A LOOK AT CENTERED VS. OFFSET SAWING

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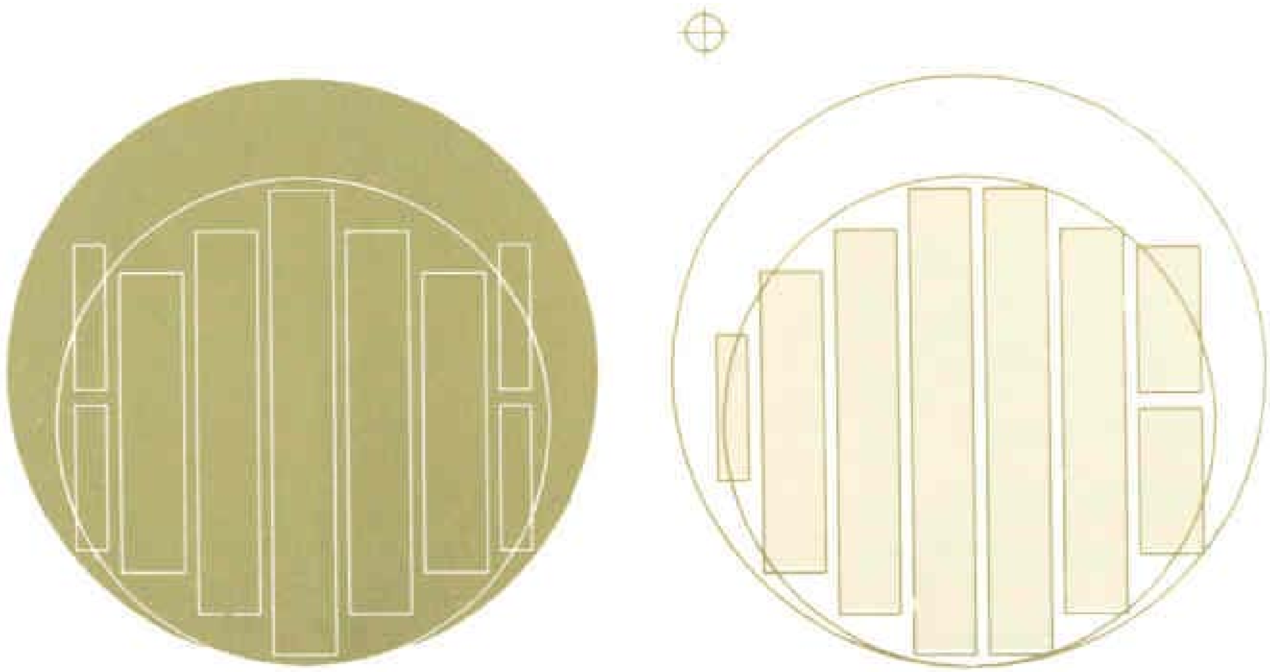

Abstract

The Best Opening Face (BOF) computer sawing program has been used to compare yield differences between four sawing systems with centered patterns and three systems where the pattern can be offset from the log center. The comparisons were made for softwood logs in the size range of 5.2- to 20.6-inch diameter, 8- to 24-foot length, and 1- to 5-inch taper per 16 feet. In ganeral, it was found that offset methods are best; yield differences between offset and centered methods are greater with live than with cant sawing. Complex interactions of diameter, length, taper and method which affect yield are reported. Findings show that clear knowledge of the nature of the log supply by management can result in processing decisions for higher yields. The study also shows that, for any given run of logs, the system with the most sawing method and pattern options, utilizing computer derived sawing solutions, will yield more lumbar.

A LOOK AT CENTERED VS. OFFSET SAWING

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Introduction

The yield of lumber obtained when logs were sawn is affected by two general types of factors. The first type includes commonly recognized factors such as kerf width, rough lumber target size, smallest lumber sawn, and the general slabbing and edging practice. The effect of these factors is predictable and logical, and is understood fairly easily. The second type, which includes sewing patterns, results from an interaction with log size and form, and is much less predictable. The effect of factors related to log conformation is not apparent from a casual consideration of the sawing patterns and the individual log factors.

The *B*est *O*pening *F*ace (BOF) computer program-–a mathematical sawing model **(1,2,4)**[2]-- was used to determine the effect of eight commonly used sawing methods on the volumetric yield of lumber when sawing small softwood logs into construction lumber. Results are reported in FPL 280 **(3).** All the sawing methods examined in that study were of the "offset" type, in which the sawline positions of the log or cant were not restrictad relative to the geometric centerline. The eight sawing methods examined in FPL 280 were:

1. Live, split taper
2. Live, full taper
3. Cant , split-taper-spilt-taper
4. Cant, full-taper-split-taper
5. Cant, split-taper-full-tape-fixed fence.
6. Cant, full-taper-full-taper-fixed fence.
7. Cant, split-taper-full-taper-variable fence.
8. Cant, full-taper-full-taper-variable fence.

The logs sawn by BOF ranged in diameter from 5 to 20 inches and in length from 8 to 24 feet, and had tapers of 1 to 5 inches per 16 feet of length.

The results from FPL 280 showed that, in general, logs sawn by any of the cant sawing methods gave higher yields than when live sawn. In addition, when cant sawing, logs 16 feet in length or shorter and with 3 inches or less of taper gave best

[1]Maintained in cooperation with the University of Wisconsin.

[2]Numbers in parentheses refer to literature cited at end of this report.

yields using one method[3] and the longer, higher taper logs by another.[4] In either case, some additional recovery resulted if a variable fence was used instead of a fixed fence when sawing the cant itself. Selecting sawing methods properly on an individual log basis when sawing a normal distribution of logs was shown to yield up to 6 percent more lumber than if all logs were sawn by the single poorest method.

Within the sawmilling industry are a fairly large number of small log mills that, because of their equipment, cannot offset the sawing pattern in relation to the geometric center of the log. This includes the common Scragg mills and a large proportion of the chipper-canter headrigs. In these mills, the log is more or less centered either in a trough, in the arms of a "Y" lift, or, with many of the chipper canters, in an alligator chain or centering rolls. In most cases, this results in applying the sawing pattern at the first breakdown station in such a way that the respective sawlines we equidistant from the log center.

In these mills, the log is sawn with the taper equally divided on both sides of the sawing plane at the first breakdown station. Sawing methods may be either or cant, with the cant more common. Thus, the centered patterns closely parallel those methods:previously studied in which the first breakdown of the log is in the split-taper mode. The Important difference is that the sawing pattern is fixed in relation to the center of the log in one case but is allowed to move to the left or right in the other.

This study reports the affects on lumbar yield when centered sawing patterns are used as compared with offset patterns under otherwise duplicate conditions. Also investigated is the interaction of log diameter, length, and taper with the yield differences. In addition, the centered sawing methods are compared.

