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Dimension Yields From Yellow-Poplar Lumber

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Abstract

The available supply of yellow-poplar *(Liriodendron tulipifera* L.), its potential for new uses, and its continuing importance to the furniture industry have created a need to accumulate additional information about this species. As an aid to better utilization of this species, charts for determining cutting stock yields from yellow-poplar lumber are presented for each of the five top grades. Adjustment charts present the changes for specified width cuttings, also by grade. Yield and cost comparisons are made for various grades and grade mixes, with a case study used for illustration. The data should aid manufacturers by making possible comparison of study yields with actual mill yields, comparison of various grade yields with one another, and the evaluation of grade mixes for most efficient production of cutting bill.

Keywords: Yellow-poplar, *Liriodendron tulipifera* L., cutting yields, lumber grades, lumber utilization, simulation.

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Dimension Yields from Yellow-Poplar Lumber

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Introduction

The available supply of yellow-poplar *(Liriodendron tulipifera* L.), its potential for new uses, and its continuing importance to the furniture industry have created a need to accumulate additional information about this species.

The objective of this report is to provide users of yellow-poplar lumber with information on cutting yields by lumber grade. These data may be used for management control and for facilitating selection of the most economical grade or grade mix for specific cutting orders. The information is presented in the form of charts for calculating yields of various combinations of dimension sizes from each of the hardwood lumber grades.

Based on forest survey data and the forest resource reports, it has been estimated that the annual growth for yellow-poplar is 620 million cubic feet. The annual removal rate has been estimated at 234 million cubic feet, with mortality of 21 million cubic feet. This indicates that the current rate of harvest could more than be doubled (Boyce and McClure 1978).

The development of particleboard as a core material greatly reduced the use of yellow-poplar lumber in the furniture industry. In 1953, about 135 million board feet of yellow-poplar (38 percent of the total lumber usage) was used by the North Carolina furniture industry. In 1968, about 55 million board feet was used. The manufacture and use of particleboard in the furniture industry increased 40 percent, nationally, from 1965 to 1970 (Smith 1978).

Yellow-poplar, however, is still very important to the industry and should not be underestimated. A review of hardwood lumber requirements reported biennially by members of the Southern Furniture Manufacturers Association from 1974 to 1981 revealed that this species represented an average of 22.8 percent of the total hardwood requirements for the reporting companies (SFMA n.d.). Millwork firms, picture frame producers, wooden toy manufacturers, and many others are increasing their yellow-poplar usage.

The yellow-poplar yield data contained in this report were collected and are presented in a manner similar to previously published work on hard maple, black walnut, and alder (Englerth 1969; Schumann 1971, 1972; Schumann and Englerth 1967a, 1967 b). The computer programs developed to process the measurement data and calculate lumber yields are described in two earlier reports (Dunmire and Englerth 1967; Wodzinski and Hahn 1966). To maintain continuity in this series of dimension cutting yield studies, the same cutting sizes and sawkerfs were used as in the previous reports. For this reason, maximum cutting lengths are limited by grade to: First and Seconds (FAS), 96 inches; First and Seconds One Face (FAS1F), 96 inches; No. 1 Common, 80 inches; No. 2A Common, 40 inches; and No. 2B Common, 40 inches. Although other research (Araman 1979; Lucas 1973; Lucas and Araman 1975) has demonstrated the feasibility of recovering longer lengths from the No. 2A and 2B Common grades--especially sound or character-marked cuttings--these were not considered in this study.

The yields calculated by the computer program are not necessarily the maximum attainable from any individual board. Rather, the program simulates a highly skilled operator who can make constantly good decisions on where to place the saw lines. The cutting yields should be possible to achieve in a well-run rough mill.

Materials and Methods

The lumber for this study was obtained from three sources to represent a geographical range. Approximately one-third of the sample came from West Virginia, one-third from western North Carolina, and one-third from eastern North Carolina. A total of 1,084 4/4 boards with a volume of 8,322 board feet provided the data for this report (table 1). National Hardwood Lumber Association (NH LA) grades for yellow-poplar included in the study were FAS, FAS1F, No. 1 Common, No. 2A Common, and No. 26 Common (NHLA 1974). Below-grade or No. 3 Common boards were dropped from the study. Since the industry seldom specified yellow-poplar saps or selects, these grades were not included in the study. All of the lumber was kiln-dried.

The sample boards were dressed two sides by abrasive planing to a final 15/16-inch thickness. This dressing provided a better opportunity to distinguish the defects in the board samples. An NHLA inspector graded each board after it was dressed, and the board number and board footage scale were recorded.

Defects were coded as to type (table 2) and recorded for size and kind by the use of a grid-mapping table (fig. 1). The table had an end stop at one end to establish a starting or zero position. The two long, parallel sides were marked in 1/4-inch increments from 0 to 800 to accommodate boards up to 16 feet 8 inches long. The table was constructed to accommodate boards up to 18 inches wide. A T square was marked in 1/4-inch increments to measure across the width of the board. The board size and defect sizes and locations were recorded for each board, first on the poor face and then on the good face. The boards and each of their defects were described as rectangles, using the lower left corner Y-X coordinates (Y = width direction; X = length direction) and the upper right corner Y-X coordinates for description. For

Table 1.—Number, board measure, and average width and length of 4/4 yellow-poplar boards by lumber grade to obtain yields

Grade	No. of Boards	Volume	Average width	Average length
		Board feet	*In.*	*Ft.*
FAS	59	513	7.7	13.8
FAS1F	13	1,197	8.0	13.5
No. 1C	314	2,324	6.7	13.2
No. 2A	374	2,880	6.8	13.7
No. 2B	204	1,408	6.4	13.0
Totals	1,084	8,322		

Table 2.—Classification of defects that may or may not be permitted on the clear and sound faces of clear one-face yellow poplar cuttings

Code	Defect	Clear Face[1]		Sound Face[1]	
		Go	No go	Go	No go
B	Bark pocket		–	[2]1-4	5
BL	Burl	+		+	
BL & C	Burl and check		–	+	
BP	Bird peck		–	1-4	5
C	Surface checks		–	+	
CW	Callus wood	+		+	
CB	Cross break		–		–
CG	Cross grain (if slope is less than 1 in 8)	+		+	
D	Distorted grain	+		+	
DH	Dog hole		–		–
DM	Mechanical damage		–		–
E	End trim--checks and other defects		–		–
EC	End check--up to 4 inches		–		–
FN	Felling notch		–		–
FT	Felling tearout		–		–
H	Heartwood	+		+	
HL	Holes, large worm		–	3-4	5
HM	Holes, medium worm		–	1-2	
HP	Holes, pinworm up to 1/16 inch		–	+	
HS	Holes, shot 1/16- to 1/8-inch		–	+	
KC	Knot cluster		–	1-4	5
KH	Knot, loose, decayed or hole		–	1-2	3
KS	Knot, sound tight		–	1	2-9
MC	Machine-chipped or torn grain		–	+	
MT	Machine tearout		–		–
MS	Mineral streak	+		+	
MP	Machine snipe		–		–
P	Pith		–		–
PF	Pith fleck	+		+	
PF & C	Pith fleck and check		–	+	
R	Rot, dote, decay		–		–
S	Sap stain		–	+	
SH	Shake		–		–
SL	Saw line		–		–
SP	Split (includes end checks longer than 4 in.)		–		–
SW	Sapwood	+		+	
SS	Scar, sound		–	+	
SU	Scar, unsound		–		–
ST	Sticker stain		–	+	
TH	Thin		–		–
V	Void		–		–
W	Wane		–		–
AB	Swirl-adventitious bud	+		+	
WK	Warp-crook, wavy edge		–		–

[1] + = permitted; — = not permitted.

