calculation

2 x 6 · 6

Edger = 32/448 = 0.07

Scragg = 80/448 = .18

2 x 6 · 2

H. Band = 96/448 = 0.21

Gang = 240/448 = .54

2 x 4 · Summary of Surface Area

Scragg	Gang	Horizontal Band	Edger	Length
(Gang)	(Scragg)			
2	4			14
2	4			8
		(Edger)	(Horizontal Band)	
		4	2	12
		4	2	12

2 x 4 · Total Surface Area Calculation

2 x 4 · 4

Scragg = (2 x 14) + (2 x 8) = 44

Edger = (2 x 12) + (2 x 12) = 48

2 x 4 · 2

Gang = (4 x 14) + (4 x 8) = 88

H. Band = (4 x 12) + (4 x 12) = 96

Total = 276

2 x 4 - Surface Area Factor Calculation

2 x 4 - 4

Scragg = 44/276 = 0.16

Edger = 48/276 = .17

2 x 4 -2

Gang = 88/276 = 0.32

H. Band = 96/276 = .35

1 x 4 - Summary of Surface Area

Scragg	*Gang*	*Horizontal Band* (Edger)	*Edger* (Horizontal Band)	*Length*
		4	1	6
		4	1	8
		4	1	8
		4	1	6
		4	1	8
		4	1	14
		4	1	14

1 x 4 - Total Surface Area Calculation

1 x 4 - 4

Edger = (1 x 6) + (1 x 8) + (1 x 8) + (1 x 6) + (1 x 8) + (1 x 14) + (1 x 14) = 64

1 x 4 - 1

H. Band = (4 x 6) + (4 x 8) + (4 x 8) + (4 x 6) + (4 x 8) + (4 x 14) + (4 x 14) = 256

Total = 320

1 x 4 - Surface Area Factor Calculation

1 x 4 - 4

Edger = 64/320 = 0.20

1 x 4 - 1

H. Band = 256/320 = 0.80

4/4 - Summary of Surface Area

Scragg	**Gang**	**Horizontal Band** (Edger)	**Edger** (Horizontal Band)	**Length**
		9.6	4/4	10
		8.7	4/4	10

4/4 - Total Surface Area Calculation

4/4

H. Band = (10 x 9.6) + (10 x 8.7) = 183

Total = 183

4/4 - Surface Area Factor Calculation

4/4

H. Band = 183/183 = 1.00

Table 1.—Calculating the volume factor

Product		Tally	Volume factor
		Fbm	
1 x 4		21.33	21.33/213.92 = 0.0997
2 x 4		30.67	30.67/213.92 = .1434
2 x 6		56.00	56.00/213.92 = .2618
2 x 8		90.67	90.67/213.92 = .4239
4/4		15.25	15.25/213.92 = .0713
	Total	213.92	1.00

Table 2.—Calculating percent contribution

Product	Machine	Surface area factor	X Volume factor =			Percent contribution
1 x 4 - 4	Edger	0.20	0.0997	0.0199	or	1.99
1 x 4 - 1	H. Band	.80	.0997	.0798	or	7.98
2 x 4 - 4	Scragg	.16	.1434	.0229	or	2.29
2 x 4 - 4	Edger	.17	.1434	.0244	or	2.44
2 x 4 - 2	Gang	.32	.1434	.0459	or	4.59
2 x 4 - 2	H. Band	.35	.1434	.0502	or	5.02
2 x 6 - 6	Edger	.07	.2618	.0183	or	1.83
2 x 6 - 6	Scragg	.18	.2618	.0471	or	4.71
2 x 6 - 2	H. Band	.21	.2618	.0550	or	5.50
2 x 6 - 2	Gang	.54	.2618	.1414	or	14.14
2 x 8 - 8	Scragg	.12	.4239	.0509	or	5.09
2 x 8 - 8	Edger	.08	.4239	.0339	or	3.39
2 x 8 - 2	Gang	.80	.4239	.3391	or	33.91
4/4	H. Band	1.00	.0713	.0713	or	7.13
					Total	= 100.00

Calculating the Volume Factor

The volume factor is calculated by first determining the total board foot tally from the lumber on the data sheet. A tally for each product and the percent of the total that each represents is calculated. Table 1 illustrates this procedure.

Calculating Percent Contribution

Percent contribution can now be calculated by multiplying the surface area factor times the volume factor. This multiplication and conversion to percent is shown in table 2.

Percent contribution by machine center can now be summarized from table 2 by summing the individual percent contributions for each product for each machine. Since this summary would be identical[7] to the summary given by the computer output in figure 8, it will not be repeated here.

The Computer Program

Hand computation has given the percentage factors for the example data. This calculation is rather tedious even for a small amount of data. If a large sample of logs is being run, use of the computer program will save much computation time.

Figure 8 shows an example of output from the computer program to calculate machine contribution. The program was run using the same sample data used for the hand calculations, with the answer identical except for rounding error.

Data are entered into the program via two types of data cards, a header card followed by cards holding study data.

Figure 9 shows the formatting of the header card used to run the sample data. This card contains only four machines, although up to six are allowed by the program.

The first six columns of the header card allow the study identifier to be entered. Columns 8 to 11 allow the entry of a sequence number of 1 to 9,999. This sequence number is referred to by error messages in the program and should be used. There are six fields for machine identification. These are located in columns 17 to 20, 23 to 26, 29 to 32, 35 to 38, 41 to 44, and 47 to 50.