Procedure

Of the eight methods previously listed and used in the offset study, only four are possible in the centered mode. Those four in which the initial lop breakdown is full taper do not lend themselves to the centered mode, and, hence, are eliminated. The four centered systems chosen for study follow, along with the comparisons made tc systems in reference **(4)** (see fig. 1):

System Studied	Compared to--
1. Live, centered flitch (live CF)	Live, spllt-taper (live ST)
2. Live, centered flitch or centered sawline (live CFGS)	Live, spllt-taper (live ST)
3. Centered cant, full-taper fixed fence (CCFTF)	Cant, split-taper-full-taper fixed fence (STFTF)
4. Centered Cant, full-taper variable fence (CCFTV)	Cant split-taper-full-taper variable fence (STFTV)

Pattern 2, live CFCS, differs from the others because one offset position is allowed. Either the centerline of a flitch or the center-line of a saw kerf may be placed at the center of the log end. These two situations result from offsetting either pattern one-half the combined thickness of a flitch and a kerf. The overall sawing pattern remains "centered" in either case.

[3]Cant, full-taper-full-taper.

[4]Cant, split-taper-full-taper.

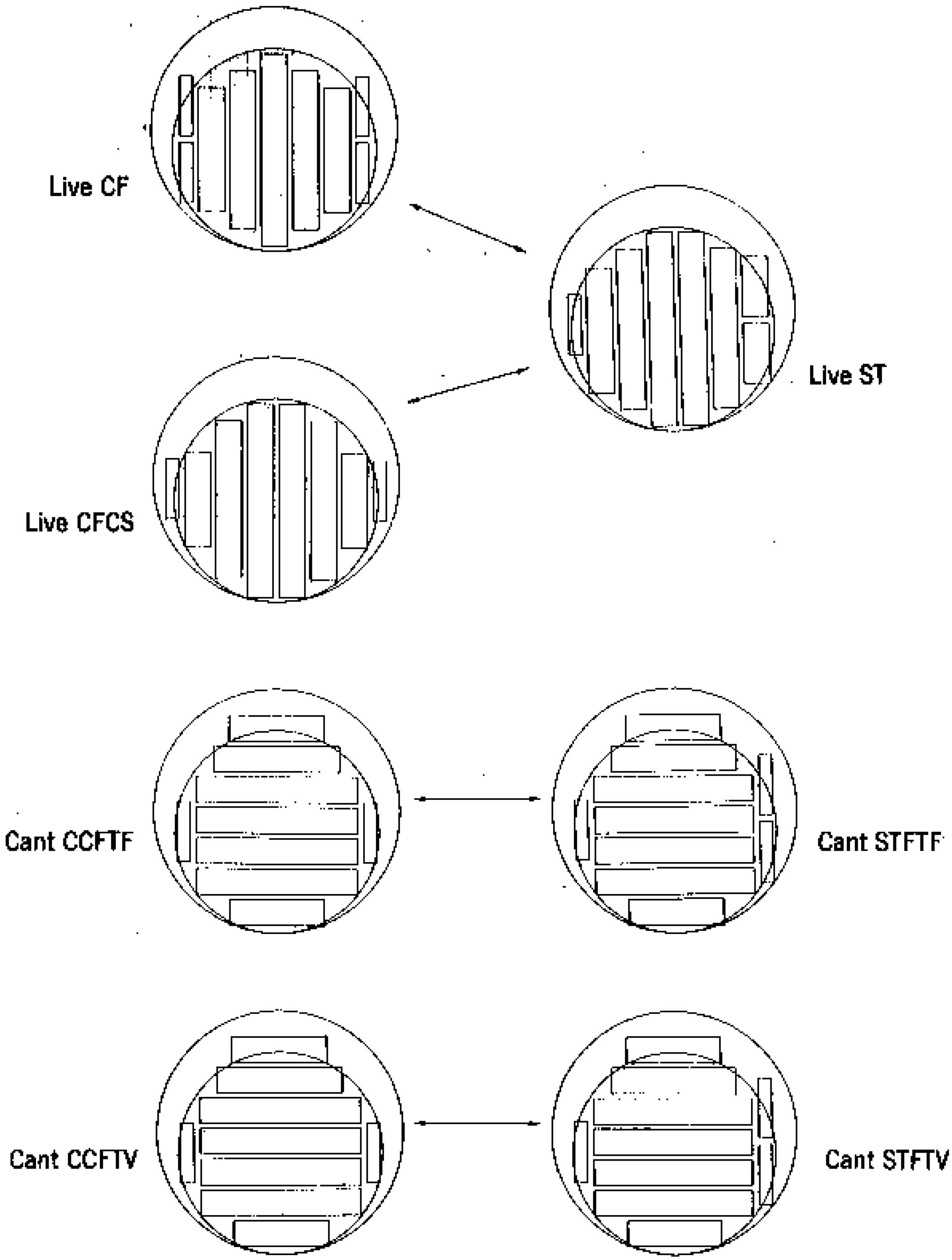

Figure 1.--The four centered sawing methods and the three counterpart offset methods with which they are compared.

(M 146 395)

The logs studied were of a size commonly converted to softwood dimension lumber in so-called “small log” mills. They ranged in diameter from 5.2 to 20.6 inches by 0.2-inch increments; in length from 8 to 24 feet by 2-foot increments; and in taper from 1 to 5 inches per 16-foot length by 1-inch increments. All of the 3,510 possible log combinations were computer-sawn, using the BOF mathematical model, by each of the four center sawing methods. Yield data for the three offset methods was taken from FPL 280 **(3).**

Conditions specified in the BOF simulation were as follows: All lumber was edged full length of the flitch allowing a maximum of 25 percent wane according to the National Grading Rule[5]. The smallest piece of lumber sawn was 4 inches wide and 8 feet long. The setting increments were 1/16 inch. Headsaw kerf (vertical) was 0.165 inch. Cant breakdown Kerf (horizontal) was 0.134 inch. Sawing variation ranged from 0.063 to 0.125 inch (table 1). When sawing with a fixed fence on full-taper sawn cants, the BOF program positioned the fence for 4-inch and 6-inch cants such that a nominal 4-inch by 8-foot face with maximum allowable wane would be produced if the cant had come from a log of 4.6 inches in diameter. On cants 8 inches and larger, the fence position was such that the 4-inch by 8-foot face would be produced if the cant had come from a log of 8.8 inches in

[5]The National Grading Rule for Dimension Lumber is an industry standard and is published in all Softwood Grading Association rule books. An example is: Grading Rules for Western Lumber, 2nd Edition, pages 67 to 102 (published by the Western Wood Products Association).

Table 1.--Lumber sizes and sizing factor values

Dimension	Nominal	Dry dressed	Dressing allowance[1]	Shrinkage[2]	Sawing variation[3]	Rough green
			In.			
Thickness						
	1	0.750	0.121	0.027	0.063	0.960
	2	1.500	.098	.049	.063	1.710
Width						
	4	3.500	.153	.113	.109	3.875
	6	5.500	.153	.175	.109	5.938
	8	7.250	.146	.229	.125	7.750
	10	9.250	.147	.291	.125	9.813
	12	11.250	.148	.352	.125	11.875

[1] Dressing allowances vary because of the necessity of having rough green thickness plus one kerf be a multiple of the 1/16-in. setting increments. In the case of widths, the width (without kerf) must be a 1/16-in. multiple. Wood added to obtain the 1/16-in. multiple is removed in the dressing operation.

[2] Shrinkage of 3 percent was allowed from rough green size after subtracting the sawing variation.