[2] Defect size code: 1 = 1/8 inch; 2 = 1/4-inch; 3 = 3/8 inch; 4 = 1/2 inch; 5 = 5/8 inch; 6 = 3/4 inch; 7 = 7/8 inch; 8 = 1 inch; and 9 = 1-1/2 inch.

example, a board 6 inches wide and 6 feet long would be recorded as (0,0)(24,288). A knot, which could be enclosed with a rectangle to describe its extent, and located between 10 and 12 inches from the end of the board and 2 to 3 inches from the edge, would be recorded as (8,40)(12,48). Figure 2 illustrates enclosing a knot with a rectangle and the use of coordinates to define the size and location of the defect to the nearest one-fourth inch.

After the diagraming of the poor face, the board was turned over, placed on the opposite side of the grid-mapping table, and the best face was diagramed. This procedure assured that all defects were located from the same reference end and reference edge. The coordinates of defects on both board faces were later combined to provide one set of coordinates for processing by the computer.

Yields are based on 4/4 kiln-dried yellow-poplar lumber. The dimension cuttings from all grades are clear, two-face, with the exception of the No. 2B grade which yielded sound two-face cuttings in accordance with the NHLA rules. Because the data were obtained from kiln-dried lumber, the yield figures take drying defects into consideration. These yields should also be applicable to rough dimension cuttings because yellow-poplar is relatively free from defects that are easier to identify after surfacing. The one exception to this is burl, which may appear when the cuttings are planed. If a mill experiences a high incidence of burl, the yields should be adjusted based on mill studies.

The computer program used to calculate the cutting yields indicates whether the boards should be crosscut or ripped as the first operation. Few plants have a choice in the manner in which they process their lumber; most of the furniture industry crosscuts lumber first. Approximately 5 percent of the boards in this study were ripped first in the computer's method of cut-up. The percentage of boards ripped first was highest in the highest grades and in recovering the longest cuttings.

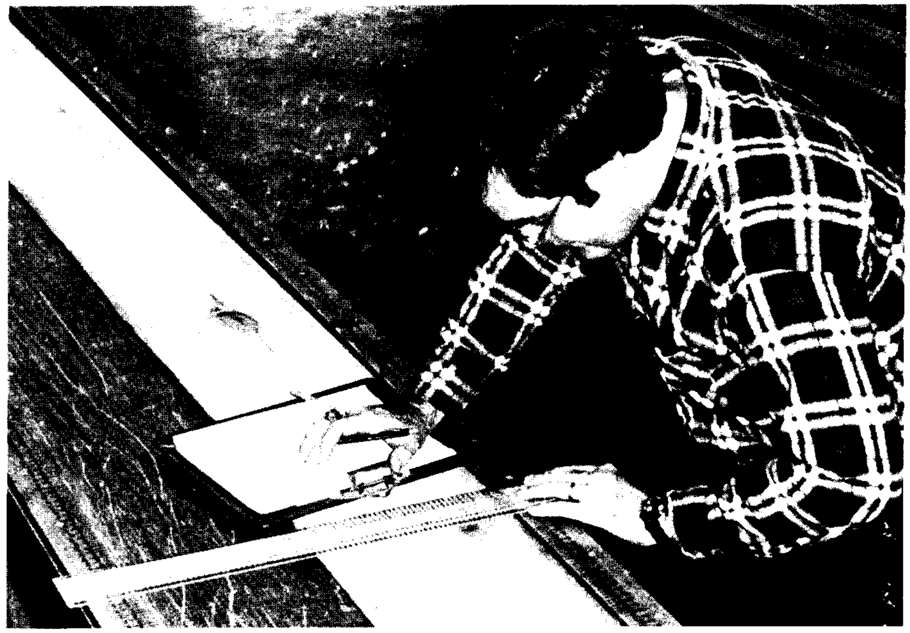

Figure 1.—View of Grid Mapper. A defect is being located by use of coordinate points on the poor face of a board. The board was then turned over and placed on the opposite side of the mapper to locate defects on the good face.

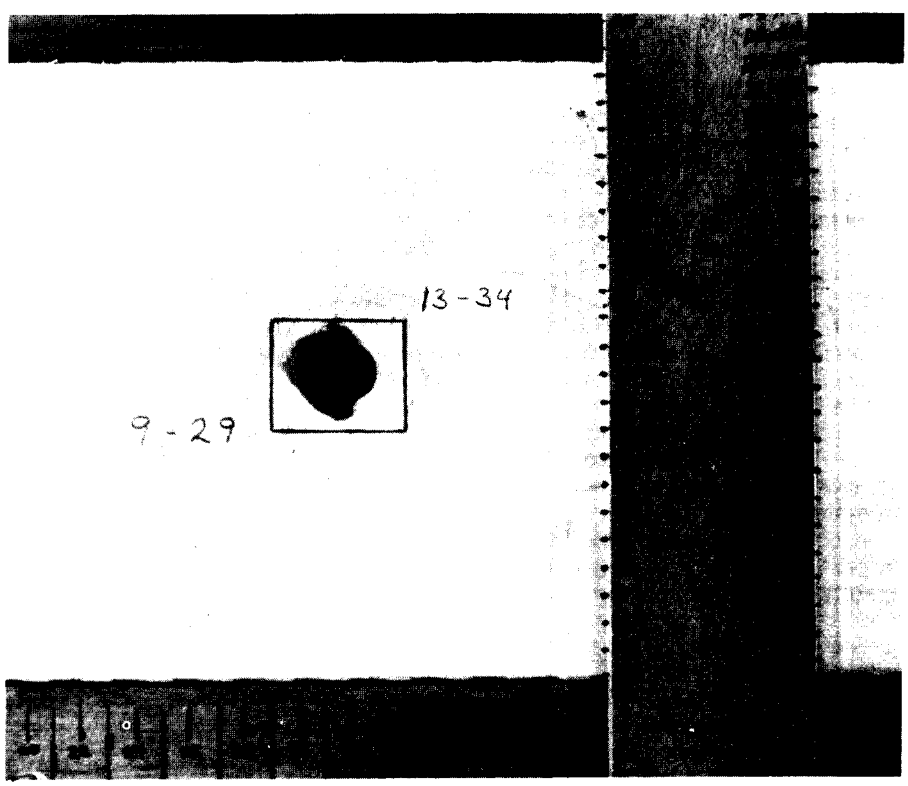

Figure 2.—A knot enclosed in a rectangle with coordinate points 9-29 and 13-24 to define its size and position.

Primary and Total Yields

The longest length in a cutting order is considered the primary cutting length. An increase in the primary cutting length results in a decrease in the primary yield, simply due to the greater difficulty of obtaining the longer, clear pieces (fig. 3). However, the length of the primary cutting had an insignificant effect on total yield since the increased yields of the shorter secondary cuttings compensated for the lower yields of the longer primary cuttings.

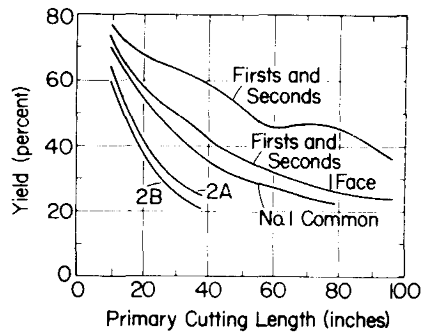

Figure 3.—Primary yield of clear two-face cuttings, from 4/4 yellow-poplar lumber, random width to a l-inch minimum. (ML84 5174)

Using the Charts

One chart for random-width cuttings is presented for each lumber grade (figs. 4,6,8,10,12). These values are based on a minimum width of 1 inch, which approximates the minimum widths cut in commercial practice. Adjustments for widths greater than 1 inch can be made from the chart on the same page (figs. 5,7,9,11,13). In all cases, the adjustment values are subtracted from the 1-inch yields.

