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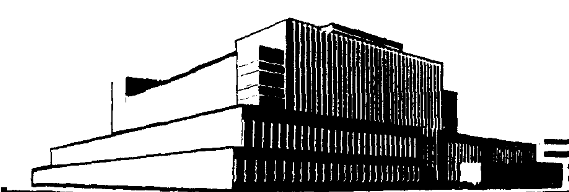

FOREST PRODUCTS LABORATORY
MADISON 5, WISCONSIN

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

In Cooperation with the University of Wisconsin

EFFECT OF DEFECT PLACEMENT AND TAPER SETOUT ON LUMBER GRADE YIELDS WHEN SAWING HARDWOOD LOGS

By

F. B. MALCOLM, Technologist

Forest Products Laboratory,[1] Forest Service
U. S. Department of Agriculture

Summary

The study here reported was made to evaluate some of the principles used by skilled sawyers as well as some of the principles developed at the Forest Products Laboratory for getting the optimum grade from all logs. The study, which was statistically designed, evaluates six sawing methods for which the sawing faces were positioned relative to gross external defects and the amount of setout for log taper. Lumber-grade yield tallies were summarized, and a quality index was computed for individual logs, each grade, and each method. This index was calculated from the value of the lumber sawn, based on prevailing market quotations. It was concluded from the study that sawmill operators lose considerable money in producing their lumber by ignoring the position of defects on sawing faces and taper setout.

Introduction

It is a recognized fact that the quality of hardwood timber in the United States has substantially decreased in the past 50 years. This fact together with present day high production costs requires that the hardwood sawyer must work carefully to develop the maximum value from logs which reach the sawmill carriage. The sawyers' problem is accentuated even further because high quality veneer logs are often diverted to the veneer mill so that the quality of logs which do get to the sawmill is much lower than those sawn in the mill of even 25 years ago.

To offset these conditions, skilled sawyers over the years have worked out their own methods of placing, turning, and sawing logs on the sawmill carriage which they believe can develop the maximum value from any given log. These methods may vary from region to region and from area to area, partially because of the character of the market for end products but more often because of a lack of study of the basic principles involved in obtaining the grade quality that may be in a log. The beginning sawyer, who rarely has the advantage of being trained by a skilled sawyer, must rely on his own trial and error methods or such written material as may be available to him.

Written instructions on hardwood grade sawing were practically nonexistent until Telford's instructions were published in 1951.[2] These instructions were based almost entirely on observations of sawing practices at many hardwood mills and from discussions with numerous experienced sawyers.

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

[2]Small Sawmill Improvement, C. J. Telford. U.S. Forest Products Laboratory Report No. R899-27, 1951.

The use of these instructions for demonstration training at sawmill clinics and subsequent observations at numerous sawmilling operations indicated that while the instructions were excellent for certain types of logs, they fell short of getting the optimum grade from all logs. Experienced sawyers in certain areas, who had developed their own methods, had opinions of their own which differed from the instructions. It was decided, consequently, to test the instructions published by the Forest Products Laboratory against some of these variations in grade-sawing procedures.

An initial pilot study,[3] which was statistically designed, was conducted on red oak logs in cooperation with Professor J. W. Creighton, Michigan State University, on the University's sawmill at East Lansing, Mich. The study encompassed the following four sawing methods and incorporated some degree of taper setout: (1) placing major log surface defects to the corners or edges of sawing faces with a full taper setout, which is the FPL method modified; (2) placing major log surface defects to the center of sawing faces and setting out only 1/2 taper, which is an industry method and is sometimes called split taper; (3) placing the log hit-or-miss fashion in which the defects as such were ignored, which is another industry method; and (4) placing the major log surface defects to the corners or edges of sawing faces and setting out only 1/2 taper, which is another modification of the FPL method.

The analyses of variance of the compiled study data on grade No. 1 logs[4] showed that the index values for the corner-and-full-taper method and the corner-and-split-taper method were significantly higher than the index value for the hit-or-miss method at the 1 percent level. In the case of grade No. 2 logs, the index values for the corner-and-full-taper, the corner-and-split-taper method, and the hit-or-miss method were significantly higher than the value for the center-and-split-taper method. In the case of grade No. 3 logs, the analysis showed no significant difference between any of the methods.

