

# FACTORS THAT IMPACT YIELD AND VALUE

Jan Wiedenbeck

## **Lumber Grade and Lumber Size:**

Most rough mill managers “choose” a particular grade mix for a cutting order based on what lumber is available both in inventory and from suppliers and on what grade mix is standard for the mill. The standard grade mix is one that has evolved over time based on observations of what runs smoothly through the mill and produces the needed parts with an acceptable yield. However, a standard grade mix may not be the best grade mix for a specific cutting order or for one species versus another. Even for a given cutting order, the best grade mix may change when relative lumber prices change, when the length and width of the lumber supply changes, when rough mill equipment or operator expertise changes, or when there are changes in cutting order specifics such as part pricing, sizes, and quality, numbers of parts, or turnaround time on the order.

Choosing the best lumber grade mix should not be a single decision for all species and all cutting orders (except for rough mills that focus on a particular product so that they produce the same part sizes using the same species every day). Choosing the best lumber grade mix should not be a one-time event or a once-a-year activity -- it should be done whenever lumber prices, products, or rough mill operations change.

In choosing the best lumber grade mix to process, it is helpful to run frequent studies in the rough mill using small groups of boards of a given grade (e.g., 5 boards). The basic design for these small-scale yield studies is shown in Figure 1. These boards are tracked through the rough mill and the yield is calculated based on the tally at the sort station. Several 5-board runs can be conducted for each lumber grade in a single day with minimum disruption. If this is done for every significant cutting order, your rough mill managers will be better able to answer the question “What is the best lumber grade mix for this rough mill to run on this cutting order given current prices, equipment, etc.?” It also will help you answer the question “What is the breakeven sales price for this cutting order when cut from each lumber grade?”

## **Optimum Lumber Grade Mix Computer Programs:**

In lieu of mill studies, computer programs can be used to estimate the optimal lumber grade mix. Two types of programs can be used: least-cost lumber grade mix programs and lumber cut-up simulation programs.

Least-cost lumber grade mix programs provide “optimal” grade mix estimates using lumber prices, part sizes and quantities, production costs, and a list of available lumber grades that the user inputs. The least-cost lumber grade mix is then derived based on expected lumber yields that are contained in the programs’ yield tables. Unfortunately, the yield tables are based on crosscut-first lumber processing so predicted rip-first yields might not be reliable. The yield tables also have some other shortcomings. The advantage of this type of program is that it is easy to use and provides quick answers. If a rough mill manager must choose between frequent least-cost grade mix computer runs to assist in the grade mix decision and infrequent rough mill grade-based yield studies, the more frequent computer runs probably are preferred.

While several least-cost lumber grade mix programs have been developed over the years, many are difficult to obtain and/or complicated to run. The more familiar of these programs include:

- **The Furniture Cutting Program** -- authored, distributed, and supported by Dr. Hank Huber of Michigan State University until his retirement (no longer distributed by Michigan State).
- **The Rough Mill Cost-Cutter Program** -- authored, distributed, and supported by Dr. Philip H. Steele of Mississippi State University.
- **OPTIGRAMI V2** -- authored, distributed, and supported by Penny Lawson and others at the Forest Service research lab in Princeton, West Virginia (phone: 304-431-2700; fax: 304-431-2772).

Lumber cut-up simulation programs are somewhat more complicated for evaluating optimal lumber grade mix but can provide better comparisons of the relative yields and cost factors for different lumber grade mixes and cutting bills. These programs are run repeatedly with different lumber grades to determine the optimal lumber grade mix. Both rip-first and crosscut-first simulation programs are available. The advantage of this type of computer program is that the user can provide more specific information on the rough mill processing system (e.g., type of gang-rip saw, cutting priorities, part quality). In addition, rip-first yields are not erroneously based on crosscut-first yields as is the case for the least cost grade mix programs.

Lumber cut-up simulation programs can be run manually or tied into another program that can serve as an interface for optimum lumber grade mix runs. Currently available lumber cut-up simulation programs include:

- **CORY** -- authored, distributed, and supported by Dr. Charlie Brunner of Oregon State University
- **RIP-X** -- authored, distributed, and supported by Dr. Philip Steele and others at Mississippi State University.
- **ROMI-RIP and ROMI-CROSS** -- authored, distributed, and supported by Ed Thomas at the Forest Service research lab in Princeton, West Virginia.

#### *The Impact of Lumber Grade on Yield:*

Part yield when cutting one grade of lumber versus another is best measured in rough mill yield studies or using a rough mill cut-up simulator. However, general data (derived from simulations) on the degree of influence of lumber grade on part yields for a variety of cutting bills look like this:

Rough mill type	Rip-First					Crosscut-First			
	FAS <sup>a</sup>	1C <sup>b</sup>	2C <sup>b</sup>	1C <sup>b</sup>	2C <sup>b</sup>	1C <sup>b</sup>	2C <sup>b</sup>	1C <sup>b</sup>	2C <sup>b</sup>
Cutting quality	C2F	C2F	C2F	C1F	C1F	C2F	C2F	C1F	C1F
Yield (%)	74	65	51	75	66	64	53	70	64

<sup>a</sup> FAS, rip-first yields are based on simulations of 12 cutting bills (Wiedenbeck & Thomas 1995).