In the random-width charts, the numbers along the diagonal line refer to the primary cutting or longest length of the secondary or subsequent cuttings. The predicted yield, in percent, is shown at the extreme left.

Assume, for example, that you want to determine the yield from FAS yellow-poplar lumber when your cutting bill calls for 57-, 44-, 36-, and 14-inch lengths, all random width, l-inch minimum. On the FAS chart (fig. 4) locate the longest length, 57 inches in this example, at the right of the chart. Then move horizontally to the Predicted Yield line on the left and read 47.5 percent as the predicted yield.

Next, find the yield of the next longest length, 44 inches. Starting again at the right of the 57-inch line, move vertically up to where the curved 44-inch line crosses, then follow horizontally to the left where the predicted yield is 57.5 percent. This 57.5 percent value, minus 47.5 percent for the 57-inch length, leaves 10.0 percent as the yield for the 44-inch cuttings.

For the third longest cutting of 36 inches, continue vertically up the line of the longest length cutting (57 in.) to where the line intersects with 36 and read across horizontally to the left for a yield of 62.5 percent. Subtracting the value of 57.5 percent for the 44-inch length from this yield of 62.5 percent gives a yield of 5.0 percent for the 36-inch cutting.

Continue in the same manne, for the fourth length of 14 inches, proceeding vertically from the 57-inch line to the intersection with curve for 14 and then read across to 71.25 percent yield. Subtracting the 62.5 percent value from 71.25 percent leaves a yield of 8.75 percent for the 14-inch span.

The total yield for the four lengths in the FAS grade is the summation of the individual yields or 71.25 percent.

The same procedure is used for any combination of cutting lengths in any of the grades by using the appropriate chart. This same cutting bill of 57-, 44-, 36-, and 14-inch random-width lengths from No. 1 Common lumber (fig. 8) would yield 28.75, 10.45, 5.8, and 13.3 percent, respectively. The total yield would be 58.3 percent.

Width Adjustments

Adjustments in yield for specific widths greater than 1 inch can be obtained by the use of the reduction for widths chart for the same grade (figs. 5,7,9,11,13). The difference between the desired width and the random width is subtracted from the percent yield of the l-inch width for any of the lengths.

Table 3 is an example of how to obtain yields of four cutting sizes from 4/4 FAS yellow-poplar lumber. The lengths are the same as used in the previous example for FAS lumber and the widths are as shown in the table. To obtain yields of specific widths from the FAS grade (fig. 5), start with the 57-inch cutting length at the bottom. From the 57-inch line, follow up to the 4-inch line, then horizontally to the left to find a reduction of 12 percent. Repeat the procedure for the 44-inch length, moving upward until it intersects the 2-inch-width line and then horizontally to find a reduction of 4 percent. The same procedure is followed for the 36-inch length. The values for the cutting bill are shown in table 3.

Odd Sizes

Lengths and widths of actual cuttings are seldom in even inches. Yields of such odd or fractional sizes can be determined by interpolating between the length and width lines as shown in table 4 for the No. 1 Common grade.

The yield of any combination of cutting lengths and widths can be determined in like manner for any of the lumber grades.

Although fractions of percentages are given in these examples, these generally would be rounded off to even numbers in practice.

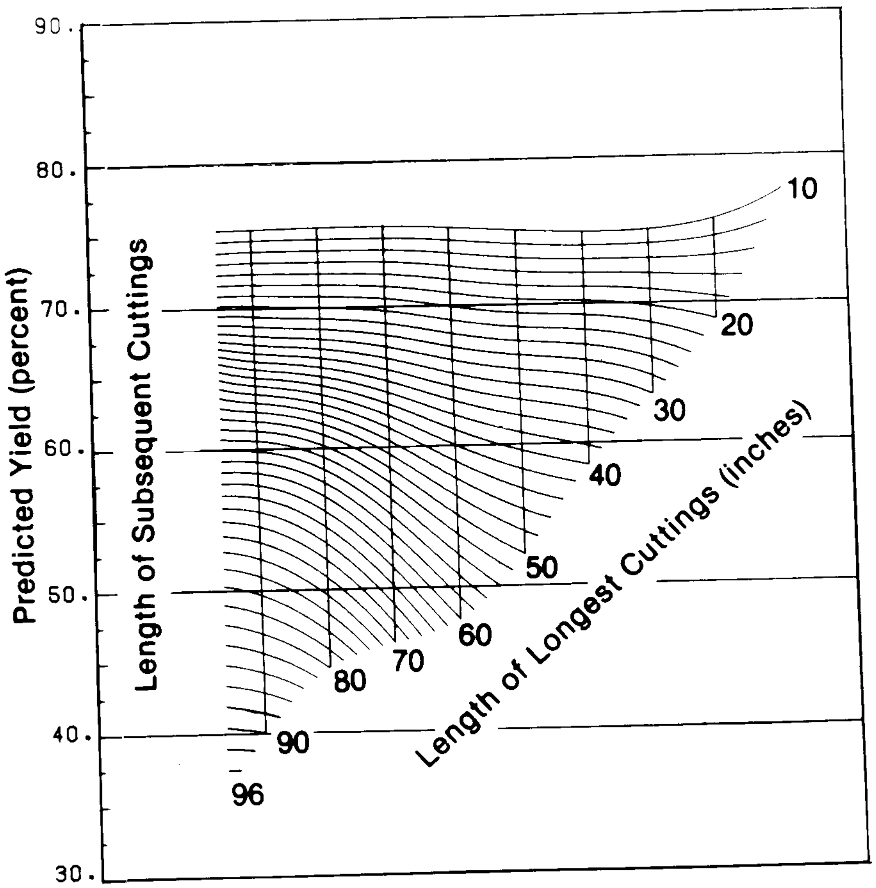

Figure 4.—Predicted yield of 1-inch-wide cuttings, First and Seconds. (M149 826)