[3] Arbitrarily chosen to represent a good milling operation.

diameter. These two log diameters are the smallest that will produce an acceptable 4-inch and 8-inch cant with the sawing conditions used.

Both 4/4-inch and 8/4-inch lumber were cut in the vertical plane. However, for split-taper, the 4/4 was limited to the first cut on the log and possibly the last cut, if in so doing the recovery was higher than would result from 8/4. All other lumber was 8/4. 6,8,10, and 12 inches. The actual widths and thicknesses cut, together with dressing allowances, shrinkage, and sawing variation, are shown in table 1.

Widths cut were nominally 4,6,8,10, and 12 inches. The actual widths and thicknesses cut, together with dressing allowances, shrinkage, and sawing variation, are shown in table 1.

When cant sawing the centered methods, the BOF program was limited in the cant size it selected. This differed from the previous offset study in which the BOF program selected the best cant size after trying all possible sizes in relation to the log diameter. Limiting the cant size was judged to more nearly duplicate mill conditions in center-only sawing systems cutting small logs where the largest cant possible from the log is usually made. Cant site was specified in relation to the log size so that 4- and 6-inch cants had to yield at least two pieces of 814, while 8-, 10-, and 12-inch cants had to yield at least 3 pieces of 814.

Results

General

The total board feet of lumber that would result for each method from sawing one log each of all study combinations is shown in table 2. Also shown is the percentage difference between the centered methods and their comparable offset methods. In all cases the offset methods recover more lumber. The difference is least (1.20 pct) between live CFCS and live ST and greatest (3.75 pct) between CCFTF and STF-TF. Note that these differences are the average for a flat distribution of all logs sawn and tend to screen substantially greater differences that exist within the diameter, length, and taper ranges to be discussed later.

The “best” values shown in table 2 for centered and offset patterns indicate the total board feet that would result if each log were sawn by whichever sawing pattern in each category gives the highest yield. The difference between “best” for offset and “best” for centered patterns is 3.59 percent in favor of offset patterns.

Specific results which follow are subdivided into three sections. The first compares the centered systems in relation to diameter and to length separately at each level of taper. The second compares related centered and offset systems in relation to diameter and to length by taper classes. The third looks at the effect of the interaction of diameter and length by taper classes on yields when using related centered and offset patterns.

Centered Systems

Diameter

Figure 2 compares expected yields with respect to diameter and taper (length pooled) for two situations: (1) each of the centered patterns is used alone; (2) the mill is mechanically restricted to centered patterns but can select the best centered pattern for each log on an individual log basis. The data have been combined into 2-inch diameter classes and only the data that fails within these classes--6 through 19.0 inches– is shown.

Generally, the cant sawing methods are substantially better at the lower diameters, with their margin of superiority lessening as taper increases. At the highest tapers of, 4 and 5 inches, live sawing methods tend to be better for diameters in the 12- to 16-inch range. However, above this diameter range the cant sawing method again ·attains superiority, although by a much narrower margin. The general decline of cant sawing superiority in relation to “best” with increase

Table 2.--Yield in board feet of all logs when swn by four centered and three offset sawing methods[1]

Sawing method				
Centered		Offset		Increase with offset method
Method	Yield	Method	Yield	
	Fbm		Fbm	Pct
Live CF	714824	Live ST	734592	2.77
Live CFCS	725901	Live ST	734592	1.20
CCFTF	730772	STFTF	758193	3.75
CCFTV	736744	STFTV	762093	3.44
Best[2]	742351	Best	769013	3.59

[1] Yield totals are based on assuming a flat distribution of one each of all combinations of diameters and lengths.

[2] "Best" is the sum of all logs when the highest yield for each log attained by any method is used.

in taper really indicates the increased performance of live sawing with higher taper. This, in turn, is due to the recovery of additional short narrow lumber from the tapered edging when highly tapered live sawn boards are edged.

Being able to select the best sawing method on an individual log basis is particularly important for small logs. In the 6- to 10-inch diameter and lower taper (1-3 in.) range of logs, using only live sawing methods results in a 5 to 15 percent reduction and using only cant sawing methods lowers possible yield by 1 to 4 percent.

Length

The effect of length and taper (diameter pooled) on each of the centered patterns is compared in figure 3 to the milling situation where each individual log could be sawn by its "best" method.

At tapers of 1 and 2 inches, cant sawn logs consistently yield more total lumber than if live sawn. However, as taper increases the interaction of length, taper, and the live sawing system alter this trend. This again is a result of the extra piece of small lumber recovered from the edging containing the flitch taper, a situation resulting especially when live sawn lumber is edged. Thus, yields decline with live versus cant sawing as length increases until the combination of length and taper produces a sufficient edging. This point is at the shortest length in logs with the highest taper (12 feet at 5 in. taper) and at the longest length at low taper (20-22 feet at 2 in. taper). The effect of the decline in the geometric fitting problem is evident at the longest length with the high tapers. The decline occurs because length combined with taper makes a substantial

