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Dimension yields from short logs of low-quality hardwood trees

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DIMENSION YIELDS FROM SHORT LOGS OF LOW-QUALITY HARDWOOD TREES

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As it becomes increasingly more difficult to obtain large sawtimber size logs for high-valued hardwoods, sawmills must look for alternative raw material sources. In the last decade researchers have suggested utilizing smaller diameter trees and shorter logs that are usually used only for pulp chips or fuel wood to make dimension cuttings for furniture parts (Bingham and Schroeder 1976a, 1976b, 1976c, 1977, Dunmire *et al.* 1972, Reynolds and Schroeder 1977). Before a manufacturer can choose among chips, fuelwood, or solid wood as a final product for small diameter short logs, the expected yield of the product must be determined. The amount of chips or fuelwood can be evaluated by volume or weight, but more sophisticated methods are required to determine yield of solid wood dimension cuttings.

A large quantity of material for short logs or bolts exists in the forest. About 87 percent of the commercial hardwood timber in the Eastern United States is in trees less than 21 inches in diameter (USDA Forest Service 1978). Additionally, thinning or pulpwood cuts are often intermediate parts of the forest management plan. Smaller diameter logs and logging residue represent a considerable quantity of material unsuitable for standard lumber. This material can be cut into short lengths for dimension cuttings. Although character marks are prevalent in the smaller logging residue, researchers have demonstrated that sound, character-marked cuttings can be manufactured from short logs or bolts (Cooper and Schlesinger 1974, Dunmire *et al.* 1972). In addition, the demand for character-marked hardwoods in furniture is increasing (Anonymous 1976). Thus, short logs contain a variety of material suitable for furniture.

A method of estimating dimension stock yields from standard graded 4/4 lumber has been described (Englerth 1969, Schumann and Englerth 1967a, 1967b, Schumann 1971). Nomographs were used to determine hard maple and black walnut yields for particular cutting bills. Comparisons were made between grades so that the most economical grade or mix of grades could be found. And Landt (1974a, 1974b, 1974c, 1974d) developed volume tables for predicting clear one-side (C1S) cuttings from small diameter short bolts of several species. A similar study on yellow-poplar by Cooper and Schlesinger (1974) predicted clear two-sides (C2S) and character-marked (CM) as well as C1S cuttings. However, the data were not in a form that could be easily converted to number of cuttings of a particular size per unit board feet.

The purpose of this paper is to put in a nomograph form the dimension cutting yields of aspen, soft maple, black cherry, yellow-poplar, and black walnut from logs 1.9 to 6.7 feet long and from 5 to 18 inches in diameter. This information may provide the furniture manufacturer or dimension plant manager a useful tool in selecting the most economical grade mix for a particular cutting bill.

METHOD OF DATA COLLECTION

Bolt material was removed from selected trees in stand improvement cuts or from residue remaining after logging on several sites from Wisconsin to Pennsylvania (table 1). The bolts were bucked from short tree sections and ranged in size from 1.9 to 6.7 feet in length and from 5 to 18 inches in diameter.

Table 1.— *Basic information on bolt material*

Species	Location	Bolts	Total volume	Bolt Diameter Mean	Bolt Diameter Range	Bolt Length Mean	Bolt Length Range
		No.	Board feet	Inches		Feet	
Aspen	Wisconsin[1]	199	1,796	7.7	5.5-14.5	4.0	2.0-6.3
Soft maple	Southern Illinois	302	3,721	8.0	5.5-14.0	4.6	2.0-6.4
Black cherry[2]	Pennsylvania West Virginia	775	6,998	7.5	5.0-18.0	3.9	1.9-6.4
Yellow-poplar	Southern Illinois	351	4,241	7.7	5.5-16.5	4.7	2.0-6.7
Black walnut	Southern Illinois	200	1,621	6.8	5.5-12.0	4.5	2.1-6.4

[1]Each location represents one stand of trees. The results of this study only apply to the site from which the logs were cut.

[2]Black cherry material came from two stands each in a different location. This is not meant to be taken as a sample from the population of black cherry sites but just a combining of two sets of data.

Bolt length was limited only by external defects or sweep exceeding 1 inch in 2 feet of length. The bolts were scaled by the International ¼-inch Rule—diameters were measured to the nearest ¼ inch and lengths to the nearest 1 inch. Bolt grades were recorded using a grading system similar to the method described by Redman and Willard (1957). The bolt distributions, representative of residue material, are skewed toward the large end for diameter, length, and grade.

METHOD OF CUTTING FLITCHES

The bolts were "live-sawn" into 1 ⅛-inch-thick rough unedged flitches on a portable bolter saw. Live-sawing consisted of slabbing one side of the bolt—the poorest side or the concave side of bolts with sweep—turning the bolt flat side down, and sawing the rest of the bolt without additional turning. The flitches were then air- and kiln-dried to a moisture content of 8 percent.

DIMENSION CUTTINGS

The dried flitches, which had been skip-dressed to 15/16-inch thick, were diagramed to determine the dimension cuttings. The dimension cuttings were of three grades: C2S, which had two faces clear of knots and defects; C1S, which had one clear face and sound defects on the second face; and CM, which had sound defects on both faces. To determine maximum yields the boards were diagramed three separate times—first for the longest cuttings of grade C2S, then for the longest cuttings of grade C1S or better, and finally for the longest cuttings of grade CM or better. Because of the higher value of a long cutting, the longest and widest cuttings were diagramed first. Priority was established by the formula $L^2 \times W$, where L was length and W was width of the cutting. Cuttings ranged from 1 to 6 inches wide and from 12 to 72 inches long.

DATA SUMMARY

The cuttings for each species and cutting grade for bolts 2 feet and longer (2-foot minimum) were summarized on the computer to yield the number of cuttings and total surface area by cutting length and width classes. A similar summary was made disregarding bolts shorter than 4 feet (4-foot minimum). The classes ran from 1 to 6 inches, in increments of ½ inch, for width, and from 12 to 72 inches, in increments of 6 inches, for length. The surface area recovered in cuttings is reported as the total surface area of all cuttings represented as a percentage of the total surface area possible, as predicted by the International ¼-inch Rule (table 2). The small differences in surface area recovered among the cutting grades for each species is in part due to the priority established

Table 2.—*Surface area recovered in cuttings by species, cutting grade, and minimum bolt length*

Species	Cutting grade	Two-foot (minimum length)	Four-foot (minimum length)
		Percent	
Aspen	C2S	68	69
	C1S	69	69
	CM	69	70
Soft maple	C2S	64	65
	C1S	65	66
	CM	67	67
Black cherry	C2S	56	58
	C1S	57	58
	CM	57	59
Yellow-poplar	C2S	58	58
	C1S	58	59
	CM	59	59
Black walnut	C2S	62	62
	C1S	62	63
	CM	63	63

for longer cuttings ($L^2 \times W$). The expected increase in surface area yield by allowing character marks on one of two faces was minimal because of the method of prioritizing cuttings (i.e., an increase in length was often accompanied by a decrease in width and an increase in waste). Also, the estimated yields are conservative because of the $L^2 \times W$ prioritizing.

The summarized number of cuttings for each length and width class was then entered into a computer program designed to determine the dimension cutting yield charts for 1-inch-wide material and yield adjustment values for material greater than 1 inch wide (figs. 1-14). Several yield charts were found to be nearly identical. In these cases one yield chart and width adjustment chart is reported and can be used to determine yield for several cutting grades and/or minimum bolt lengths without substantial loss in accuracy.

USING THE CHARTS

Length

The predicted percent yield of the longest desired cutting and subsequent shorter cuttings can be obtained from the charts given the length of the longest cutting required. To use the chart, first locate the maximum cutting length required on the right-hand side of the chart. The percent yield, in surface area of a 1-inch-wide cutting, is found by moving horizontally to the left until the point of intersection with the percent yield scale on the far left. This is the percent yield of the longest 1-inch-wide cutting. To find the percent yield of the second longest cutting, begin at the point on the right corresponding to the maximum cutting length and proceed vertically to the intersection with the line corresponding to the length of the second cutting. Now move horizontally to the percent yield scale. The percent yield of the second longest cutting, given the removal of the longest cutting, is obtained by subtracting the percent yield for the longest cutting from the percent yield for the second longest cutting. Other yields are obtained in a similar fashion always beginning at the point on the right corresponding to the maximum cutting length, proceeding vertically to the line corresponding to the next desired length, and then moving horizontally to the percent yield scale. The percent yield for each new length is found by subtracting the unadjusted percent yield of the previous cutting length from the percent yield of the new cutting length.

For example, if the cutting bill called for black walnut, C2S, 4-foot minimum bolt length, 1-inch-wide cuttings of lengths 48, 24, and 12 inches, the yield of 48-inch cuttings would be 14 percent (fig. 15). For 24-inch cuttings, the yield would be 22 percent (36 percent-14 percent), and the yield of 12-inch cuttings would be 15 percent (51 percent-36 percent). The total yield of all cuttings would be 51 percent (which is also the accumulated percentage of the shortest length) or 510 square feet of surface area per 1,000 board feet of bolts, scaled according to the International ¼-inch Rule.

Width Adjustments

To determine the percent yield of cuttings other than 1-inch-wide, a correction multiplier chart is given. The percent yield for cuttings greater than 1 inch are found by locating the length of the desired cutting at the base of the correction multiplier chart. Then move vertically to the intersection with the line for the needed width and then horizontally to the correction multiplier scale. Multiply the correction multiplier by the percent yield for a 1-inch-wide cutting of the required length to obtain the percent yield for the needed width.