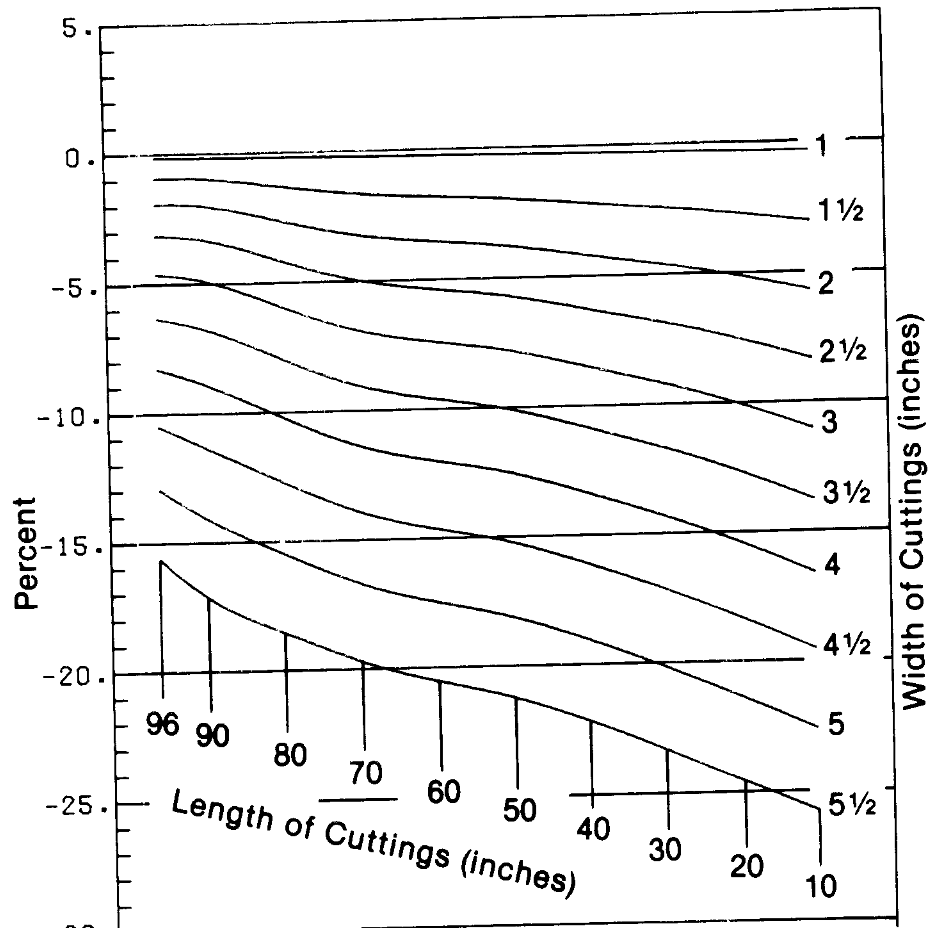

Figure 5.—Reduction for widths other than 1 inch, First and Seconds. (M149 828)

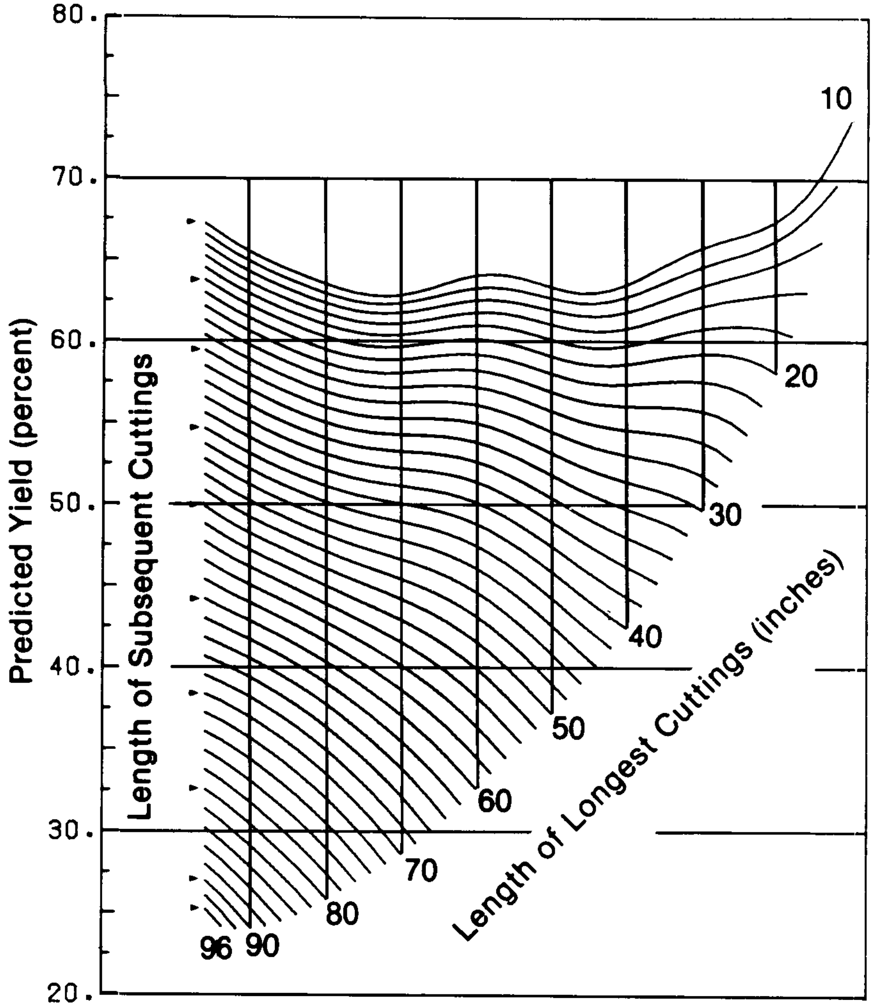

Figure 6.—Predicted yield of 1-inch-wide cuttings, First and Seconds—1 Face. (M149 827)

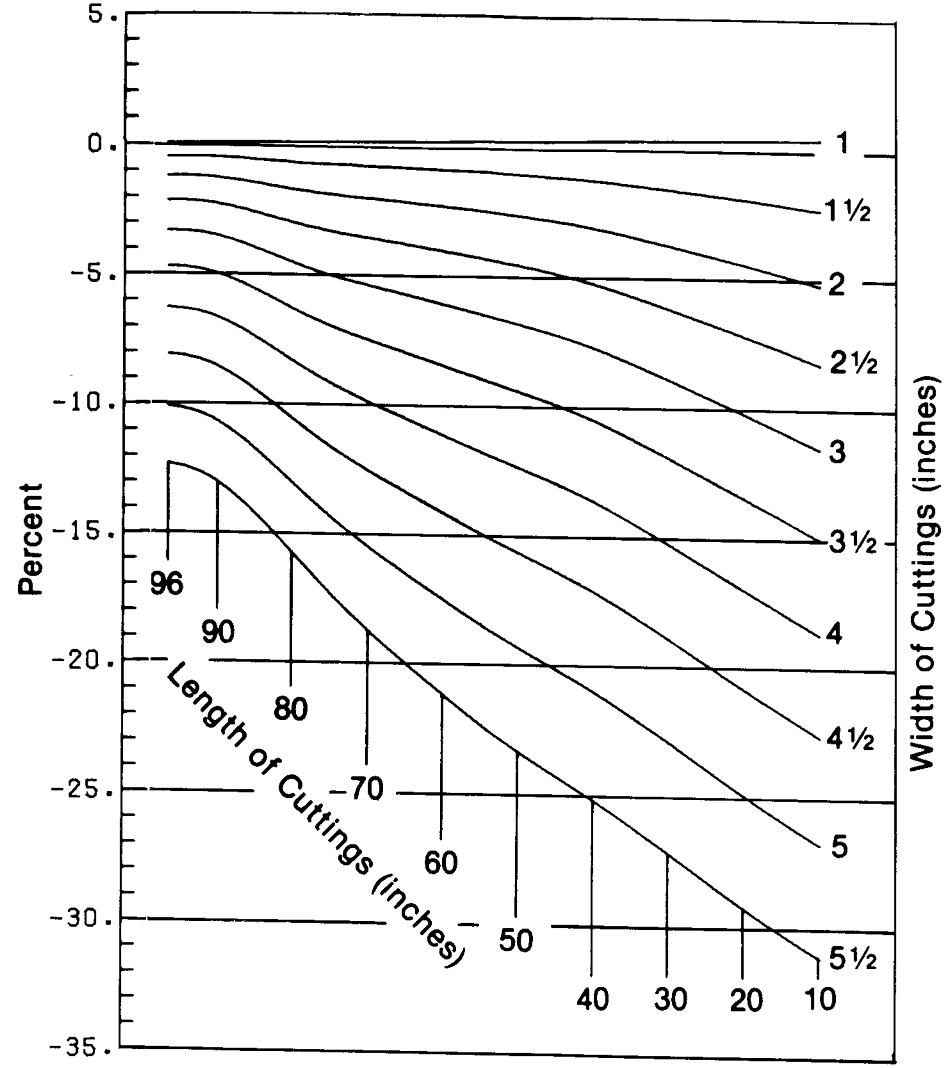

Figure 7.—Reduction for widths other than 1 inch, First and Seconds—1 Face. (M149 829)