The first two columns of each machine identification field hold the machine code. This code allows the designation of a machine name without writing it out completely. The code references a list of machines in the program. This list contains most names it is thought will be encountered in a sawmill. The list shown in Appendix I currently contains 22 names and the array holding

---

[7] Due to rounding errors, the values arrived at by hand computation differ somewhat from those by computer calculation.

```
                    SAMPLE MACHINE CONTRIBUTION STUDY

                PRODUCT PRODUCED          PERCENT MILL VOLUME
                ----------------          -------------------
                    1 X  4                       9.97
                    2 X  4                      14.34
                    2 X  6                      26.18
                    2 X  8                      42.38
                     4/4                         7.13
                                              --------
                                               100.00 %
                  MACHINE: 2-SAW SCRAGG

DIMENSION PRODUCED    PERCENT SURFACE AREA    PERCENT CONTRIBUTION
------------------    --------------------    --------------------
    2 X 4 - 4                15.94                    2.29
    2 X 6 - 6                17.86                    4.67
    2 X 8 - 8                11.76                    4.99
                                                    ---------
                      TOTAL MACHINE CONTRIBUTION     11.95 %

                  MACHINE: GANG EDGER(SINGLE ARBOR)

DIMENSION PRODUCED    PERCENT SURFACE AREA    PERCENT CONTRIBUTION
------------------    --------------------    --------------------
    2 X 4 - 2                31.88                    4.57
    2 X 6 - 2                53.57                   14.02
    2 X 8 - 2                80.00                   33.91
                                                    ---------
                      TOTAL MACHINE CONTRIBUTION     52.50 %

                  MACHINE: HORIZONTAL BAND

DIMENSION PRODUCED    PERCENT SURFACE AREA    PERCENT CONTRIBUTION
------------------    --------------------    --------------------
    1 X 4 - 1                80.00                    7.98
    2 X 4 - 2                34.78                    4.99
    2 X 6 - 2                21.43                    5.61
     4/4                    100.00                    7.13
                                                    ---------
                      TOTAL MACHINE CONTRIBUTION     25.70 %

                  MACHINE: 2 OR 3 SAW EDGER

DIMENSION PRODUCED    PERCENT SURFACE AREA    PERCENT CONTRIBUTION
------------------    --------------------    --------------------
    1 X 4 - 4                20.00                    1.99
    2 X 4 - 4                17.39                    2.49
    2 X 6 - 6                 7.14                    1.87
    2 X 8 - 8                 8.24                    3.49
                                                    ---------
                      TOTAL MACHINE CONTRIBUTION      9.85 %
```

Figure 8.—Computer Output

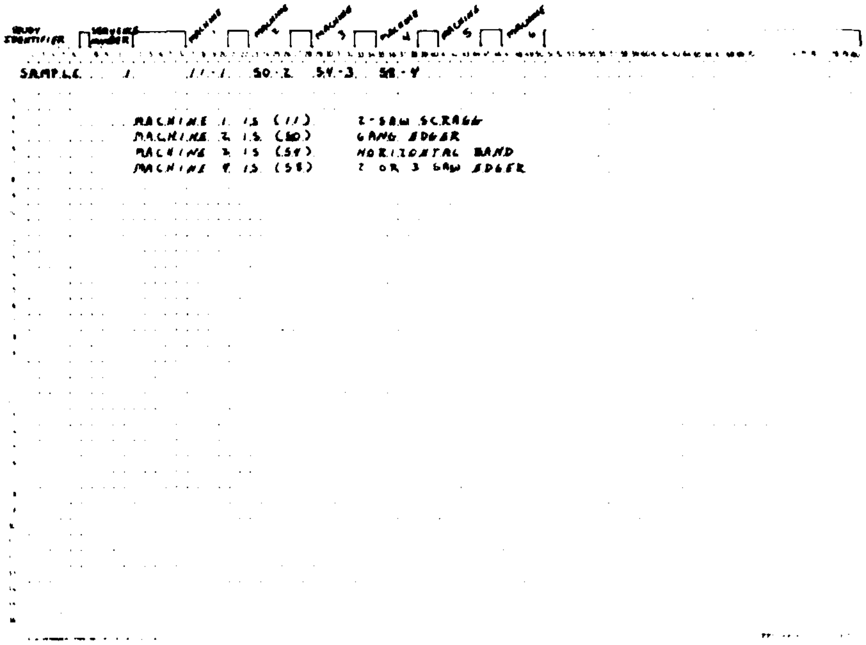
the names will allow up to 100. If a name is not in the list, it can easily be added to the program's array. To enter the machine code, locate the machine name in the machine code list and select the proper code.

A dash separates the machine code entered in the first two columns of each four-column machine identification field from a machine number entered in the last column of the field. The purpose of the number is to identify a machine if two machines in a mill should happen to have the same name. If a flow chart of the mill operation, as shown in figure 1, is made as it probably should be for every mill study, it is easy to reference the exact machine in the mill that the program output references. The machine code and number identifying each machine are shown in figure 1.

The purpose of the header card is to identify the surface area/volume data to follow on the study data cards as to machine responsibility. The format for the cards holding the sample surface area/volume data is shown in figure 10. The fields on these cards are set up as they appear on the data form. Each of six possible machines can contain data for both thickness and width. That is, since each machine is capable of producing both thickness and width, a field is available for each. The method of entry for each machine is the same, and the column locations are shown in figure 10.

The entry of the data on the surface area/volume data cards is straightforward. The data taken from the data form are entered right-justified in the appropriate machine fields on the cards.