For example, given a cutting bill as before, but with a width requirement of 2.5 inches for 48-inch cuttings, 3 inches for 24-inch cuttings, and 2 inches for 12-inch cuttings, take the percent yield before subtraction for previous lengths and multiply it by the width correction multiplier of the length needed (fig. 16, table 3). Now the yield of 48-inch cuttings is 9 percent— the original yield of 14 percent times the correction multiplier for a 2.5-inch-wide 48-inch-long cutting of 0.62. For the 3-inch-wide 24-inch cutting, the yield is now 7 percent— the original 36 percent times the correction of 0.43 and finally minus 9 percent for the 48-inch cuttings already removed. Similarly, the yield for the 2-inch-wide 12-inch cuttings is 26 percent— 51 percent times 0.82 minus 16 for the 48- and 24-inch cuttings already removed. The total yield of all desired cuttings is 42 percent or 42 square feet per 1,000 board feet, as scaled by the International ¼-inch Rule.

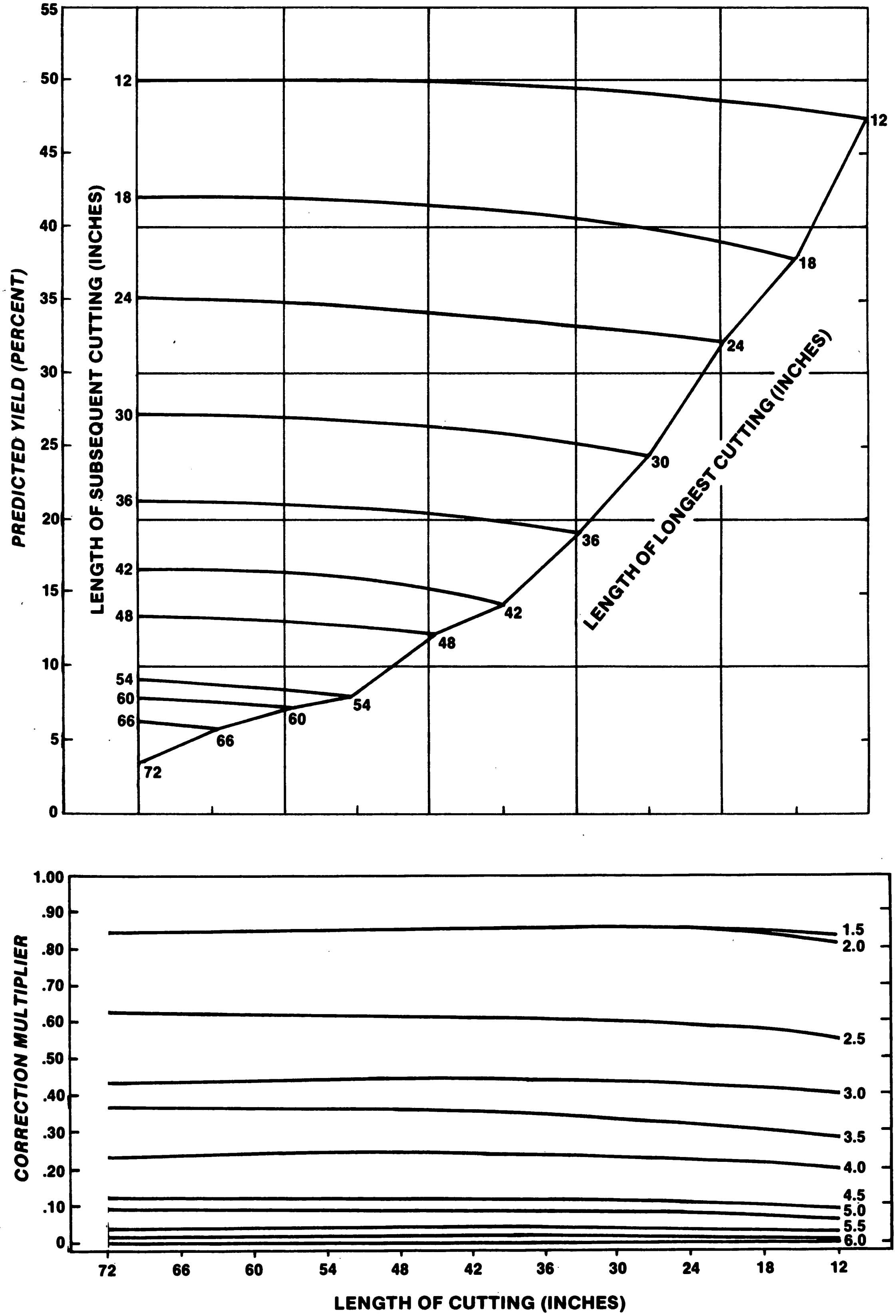


Figure 1.—*Yield prediction of 1-inch-wide cuttings with width corrections for black walnut C2S—2-foot minimum.*

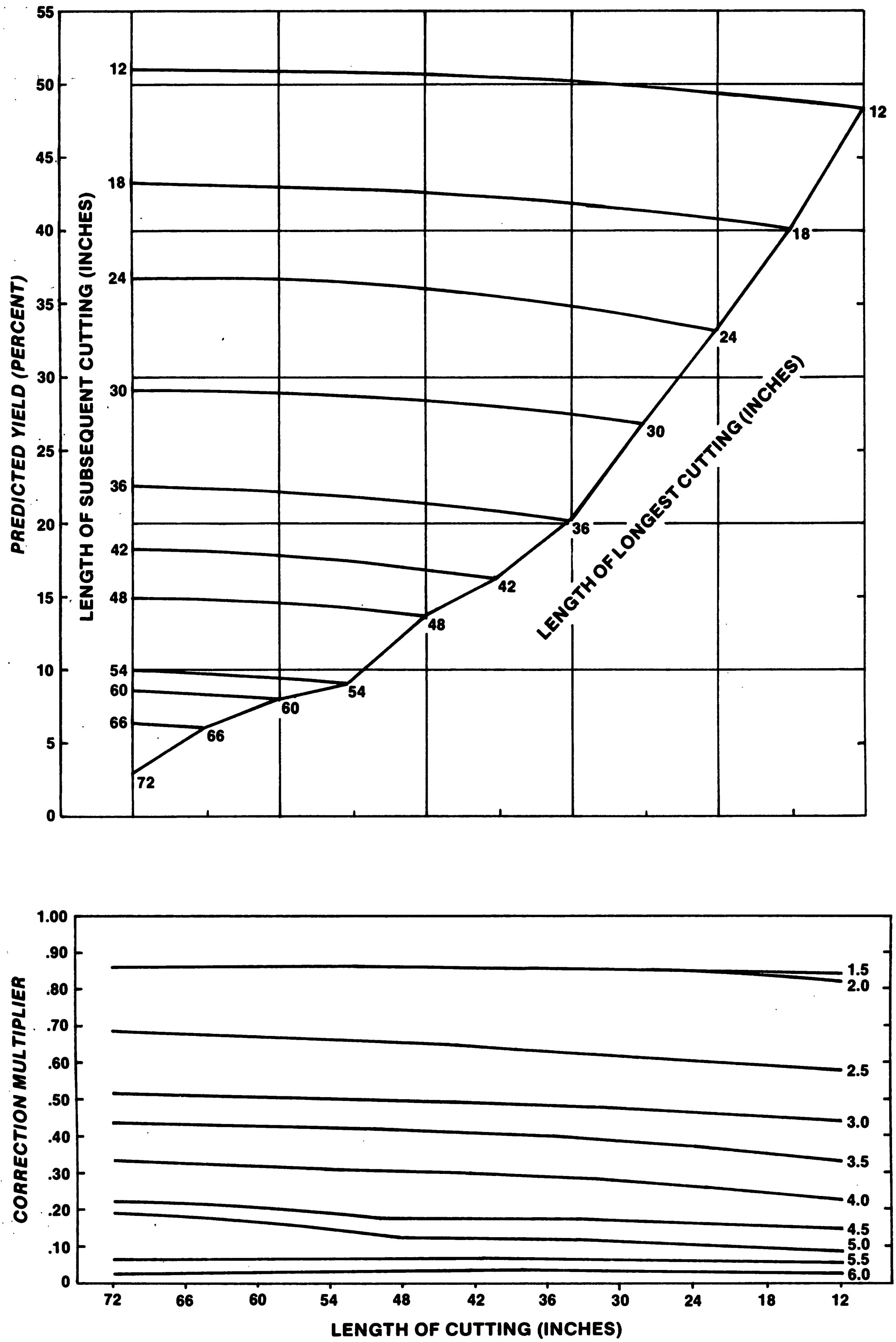


Figure 2.—*Yield prediction of 1-inch-wide cuttings with width corrections for black walnut C1S—2-foot minimum.*