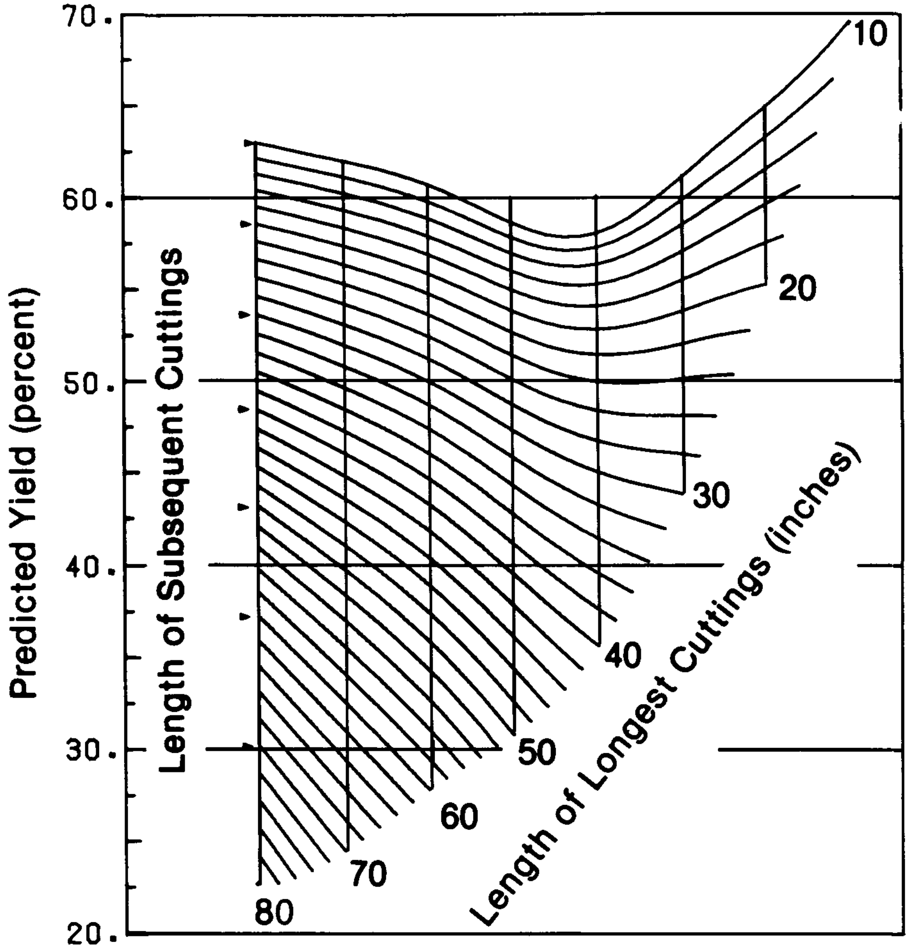

Figure 8.—Predicted yield of 1-inch-wide cuttings, 1 Common. (M149 823)

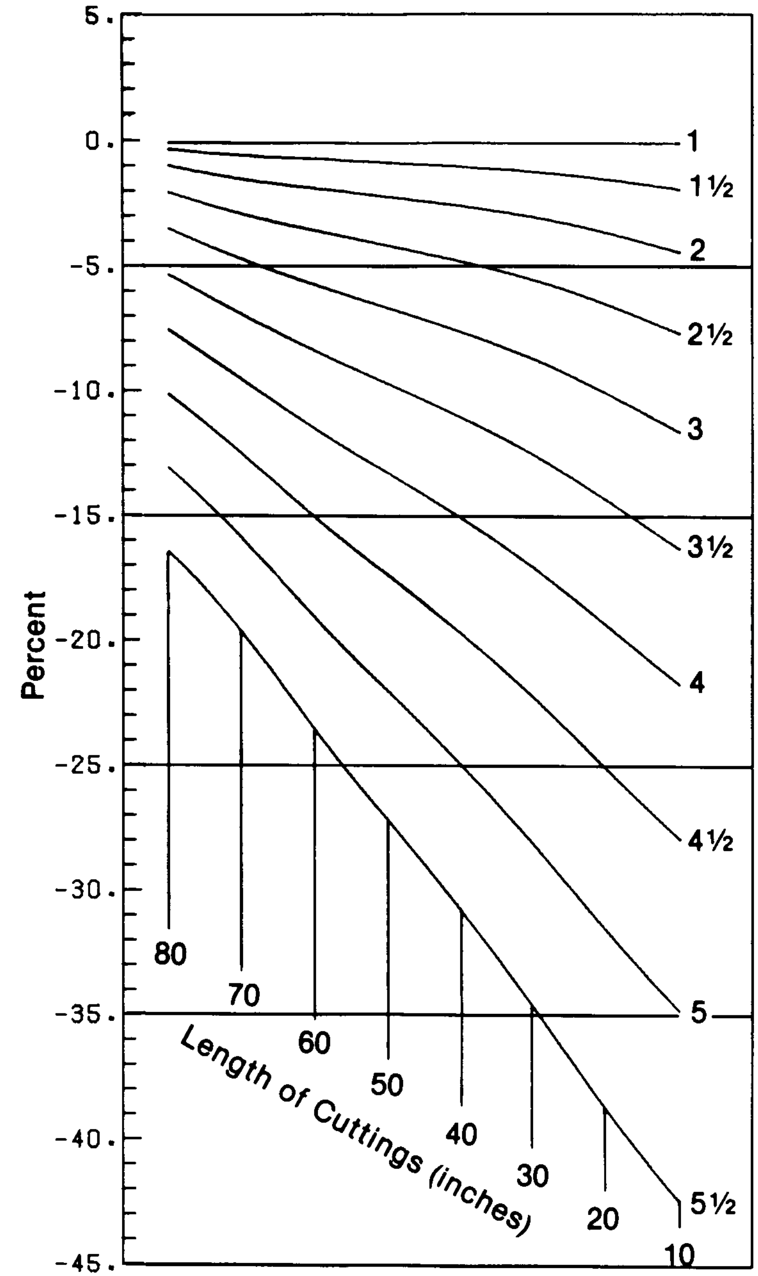

Figure 9.—Reduction for widths other than 1 inch, 1 Common. (M149 830)