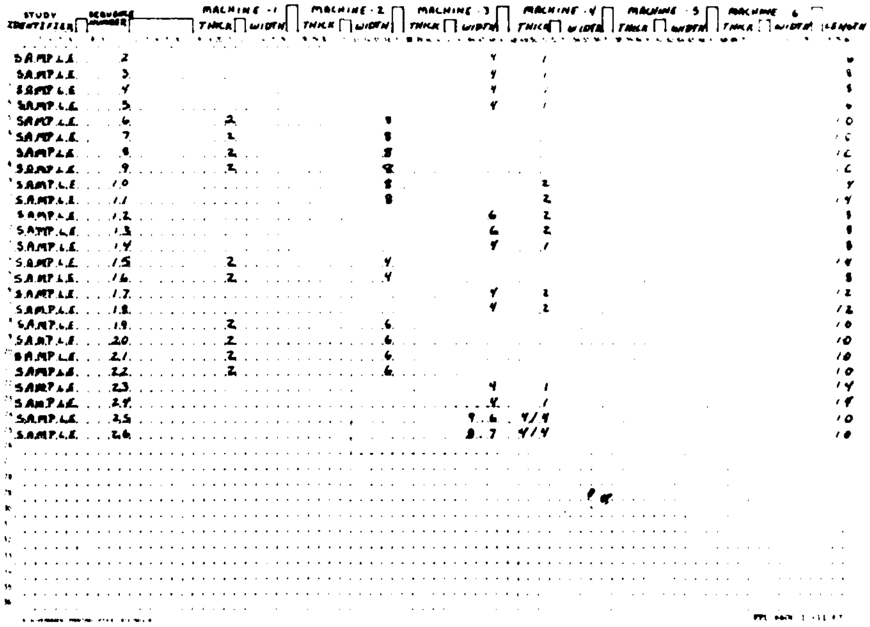
An alphabetized definition of program variables is given in Appendix II, and the program listing is given in Appendix III.



SAMPLE 1 11-1 50-2 54-3 58-4

MACHINE 1 IS (11) 2-SAW SCRAGG
MACHINE 2 IS (50) GANG EDGER
MACHINE 3 IS (54) HORIZONTAL BAND
MACHINE 4 IS (58) 2 OR 3 SAW EDGER

Figure 9.—Format of Header Card



STUDY IDENTIFIER	SEQUENCE NUMBER	MACHINE 1 THICK	MACHINE 1 WIDTH	MACHINE 2 THICK	MACHINE 2 WIDTH	MACHINE 3 THICK	MACHINE 3 WIDTH	MACHINE 4 THICK	MACHINE 4 WIDTH	MACHINE 5 THICK	MACHINE 5 WIDTH	MACHINE 6 THICK	MACHINE 6 WIDTH	LENGTH
SAMPLE	2						4	1						[illegible]
SAMPLE	3						4	1						8
SAMPLE	4						4	1						8
SAMPLE	5						4	1						[illegible]
SAMPLE	6	2			8									10
SAMPLE	7	2			8									16
SAMPLE	8	2			8									16
SAMPLE	9	2			4									16
SAMPLE	10				8			2						4
SAMPLE	11				8			2						14
SAMPLE	12						6	2						8
SAMPLE	13						6	2						8
SAMPLE	14						4	1						8
SAMPLE	15	2			4									14
SAMPLE	16	2			4									8
SAMPLE	17						4	2						12
SAMPLE	18						4	2						12
SAMPLE	19	2			6									10
SAMPLE	20	2			6									10
SAMPLE	21	2			6									10
SAMPLE	22	2			6									10
SAMPLE	23						4	1						14
SAMPLE	24						4	1						14
SAMPLE	25						9.6	4/4						10
SAMPLE	26						8.7	4/4						10

Figure 10.—Format of Sample Data

APPENDIX I— Machine Code List

Code	
01	Band Headrig
02	Circular Headrig
03	Circular Headrig/Vertical Edger
04	Band Headrig/Slab Chipper
05	Circular Headrig/Slab Chipper
06	Twin Band
07	Quad Band
08	Twin Band/Slab Chipper
09	Quad Band/Slab Chipper
10	Sash Gang (Log)
11	2-Saw Scragg
12	4-Saw Scragg
13	Chipper Canter
50	Gang Edger (Single Arbor)
51	Gang Edger (Double Arbor)
52	Band Linebar
53	Circular Linebar
54	Horizontal Band
55	Horizontal Circular
56	Sash Gang
57	Vertical Band Splitter
58	2 or 3 Saw Edger

APPENDIX II— Alphabetized Definition of Program Variables

```
                              PROGRAM VARIABLES

VARIABLE TYPES

   A = ALPHANUMERIC
   I = INTEGER
   R = REAL

VARIABLE     TYPE  DEFINITION
*****************************************************************************
CHAR(2,6)     A    A SPACE (' '), SLASH ('/'), DECIMAL POINT ('.'),
                   OR ONE ('1'). DETERMINES WHETHER THE PRODUCT BEING
                   PROCESSED IS RANDOM WIDTH OR SPECIFIED DIMENSION.
                   FOUND ON EACH DATA CARD IN COLUMNS 20&25,30&35,40&45,
                   50&55,60&65,AND 70&75.
                   CHAR(A,B):
                   A = COLUMN IN WHICH THE DIMENSION OR THE SURFACE AREA
                       OF EACH PRODUCT IS FOUND.
                   B = MACHINE NUMBER.
CNTRIB        R    PERCENT CONTRIBUTION OF EACH DIMENSION FOR EACH
                   MACHINE.
ERROR              SUBROUTINE USED TO PRINT OUT ERROR MESSAGES.
I             I    COUNTER FOR DO LOOPS.
II            I    COUNTER FOR THE NUMBER OF DATA CARDS READ IN.  THE
                   PROGRAM IS CURRENTLY SET AT A MAXIMUM OF 1000 DATA
                   CARDS.
IP            I    HOLDS ONE OF THE SPECIFIED NOMINAL DIMENSIONS FOR A
                   SINGLE PRODUCT.  "JP" HOLDS THE OTHER.
ISAV          I    USED TO PRINT OUT ONE NOMINAL DIMENSION FOR SPECIFIED
                   DIMENSION LUMBER. "JSAV" PRINTS THE OTHER.
J             I    COUNTER FOR DO LOOPS.
JP            I    HOLDS ONE OF THE SPECIFIED NOMINAL DIMENSIONS FOR A
                   SINGLE PRODUCT.  "IP" HOLDS THE OTHER.
JSAV          I    USED TO PRINT OUT ONE NOMINAL DIMENSION FOR SPECIFIED
                   DIMENSION LUMBER. "ISAV" PRINTS THE OTHER.
```