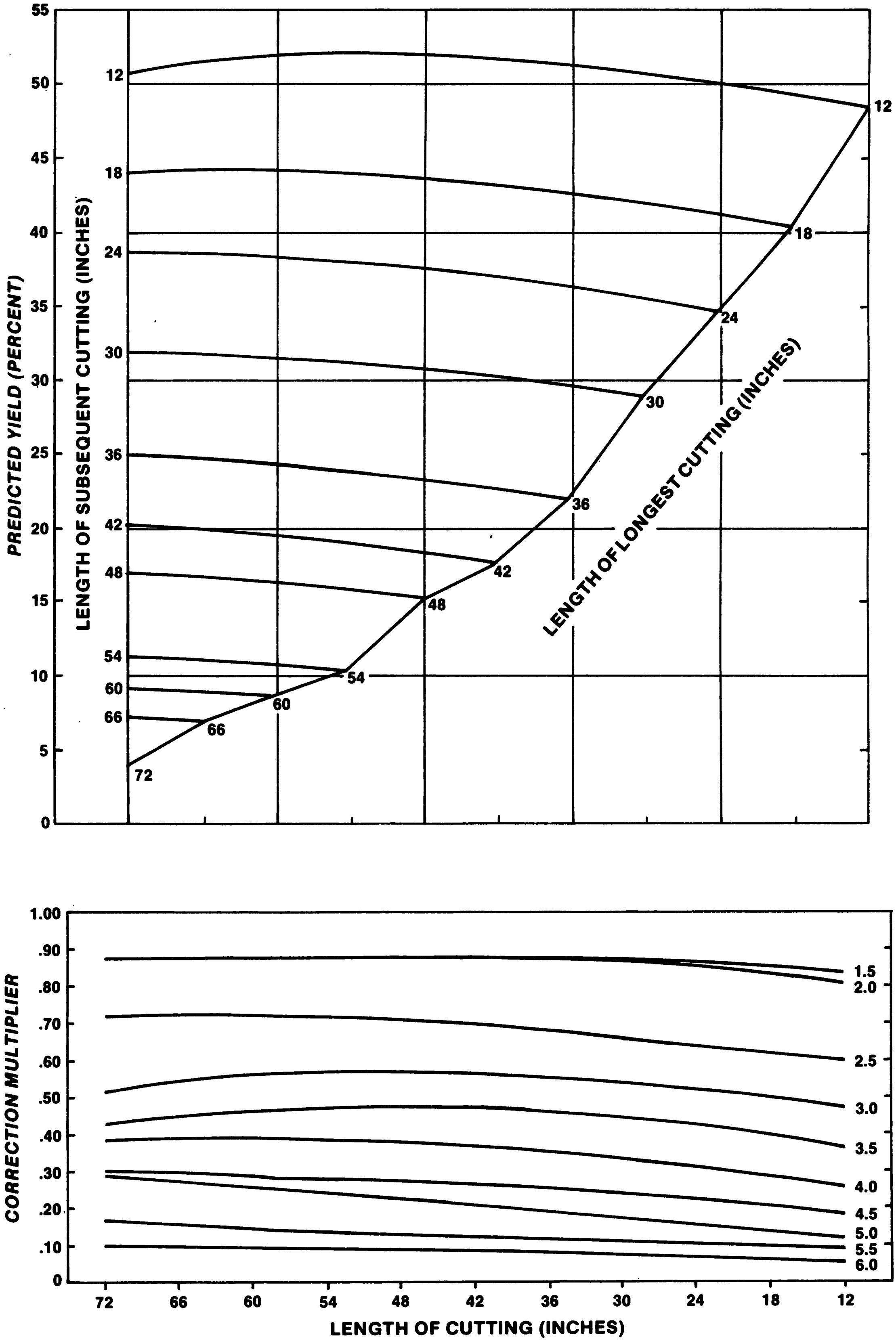


Figure 3.—*Yield prediction of 1-inch-wide cuttings with width corrections for black walnut CM—2-foot minimum.*

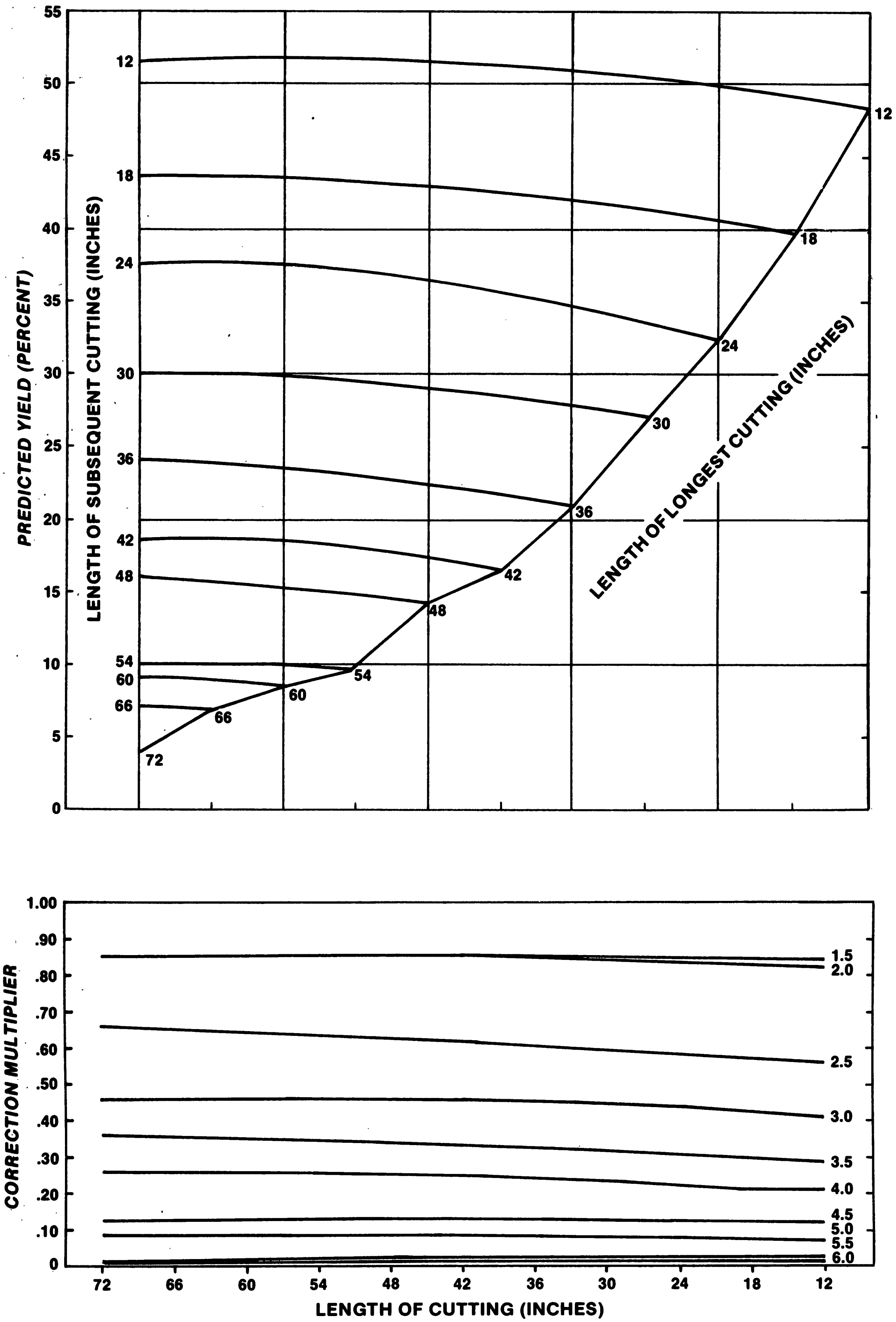


Figure 4.—*Yield prediction of 1-inch-wide cuttings with width corrections for black walnut C2S—4-foot minimum.*

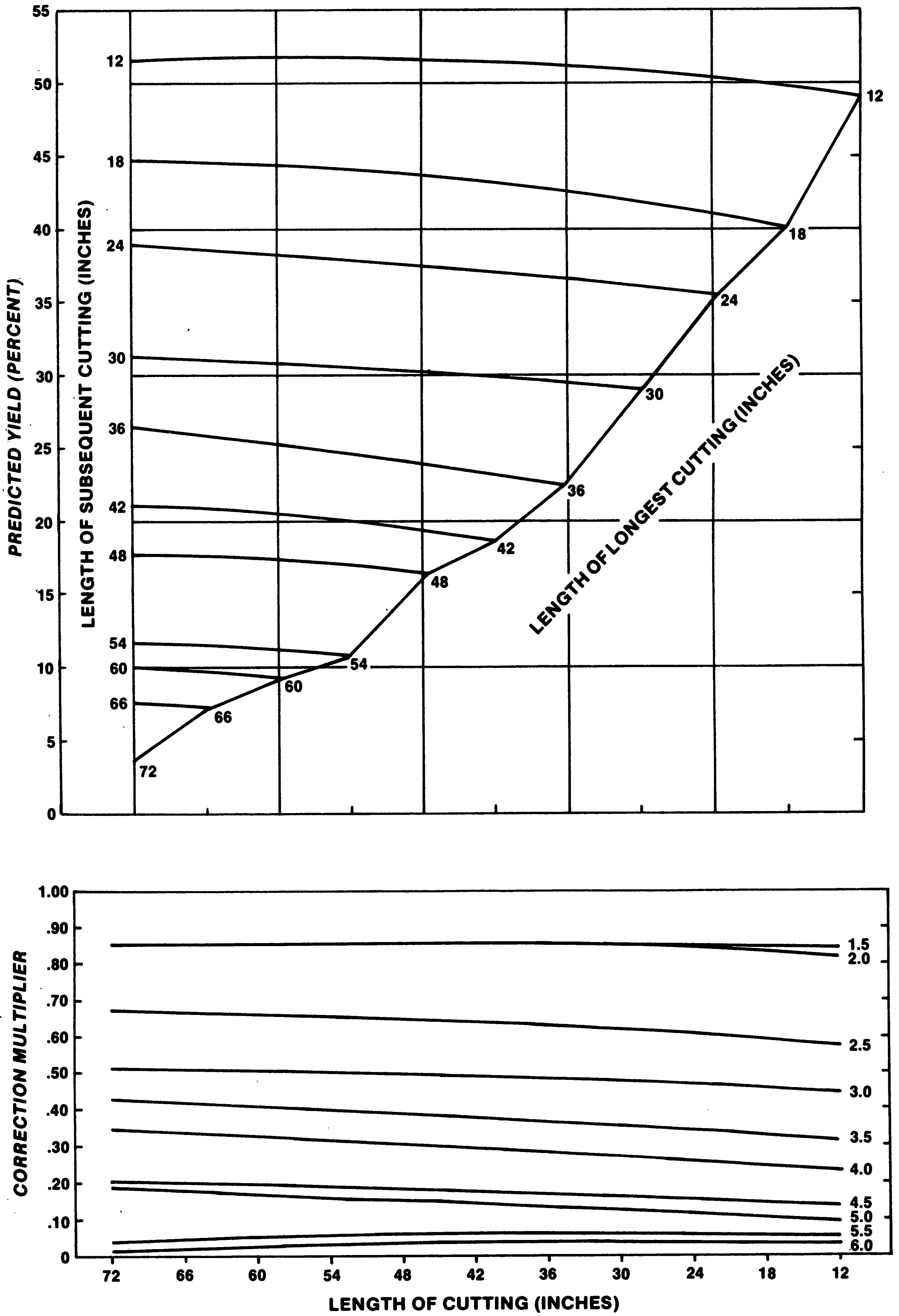


Figure 5.—*Yield prediction of 1-inch-wide cuttings with width corrections for black walnut C1S—4-foot minimum.*