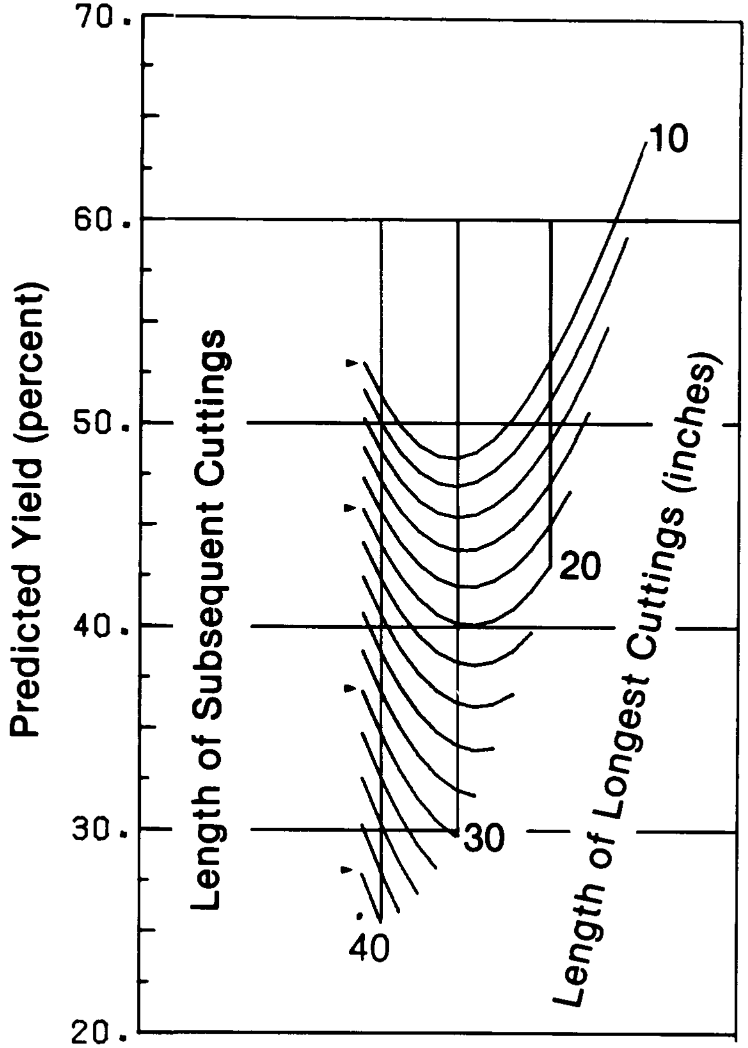

Figure 10.—Predicted yield of 1-inch-wide cuttings, 2A Common. (M149 824)

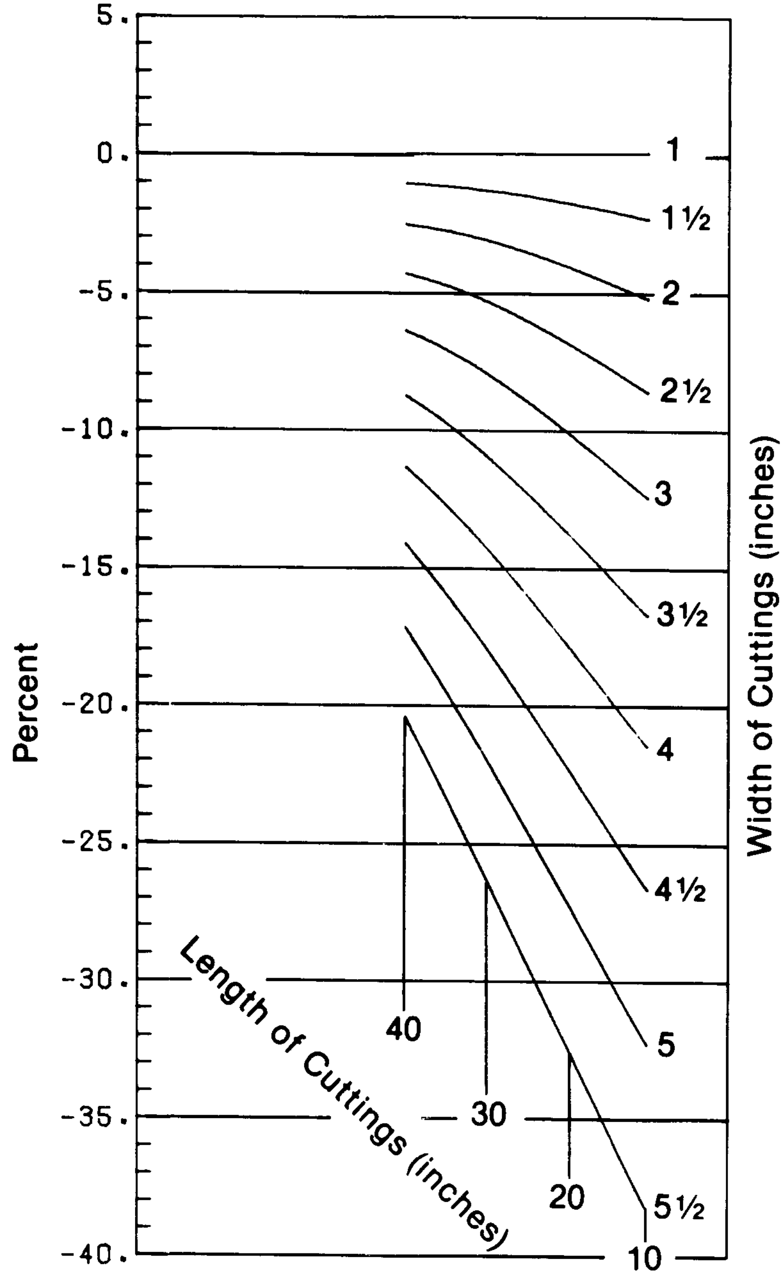

Figure 11.—Reduction for widths other than 1 inch, 2A Common. (M149 831)

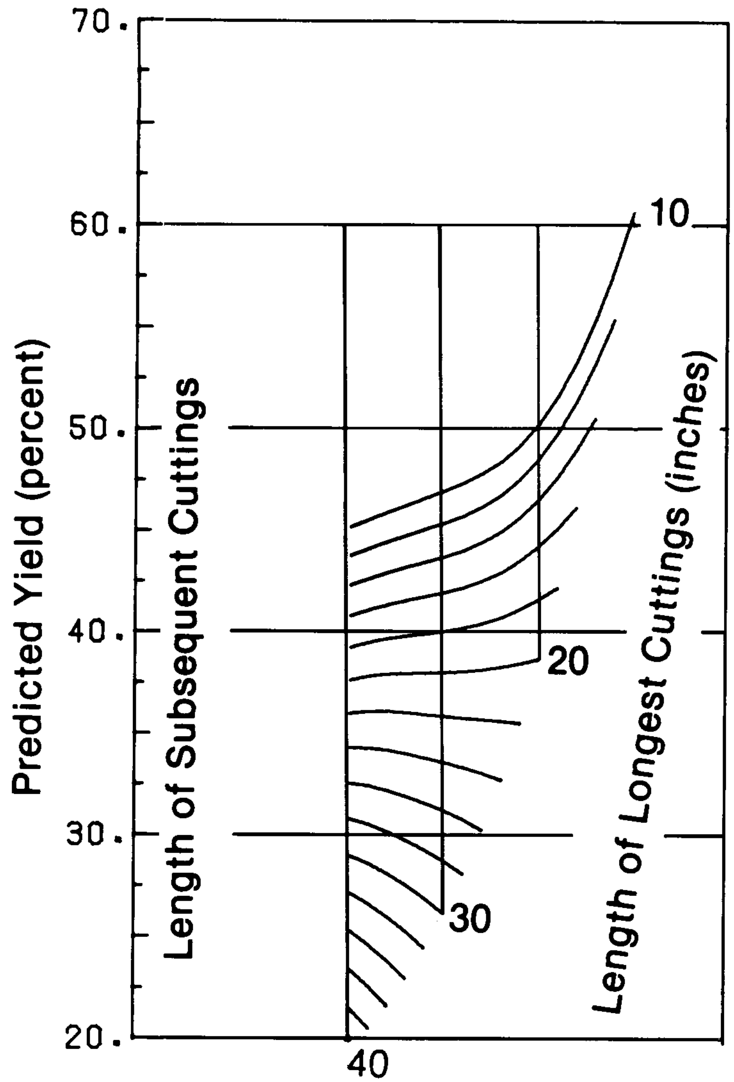

Figure 12.—Predicted yield of 1-inch-wide cuttings, 2B Common. (M149 825)