K	I	COUNTER FOR DO LOOPS.
KM	I	MACHINE NUMBER (1-6).
LENGTH	I	BOARD LENGTH.
MACHIN(2,2,6)	I	ARRAY USED TO STORE SURFACE AREA INFORMATION FROM EACH DATA CARD AS IT IS READ. MACHIN(A,B,C): A = THE DIMENSION OR THE SURFACE AREA BEING PROCESSED. B = ONE OF THE TWO COLUMNS ASSIGNED TO EACH MACHINE HOLDING DIMENSION OR SURFACE AREA INFORMATION. C = MACHINE NUMBER.
MCODE(6)	I	MACHINE CODE INDICATING MACHINE TYPE. FOUND ON THE HEADER CARD IN COLUMNS: 16-18,22-24,28-30,34-36,40-42, 46-48. MCODE(A): A = MACHINE NUMBER.
MM	I	COUNTER FOR THE MACHINE NUMBER.
MN	I	COUNTER FOR THE MACHINE NUMBER.
MP	I	COUNTER FOR DO LOOP.
MSKIP	I	INTEGER VALUE EQUAL TO SPCT.
MSUM	I	INTEGER VALUE EQUAL TO SMSUM OR RMSUM.
M1	I	MACHINE NUMBER (1-6) CORRESPONDING TO THE FIRST PIECE OF SURFACE AREA OR DIMENSION DATA ON A SINGLE DATA CARD.
M2	I	MACHINE NUMBER (1-6) CORRESPONDING TO THE SECOND PIECE OF SURFACE AREA OR DIMENSION DATA ON A SINGLE DATA CARD.
N	I	COUNTER FOR DO LOOP.
NBLANK(6)	I	CHARACTER FALLING BETWEEN THE MACHINE CODE "MCODE" AND THE MILL SEQUENCE NUMBER "NCODE" ON THE HEADER CARD. MUST BE EITHER A SPACE OR A DASH. NBLANK(A): A = MACHINE NUMBER.
NCODE(6)	I	SEQUENCE NUMBER FOR EACH MACHINE FROM FLOW CHART OF MILL. FOUND ON THE HEADER CARD IN COLUMNS: 20,26,32, 38,44,50. NCODE(A): A = MACHINE NUMBER.
NSEQ	I	SEQUENCE NUMBER OF THE DATA CARDS. USED FOR ERROR CHECKING. FOUND IN COLUMNS 8-11 ON EACH CARD.
NT	I	USED AS A FLAG IN A DO LOOP.
NWID	I	INTEGER USED TO CHECK THE WIDTH VALUE.
PCTRVM(20)	R	PERCENT OF MILL'S VOLUME MADE UP BY EACH RANDOM WIDTH PRODUCT. PCTRVM(A): A = THICKNESS OF RANDOM WIDTH PRODUCT.
PCTSVM(18,18)	R	PERCENT OF MILL'S VOLUME MADE UP BY EACH SPECIFIED DIMENSION PRODUCT. PCTSVM(A,B): A&B = THE SPECIFIED NOMINAL DIMENSIONS.
RAREA(6,20)	R	TOTAL SURFACE AREA OF EACH RANDOM WIDTH PRODUCT FOR EACH INDIVIDUAL MACHINE. RAREA(A,B): A = MACHINE NUMBER. B = THICKNESS OF RANDOM WIDTH PRODUCT.
RM	I	COUNTER FOR THE MACHINE NUMBER.
RMSUM(20)	R	TOTAL SURFACE AREA OF ALL RANDOM WIDTH PRODUCTS. RMSUM(A): A = THICKNESS OF RANDOM WIDTH PRODUCT.
RP	I	THICKNESS OF RANDOM WIDTH PRODUCT.

