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Maximum Cutting Yields for 6/4 Ponderosa Pine Vertical Grain Lumber

Kent A. McDonald
Pamela J. Giese
and
Richard O. Woodfin

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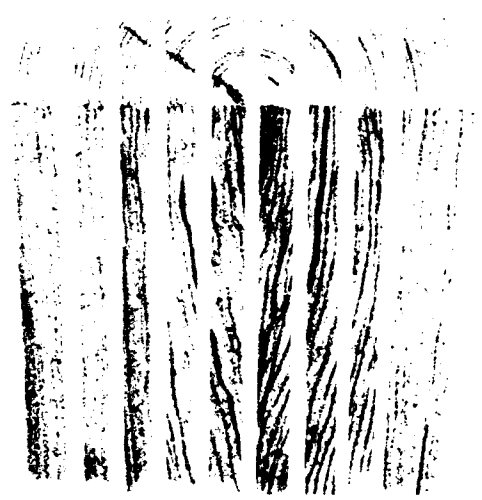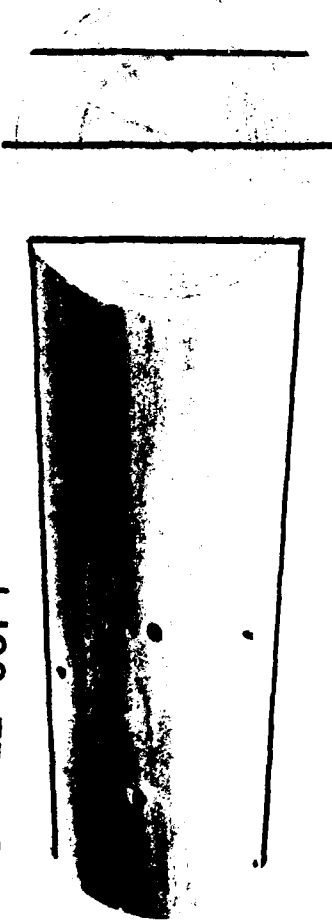## Abstract

The moulding and millwork industries process nearly 1.3 billion board feet of Ponderosa Pine annually. Unfortunately, thousands of trees are harvested unnecessarily to compensate for less than optimum processing. To help improve this situation, researchers at the Forest Products Laboratory developed maximum cutting yields for 6/4 Vertical Grain Ponderosa Pine lumber in grades No. 1, No. 2, and No. 3. Yields were developed by building a representative 6/4 Vertical Grain lumber data base and simulating sawing of the lumber by the computer program OPTYLD. Results may be used to compare cutting yields between 6/4 Vertical Grain grades, to guide grade selection, and to estimate possible improvements in processing. Results also encourage more automation in lumber processing.

This paper is part of a series by the U.S. Department of Agriculture, Forest Service, Forest Products Laboratory on maximizing cutting yields of 5/4 and 6/4 Shop, and 6/4 Vertical Grain lumber.

Acknowledgment

Maximum Cutting Yields for 6/4 Ponderosa Pine Vertical Grain Lumber

Kent A. McDonald, Research Forest Products Technologist
Pamela J. Giese, Computer Programmer
and
Richard O. Woodfin, Forest Products Technologist
Pacific Northwest Forest and Range Experiment Station
Portland, Oregon

Introduction

The moulding and millwork industries consume about 1.3 billion board feet of Ponderosa Pine lumber annually. A sizable portion of the volume consumed is in 6/4 Vertical Grain lumber. Because of manual processing operations and high production speeds, many processing inefficiencies occur. The purpose of this research is to develop maximum cutting yield information for individual grades that can help improve the efficiency of such operations.

The industry resaws cants to produce Vertical Grain lumber for the millwork market. These cants are sawn into boards with widths equal in size to the cant thickness. Boards produced in this manner feature edge grain or vertical grain characteristics, hence the nomenclature Vertical Grain. Vertical Grain, sometimes referred to as "Sized Shop", is graded under the Jamb and Headstock rules of the Western Wood Products Association (WWPA) (2)[2] (par. 97.00).

Information on the clear cutting yields of 6/4 Vertical Grain lumber has been unavailable and awaiting the sophistication of the computer. With this tool now available, we developed the information by obtaining a board data base for computer simulation of the cut-up operations for Vertical Grain lumber; developing maximum clear cutting yields for No. 1, No. 2, and No. 3 grades of Ponderosa Pine Vertical Grain lumber; and developing yield data on cuttings salvageable from defective pieces ("ripped" clear cuttings).

This report is the third in a series (6,7) aimed at improving the efficiency of utilization of Shop and Vertical Grain lumber in the moulding and millwork industry.