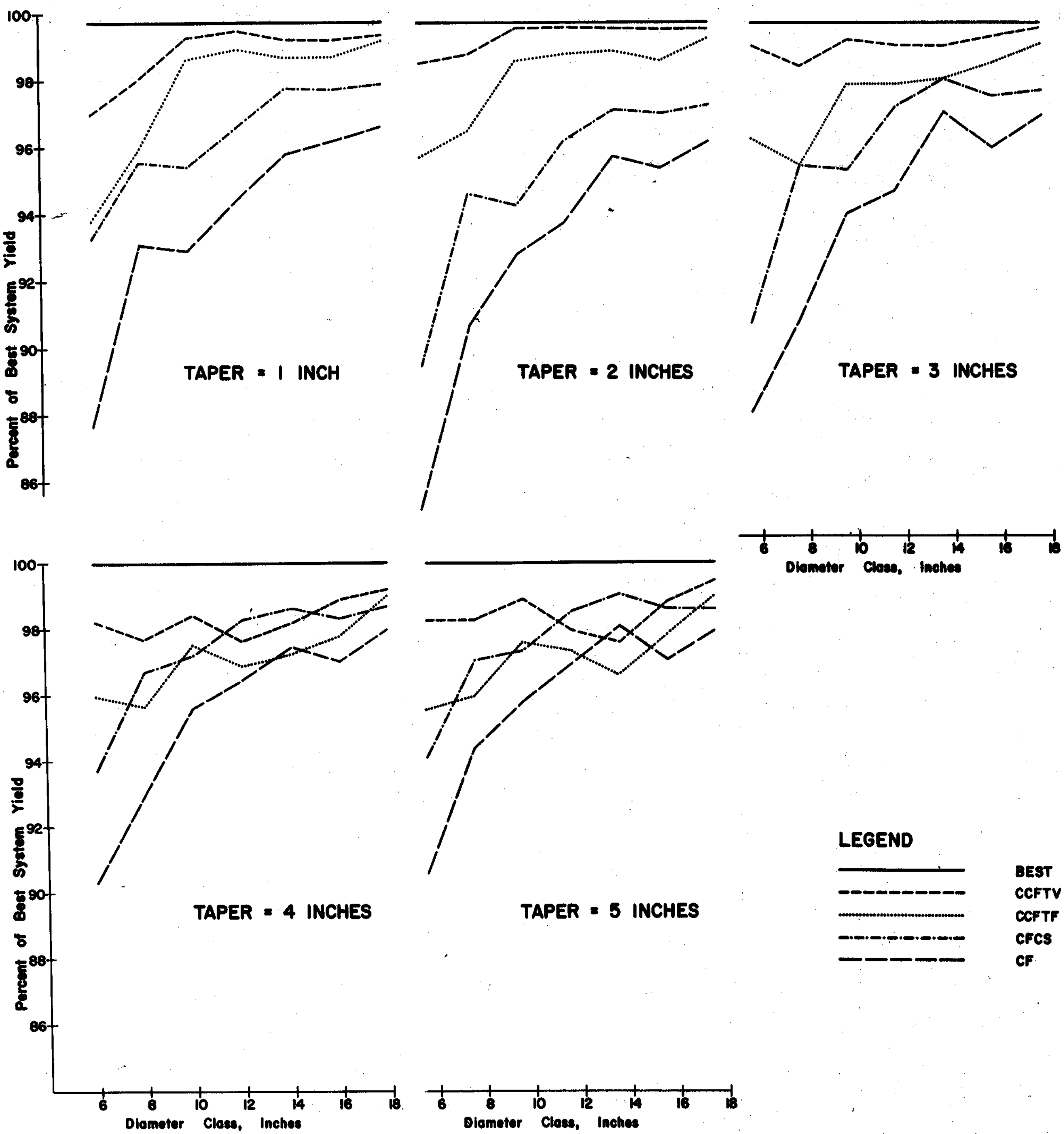

Figure 2.--The effect of diameter on yield by taper classes for the centered methods when all lengths are pooled. "Best" is the yield resulting from using the best mix of all four methods.

(M146 510)

segment of the log appreciably larger in diameter than its small end. This shows up in a trend for all methods to converge: for example, with 5 inches taper the difference between live CFCS and CCFTF declines from 3.4 percent at 20 feet to 1.8 percent at 24 feet.

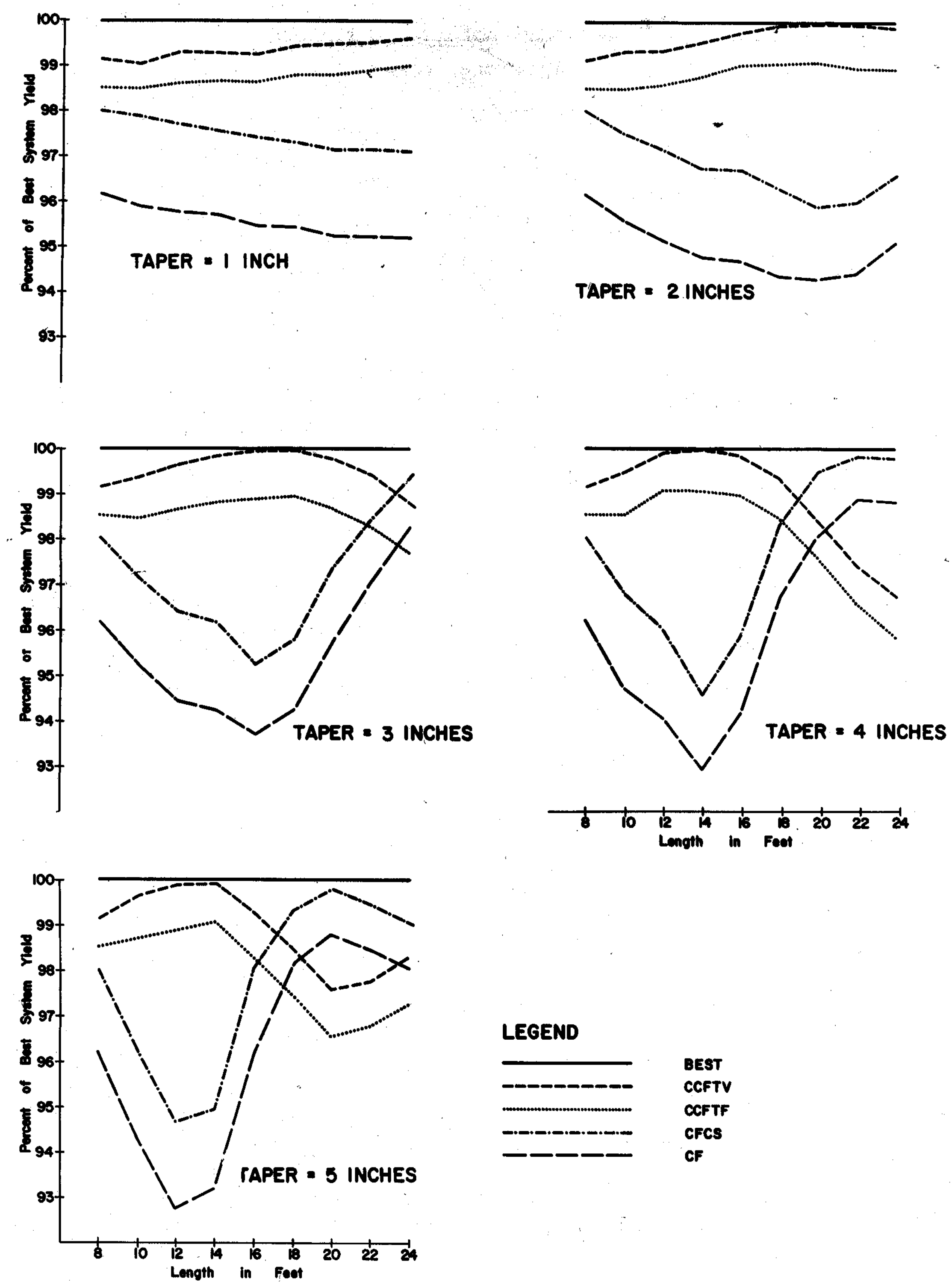

Figure 3.--The effect of length on yield by taper classes for the centered methods when all diameters are pooled. "Best" is the yield resulting from using the best mix of all four methods.

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Offset Vs. Centered Systems

Diameter

The yield difference between the offset and center sawing patterns as related to log diameter and taper (all lengths pooled) is shown in figure 4.

The margin of superiority of the offset vs. centered patterns tends to decline rather sharply as log diameter increases. The rate of this decline is highest in low taper logs in the live ST vs. live CF comparison and lowest in low taper cant STFTV vs. cant CCFTV. The increasing problem of geometrical fit of the lumber in the log as diameter decreases is clearly emphasized by the increasing superiority of the offset patterns. These patterns have the latitude to adjust themselves to optimum fit while the centered patterns do not.

Taper appears to affect the difference between centered and offset patterns oppositely in cant and live sawing. In live sawing, differences tend to decline with increase in taper, whereas for cant sawing they increase. The explanation for this is not immediately obvious and would require detailed geometrical plotting which was not within the scope of this study. The effect of taper is no doubt related to recovery of lumber in two planes with cant sawing and only one in live sawing. It is also related to the relative curvature of the large end of the log and the fact that cant sawing is better able to take advantage of the decreased curvature on the large end of high taper logs. Additional complications relate to specified cant sizes in centered patterns and best cant sizes in offset patterns.