RPCT(6,20)	R	PERCENT OF EACH RANDOM WIDTH PRODUCT PRODUCED ON EACH INDIVIDUAL MACHINE. RPCT(A,B): A = MACHINE NUMBER. B = THICKNESS OF RANDOM WIDTH PRODUCT.
RSKIP(6)	I	FLAG VARIABLE EQUAL TO ONE WHEN RANDOM WIDTH PRODUCT BEING PROCESSED. RSKIP(A): A = MACHINE NUMBER.
RVOLUM(20)	R	TOTAL VOLUME OF EACH RANDOM WIDTH PRODUCT. RVOLUM(A): A = THICKNESS OF RANDOM WIDTH PRODUCT.
SAREA(6,18,18)	R	TOTAL SURFACE AREA OF EACH SPECIFIED DIMENSION PRODUCT FOR EACH INDIVIDUAL MACHINE. SAREA(A,B,C): A = MACHINE NUMBER. B&C = THE SPECIFIED NOMINAL DIMENSIONS.
SAWS(5,100)	A	STORES THE NAMES OF THE MACHINES. SAWS(A,B): A = NUMBER (5) OF SIX CHARACTER ALPHA FIELDS. B = MACHINE CODE "MCODE".
SMSUM(18,18)	R	TOTAL SURFACE AREA OF ALL SPECIFIED DIMENSION PRODUCTS. SMSUM(A,B): A&B = THE SPECIFIED NOMINAL DIMENSIONS.
SPCT(6,18,18)	R	PERCENT OF EACH SPECIFIED DIMENSION PRODUCED ON EACH INDIVIDUAL MACHINE. SPCT(A,B,C): A = MACHINE NUMBER. B&C = THE SPECIFIED NOMINAL DIMENSIONS.
SP1	I	HOLDS ONE OF THE SPECIFIED NOMINAL DIMENSIONS FOR A SINGLE PRODUCT. "SP2" HOLDS THE OTHER.
SP2	I	HOLDS ONE OF THE SPECIFIED NOMINAL DIMENSIONS FOR A SINGLE PRODUCT. "SP1" HOLDS THE OTHER.
SSKIP(6)	I	FLAG VARIABLE EQUAL TO ONE WHEN SPECIFIED DIMENSION IS BEING PROCESSED. SSKIP(A): A = MACHINE NUMBER.
STUDY(3)	A	STUDY IDENTIFIER FOUND IN COLUMNS 1-6 OF EACH DATA CARD. STUDY(A): A = NUMBER (3) OF TWO CHARACTER ALPHA FIELDS.
SVOLUM(18,18)	R	TOTAL VOLUME OF EACH SPECIFIED DIMENSION PRODUCT. SVOLUM(A,B): A&B = THE SPECIFIED NOMINAL DIMENSIONS.
TOTCTB	R	TOTAL PERCENT CONTRIBUTION OF EACH MACHINE.
TOTPCT	R	TOTAL PERCENT BY VOLUME OF ALL PRODUCTS PRODUCED.
TOTVOL	R	TOTAL VOLUME OF ALL PRODUCTS PRODUCED.
TYPE	I	REFERENCES ERROR MESSAGE TO BE PRINTED.
WIDTH	R	THE RANDOM WIDTH BEING PROCESSED.
XMCHNS(15)	A	USED TO DETERMINE IF MORE THAN SIX MACHINES ARE BEING READ FROM THE HEADER CARD. XMCHNS(A): A = NUMBER (15) OF TWO CHARACTER ALPHA FIELDS.