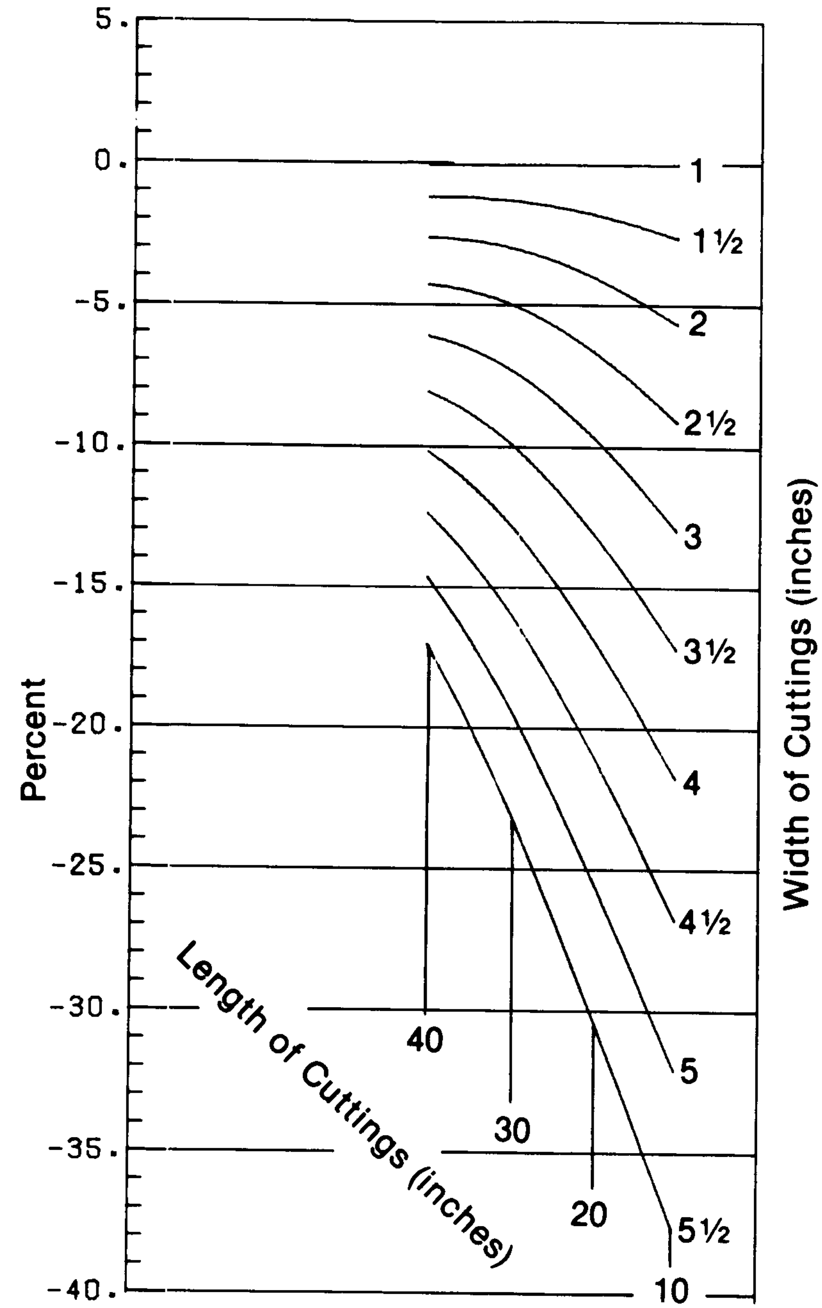

Figure 13.—Reduction for widths other than 1 inch, 2B Common. (M149 832)

Determining Number of Cuttings per 1,000 Board Feet

The yields so far have been in percentages. These, however, are easily converted to number of cuttings per 1,000 board feet by the equation:

$$\text{NO. CUT} = \frac{\text{PY X 1,000}}{\text{SA}} \qquad (1)$$

where
NO. CUT = number of cuttings per 1,000 board feet of lumber
PY = percent yield as a decimal
SA = surface area of cutting in square inches

Using the previous example of sizes and yields for the FAS grade, the number of cuttings per 1,000 board feet is as shown in table 5.

A 35.5 percent yield means that 355 board feet of clear, two-face cuttings 57 by 4 inches in size can be obtained from 1,000 board feet of FAS yellow-poplar lumber. The surface area of a 57- by 4-inch cutting is 1.583 square feet: 355/1.58 = 224 cuttings per 1,000 board feet.

In addition, 294, 100, and 1,314 cuttings for the 44-, 36-, and 14-inch lengths, respectively, can be obtained from the same 1,000 board feet of lumber.

Calculating Footage Requirements

The number of cuttings obtainable from 1,000 board feet of lumber is divided into the number of cuttings required and multiplied by 1,000 to give the amount of lumber needed. This is shown in table 6 using the previous cutting sizes for the FAS grade.

As an illustration, the following cutting bill with the required number of cuttings was used: 1,200 of 57-inch length and 4-inch width; 1,700 of 44-inch length and 2-inch width; 600 of 36-inch length and 2-inch width; and 7,200 of 14-inch length and random width.

Table 3.—Example of how to obtain yields of four cutting sizes from 4/4 FAS yellow-poplar lumber

Cutting Size		Random width reading	Adjustment	Adjusted reading	Yield
Length	Width				
In.		*Pct*			
57	4	47.5	Subtract 12.0	35.5	35.5
44	2	57.5	Subtract 4.0	53.5	18.0
36	2	62.5	Subtract 4.0	58.5	5.0
14	Random width	71.25	—	71.25	12.75
Total Yield					71.25

Table 4.—Example of how to obtain yields of odd-size cuttings from 4/4 No. 1 Common yellow-poplar lumber.

Cutting Size		Random width reading	Adjustment	Adjusted reading	Yield
Length	Width				
In.		*Pct*			
60½	3¾	27.5	Subtract 10.1	17.5	17.5
41½	3 ⅛	42.5	Subtract 8.5	34.0	16.5
30 ⅛	2¼	50.0	Subtract 4.0	46.0	12.0
11½	Random width	60.0	—	60.0	14.0
Total Yield					60.00

Table 5.—Number of cuttings per thousand board feet on four cutting sizes from 4/4 FAS yellow-poplar lumber

Cutting size		Surface measure	Yield	Cuttings/ 1,000 board feet
Length	Width			
In.		*Ft²*	*Pct*	*No.*
57	4	1.583	35.5	224
44	2	.611	18.0	294
36	2	.500	5.0	100
14	Random width	[1].097	12.75	1,314

[1]Per inch width.

Table 6.—Number of cuttings for four cutting sizes from 5,358 board feet of 4/4 FAS yellow-poplar lumber

Cutting size		Cuttings/ 1,000 board feet	Cuttings required	Cuttings/ 5,358 board feet	Cutting balance
Length	Width				
In.					
57	4	224	1,200	1,200	—
44	2	294	1,700	1,575	-125
36	2	100	600	536	-65
14	Random width	1,314	7,200	7,039	-160

Using the equation:

$$\text{BF NEED} = \frac{\text{CB}}{\text{NO. CUT}} \times 1{,}000 \quad (2)$$

where

BF NEED = board feet of lumber needed to fill the cutting bill
CB = cutting bill requirement, number of pieces of a given size
NO.CUT = number of cuttings per 1,000 board feet of lumber

Thus, 1,200 cuttings of the 57-inch length divided by 224 times 1,000 equals 5,358 board feet required.