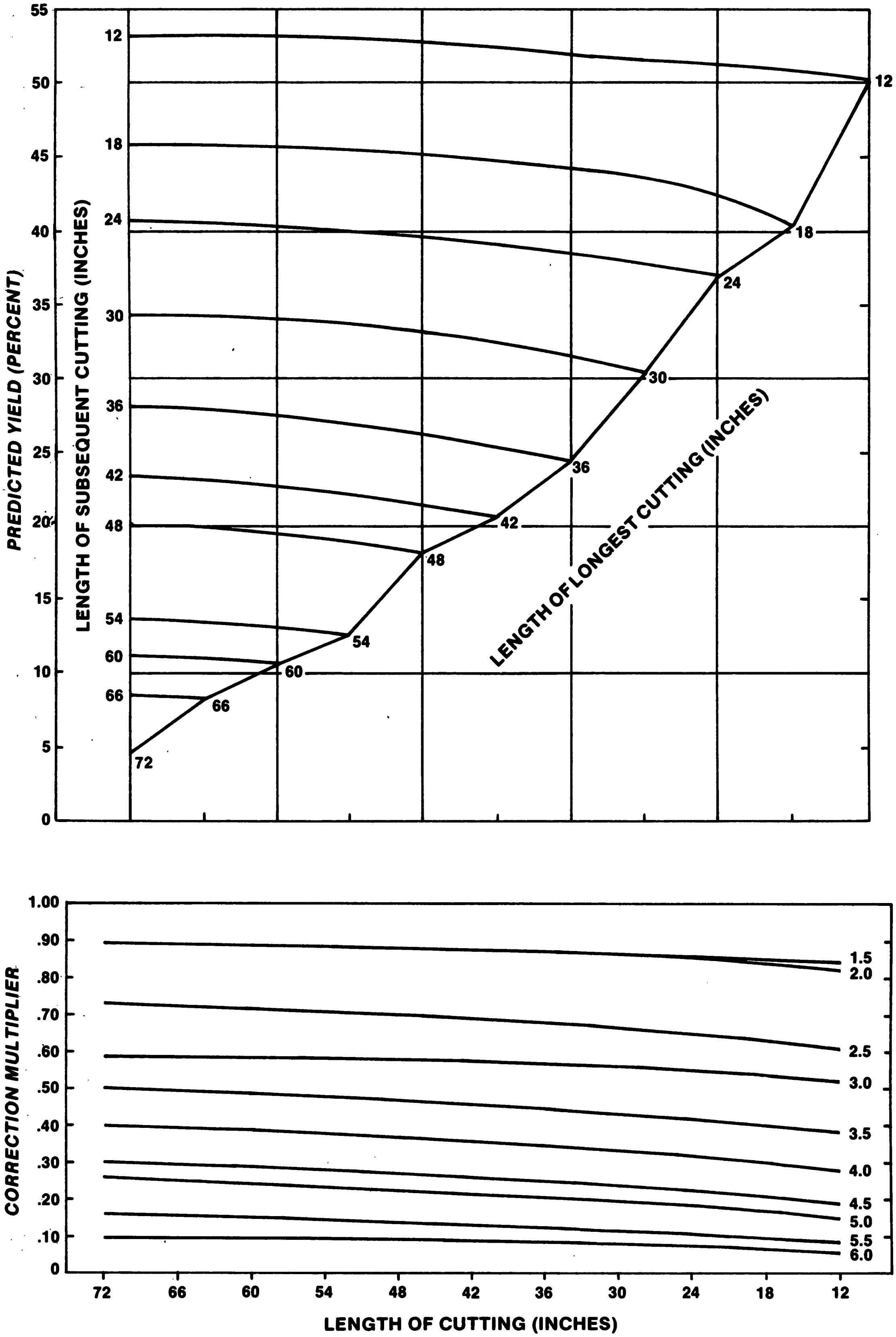


Figure 6.—*Yield prediction of 1-inch-wide cuttings with width corrections for black walnut CM—4-foot minimum.*

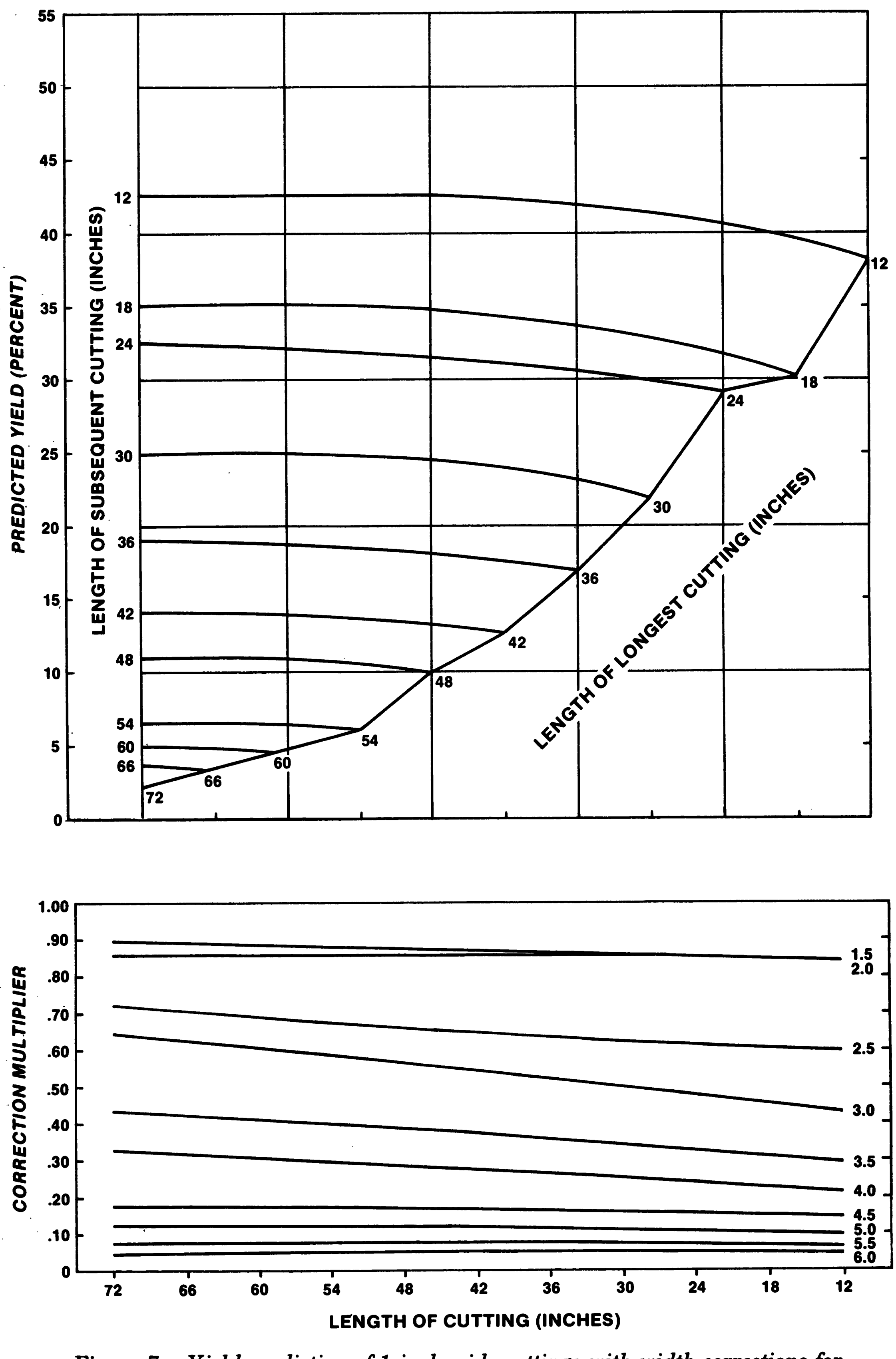


Figure 7.—*Yield prediction of 1-inch-wide cuttings with width corrections for black cherry C2S—2- and 4-foot minimum.*