APPENDIX III— Program Listing

```
      DIMENSION CHAR(2,6),MACHIN(2,2,6),MCODE(6),NBLANK(6),NCODE(6),
     1 PCTSVM(18,18),PCTRVM(20),RAREA(6,20),RMSUM(20),RPCT(6,20),
     2 RSKIP(6),RVOLUM(20),SAREA(6,18,18),SAWS(5,100),SMSUM(18,18),
     3 SPCT(6,18,18),SSKIP(6),STUDY(3),SVOLUM(18,18),XMCHNS(15)
      INTEGER RM,RP,RSKIP,SP1,SP2,SSKIP
C                    ***** THE FOLLOWING DATA STATEMENT USES  *****
C                    ***** AN "A6" FORMAT.  YOUR COMPUTER MAY *****
C                    ***** NOT ALLOW THIS.  ALL OTHER ALPHA-  *****
C                    ***** NUMERIC FORMATS IN THIS PROGRAM    *****
C                    ***** ARE EITHER "A4" OR "A2".           *****
      DATA ((SAWS(I,J),I=1,5),J=1,13)/'BAND HEADRIG                  ',
     1 'CIRCULAR HEADRIG               CIRCULAR HEADRIG/VERT.EDGER  ',
     2 'BAND HEADRIG/SLAB CHIPPER      CIRCULAR HEADRIG/SLAB CHIPPER',
     3 'TWIN BAND                      QUAD BAND                    ',
     4 'TWIN BAND/SLAB CHIPPER         QUAD BAND/SLAB CHIPPER       ',
     5 'SASH GANG(LOG)                 2-SAW SCRAGG                 ',
     6 '4-SAW SCRAGG                   CHIPPER CANTER               ',
C                    ***** SECOND HALF OF ARRAY *****
      DATA ((SAWS(I,J),I=1,5),J=50,58)/'GANG EDGER(SINGLE ARBOR)      ',
     1 'GANG EDGER(DOUBLE ARBOR)       BAND LINEBAR                 ',
     2 'CIRCULAR LINEBAR               HORIZONTAL BAND              ',
     3 'HORIZONTAL CIRCULAR            SASH GANG                    ',
     4 'VERTICAL BAND SPLITTER         2 OR 3 SAW EDGER             '/
C                    ***** READ HEADER CARD *****
      READ(5,1) (STUDY(I),I=1,3),NSEQ,(MCODE(J),NBLANK(J),NCODE(J),
     1   J=1,6),(XMCHNS(K),K=1,15)
 1    FORMAT(3A2,1X,I4,3X,6(1X,I3,A1,I1),15(A2))
C                    ***** BEGIN PAGE *****
      WRITE(6,69)
C                    ***** TEST FOR TOO MANY MACHINES *****
      DO 2 K=1,5
       IF(XMCHNS(K).NE.'      ')CALL ERROR(01,NSEQ)
 2    CONTINUE
C                    ***** TEST FOR CORRECT FORMAT *****
      DO 4 J=1,6
       IF(NBLANK(J).NE.'-'.AND. NBLANK(J).NE.' ')CALL ERROR(02,NSEQ)
 4    CONTINUE
C                    ***** READ AND PRINT EACH DATA CARD *****
      DO 38 II=1,1000
       READ(5,5,END=40) (STUDY(I),I=1,3),NSEQ,(MACHIN(1,1,K),CHAR(1,K),
     1    MACHIN(1,2,K),MACHIN(2,1,K),CHAR(2,K),MACHIN(2,2,K),K=1,6),
     2    LENGTH
 5     FORMAT(3A2,1X,I4,6X,6(I2,A1,I1,1X,I2,A1,I1,1X),I3)
       WRITE(6,7) (STUDY(I),I=1,3),NSEQ,(MACHIN(1,1,K),CHAR(1,K),
     1    MACHIN(1,2,K),MACHIN(2,1,K),CHAR(2,K),MACHIN(2,2,K),K=1,6),
     2    LENGTH
 7     FORMAT(' ',3A2,1X,I4,6X,6(I2,A1,I1,1X,I2,A1,I1,1X),I3)
C                    ***** TEST FOR NO GIVEN LENGTH *****
       IF(LENGTH.EQ.0)CALL ERROR(03,NSEQ)
       DO 10 MM=1,6
        DO 8 I=1,2
C                    ***** ALLOW FOR DIMENSIONS LARGER THAN *****
C                    ***** 9 TO USE CHARACTER COLUMN        *****
         IF(CHAR(I,MM).EQ.'1')MACHIN(I,2,MM)=MACHIN(I,2,MM)+10.
```

```
        IF(CHAR(I,MM).EQ.'1')GO TO 8
C                 ***** TEST FOR CORRECT FORMAT *****
        IF(CHAR(I,MM).NE.' '.AND.CHAR(I,MM).NE.'/'.AND.
     1   CHAR(I,MM).NE.'.')CALL ERROR(02,NSEQ)
 8     CONTINUE
C                 ***** TEST FOR DIMENSIONS LARGER THAN  *****
C                 ***** 20/4 RANDOM THICKNESS OR 18 INCH *****
C                 ***** SPECIFIED THICKNESS OR WIDTH     *****
       IF((MACHIN(1,1,MM).GT.20.OR.MACHIN(2,1,MM).GT.20).AND.
     1  (CHAR(1,MM).EQ.'/'.OR.CHAR(2,MM).EQ.'/')) CALL ERROR(04,NSEQ)
       IF((MACHIN(1,1,MM).GT.18.OR.MACHIN(2,1,MM).GT.18).AND.
     2  (CHAR(1,MM).EQ.' '.OR.CHAR(2,MM).EQ.' ')) CALL ERROR(04,NSEQ)
C                 ***** DETERMINE WHETHER SPECIFIED OR *****
C                 ***** RANDOM DIMENSIONS ARE USED     *****
       IF(CHAR(1,MM).EQ.'/') GO TO 24
       IF(CHAR(2,MM).EQ.'/') GO TO 26
 10   CONTINUE
C                 ***** TEST FOR ILLEGAL DECIMAL POINT *****
      DO 12 MM=1,6
      IF(CHAR(1,MM).EQ.'.'.OR.CHAR(2,MM).EQ.'.') CALL ERROR(05,NSEQ)
 12   CONTINUE
      SP1=0
      SP2=0
      NT=0
C                 ***** FIND THE MACHINE NUMBER(S) *****
C                 ***** AND EACH DIMENSION         *****
C                 ***** FOR SPECIFIED DIMENSIONS   *****
      DO 20 KM=1,6
       DO 18 I=1,2
        IF(SP1.NE.0) NT=1
        DO 14 J=1,2
         IF(MACHIN(I,J,KM).NE.0) GO TO 16
 14     CONTINUE
        GO TO 18
 16     IF(NT.EQ.0) SP1=MACHIN(I,J,KM)
        IF(NT.EQ.0) M1=KM