The results of this pilot test were sufficiently encouraging to warrant more comprehensive studies. In 1955, therefore, a study was initiated in cooperation with the Central States Forest Experiment Station and its Carbondale Research Center.[5] The study was conducted on the Center's sawmill at the Kaskaskia Experimental Forest in Illinois.

Although this study is concerned with a certain aspect of developing maximum grade value from logs based on attention to external log defects, it is actually only a small part of the overall problem of how to obtain maximum value from sawlogs.

Objectives

The basic objectives of this study were to determine the effect of varying the position of sawing faces of a log in relation to the most prominent visible gross log surface defects and the effect of taper setout on yields of factory grades of lumber when sawing hardwood logs. Knots, when present, were considered as the log surface defects controlling the positioning of sawing faces. In the absence of gross knots major log end defects, such as rot and holes, when present, were the controlling surface defects. Over-growth, bark scars, and small visible end defects were the controlling defects in the absence of other gross defects.

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[3] An Evaluation of Defect Orientation Methods in Grade Sawing Northern Hardwoods, by Creighton, J. W., Malcolm, F. B., and Wollin, A. C. Michigan State University Agricultural Experiment Station Quarterly Bulletin 38: 216-224. November 1955.

[4] Hardwood Log Grades for Standard Lumber, Proposals and Results, "Forest Products Laboratory Report No. D1737. "Hardwood Log Grades for Standard Lumber and How to Apply Them." Report No. D1737-A, pocket edition.

[5] The study was designed with the advice of D. O. Yandle, Laboratory statistician, C. L. Vaughan, Laboratory log quality specialist, D. E. Herrick, Central States Forest Experiment Station utilization specialist, and other members of the Station staff.

Scope

Although several of the most important hardwood lumber species will be tested eventually, only species in the red oak group were tested in this study. This was done to eliminate the the effect of the species variable in the analysis. For the same reason, only 4/4 lumber was sawed except for the dog board. The hardwood lumber grade rules are identical for all the red oak group. Logs used in the study were obtained from the Experimental Forest in the normal logging operation for forest management studies.

Design

Because lumber quality yield was the criterion for evaluating each method tested, a uniform distribution of logs of similar quality for each method was determined essential for a balanced study. The FPL log grade specifications!! were used as a basis for obtaining the desired quality distribution. Excessive sweep, however, was considered a variable that could obscure the effect of orienting surface defects. Logs having sweep in excess of 10 percent as calculated by the method indicated in FPL Report No. Dl737-A, therefore, were rejected for use in the study. With this exception, only logs which met the FPL log grade specifications for factory grades Nos. 1, 2, and 3 were used. An equal number of logs were selected as a means of obtaining the desired distribution. Two different positions of sawing faces relative to the location of major knot defects or other prominent defects on the sawing faces were used as the basic defect-orientation factor; specifically, defects on the edges of the sawing faces, and, defects in the center of the sawing faces. Two degrees of taper setout, one-half taper, and full taper, were also considered essential factors to investigate. A control method was included in which defect placement and compensation or adjustment for taper as such were ignored.

Equal effort was made in each sawing method to develop the best grade lumber from the standpoint of turning the logs and edging, ripping, and trimming the lumber for the highest value return consistent with the minimum volume loss. Although maximum grade yield was the controlling factor in edging and trimming, potential monetary value of individual boards was equally considered so that scale was not sacrificed merely to up-grade. The optimum board value was thus obtained.

The Michigan State University pilot study data were used as a basis for statistically determining that 21 logs of each log grade for each sawing method were required for a balanced study. Five methods combining the variants mentioned above and one control method were designed for testing.[6] There were, consequently, three grades of logs used for each of the six methods. This required 378 logs, or 18 groups of 21 logs each.

Sawing Methods

The methods tested are described below:

Method 1. Control. Logs were sawed in the position they hit the carriage with defects and taper being ignored.