Study Procedures

Sampling

A 5,374-board-foot sample of 6/4 Vertical Grain lumber was selected (7) from mills located throughout the geographical range of ponderosa pine (fig. 1). This lumber was selected to locate and measure the size and distribution of defects.

All sample material was inspected by Quality Supervisors of the WWPA to verify the grade and scale. If a supervisor determined any board was misgraded it was changed to the correct grade. Each board was numbered and its grade and measurements recorded. Board measure for these 6/4 boards was obtained by the standard procedure of multiplying surface measure by 1.5.

All samples were 4-7/8 inches wide and ranged in length from 10 to 16 feet. Only eight boards sampled from the No. 3 and Better mix graded No. 1 (table 1) and are not considered representative of the grade.

Data Collection

A complete digital record was made of each board and all defects, including the type of defect and its location, to the nearest 1/4 inch. Board data recorded include board number, grade, unit number, width, length, gross surface measure, and net surface measure.

Defects were measured on both sides of each board (fig. 2) using a measuring table designed for this purpose. Defects were tallied by type and four coordinate points of a quadrilateral which contained the defect (fig. 3). All wood was classified as either defect or clear. Any blemish not acceptable in a clear cutting was classified as defect and recorded.

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

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

Figure 1.—Distribution of ponderosa pine. (ML83 5059)

Measure First Face

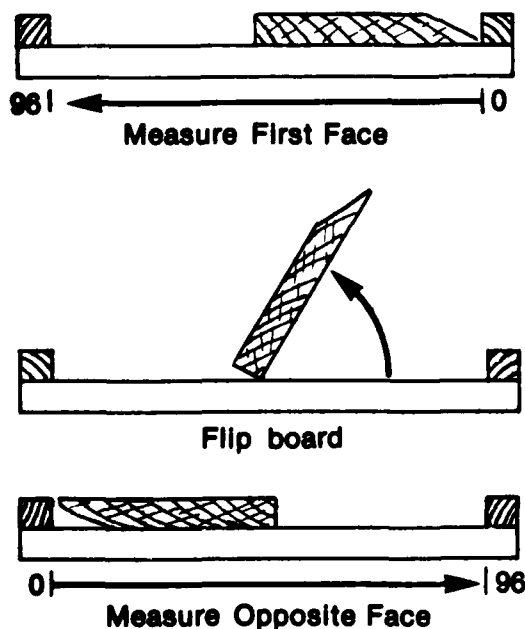Flip board

Measure Opposite Face

Figure 2.—Board measuring procedure. (M148959)

Table 1.—Sample data, 6/4 Ponderosa Pine Vertical Grain

Grade	Number of boards	Total volume	Average volume per board
		- - - - -Board feet[1] - - - - - -	
No. 1	8	84	10.5
No. 2	317	3,264	10.3
No. 3	197	2,026	8.6
Combined	522	5,374	10.3

[1] Scaled net surface measure times 1.50.

Simulated Board Processing Program (OPTYLD)

The maximum clear cutting yields for the 6/4 Vertical Grain lumber were determined using a specially designed computer program, OPTYLD (pronounced opt yield) (5). Although specifically developed for obtaining the maximum clear cutting yield from random-width lumber, the OPTYLD program was easily adapted to calculate the yield of fixed-width boards. Crosscut first, followed by ripping, are the operations typically used to produce cuttings from the Vertical Grain lumber. The single width of Vertical Grain lumber eliminates the need for the initial ripping operation common to processing of random-width 5/4 and 6/4 Shop grade lumber.

The computer program OPTYLD combines the digital board and defect data of both faces and selects the sawing solution that results in the highest value and/or yield of clear cuttings. To obtain the best crosscutting solution, all full-width clear cuttings longer than 9 inches are determined and their values computed. After the best crosscutting solution is selected, the remaining defective pieces are assessed for additional clear cuttings obtained by ripping.

For the Vertical Grain lumber, crosscutting was specified to produce fullwidth, random-length clear cuttings, 9 inches and longer in increments of 1 inch but not to exceed 84 inches. The remaining defective pieces were ripped to 1.75, 2.5, 3.0, and 3.5 inches. The limits (constraints) of this computer model are:
  —maximum board length of 16 feet
  —only clear, two-face cuttings can be obtained
  —1/4-inch increments used to describe the clear cutting dimensions, defect coordinates, board size, and saw kerf.

The maximum clear cutting yields were computed for the Vertical Grain sample by computer simulation using conventional processing procedures. These maximum yields were compiled by lumber grade from the individual board solutions. Boards were crosscut into the longest length, full-width clear cuttings obtainable from 9 to 84 inches long. A cutting value index (table 2) was developed to compare the value of different size cuttings so that the highest return from each board could be calculated. The values are based on information from industry cooperators and are assumed to represent industry practice. Note that these units are not dollars.