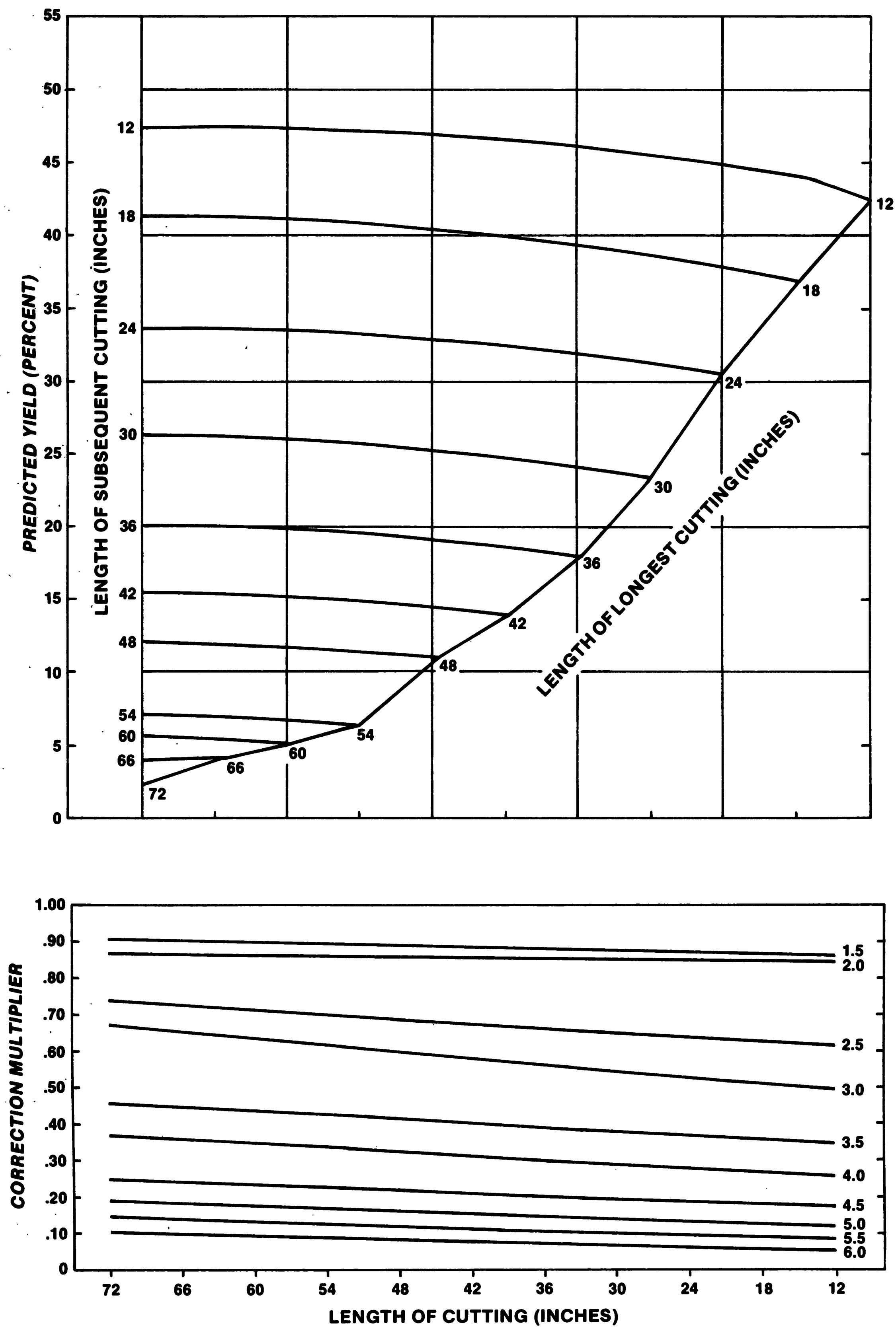


Figure 8.—*Yield prediction of 1-inch-wide cuttings with width corrections for black cherry C1S—2- and 4-foot minimum.*

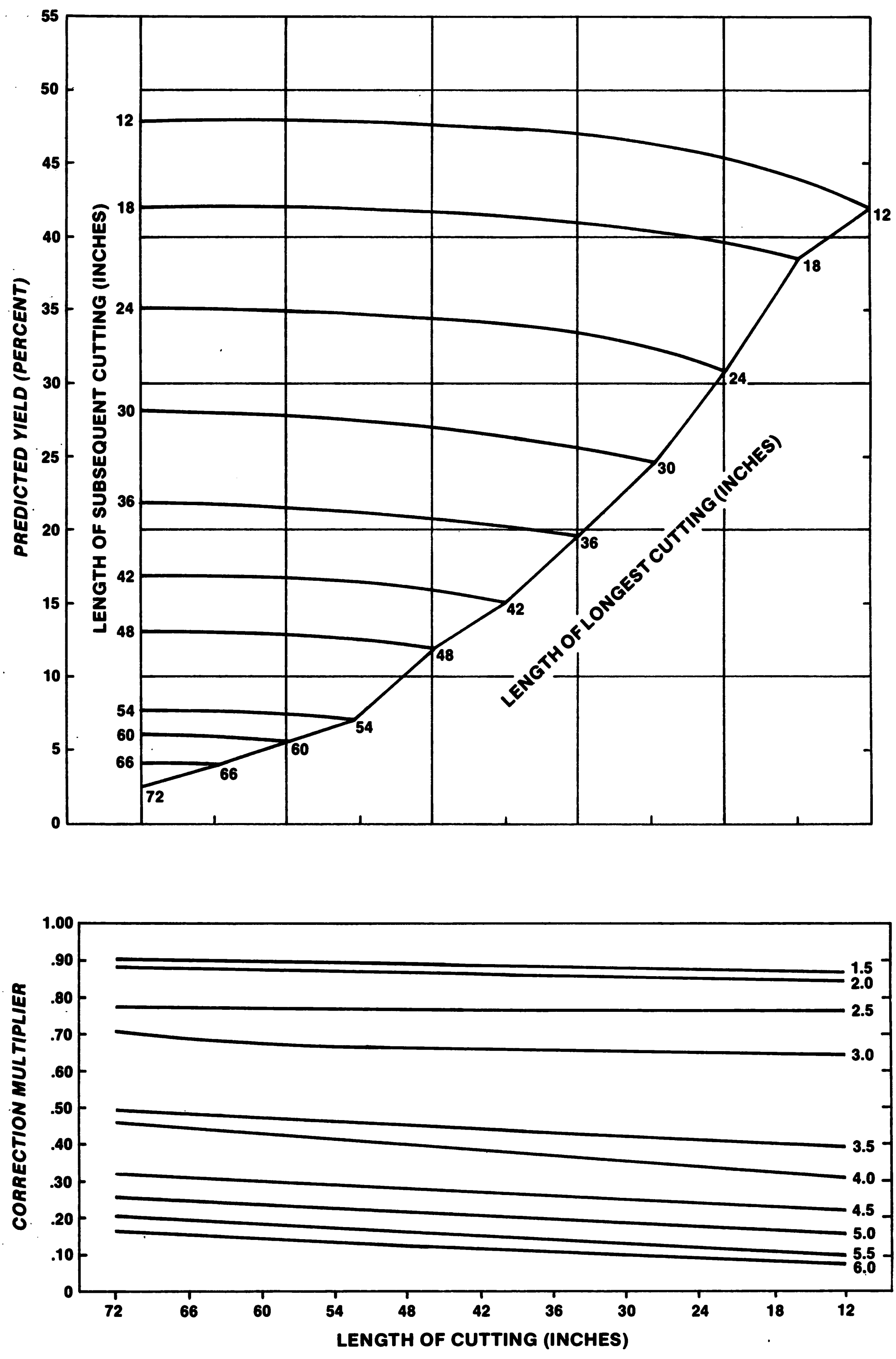


Figure 9.—*Yield prediction of 1-inch-wide cuttings with width corrections for black cherry CM—2- and 4-foot minimum.*

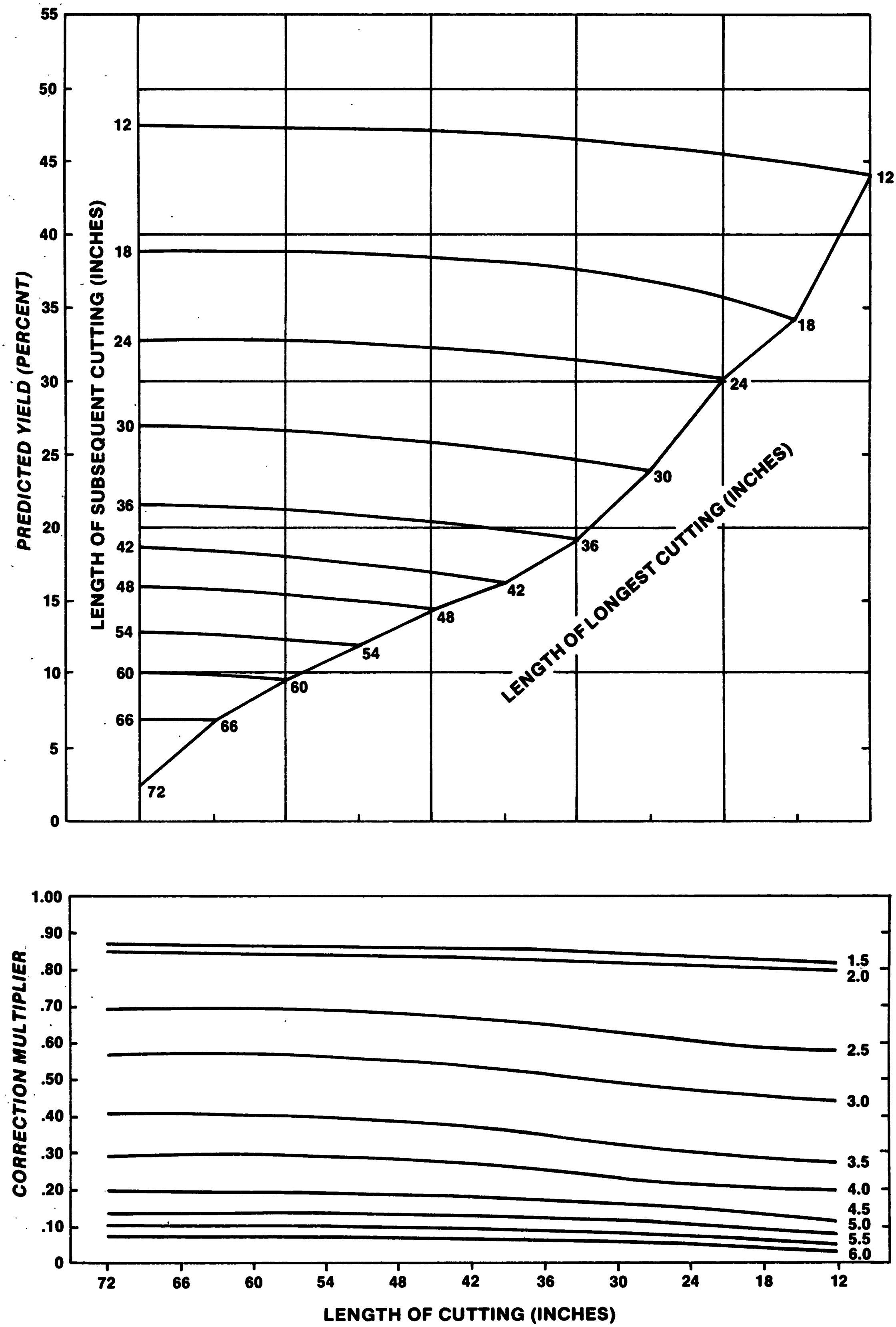


Figure 10.—*Yield prediction of 1-inch-wide cuttings with width corrections for yellow-poplar C2S—2- and 4-foot minimum.*