Method 2. Logs were positioned so that major visible defects, such as knots, were oriented to the center of the sawing faces and setout one-half the taper on the first of opposite unsawed faces. The best face, which was determined by selecting the face with the longest cuttings and the least number of defects, was sawed first. This determination was made from log diagrams.

[6] There are many other possible combinations of the three variables described above, but these are the more common ones referred to as used by sawyers.

Method 3. Logs were positioned so that major visible defects, such as knots, were oriented to the center of sawing faces and setout full taper. The best face was sawed first, and the taper was removed from the lower grade heart portion.

Method 4. Logs were positioned so that major visible defects, such as knots, were oriented to the edges of the sawing faces and not setout for taper. The poorest faces, which were determined from log diagrams, were sawed first. This was a method developed at the Forest Products Laboratory.

Method 5. Logs were positioned so that the major visible defects, such as knots, were oriented to the edges of sawing faces and setout one-half the taper on the first of opposite unsawed faces. The best faces were sawed first.

Method 6. Logs were positioned so that major visible defects, such as knots, were oriented to the edges of the sawing faces and setout full taper. The best faces were sawed first, and the taper was removed from the lower grade heart portion.

Field Procedure

The Kaskaskia Experimental Forest's sawmill, on which the logs were sawn, is a conventional circular mill that has a standard medium-weight 3-headblock carriage. The logs for the study were obtained from various forest management compartments in which several types of forest management research studies were being conducted. Logging and sawmilling operations are intermittent because the crew also work at other jobs concerned with the operation of the Forest. The sawing study was activated whenever a sufficient stock pile of logs had accumulated to warrant operating 2 or 3 days and the crew was not required to work on other projects. The number of Grade No. 1 logs that were necessary for the completion of the study accumulated slowly because of the character of the timber types logged and the nature of the forest management studies, These factors resulted in the study being spread over a considerable period of time.

Diagraming and Grading Logs

All logs were given a number and diagramed before sawing in accordance with methods used for the FPL log grade studies and graded in accordance with FPL log grade rules. The pattern of sawing faces for each specific method was marked on both ends of the log before diagraming. The diagram faces were developed to coincide with them. When the control logs were sawed, of course, these diagramed faces were ignored.

Sawing the Logs and Recording Data

The sequence of sawing by methods was as listed previously, starting with Method 1 and continuing through Method 6. Within a given log grade, a full group of 21 logs was sawed for each method before progressing to the next method. Two or three extra logs were diagramed and sawed for each grade and method in case of miscounting and misgrading. As each log was sawed, individual boards were given a sequence number for that log. The position and sequence number of each board sawed were diagramed with reference to the four sawing faces and the log diagram faces on a circle diagram representing the end of the log. Each board was edged, ripped, and trimmed so as to obtain the maximum grade value of the board consistent with the minimum volume loss. This insured that the optimum monetary value of the board was obtained. A separate tally of the scale, grade, and sequence number of every board was made for each log by a hardwood lumber grader experienced in using National Hardwood Lumber Association rules.

Office Procedure

Computation, Tabulation, and Summarization

The total scale of each grade of lumber was determined for each log and the yield by individual grades was reduced by 5 percent so as to allow for shrinkage. This placed the final tally on a dry lumber basis, which is in accordance with practices established by the Forest Products Laboratory for hardwood log grade studies. The total dry lumber footage for each log was thus obtained. A quality index value was computed for each log using the method reported in the Tennessee Valley Authority Technical Note No. 15.[7] Grade yield percentages also were computed.

As field data of each sawing method for log grades Nos. 2 and 3 were completed, rough preliminary summaries of grade yield percentage for each log were computed. When all the grade No. 2 and 3 logs for all methods were sawed, the quality indexes for the individual log grade were also computed.[7] An analysis of variance was run on these data using the quality index values thus obtained. Values obtained were in line with the final results. None of the data, however, showed significance at the 1 percent level. Some of the data showed significance at the 5 percent level, although a major portion of the data approached significance at this significance level.