A summary of the full-width clear cuttings calculated per 1,000 board feet (table 3) shows the distribution by grade and by cutting length groupings. Longer cuttings come from grade No. 1 and proportionately shorter cuttings from No. 3. The total lengths of all cuttings per 1,000 board feet are summarized in table 3. They are respectively 1,294, 1,139, and 808 lineal feet for grades No. 1, No. 2, and No. 3.

Yields of ripped clear cuttings were computed for the No. 2 and No. 3 grades of Vertical Grain (table 4). The No. 1 did not produce any ripping yield, apparently due to its high quality or the small (eight) sample of boards. The distribution of ripped cuttings by width and length shows the increase in yield from the ripping operation. The summary of yield for crosscut and ripped clear cuttings by area and value (table 5) shows a 7.1 percent increase in total cutting area for No. 2 and an 18.6 percent increase for No. 3. Likewise, value increases from the ripping operation are 6.6 percent for No. 2 and 18.1 percent for No. 3.

The relative difference that occurs between the grades of Vertical Grain lumber is evident from the values obtained per unit area of cuttings, the recovery percentages, and the calculated values of clear cuttings per board measure as shown in table 6. (Remember, these values have no units and are derived using values from the cutting value index in table 3).

The value per unit of clear cuttings obtained for each grade is calculated by:

$$\frac{V}{A} = UV \qquad (1)$$

where V = total value of clear cuttings
A = total board area in clear cuttings (ft²)
UV = value per unit of clear cutting

These values are 1.073, 0.907, and 0.863 for grades No. 1, No. 2, and No. 3, respectively.
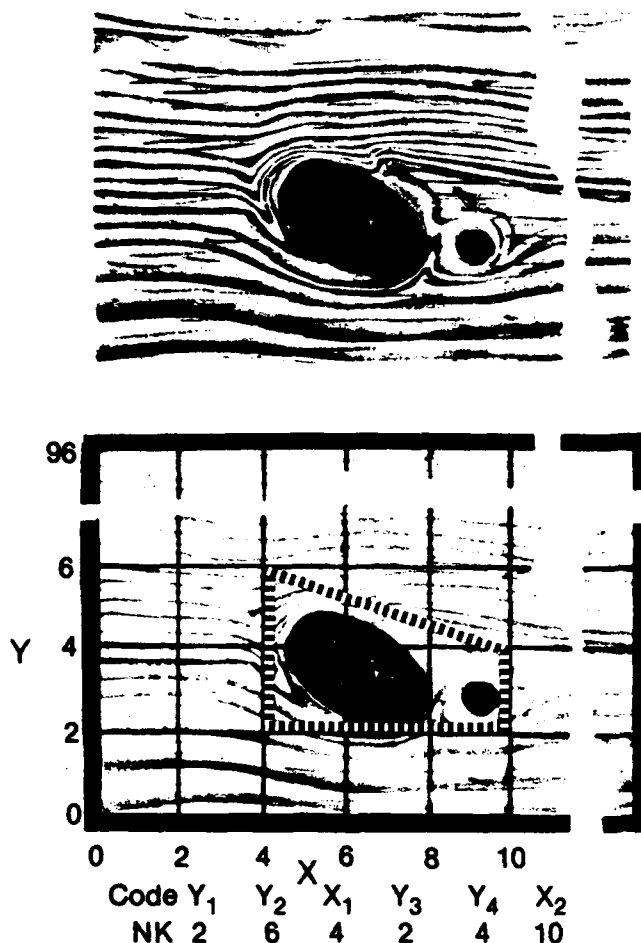

Figure 3.—Defect measuring procedure. (M148955, M148954)

Table 2.—Relative cutting value index, 6/4 Ponderosa Pine Vertical Grain

Width	Cutting length (inches)								
	9-12	13-19	20-26	27-35	36-47	48-59	60-71	72-83	84
In.	——————————Value[1] per 1,000 ft² ——————————								
2.50	800	810	820	840	860	880	1,000	1,030	1,150
3.00	800	810	820	840	860	880	1,000	1,030	1,150
3.50	810	830	840	860	880	910	1,040	1,070	1,200
4.50	820	840	850	870	890	930	1,080	1,120	1,250
4.75	825	845	855	875	895	950	1,100	1,145	1,300

[1] Value has no units.

3

Recovery of clear cutting area relative to the board footage in the sample is obtained by:

$$\frac{A}{B} \times 100 = R \qquad (2)$$

where A = total board area in clear cuttings (ft²)
 B = total board feet in sample
 R = percent recovery of cutting area to board feet

By grade, recovery percents are 48.8, 46.0, and 37.2 for No. 1, No. 2, and No. 3, respectively. To convert these values to percent recovery of cuttings in board feet, multiply the percentages by 1.5.