Length

Differences in yield between offset and centered sawing patterns are shown in figure 5 as related to length and taper (all diameters pooled). The margin of superiority of offset over centered patterns tends to increase with length for cant sawing but to decrease for live sawing. This superiority is substantially greater for cant than live sawing.

For both cant and live sawing, taper has almost no effect in logs shorter than 12 feet for high tapers and 14 or 16 feet for the lower tapers. This results from an 8-foot minimum length limit interacting with the degree of taper. As taper increases, the potential of getting at least an 8-foot piece from flitches developed outside the small end diameter increases. For the tapers studied, this piece outside the small end diameter is seldom recovered from logs less than 12 feet in length. A close look at the curves for cant sawing shows this critical length to be 12 feet for 5-inch taper, 14 feet for 4-inch taper, 16 feet for 3-inch taper, 20-22 feet for 2-inch taper and more than 24 feet for 1-inch taper. The same general response, but in the other direction, is evident for live sawing, but the breaks in the curves are not as well defined.

As in the diameter analysis, the difference between yields from offset sawing and centered sawing is greater with decreases in taper for live sawing and with increases in taper for cant sawing. Reasons for this are believed to be the same as given for similar trends in the diameter analysis.

Suppose that the interacting effects of different cants--specified cant sizes in centered patterns and best cant sizes in offset patterns--were removed. If so, the general response' of yield to length and taper probably would approach the response for live sawing because live sawing does not include these effects.

Note also the apparent tendency of the yield differences between offset Sawing and centered sawing to reach a maximum and then decline. The maximum yield difference occurs at shorter lengths for the higher taper. This phenomenon is no doubt related to the decreasing problems of fit as diameters increase. Finally, a point is reached where the differences due to offset vs. centered patterns are overshadowed by the increased diameter of the log at its larger diameter section.

Diameter, Length, Taper–Centered vs. Offset Interaction

The interaction between the various factors illustrated in figures 2 through. 5 is clearly complex. These figures have shown the effects of diameter, length, taper, and sawing method and patterns on yield. Although the trends are usually explainable, they are not easily predicted beforehand.

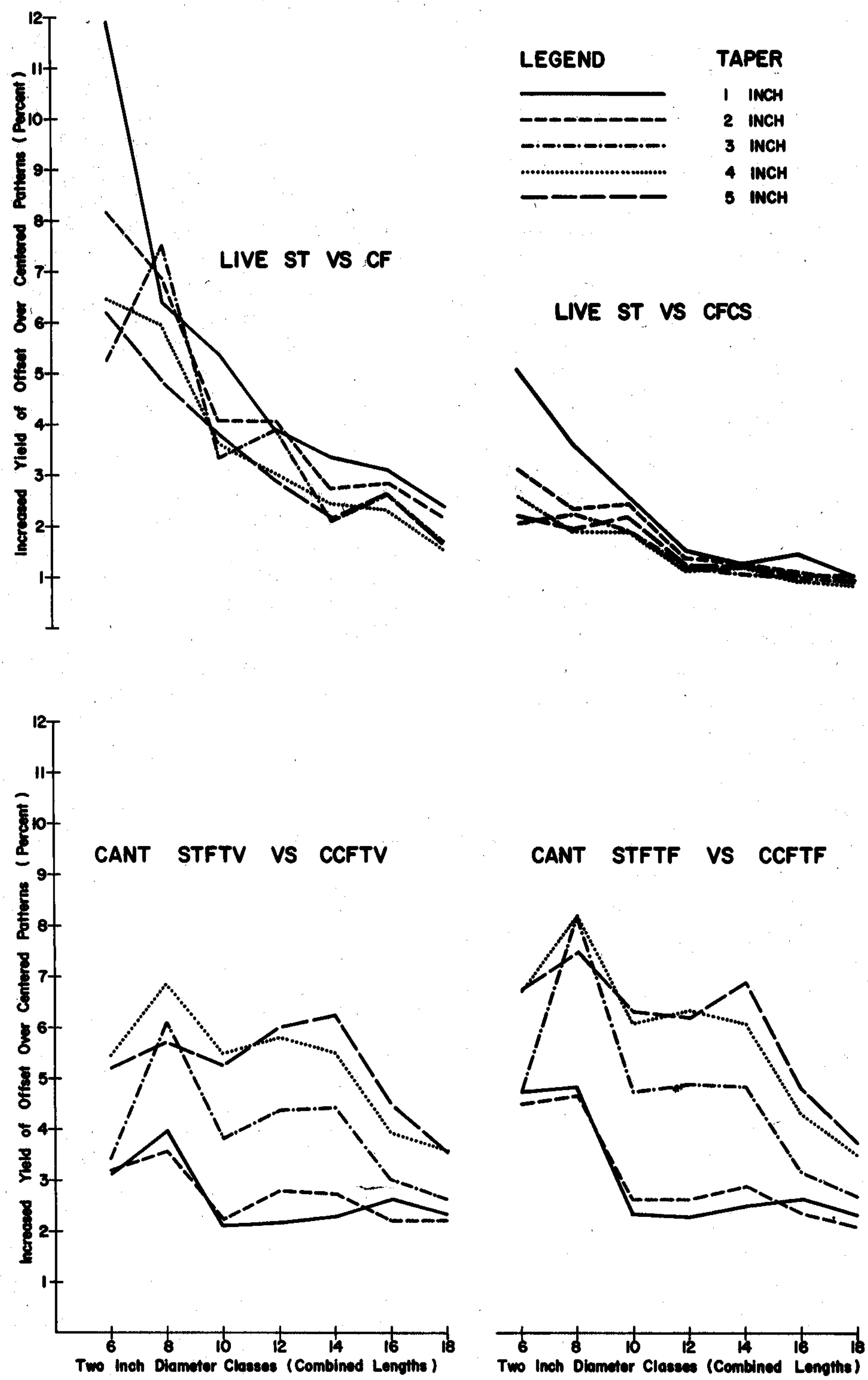

Figure 4.--The effect of diameter and taper on the difference in yield between four centered sawing methods and their comparable offset methods.