Subsequent to making this analysis, a conference was held with the personnel from the Carbondale Research Center, and it was decided to use current market values rather than a quality index system for analyzing the overall study. Monetary values, consequently, were computed for each individual log as well as the monetary value per thousand board feet for each log. These data, as well as lumber grade yield data, log diameters, length, log and lumber scale, log grade, and sawing method, for each log were punched on IBM. The values used for computing log and lumber values were based on January 1958 Memphis Market Report for red oak as follows: FAS, $190; Sel., $175; No. 1C, $90; No. 2C, $60; No. 3AC, $50; and No. 3BC, $26.

When the field work was completed for all grade No. 1 logs in all methods, a review and recheck was made of field data for all grades and methods and of computations.

Results

Summary of Grade Yields, Monetary Values, and Statistical Analysis Data

Tables 1 to 3 contain summaries of the comparisons of sawing methods by grade yields and monetary values, based on the computed summaries of the field data in accordance with the procedure as previously outlined. In order to simplify comparisons, the grade yield percentages for each sawing method have been rounded to the nearest whole number.

Tables 4 to 9 contain summaries of the statistical analysis computations made to test the validity of the data obtained from the study.

Discussion of Results

In each method used in the study, including the control method, every effort was made to continue to turn every log and to edge, rip, and trim all boards so as to get the maximum grade in the log consistent with optimum monetary value as related to volume loss in terms of board scale.

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[7] Lumber Price Ratios for Computing Quality Index of Tennessee Valley Hardwoods, Technical Note No. 15, Tennessee Valley Authority, Division of Forestry Relations, Norris, Tenn.

Table 1 is the overall comparison of methods in which the data for all grades of logs for each method are combined. These data were treated statistically for variance to test the validity of the spread of log values between log grades and to test the validity of the spread of value between methods. The lumber value per thousand board feet was the index used in this analysis. Table 5 gives the results of the treatment.

As would be expected from the design of the log grades themselves, the log-grade value differences were highly significant at the 1 percent level. Of more importance, as far as the study is concerned, however, is the test showed that value differences between methods were highly significant and that these differences were not due to chance alone but to certain variables within the individual method.

The next step was to determine which methods, if any, had a significant difference from the others statistically. Tables 6 to 9 give the results of the statistical treatment for all log grades combined and for individual log grades.

Lumber Values. --It is evident from table 1 that Methods 3, 4, and 6 return the highest lumber value when sawing for grade. When analyzed statistically for a comparison of methods, the data in table 6 shows that the value differences between Methods 1 and 2 and Methods 4 and 6 are significant at the 1 percent level, and that there is a significant difference at the 5 percent level between Method 2 and Methods 3 and 5.

There are several possible ways of interpreting these data. It seems logical to assume that since the controlled variable of orienting defects to the *edges* of sawing faces is common to both Methods 4 and 6, this factor has a strong influence on developing the highest value when sawing for grade. It could be further assumed that since Methods 3 and 6 have a controlled variable of full-taper setout common to them, this factor, likewise, has a strong influence on developing the highest value when grade sawing. If this premise is accepted, then conversely, using the same order of reasoning, the other controlled variable for Method 3, orienting defects to the center of sawing faces, can have little influence on developing optimum lumber values. it can also be assumed, then, that the controlled variable 1/2-taper setout, which is common to Methods 2 and 5, likewise, has little effect in developing the highest lumber values in grade sawing. This premise is deduced from the fact that Method 5 has the controlled variable of defects oriented to the edges of sawing faces; this variable is common to Methods 4 and 6, and appears to be one of the factors that strongly influences development of higher values in these methods. It is logical, consequently, to assume that failure to take full advantage of developing full-length boards from the outer one-third portion of the log, which generally has fewer knots and other defects than the heart portion, has considerable influence on lowering the lumber values in Method 5.