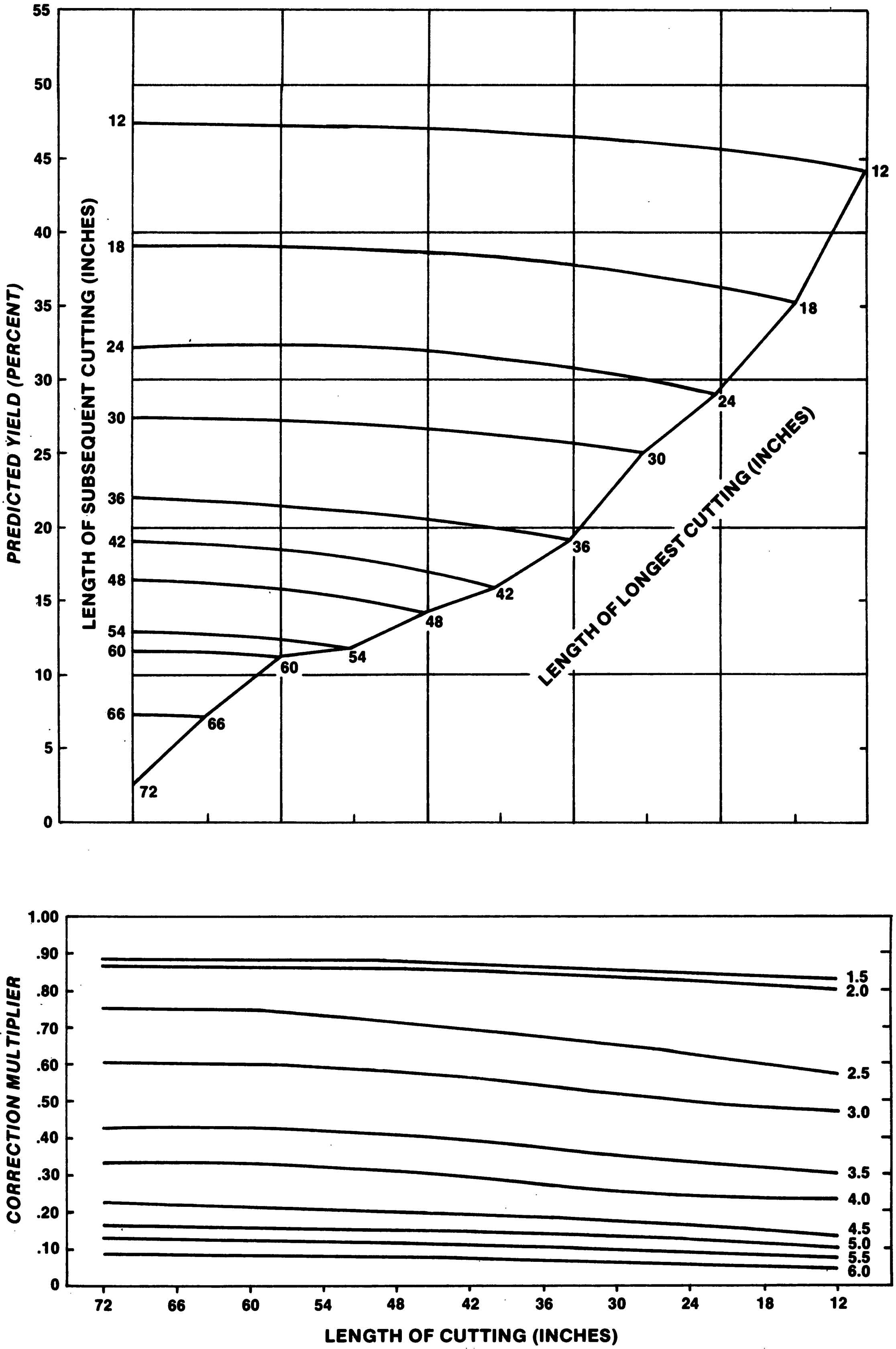


Figure 11.—*Yield prediction of 1-inch-wide cuttings with width corrections for yellow-poplar C1S—2- and 4-foot minimum.*

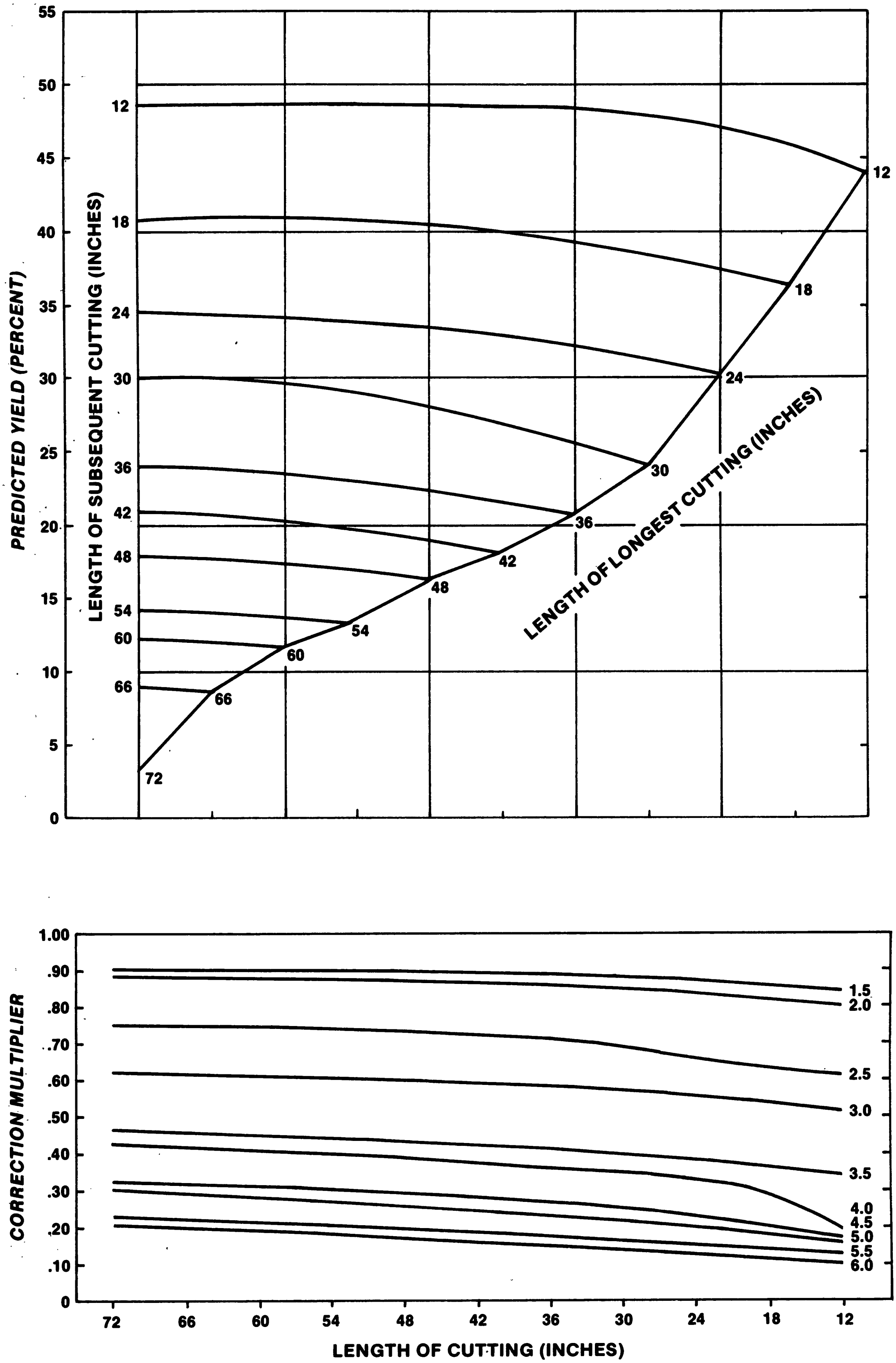
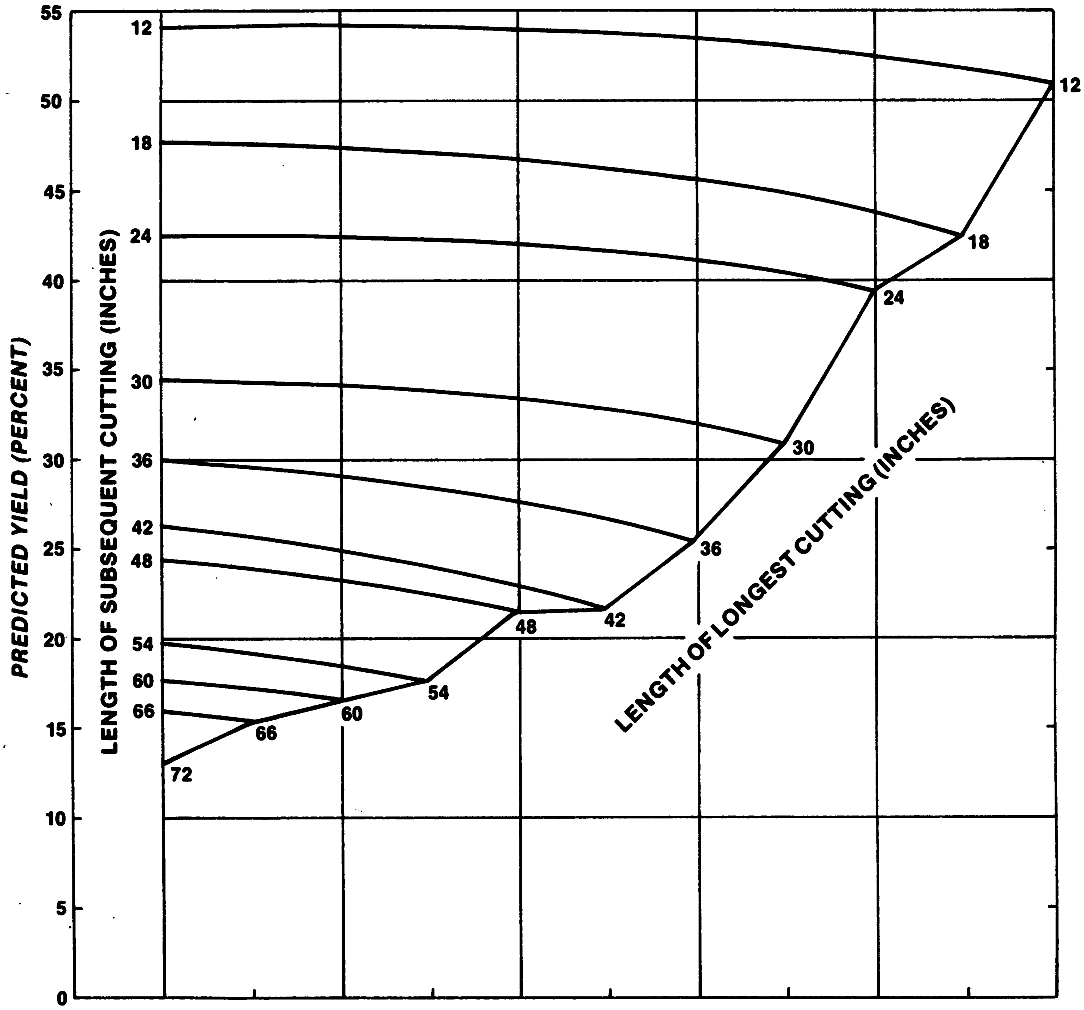