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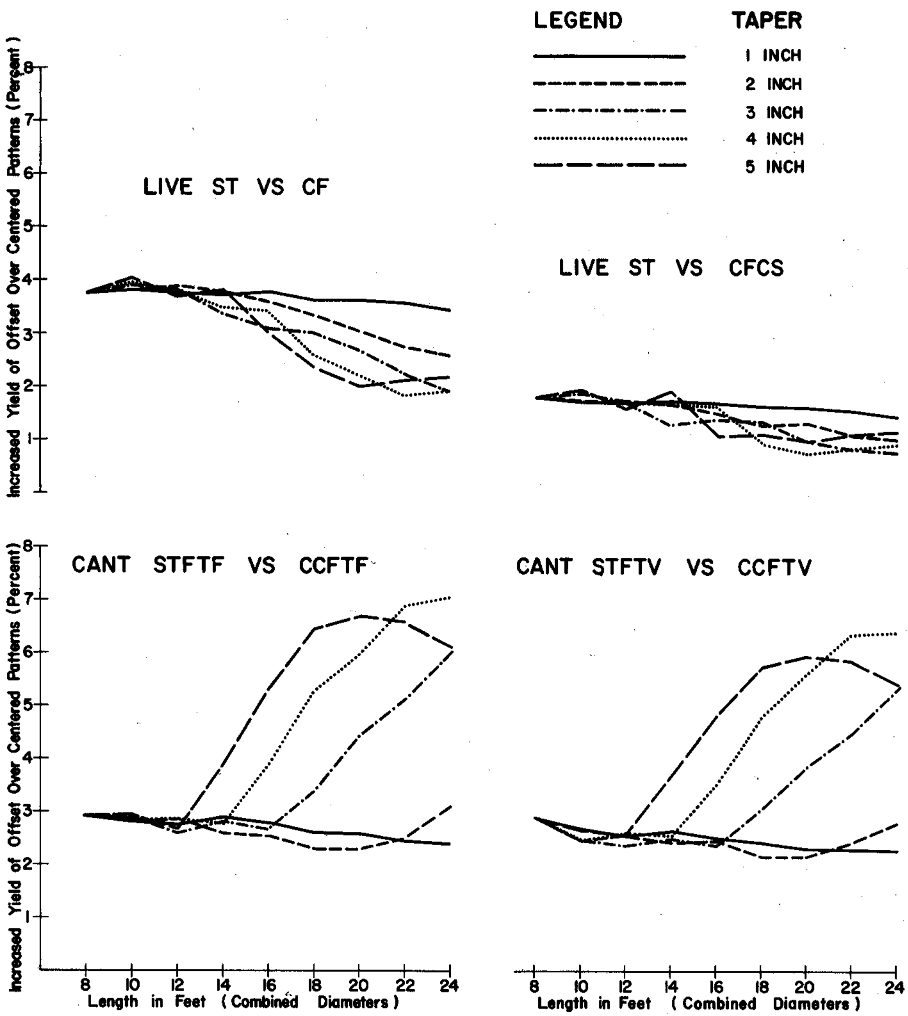

Figure 5.--The effect of length and taper on the difference in yield between four centered sawing methods and their comparable offset methods.

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The differences in yield between centered and offset patterns for all factors combined are shown by the three-dimensional plots in figures 6,7,8, and 9.

All of these figures have the same general format. The two horizontal axes (x and y) represent the diameters and lengths. The vertical axis is the percent improvement of the offset methods over the comparable centered method. The difference in yield is plotted as a point for each diameter and each length. These points are then connected with a line for each diameter and length class. The result is a response plane, topographic in nature, which represents the interaction between diameter and length on the difference in yield. Each taper. class has a separate graph.

Figures 6 and 7 are for live sawing methods and have similar topography of the response plane. However, the yield increase from using offset patterns rather than centered patterns is substantially higher for live CF vs. ST (fig. 6) than for live CFCS vs. ST (fig. 7). Although there are several exceptions, in general differences in yield increase 'with decreasing diameter and length. Also, to be able to choose either a centered sawline or centered flitch as opposed to being forced into a single centered pattern produces a substantial improvement in recovery.

The topography of the response planes for the difference in yield between cant sawing CCFTF and STFTF (fig. 8) and cant sawing CCFTV and STFTV (fig. 9) are also very similar, with differences in figure 8 a little greater.

Generally speaking, the superiority of offset patterns in cant sawing increases with decreasing log diameter. There is a definite interaction between length and taper. At low (1 in.) taper and small (6-10 in.) diameters the difference in recovery tends to increase with decreasing length. However, as taper increases, yield differences increase substantially for the long and the short logs but only slightly for the logs in the 14 to 18 foot range.

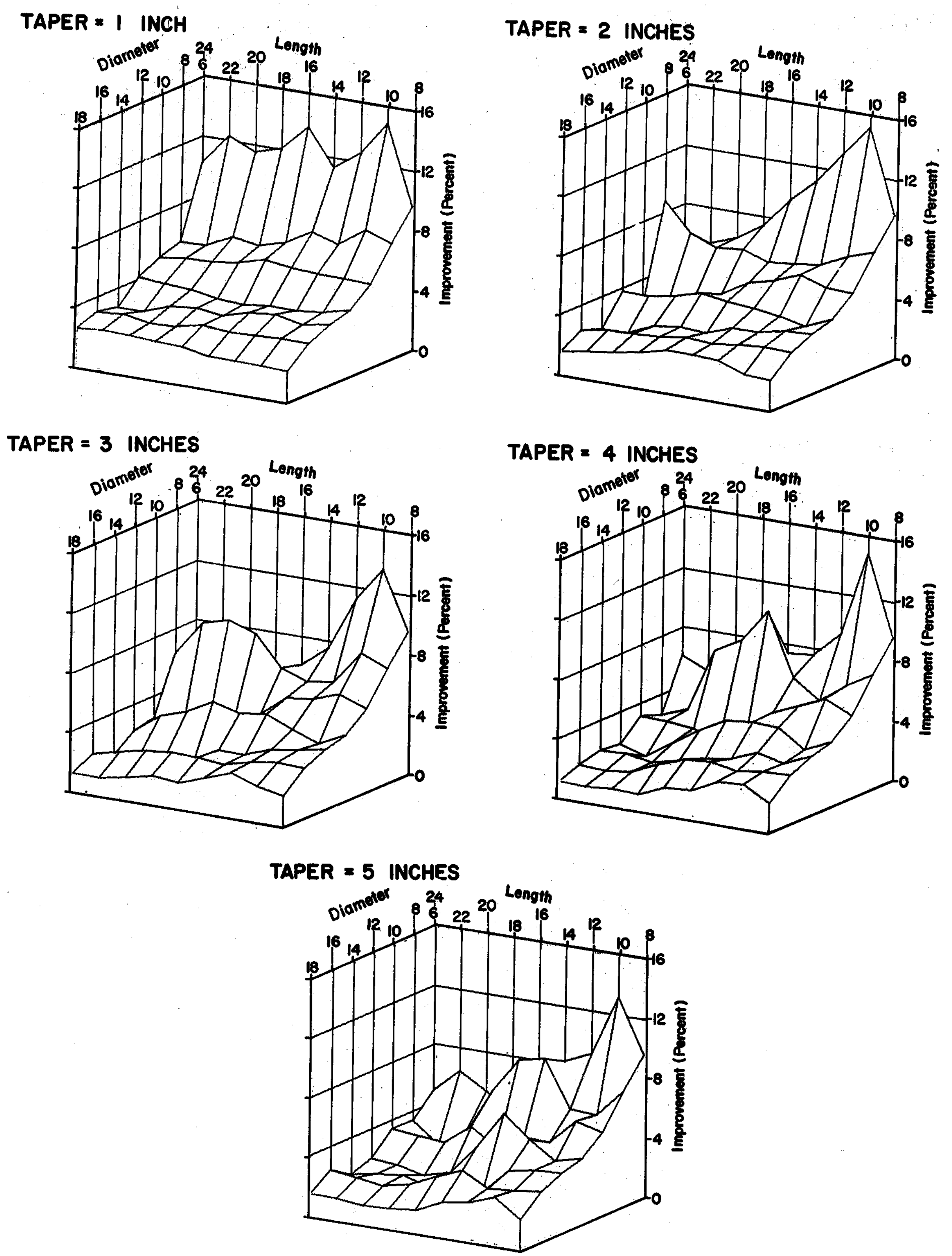

Figure 6--The interaction between length, diameter, and the difference in yield between live ST and live CF sawing methods by taper classes.