The results from Method 4 also tend to support the assumption that full taper setout helps develop higher values when grade sawing. When poor quality faces are sawed first without taper setout as in Method 4, the opposite higher quality sawing faces of logs, in effect, are sawed to the equivalent of full taper setout. In this case, the higher quality faces automatically have become parallel to the sawline and there is no need to setout for taper. This will enable the development of all full length boards from the higher quality faces. Logs with several knots on the poorer faces, consequently, can be expected to develop values somewhat comparable to Method 6. This fact was taken into consideration in the development of the hardwood grade-sawing guide, "Simplified Method for Developing Grade Lumber from Hardwood Logs," Forest Products Laboratory Report No. 2056.

In considering the results from individual log grades (tables 3 and 4), it is not to be expected that the same relative rating of value would develop for each of the three log grades as in the overall summary. The study was designed for a uniform sample of quality for each method rather than a uniform sample of quality within grades. Therefore, it is worth noting that some of the data for the individual log grades did show significance in the statistical analysis of the individual methods within grades (tables 7, 8, and 9), and that this significance was in the same relative order as the significance shown in the data for the summary of the combined grades. In addition, there appears to be a trend toward significance of the other values in the same order of results.

Grade Yield Recovery. --Although the overall value of the product is the important consideration to the sawmill operator, he is also vitally concerned with the proportion of the various grades of lumber that are developed. He usually has little trouble in marketing his FAS and Select grades. His problem frequently is in marketing his No. 3A and B Common grades, which he often has to sell at a loss. It is logical to assume, therefore, that any method of reducing this loss would be of value to him.

Visual inspection of the grade yield summary (table 1) shows that a sawmill operator using Methods 4 or 6 can not only expect to obtain a much better yield of Selects and better, but also expect some reduction in the amount of No. 3 Common lumber, particularly No. 3B Common. In considering the grade yield by log grades, the results are even more noteworthy. It has been observed that most sawyers will take particular care in sawing grade No. 1 logs. It might be expected, consequently, that there would be only minor differences between methods for this grade. In the yield of Selects and better from grade No. 1 logs (table 2), nevertheless, the differences between the defect-controlled methods and the other methods are appreciable. In grade No. 2 logs (table 3), these differences are even more pronounced. This grade, of course, is characterized by logs having considerably greater number of defects[8] than grade No. 1 logs; such clear logs as may occur in this grade are of small diameter.

In grade No. 3 logs, defect orientation and taper setout appear to have an influence that should not be ignored. Most sawyers, however, are prone to pay little attention to these logs, other than to get them off the carriage as quickly as possible. They are, consequently, either "live sawed" (through and through) or sawn into timbers. Although statistically the summary data for this grade (table 9) are not significant, there is a definite trend toward significance indicating that defect orientation and taper setout have a considerable influence on getting better value from grade No. 3 logs.

Of particular importance in this regard is the reduction in the amount of No. 3 Common lumber produced. It appears from these data that by ignoring defects in grade No. 3 logs, a sawyer is producing 25 percent more No. 3 Common lumber than is necessary.

Overrun

Volume recovery was not a controlled factor of this study, because log diameters and lengths were selected at random. The overrun figures for the study, nevertheless, are given to show that there was no great difference in volume recovery in any one method, although the overrun appears to be greatest for grade No. 3 logs in Methods 3 and 5, the 1/2-taper setout methods. Since log diameters and length may have some effect on volume recovery, no specific conclusions are warranted on overrun in this study.

Sawing Time

The character of the study did not permit making a sawing-time study. In view of this, a summary of the number of saw lines and log turns was made from the board-sawing-sequence diagrams for each log from each method. An analysis of the summary data did not indicate any appreciable differences either between methods or log grades. The data simply indicated that the larger the

[8] The clear cuttings for the most part are of smaller size in this grade than in log grade 1 because of the distribution of defects.

log, the greater the number of saw lines and turns. This was in line with what would be expected, because the only basic difference between methods from the standpoint of actual sawing was the placing of the log for the first sawing face.

Conclusions

The results of this study show sufficient trends to warrant the following broad conclusions:

1. When the relative position of defects on sawing faces is ignored, a loss results in potential lumber quality for any given group of reasonably straight factory-grade red oak logs.