        IF(NT.EQ.1) SP2=MACHIN(I,J,KM)
        IF(NT.EQ.1) M2=KM
        IF(NT.EQ.1) GO TO 22
 18    CONTINUE
 20   CONTINUE
C                 ***** PROGRAM SHOULD NEVER REACH THIS POINT *****
C                 ***** AS IT SHOULD HAVE TAKEN THE GO TO 22  *****
C                 ***** WHEN IT HAD A FULL SET OF DATA        *****
      CALL ERROR(06,NSEQ)
C                 ***** CALCULATE THE SURFACE AREA   *****
C                 ***** FOR EACH SPECIFIED DIMENSION *****
 22   SAREA(M1,SP1,SP2)=SAREA(M1,SP1,SP2)+FLOAT(SP1)*FLOAT(LENGTH)/12.
      SAREA(M2,SP2,SP1)=SAREA(M2,SP2,SP1)+FLOAT(SP2)*FLOAT(LENGTH)/12.
      SVOLUM(SP1,SP2)=SVOLUM(SP1,SP2)+FLOAT(SP1*SP2*LENGTH)/12.
      GO TO 38
C                 ***** TEST FOR NO THICKNESS    *****
C                 ***** FOR RANDOM WIDTH PRODUCT *****
 24   IF(MACHIN(1,1,MM).EQ.0) CALL ERROR(07,NSEQ)
      PP=MACHIN(1,1,MM)
      GO TO 28
 26   IF(MACHIN(2,1,MM).EQ.0) CALL ERROR(07,NSEQ)
```

```
            RP=MACHIN(2,1,MM)
      28    DO 30 RM=1,6
C                            ***** TEST FOR MISSING DECIMAL ON WIDTH *****
C                            ***** FOR RANDOM WIDTH PRODUCT          *****
             IF(CHAR(1,RM).EQ.'.') GO TO 32
             IF(CHAR(2,RM).EQ.'.') GO TO 34
             IF(RM.EQ.6) CALL ERROR(08,NSEQ)
      30    CONTINUE
      32    WIDTH=FLOAT(MACHIN(1,1,RM))+FLOAT(MACHIN(1,2,RM))/10.
            GO TO 36
      34    WIDTH=FLOAT(MACHIN(2,1,RM))+FLOAT(MACHIN(2,2,RM))/10.
C                            ***** TEST FOR UNACCEPTABLE WIDTH *****
C                            ***** FOR RANDOM WIDTH PRODUCT    *****
      36    NWID=WIDTH*10
            IF(NWID.LT.1) CALL ERROR(09,NSEQ)
            RAREA(RM,RP)=RAREA(RM,RP)+WIDTH*FLOAT(LENGTH)/12.
            RVOLUM(RP)=RVOLUM(RP)+FLOAT(RP)/4.*WIDTH*FLOAT(LENGTH)/12.
      38   CONTINUE
C                            ***** IF THE STUDY DOES NOT HAVE ANY      *****
C                            ***** SPECIFIED DIMENSIONS, THE MULTIPLE *****
C                            ***** FACE CALCULATION IS SKIPPED.        *****
      40   IF(SP1.EQ.0.AND.SP2.EQ.0) GO TO 54
C                            ***** CALCULATE THE TOTAL SURFACE AREA *****
C                            ***** FOR SPECIFIED DIMENSIONS         *****
           DO 46 I=1,18
            DO 44 J=1,18
             DO 42 K=1,6
              SMSUM(I,J)=SMSUM(I,J)+SAREA(K,I,J)
      42     CONTINUE
      44    CONTINUE
      46   CONTINUE
C                            ***** CALCULATE SURFACE AREA PERCENTAGE *****
C                            ***** FOR SPECIFIED DIMENSIONS          *****
           DO 52 I=1,6
            DO 50 J=1,18
             DO 48 K=1,18
              MSUM=SMSUM(J,K)
              IF(MSUM.LE.0) GO TO 48
              SPCT(I,J,K)=SAREA(I,J,K)*100./(SMSUM(J,K)+SMSUM(K,J))
              IF(SPCT(I,J,K).GT.0.) SSKIP(I)=1
      48     CONTINUE
      50    CONTINUE
      52   CONTINUE
C                            ***** CALCULATE THE TOTAL SURFACE AREA *****
C                            ***** FOR RANDOM WIDTHS                *****
      54   DO 58 N=1,20
            DO 56 K=1,6
             RMSUM(N)=RMSUM(N)+RAREA(K,N)
      56    CONTINUE
      58   CONTINUF
           DO 62 N=1,20
C                            ***** CALCULATE SURFACE AREA PERCENTAGE *****
C                            ***** FOR RANDOM WIDTHS                 *****
            MSUM=RMSUM(N)
            IF(MSUM.LE.0) GO TO 62
            DO 60 K=1,6
             RPCT(K,N)=RAREA(K,N)*100./RMSUM(N)
```

```
        IF(RPCT(K,N).GT.0.) RSKIP(K)=1
 60    CONTINUE
 62   CONTINUE
      DO 66 SP1=1,18
       DO 64 SP2=1,18
        TOTVOL=TOTVOL+SVOLUM(SP1,SP2)
 64    CONTINUE
 66   CONTINUE
      DO 68 RP=1,20
       TOTVOL=TOTVOL+RVOLUM(RP)
 68   CONTINUE
      WRITE(6,69)
C                     ***** NEW PAGE *****
 69   FORMAT('1')
C                     ***** CALCULATE AND PRINT    *****
C                     ***** PERCENT OF MILL VOLUME *****
C                     ***** BY PRODUCT             *****
      WRITE(6,71) (STUDY(I),I=1,3)
 71   FORMAT(24X,3A2,' MACHINE CONTRIBUTION STUDY '//
     1 20X,'PRODUCT PRODUCED',7X,'PERCENT MILL VOLUME'/
     2 20X,16('-'),7X,19('-'))
C                     ***** CALCULATE PERCENT OF MILL VOLUME *****
C                     ***** FOR SPECIFIED DIMENSION PRODUCTS *****
      DO 76 SP1=1,18
       DO 74 SP2=1,18
        IF(SP1.LE.SP2)PCTSVM(SP1,SP2)=(SVOLUM(SP2,SP1)+SVOLUM(SP1,SP2))
     1   /TOTVOL*100.