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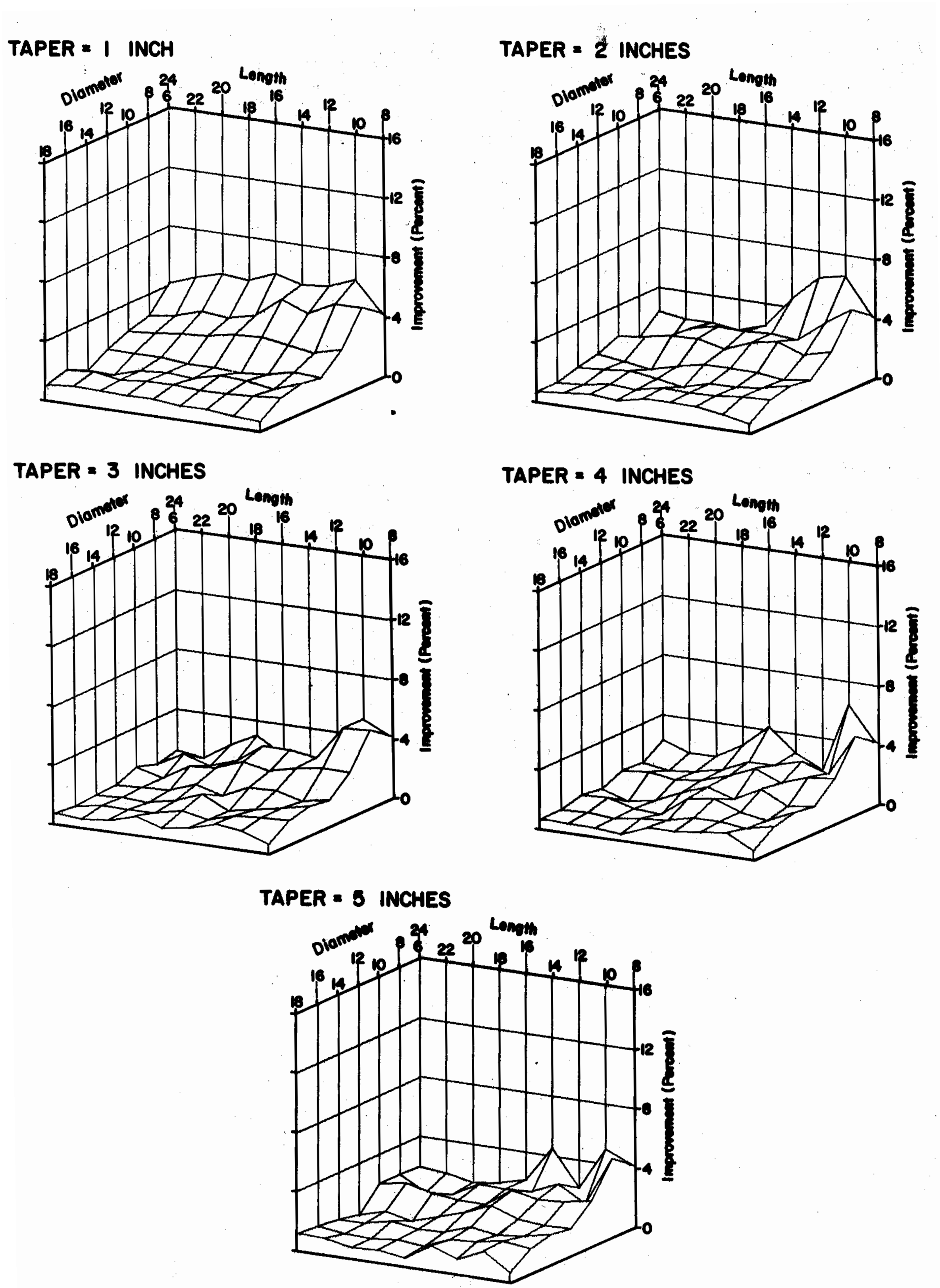

Figure 7.--The interaction between length, diameter, and the difference in yield between live ST and live CFCS. (M 146 506)