Figure 12.—*Yield prediction of 1-inch-wide cuttings with width corrections for yellow-poplar CM—2- and 4-foot minimum.*



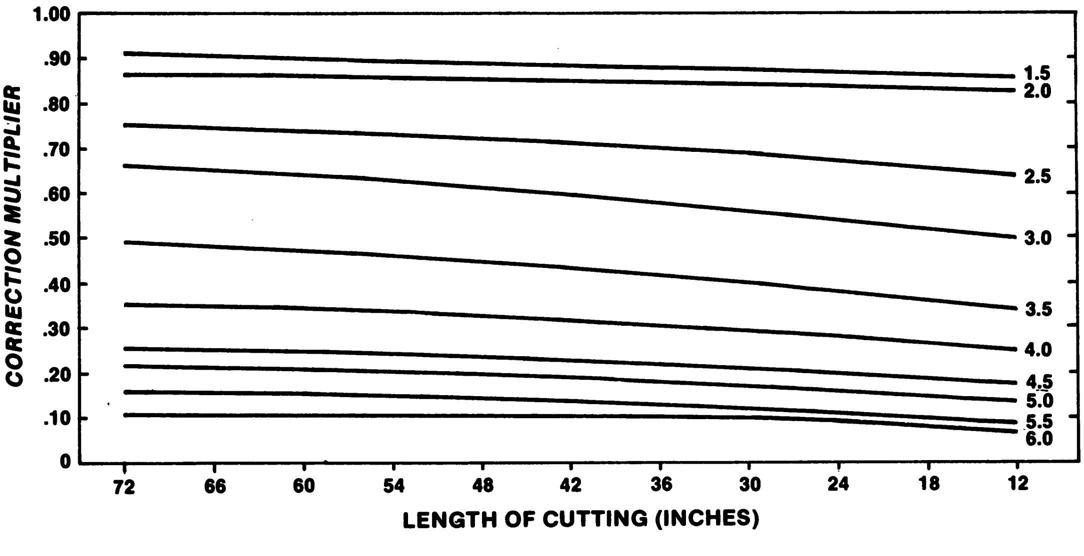


Figure 13.—*Yield prediction of 1-inch-wide cuttings with width corrections for soft maple C1S, C2S, and CM—2- and 4-foot minimum.*

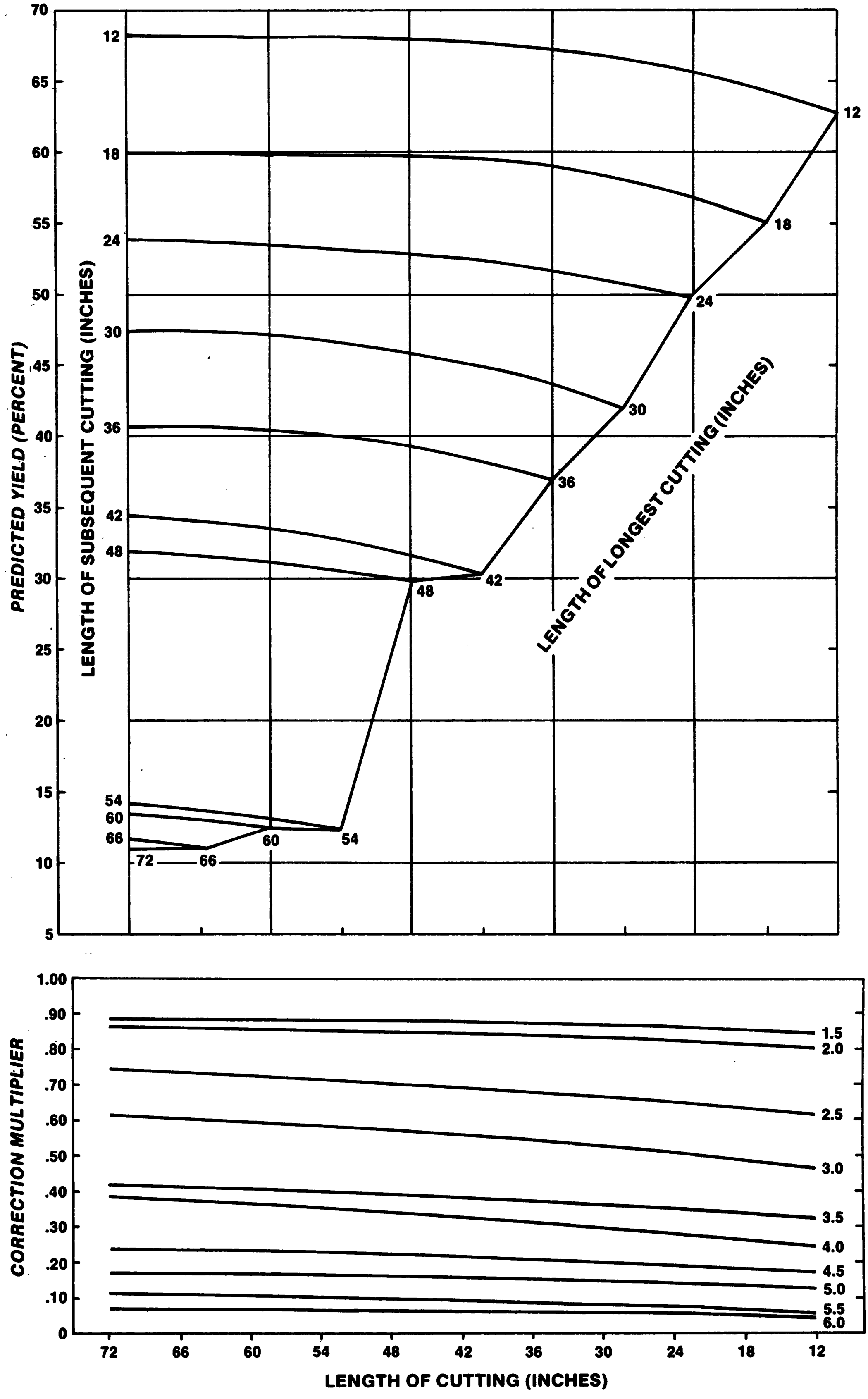


Figure 14.—*Yield prediction of 1-inch-wide cuttings with width corrections for aspen C1S, C2S, and CM—2- and 4-foot minimum.*