        IF(SP1.GT.SP2)PCTSVM(SP2,SP1)=(SVOLUM(SP2,SP1)+SVOLUM(SP1,SP2))
     1   /TOTVOL*100.
        IF(SP1.GT.SP2)GO TO 74
        TOTPCT=TOTPCT+PCTSVM(SP1,SP2)
        IF(PCTSVM(SP1,SP2).NE.0)WRITE(6,73)SP1,SP2,PCTSVM(SP1,SP2)
 73     FORMAT(24X,I2,' X ',I2,18X,F6.2)
 74    CONTINUE
 76   CONTINUE
C                     ***** CALCULATE PERCENT OF MILL VOLUME *****
C                     ***** FOR RANDOM WIDTH PRODUCTS        *****
      DO 78 RP=1,20
       PCTRVM(RP)=RVOLUM(RP)/TOTVOL*100.
       TOTPCT=TOTPCT+PCTRVM(RP)
       IF(PCTRVM(RP).NE.0)WRITE(6,77)RP,PCTRVM(RP)
 77    FORMAT(25X,I2,'/4',20X,F6.2)
 78   CONTINUE
      WRITE(6,79)TOTPCT
79    FORMAT(48X,'---------'/49X,F6.2,' % '//)
      DO 94 MN=1,6
       TOTCTB=0.
       IF(SSKIP(MN).NE.1.AND.RSKIP(MN).NE.1) GO TO 94
       MM=MCODE(MN)
C                     ***** PRINT MACHINE CONTRIBUTION TABLE *****
       WRITE(6,81) (SAWS(I,MM),I=1,5)
 81    FORMAT('1'///20X,'MACHINE: ',5(A6)//,
     1  5X,'DIMENSION PRODUCED',4X,'PERCENT SURFACE AREA',
     2  4X,'PERCENT CONTRIBUTION'/5X,18('-'),4X,20('-'),4X,20('-'))
       IF(SSKIP(MN).NE.1) GO TO 90
       DO 88 IP=1,18
C                     ***** PRINT MACHINE CONTRIBUTION FOR *****
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C                       ***** SPECIFIED DIMENSION PRODUCTS   *****
        DO 86 JP=1,18
         MSKIP=SPCT(MN,IP,JP)
         IF(MSKIP.LE.0) GO TO 86
         ISAV=IP
         JSAV=JP
         IF(IP.GT.JP) ISAV=JP
         IF(IP.GT.JP) JSAV=IP
         IF(JP.GE.IP)CNTRIB=PCTSVM(IP,JP)*SPCT(MN,IP,JP)*.01
         IF(IP.GT.JP)CNTRIB=PCTSVM(JP,IP)*SPCT(MN,IP,JP)*.01
         TOTCTB=TOTCTB+CNTRIB
         IF(JSAV.GE.10.OR.JP.GE.10)WRITE(6,83)ISAV,JSAV,JP,
     1    SPCT(MN,IP,JP),CNTRIB
 83      FORMAT(9X,I2,' X ',I2,' - ',I2,13X,F6.2,17X,F6.2)
         IF(JSAV.LT.10.AND.JP.LT.10)WRITE(6,85) ISAV,JSAV,JP,
     1    SPCT(MN,IP,JP),CNTRIB
 85      FORMAT(10X,I1,' X ',I1,' - ',I1,15X,F6.2,17X,F6.2)
 86     CONTINUE
 88    CONTINUE
 90    DO 92 MP=1,20
C                       ***** PRINT MACHINE CONTRIBUTION FOR *****
C                       ***** RANDOM WIDTH PRODUCTS          *****
        MSKIP=RPCT(MN,MP)
        IF(MSKIP.LE.0) GO TO 92
        CNTRIB=PCTRVM(MP)*RPCT(MN,MP)*.01
        TOTCTB=TOTCTB+CNTRIB
        WRITE(6,91),MP,RPCT(MN,MP),CNTRIB
 91     FORMAT(10X,I2,'/4',20X,F6.2,17X,F6.2)
 92    CONTINUE
       WRITE(6,93)TOTCTB
 93    FORMAT(57X,9('-')/27X,'TOTAL MACHINE CONTRIBUTION',4X,F6.2,' %',
     1 /////)
 94   CONTINUE
      WRITE(6,69)
      END
```

```
      SUBROUTINE  ERROR(TYPE,NSEQ)
      INTEGER  TYPE
      WRITE(6,5)
    5 FORMAT('0',6X,' TYPE OF ERROR: ')
      GO TO (100,200,300,400,500,600,700,800,900),TYPE
  100 WRITE(6,10)
   10 FORMAT('+',22X,'MAXIMUM OF 6 MACHINES EXCEEDED ON HEADER CARD')
      GO TO 1000
  200 WRITE (6,20)
   20 FORMAT('+',22X,'BAD FORMAT ON CARD')
      GO TO 1000
  300 WRITE(6,30)
   30 FORMAT('+',22X,'LENGTH IS UNDEFINED')
      GO TO 1000
  400 WRITE(6,40)
   40 FORMAT('+',22X,'MAXIMUM BOARD DIMENSION EXCEEDED.')
      GO TO 1000
  500 WRITE(6,50)
   50 FORMAT('+',22X'INTEGER MUST BE USED FOR A STANDARD DIMENSIONS LOG'
     1)
      GO TO 1000
```

```
  600 WRITE(6,60) NSEQ
   60 FORMAT('+',22X,'UNABLE TO FIND COMPLETE DATA ON CARD: ',I8,
     1/,' PROGRAM TERMINATED.')
C***************************
             STOP
C***************************
  700 WRITE(6,70)
   70 FORMAT('+',22X'THICKNESS IS UNDEFINED ')
      GO TO 1000
  800 WRITE(6,80)
   80 FORMAT('+',22X'A DECIMAL MUST BE IN PROPER POSITION TO INDICATE '
     1 'WHICH MACHINE IS USED TO CUT THE WIDTH')
      GO TO 1000
  900 WRITE(6,90)
   90 FORMAT('+',22X'THE WIDTH IS TOO SMALL')
      GO TO 1000
 1000 WRITE(6,1111) NSEQ
 1111 FORMAT(6X,'ERROR DETECTED AT CARD NUMBER :',I8)
      RETURN
      END
```

SA 1-2, 4-3

U.S. Forest Products Laboratory.

Procedure and Computer Program to calculate machine contribution to sawmill recovery, by P. H. Steele, H. Hallock, and S. Lunstrum. Madison, Wis., FPL 1981. 20p. (USDA For. Serv. Res. Pap. FPL 383).

The importance of considering individual machine contribution to total mill efficiency is discussed, and a method for accurately calculating machine contribution is introduced along with an example using this method. Also presented is a FORTRAN computer program to make the necessary calculations automatically.

Key Words: Sawmilling, Computer Program, Variation, Quality Control, Surface area.

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