2. The placement of sawing faces of logs so that the major defects come to the edges of sawing faces should result in higher quality lumber than when the sawing faces are placed with the major defects in the centers of the faces.

3. When taper is ignored, a loss can result in potential lumber quality.

4. Full-taper setout has a greater potential for producing higher lumber quality than 1/2-taper setout.

5. Lumber quality comparable to that obtained from sawing full-taper setout can be obtained from similar logs having opposite low quality and high quality sawing faces if the low quality faces are sawed first without setting out for taper. This has the effect of automatically putting the high quality faces parallel to the saw line, which results in production of the maximum number of full length boards from the high quality faces.

Additional Studies Indicated

This study does not contain the final answer for grade sawing. It is only a beginning of the search to find out the best way to saw so as to develop optimum lumber value from any given type and species of hardwood log. It was evident in reviewing the diagrams, data sheets, and the sawing patterns for individual logs from this study that logs having certain characteristics could possibly be sawed differently for better yield and that taper of the log within the same diameters appears to influence grade recovery as well as volume recovery. It also appears that logs having certain similar characteristics could possibly be grouped for a given sawing method. Logs having certain combinations of good and poor faces might be sawed by one method, whereas logs having unusual taper or having eliptical cross sections might be sawed by another. Sawing for combination of factory lumber and industrial stock, likewise, may require a modified method. Further study also appears to be needed on the effect of diameter on grade recovery. The study did not include logs with sweep in excess of 10 percent or logs with crook. These, too, may require a different method of sawing to get the highest value lumber.

Table 1.--Comparison of sawing methods in terms of average lumber grade yields and monetary values from all log grades combined

Method	Lumber grade yields								Lumber tally per log	Lumber value per 1,000 board feet	Overrun net scale (green)
	FAS	Selects	Total Selects and better	No. 1 Common	No. 2 Common	No. 3A Common	No. 3B Common	Total No. 3 Common			
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Board feet	Dollars	Percent
1	22	7	(29)	28	14	9	20	(29)	121	$98.15	-1
2	23	4	(27)	29	14	9	21	(30)	120	95.11	+4
3	22	13	(35)	23	14	16	12	(28)	88	104.06	+5
4	21	16	(37)	24	14	15	10	(25)	103	107.40	+5
5	20	10	(30)	28	16	10	16	(26)	106	99.24	+6
6	23	14	(37)	22	14	16	11	(27)	88	106.94	0

Table 2.--Comparison of sawing methods in terms of average lumber grade yields and monetary values for Grade No. 1 logs

Method	Lumber grade yields								Lumber tally per log	Lumber value per 1,000 board feet	Overrun net scale (green lumber tally)
	FAS	Selects	Total Selects and better	No. 1 Common	No. 2 Common	No. 3A Common	No. 3B Common	Total No. 3 Common			
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Board feet	Dollars	Percent
1	40	9	(49)	25	7	7	12	(19)	174	$124.90	-3
2	45	6	(51)	24	7	3	15	(18)	171	127.26	+8
3	39	17	(56)	19	8	12	5	(17)	133	132.15	+5
4	34	24	(58)	16	10	11	5	(16)	133	134.57	+5
5	35	15	(50)	22	10	11	7	(18)	139	125.65	+5
6	39	19	(58)	15	10	9	8	(17)	114	133.27	+4

Table 3.--Comparison of sawing methods in terms of average lumber grade yields and monetary values for Grade No. 2 logs

Method	Lumber grade yields								Lumber tally per log	Lumber value per 1,000 board feet	Overrun net scale (green)
	FAS	Selects	Total Selects and better	No. 1 Common	No. 2 Common	No. 3A Common	No. 3B Common	Total No. 3 Common			
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Board feet	Dollars	Percent
1	10	8	(18)	33	18	9	22	(31)	124	$83.39	-1
2	5	5	(10)	38	19	10	23	(33)	93	74.33	+6
3	9	15	(24)	31	21	11	13	(24)	67	92.08	0
4	18	12	(30)	31	13	14	12	(26)	102	100.74	+6
5	13	11	(24)	33	14	11	18	(29)	95	91.91	+4
6	16	16	(32)	26	14	18	10	(28)	78	100.71	-4