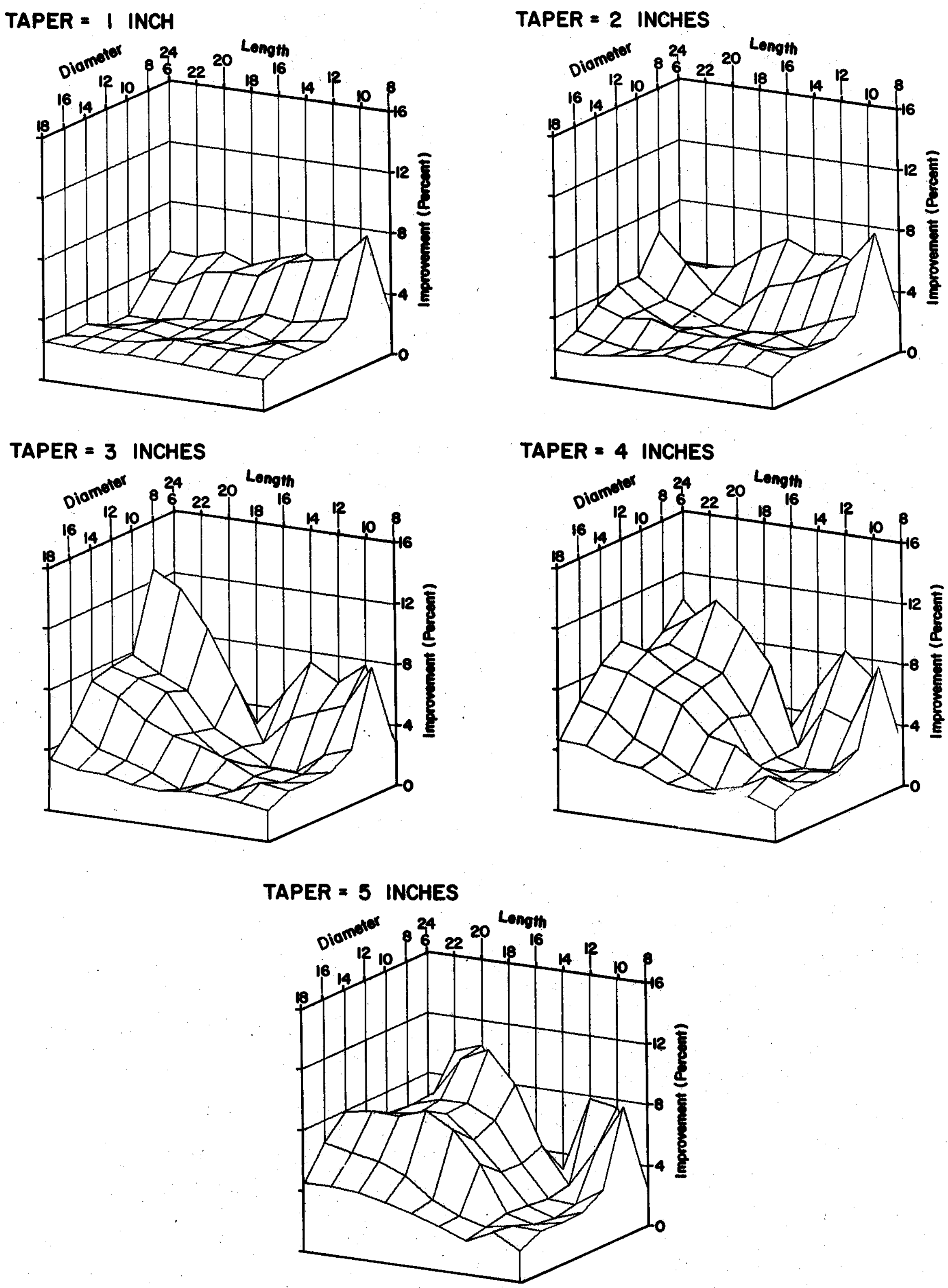

Figure 8.--The interaction between length, diameter, and the difference in yield between cant STFTF and cant CCFTF sawing methods by taper classes. (M 146507)

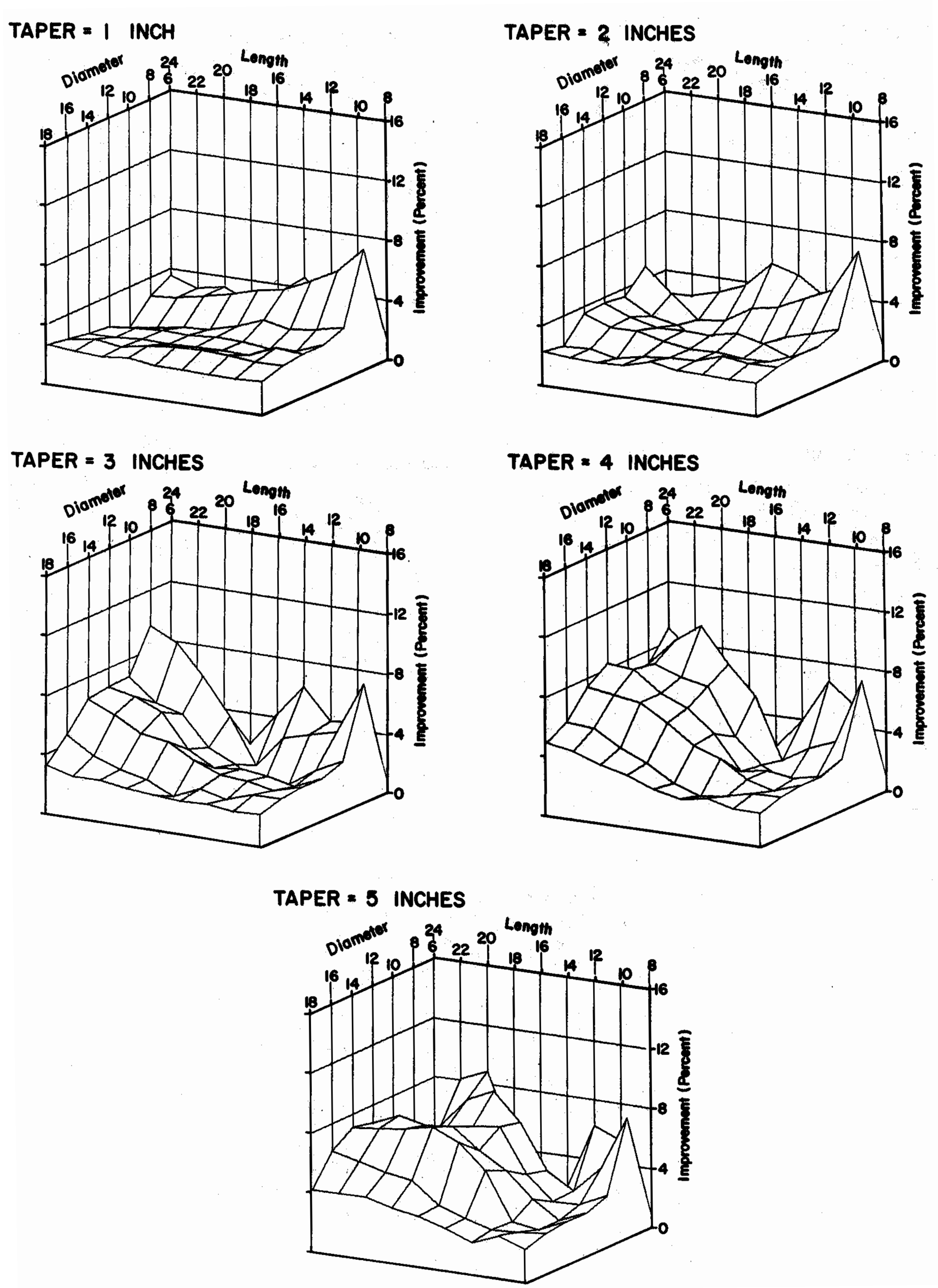

Figure 9--The interaction between length, diameter, and the difference in yield between cant STFTV and cant CCFTF sawing methods by taper classes.

(M 146 508)

Discussion

This work suggests the importance of knowing, in reasonably precise terms, the nature of the log supply if the results are to be used in the decisionmaking process by mill management. For example, if little is known, one might assume that the values shown in table 2 (an average derived from a flat log distribution) could be used to decide the advisability of changing from centered to offset sawing patterns. However, these averages result from one log each of all combinations of diameter, length, and taper. Such averages become heavily biased in the direction of the very small difference for the larger log. This bias is due to very low differences between offset and centered methods for the longer, larger logs and is also because these logs may individually contain up to 10 times the volume of the smaller, shorter logs. A glance at table 2 shows these average differences to be in the range of 1.20 to 3.75 percent.

If, in fact, the log supply is in the typical range of 5 to 15 inch diameter and 8 to 16 foot length with a concentration of 6 to 11 inch, 14 and 16 foot logs, the probable difference between yields by offset vs. centered sawing patterns is between 5 and 10 percent. Clearly, the investment justified for a 5 to 10 percent yield increase is substantially greater than for a 1.2 to 3.75 percent increase.

A review of the results summarized in figures 4 and 5 points up the substantial increases possible in a centered sawing operation if several centerzd options are available, compared with the much more common situation where the mill is locked into a single system. Depending on the log size distribution, this might easily fall in the 3 to 10 percent range.

All the results emphasize the maximum recovery cannot be realized unless the proper sawing method and pattern is used to saw every log on an individual basis. There simply is no best method for all logs, although within certain ranges of diameter, length, and taper a single method may be consistently better than others. In any given run of logs, the system with the most sawing method and pattern options, equipped with properly operating sawing equipment, and utilizing computer derived sawing solutions, will yield more lumber.

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