Then, 294 of the 44-inch-length cuttings obtainable from 1,000 board feet times 5,358 and divided by 1,000 shows that 1,575 cuttings of this length can also be obtained, However, 125 pieces are still needed.

The method of determining cuttings obtained from the 36- and 14-inch lengths follows the same pattern.

In calculating the footage requirements, fractional parts of a board foot are raised to the next higher board foot. This is necessary because rounding down would result in not having enough material available to recover the last cutting. For instance, in the example above of 1,200 57-inch cuttings, 1,200 divided by 224 times 1,000 actually equals 5,357.14 board feet required. If this were rounded down, and 5,357 board feet ordered, the number of cuttings recovered would be only 224 cuttings per 1,000 board feet times 5,357 board feet divided by 1,000, or 1,199 cuttings recovered.

Since the cutting bill requires 1,700 of the 44-inch cuttings and only 1,575 were obtained from 5,358 board feet, 12544- by 2-inch cuttings are needed. The 44-inch cutting now becomes the primary cutting length, and it becomes necessary to repeat the same procedure, using the charts, as followed to obtain the information in tables 3 and 5. The results of these computations are shown in table 7.

Table 7.—Example of how to obtain yields of three cutting sizes from 4/4 FAS yellow-poplar lumber

Cutting size		Random width reading	Adjustment	Adjusted reading	Yield	Surface measure	Cuttings/ 1,000 board feet
Length	Width						
In.		*Pct*				*Ft²*	
44	2	56.5	Subtract 4.0	52.5	52.5	0.611	859
36	2	62.0	Subtract 4.0	58.0	5.5	.500	110
14	Random width	73.0	—	73.0	15.0	.097	1,546
Total yield					73.0		

Table 8.—Number of cuttings for three cutting sizes from 146 board feet of 4/4 FAS yellow-poplar lumber

Cutting size		Cuttings/ 1,000 board feet	Cuttings required	Cuttings/ 146 board feet	Cutting balance
Length	Width				
In.					
44	2	859	125	125	—
36	2	110	65	16	-49
14	Random width	1,546	160	225	+65

Now, using equation (2), 125 divided by 859 cuttings per 1,000 board feet times 1,000 equals 146 board feet required to cut the balance of the cuttings in the 44-inch length (table 8).

Subsequently, sixteen 36-inch cuttings can also be obtained from this 146 board feet. In addition, 225 of the 14-inch, random-width requirements were obtained. In this example, 49 cuttings of the 36- by 2-inch cutting size are still required, but an excess of 65 pieces of the 14-inch-long, random-width cuttings has developed. To meet the requirement for the 49 pieces of the 36- by 2-inch cuttings, an additional 43 board feet are needed. This was determined by repeating the procedure using two cutting sizes, 36 and 14 inches. These 43 board feet will yield an excess of another 73 pieces of the 14-inch-long, random-width cuttings.

A total of 5,547 board feet (5,358 + 146 + 43) is required to cut this order from the FAS grade. This, divided into the surface measure of all the cuttings (3,950.1 ft^2 including the excess 14-in. lengths), results in a total yield of 71.2 percent.

Shortcut to Determining Required Footage

A rule of thumb for determining the required footage may be used, especially when a relatively large number of short, narrow cuttings is needed in the order. As seen in table 3, the total yield in the FAS grade is very close to 71.25 percent regardless of the cuttings order--provided there is a requirement for the short, narrow cuttings.

First, obtain the reciprocal of the total yield, which in the last example presented is 1 divided by 0.712, which equals 1.404. This number, multiplied by the surface measure in board feet of all the cuttings in the cutting bill, gives the estimated footage (1.404 x 3,936.7 = 5,527 board feet). The difference between the two footages, 5,527 and 5,547, occurs because extra pieces of the smallest size must be cut to meet the cutting bill for the larger pieces. The error, less than 0.5 percent in this case, is within reasonable degrees of accuracy.

Table 9.—Comparison of costs to cut 500 pieces 60- by 2-1/2-inches, 500 pieces 48-by 3-inches, 1,000 pieces 24- by 2-inches, and 1,000 pieces 12- by 2-inch clear, two-face dimension from various grades of 4/4 yellow-poplar lumber

Grades and grade mix	Lumber required	Cost/ thousand	Cost: Subtotal	Cost: Total
	Board feet	———	*Dol.*	———
FAS for all lengths	2,269	420	—	952.98
FAS for only 60-inch length[1]	1,276	420	535.92	
No. 1C for remainder	1,648	283	466.38	1,002.30
FAS for 60-inch and 48-inch lengths[2]		2,167	420	910.14
No. 2A for remainder	127	175	22.23	932.37
FAS1F for all lengths	3,022	410	—	1,239.02
FAS1F for only 60-inch lengths[3]	1,846	410	756.86	
No. 1C for remainder	1,466	283	414.88	1,171.74
No. 1C for all lengths	3,612	283	—	1,022.20

[1]Includes 93 of 48-inch, 529 of 24-inch, and 355 of 12-inch lengths.
[2]Includes surplus of 9 pieces of 24-inch lengths.
[3]Includes 138 of 48-inch, 985 of 24-inch, and 452 of 12-inch lengths.

Cost Comparison by Grade

Material cost comparisons can be made between two grades, or a mixture of grades, for any given cutting order. Assume, for example, that cuttings are wanted in the following quantities and sizes: 500 pieces 60 by 2-1/2 inches, 500 pieces 48 by 3 inches, 1,000 pieces 24 by 2 inches, and 1,000 pieces 12 by 2 inches. What is the most economical grade or mixture of grades? Assume a cost per 1,000 board feet for FAS of $420; FAS1F, $410; No. 1 Common, $283; and No. 2A Common, $175. Table 9 shows the cost comparisons for six possible choices.

With the assumed costs, using FAS for the 60- and 48-inch lengths and No. 2A Common for the remainder is most economical at a cost of $932.37. The FAS1F grade is the least economical at a cost of $1,239.02. The difference between these two extremes is $306.83. The sizes and quantities of cuttings in a given cutting order will affect the outcome of material cost comparisons. One pitfall that should be avoided is the danger of accumulating large excesses of short, narrow cuttings by constantly selecting the lower grades.

One must remember that these values are based solely on the quoted prices. Substitution of prices that are particular to a certain locale or market situation may show that another grade or mix of grades is more economical. Also, one must keep in mind that these values are based entirely on lumber prices and that handling and processing costs must be included.

Although the quantities and sizes used in this particular example indicated a cost advantage in using the FAS lumber grade, for the longer cuttings, in many cases the lower lumber grades will most economically meet specific cutting requirements, especially when the cutting bill predominantly calls for shorter length cuttings.

Future of Research on Cutting Yields

Technological advances in computers, defect sensing, automated controls, and computer models for determining maximum cutting yields have made it feasible for the furniture industry to advance beyond the techniques and tools for predicting cutting yields presented in this publication and its predecessors (Englerth 1969; Schumann 1971, 1972; Schumann and Englerth 1967a, 1967 b). For this reason, the yellow-poplar dimension yield study will be the last of this series. Future research will provide new technology to the furniture industry for improving yield to maximum levels.

Lasers are now being used to cut intricate shapes in the furniture industry (Huber and Ward 1980), and automatic control of lasers is possible (Huber et al, 1982). Recent computer models (Giese and Danielson 1983; Giese and McDonald 1982; Hallock and Giese 1980; Stern and McDonald 1978) are designed to provide maximum yield data for cut-up of rough lumber. By coupling the computer models with defect detection equipment and automatic controls on either lasers or conventional saws, maximum cutting yields in the rough mill will be possible.

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