Table 4.--Comparison of sawing methods in terms of average lumber grade yields and monetary values for Grade No. 3 logs

Method	Lumber grade yields								Lumber tally per log	Lumber value per 1,000 board feet	Overrun net scale (green)
	FAS	Selects	Total Selects and better	No. 1 Common	No. 2 Common	No. 3A Common	No. 3B Common	Total No. 3 Common			
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Board feet	Dollars	Percent
1	4	2	(6)	23	21	15	35	(50)	76	$57.77	+6
2	0	1	(1)	29	22	19	29	(48)	96	61.05	-5
3	2	2	(4)	21	19	29	27	(56)	64	58.61	+10
4	2	5	(7)	28	24	25	16	(41)	76	68.87	+5
5	1	2	(3)	34	29	7	27	(34)	83	63.32	+10
6	4	6	(10)	27	22	25	16	(41)	73	72.14	0

Table 5.--Analysis of variance comparing methods and grades and their interaction

Source	Degrees of freedom	Sums of squares	Mean squares	"F" ratio
Total	377	455,563.18		
Deviation between methods	5	10,843.49	2,168.70	4.31**
Deviation between grades	2	260,464.37	130,232.18	258.81***
Interaction of methods and grades	10	3,101.65	310.16	.62 N.S.
Error of estimate	360	181,153.67	503.20	

** 5 and 360 degrees of freedom = 3.07 (0.01)

*** 2 and 360 degrees of freedom = 7.20 (0.001)

Table 6.--Comparison of sawing methods for all log grades combined by their mean dollar value indexes using least significant differences

Method →	Mean →	6	4	3	5	1	2
↓	↓	97.81	95.90	91.52	90.48	85.38	82.60
6	97.81	....					
4	95.90	1.91	....				
3	91.52	6.29	4.38	....			
5	90.48	7.33	5.42	1.04			
1	85.38	12.43**	10.52**	6.14	5.10	0	
2	82.60	15.21**	13.30**	8.92*	7.88*	2.78	....

*Least significant difference (0.05) = 7.86.

**Least significant difference (0.01) = 10.35.

Table 7.--Comparison of sawing methods for Grade No. 1 logs by their mean dollar value indexes using least significant differences

Method	Mean	4	3	6	5	2	1
		131.00	128.15	127.87	123.53	120.14	117.13
4	131.00	....					
3	128.15	2.85	....				
6	127.87	3.13	0.28	....			
5	123.53	7.47	4.67	4.34	....		
2	120.14	10.86	8.01	7.73	3.39	0	
1	117.13	13.87*	11.02	10.74	6.40	3.01	0

*Least significant difference (0.05) = 13.62.

**Least significant difference (0.01) = 17.93.

Table 8.--Comparison of sawing methods for Grade No. 2 logs by their mean dollar value indexes using least significant differences

Method	Mean	6	4	3	5	1	2
		98.16	90.69	90.18	85.58	81.70	72.67
6	98.16	....					
4	90.69	7.47	....				
3	90.18	7.98	0.51	....			
5	85.38	12.78	5.31	4.80	....		
1	81.70	16.46*	8.99	8.48	3.68	....	
2	72.67	25.49**	18.02**	17.51*	12.71	9.03	....

*Least significant difference (0.05) = 13.62

**Least significant difference (0.01) = 17.93.

Table 9.--Comparison of sawing methods for Grade No. 3 logs by their mean dollar value indexes using least significant differences

Method →	Mean →	6	4	5	1	3	2
		67.38	66.01	62.55	57.29	56.22	55.00
6	67.38	....					
4	66.01	1.37	....				
5	62.55	4.83	3.46	....			
1	57.29	10.09	8.72	5.26	....		
3	56.22	11.16	9.79	6.33	1.07	....	
2	55.00	12.38	11.01	7.55	2.29	1.22	....

*Least significant difference (0.05) = 13.62.

**Least significant difference (0.01) = 17.93.