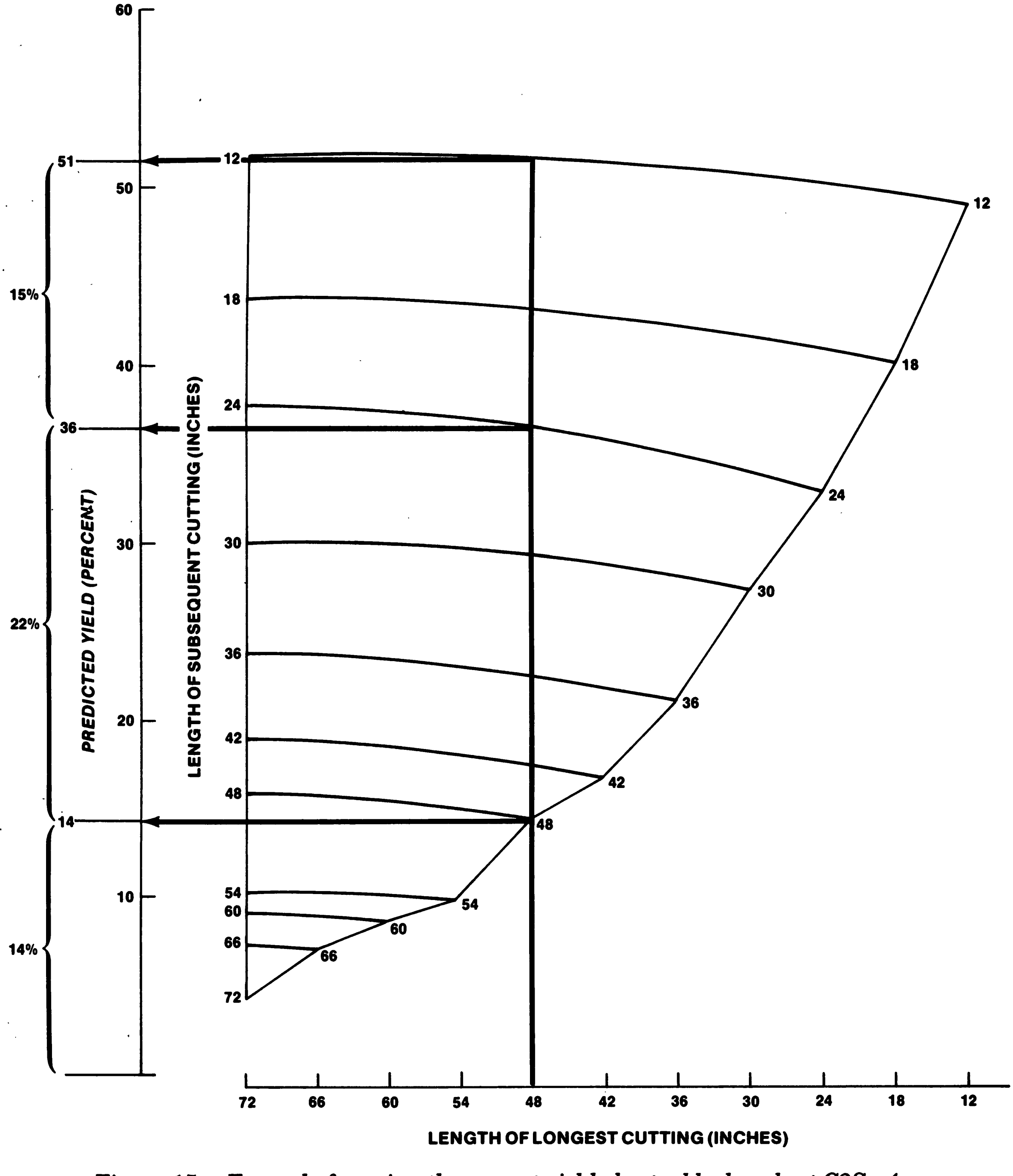


Figure 15.—*Example for using the percent yield charts: black walnut C2S—4-foot minimum.*

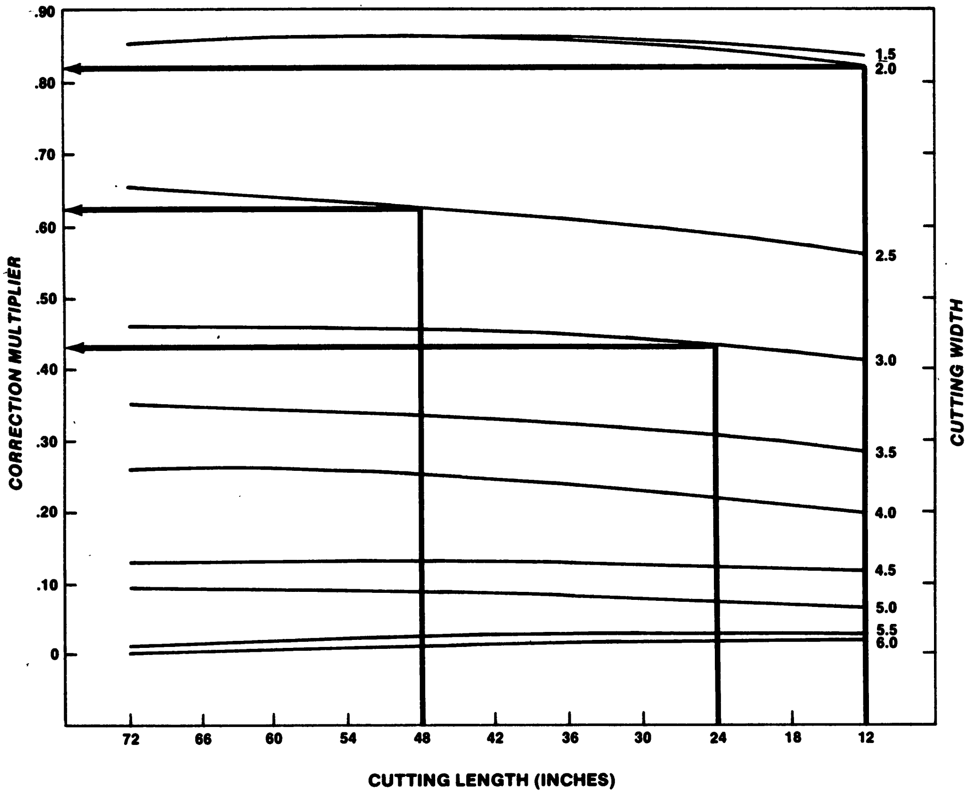


Figure 16.—*Example for using the width adjustment chart: black walnut C2S—4-foot minimum.*

Table 3.—*Example for obtaining percent yields for cuttings of various widths from black walnut, C2S lumber, and 4-foot minimum logs*

Cutting size Length	Cutting size Width	Yield of 1-inch-wide boards	Width correction multiplier	Adjusted yield	Yield given removal of previous cuttings
Inches		*Percent*		*Percent*	
48	2.5	14	0.62	9	9
24	3.0	36	0.43	16	7
12	2.0	51	0.82	42	26
				Total yield	42

Conversion of Percent Yield to Number of Cuttings per Thousand Board Feet

Yields are easily converted from percents to number of cuttings per 1,000 board feet by dividing the percent yield by 100, multiplying by 1,000, and dividing by the area of the cutting surface in square feet (table 4).

Table 4.—*Number of cuttings per 1,000 board feet of three cutting sizes from black walnut, C2S lumber, and 4-foot minimum logs*

Cutting size		Surface	Yield	Cuttings per 1,000
Length	Width	area		board feet
--------*Inches*--------		*Ft*^{2}	*Percent*	*No.*
48	2.5	0.83	9	108
24	3.0	0.50	7	140
12	2.0	0.17	26	1,529

COMPARISON OF SHORT LOGS AND STANDARD GRADE LUMBER— YIELDS AND COSTS

Two general observations can be made comparing cutting yields from short logs to standard grade lumber: (1) overall yields are less for short logs and (2) distributions of cuttings are more heavily weighted to short and narrow pieces for short logs. For example, yields of short logs (C2S— 4-foot minimum) compared to No. 2 Common lumber for black walnut show that recoveries for 1-inch-wide cuttings are similar, but recoveries from 3-inch lumber are better for No. 2 Common (table 5). For black walnut, yields from short logs are less than 15 percent for all lengths of cuttings 4 inches wide and above, whereas FAS grade lumber can yield up to 60 percent for the same product (Schumann 1971). The same is true for the other wood species of this study. Integrated sawmill-dimension plants can best use short logs for dimension lumber when the cutting bill requires narrow cuttings and a large percentage of the cuttings are short.

Table 5.—*Comparison of black walnut yields for No. 2 Common and short logs (C2S—4-foot minimum) for different width cuttings*

(In percent)

Cutting length	1-inch width		3-inch width	
(Inches)	No. 2 Common[1]	Short logs	No. 2 Common[1]	Short logs
48	14	14	7	7
24	28	22	24	9
12	11	5	13	5
Total	53	51	44	21

[1]From charts of Schumann (1971).

Because of the large differences in prices of lumber that exist depending on area of the country and time of year, estimating a price on standard grade lumber, much less on short log material, is difficult. Because black walnut is the most valuable wood type in this study, we estimated the cost of this wood for different grades to fill a specific cutting bill. We assumed the following quantity and sizes: 400 48- by 2½-inch, 400 24- by 3-inch, and 2,000 12- by 2-inch. We also assumed a cost per 1,000 board feet for FAS of $1,300, No. 1 Common $800, No. 2 Common $400, and the lumber derived from short logs $250.

After calculating lumber costs for several short log and grade combinations, we found that using entirely short log material was the most economical (table 6). Although three times as much short log lumber was required as for FAS lumber, the cost of cuttings from FAS lumber was almost twice as much. Combinations of No. 1 Common for the longer cuttings and short logs for the remainder reduced the lumber required, compared to only short logs, by more than half; but the lumber cost was still about $150 per 1,000 board feet higher.

The cost comparison example given is dependent upon particular prices. Also processing, handling, and drying costs may be larger due to the greater quantities of lumber needed to fill the cutting bill. Nevertheless the analysis demonstrates that short log material has potential economic value and that hardwood dimension producers and furniture manufacturers that produce their own raw material should consider this material when choosing the best grade mix to meet a specific cutting bill.

Table 6.—*Comparison of costs to cut 400 48- by 2½-inch, 400 24- by 3-inch, and 2,000 12- by 2-inch 4/4 black walnut cuttings from various grades and short logs*[1]

Lumber mix	Lumber required	Cost per 1,000 board feet	Total
	Board feet	Dollars	
Short logs for all lengths	3,774	250	944
FAS for all lengths	1,247	1,300	1,621
No. 1 Common for all lengths	1,544	800	1,235
No. 2 Common for all lengths	3,008	400	1,203
FAS for 48-inch lengths[2]	678	1,300	
Short log for remainder	913	250	1,110
No. 1 Common for 48- and 24-inch lengths[3]	1,278	800	
Short log for remainder	282	250	1,093

[1]Yields of standard grade from Schumann (1971).

[2]Includes 230 of 24-inch and 199 of 12-inch.

[3]Includes 1,348 of 12-inch.

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KEY WORDS: utilization, bolts, grades, dimension stock, cutting bill, costs, *Liriodendron tulipifera, Juglans nigra, Prunus sertina, Acer rubrum, Populus grandidentata.*

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1980. Dimension yields from short logs of low-quality hardwood trees. U.S. Department of Agriculture Forest Service, Research Paper NC-184, 22 p. U.S. Department of Agriculture Forest Service, North Central Forest Experiment Station, St. Paul, Minnesota.

Charts are presented for determining yields of 4/4 dimension cuttings from short hardwood logs of aspen, soft maple, black cherry, yellow-poplar, and black walnut for several cutting grades and bolt sizes. Cost comparisons of short log and standard grade mixes show the estimated least expensive choice for a specific cutting bill.

KEY WORDS: utilization, bolts, grades, dimension stock, cutting bill, costs, *Liriodendron tulipifera, Juglans nigra, Prunus sertina, Acer rubrum, Populus grandidentata.*

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