Finally, the cutting value obtained for 1,000 board feet is calculated by:

$$\frac{V}{B} \times 1,000 = V/M \qquad (3)$$

where V = total value of clear cuttings
 B = total board feet in sample
 V/M = value per 1,000 board feet

By grades, the cutting values per 1,000 board feet are 524, 417, and 321 for No. 1, No. 2, and No. 3, respectively. Assuming the relative value index used was realistic, these cutting values should represent the absolute differences between these grades.

Table 3.—Crosscutting yield[1] to board measure, 6/4 Ponderosa Pine Vertical Grain

Grade	Cutting length class (inches)									Lineal feet cuttings per 1,000 board feet
	9-12	13-19	20-26	27-35	36-47	48-59	60-71	72-83	84	
	Full-width cuttings per 1,000 board feet									
No. 1	59.5	178.6	47.6	23.8	23.8	23.8	0	11.9	83.3	1,294
No. 2	95.9	123.2	90.4	88.5	52.7	36.8	16.2	6.1	3.1	1,139
No. 3	139.6	180.1	93.3	56.3	24.2	5.4	1.5	.5	2.0	808

[1] Does not include ripped cuttings.

Table 4.—Ripped yield to board measure, 6/4 Ponderosa Pine Vertical Grain

Width	Cutting length class (inches)								
	9-12	13-19	20-26	27-35	36-47	48-59	60-71	72-83	84
In.	Ripped pieces per 1,000 board feet								
	GRADE NO. 1								
	(No ripped yield)								
	GRADE NO. 2								
1.75	15.3	8.3	4.6	1.2	0.3	0.3	0.3	0.3	0.3
2.50	11.3	4.6	2.1	.6	.3	—	—	—	—
3.00	9.8	5.5	.6	.3	.3	—	—	—	—
3.50	21.4	11.9	4.9	2.1	1.2	.6	—	—	.3
	GRADE NO. 3								
1.75	20.2	13.8	5.9	6.9	5.4	2.5	.5	1.0	—
2.50	15.3	16.8	6.4	3.9	—	.5	.5	—	—
3.00	12.3	11.3	4.4	1.0	1.0	2.5	—	—	—
3.50	37.5	26.2	5.9	3.0	2.0	1.0	—	—	—

Table 5.—Crosscut and ripped cutting yield summary, 6/4 Ponderosa Pine Vertical Grain

Shop grade	Total cutting area			Total value		
	Crosscut	Ripped	Ripped	Crosscut	Ripped	Ripped
	Ft²	Ft²	Pct	([1])	([1])	Pct
No. 1	41	0	—	44	0	—
No. 2	1,394	106	7.1	1,270	90	6.6
No. 3	614	140	18.6	532	118	18.1

[1] Value has no units.

Table 6.—Total recovery from 6/4 Ponderosa Pine Vertical Grain

Grade	B Total board measure	[1]V Total value of cuttings	A Total area of cuttings	UV = V/A Value per unit cutting	R = 100A/B Recovery cutting area to board measure	[2]V/M = 1,000V/B Cutting value per 1,000 board feet
	Board feet		Ft²	V/ft²	Pct	
No. 1	84	44	41	1.073	48.8	524
No. 2	3,264	1,360	1,500	.907	46.0	417
No. 3	2,026	651	754	.863	37.2	321

[1] Value has no units.
[2] Value has no units. M = 1,000 board feet.

Summary

Completion of the 6/4 Vertical Grain cutting yield study provides maximum clear cutting yield information for three grades. Although the board sample is small for grade No. 1, the samples for grades No. 2 and No. 3 are considered a valid data base. Using the OPTYLD computer program, the maximum cutting yields were determined with consistency and without human bias. The results present valuable information about yield differences between grades of Vertical Grain lumber. This should permit mill operators to schedule and allocate individual grades for processing as an alternative to the present practice of combining all grades. These cutting yields also make it possible for mill operators to investigate potential processing improvements and calculate production requirements against lumber grade input. Mill personnel can now collect their own board data for computation of maximum yields using the OPTYLD computer program. The program options can then be tailored to any desired mill conditions for improved processing.

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Less than optimum utilization of Ponderosa Pine 6/4 Vertical Grain lumber causes
unnecessary losses to the timber resource. From a representative lumber data
base and simulation of the lumber sawing process, the maximum clear cutting
yield for 6/4 Vertical Grain lumber was determined using the computer program
OPTYLD. Processors of Vertical Grain lumber can compare their yields with the
computer yields by lumber grade, can improve grade selection, and can estimate
improvements in processing.

Keywords: Maximum cutting yields, crosscutting, Vertical Grain grades,
moulding and millwork, sawing simulation, computer processing,
utilization research.

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