<sup>b</sup> No. 1 and 2A Common yields are based on simulations of the same 7 cutting bills for both the rip-first and crosscut-first mill configurations. This was a rigorous analysis that allowed direct comparison of the relative difference in yields expected for 1C versus 2C lumber when cutting a variety of cutting orders (Buehlmann et al. 1998, 1999).

When comparing simulation-derived part yields from No. 1 and 2A Common lumber, the differences in yield between rip-first and crosscut-first systems for each grade appear to be significant. It is important to note that the computer simulation of the cutup process assumes an ideal, fully optimized operation. The yields from actual operations typically are lower since the potential yield gains from full optimization are difficult to achieve in practice. The rip-first configuration produced consistently higher part yield when processing 1 Common lumber than the crosscut-first configuration (6 of 7 cutting orders) (Buehlmann et al. 1999). The crosscut-first configuration produced higher part yield than the rip-first configuration when cutting 2A Common lumber into C2F parts, though this result was less consistent (4 of 7 cutting orders). When a cutting order calls for wider parts from 2A Common lumber, the crosscut-first system outperforms the rip-first system. For narrower parts (less than 3.5 inches), the rip-first system seems to perform better.

*The Impact of Lumber Grade on Productivity and Operating Costs:*

Higher lumber yields do not necessarily mean greater profits. The cost element must be weighed for every decision. Although the purchase price of higher grade lumber is higher than for lower grade lumber, processing costs for lower grade lumber are usually greater than for higher grade lumber. For example, processing costs are greater because more cutting operations are required to isolate usable board sections from defects in 2A and 3A Common lumber compared to higher grade lumber (Gatchell and Thomas 1997, Gatchell et al. 1999, Steele et al. 1999). For FAS lumber, most of the cutting that is done is for the purpose of sizing the parts since only a few defects need to be removed. Also, a higher percentage of the cuttings produced from upper grade lumber are primary parts rather than higher cost salvage parts (Gatchell and Thomas 1997, Gatchell et al. 1999). Other costs associated with processing lower grade lumber that are difficult to quantify

include higher part reject rates (due to defecting mistakes and machining defects that arise where cross-grain occurs near knots) and longer inspection times for operators as they try to make decisions concerning part placement and the importance of defect blemishes.

The number of cutting operations required to extract needed parts climbs significantly when cutting FAS versus 1 Common versus 2A Common lumber in both gang-rip-first and crosscut-first rough mills. For a difficult cutting order, the number of chopsaw cuts (in a rip-first rough mill) required per part produced is 27% higher for 1 Common lumber than for FAS lumber and 53% higher for 2A Common lumber than for FAS lumber (Gatchell and Thomas 1997). The number of crosscuts required (in a crosscut-first rough mill) to fill the same cutting order is 70% higher for 1 Common lumber than for FAS lumber and 200% higher for 2A Common lumber than for FAS lumber (Steele et al. 1999). For the straight-line rip saw in the crosscut-first rough mill the number of cutting operations required to extract needed parts also goes up significantly as lumber grade is reduced. Fortunately, this increase is not as great as for the crosscut saw. The productivity of the crosscut saw-straight-line rip saw system is less affected by a reduction in lumber grade when cutting an order that is made up of shorter and narrower parts than when cutting larger parts (Steele et al. 1999).

*The Impact of Lumber Size on Yield and Value:*

Lumber length affects part yield and value in several ways. Obviously, more boards typically will be required to obtain longer parts when cutting shorter lumber (e.g., 4 to 8 feet long). Where part-size requirements emphasize shorter lengths, short lumber can be used. For some cutting orders, long lumber provides a higher part yield than short lumber in a crosscut-first rough mill. This is because there are more ways in which required lengths can be combined to fit a longer board. Thus, there is less potential yield loss associated with crosscut waste. Also, 2 inches of end trim on a short board represents greater yield loss than on a long board. By contrast, in rip-first operations, shorter lumber may give higher yields (typically 1 to 3 percent) than long lumber (Wiedenbeck 1992). This is largely due to the fact that longer boards tend to have more crook (or sidebend) and, consequently, produce lower strip yields when they pass through the gang-rip saw. Lumber width also impacts rough mill yield, particularly when narrow lumber is used in rip-first rough mills. This impact is most significant for gang-rip saws with fixed arbors and when there are a limited number of part widths in the cutting order. Of course, wider parts are more difficult to obtain from narrow lumber and wider cutting orders will produce more waste when narrower boards are being processed. The impact of width on yield in a rip-first rough mill can be so important that it dictates buying upper grade lumber for some orders.

FAS and F1F lumber is wider than Selects and Common grade lumber. The width differences can be large. For example, the average width of 4/4-inch thick, dry, FAS and F1F red oak lumber measured in a mid-1990's multi-mill study was approximately 7<sup>3</sup>/<sub>4</sub> inches. The average width of the Selects grade lumber was closer to 5<sup>1</sup>/<sub>4</sub> inches. The average width of 1 Common lumber increased to approximately 7 inches but the average width of 2A Common lumber was only to 5<sup>1</sup>/<sub>4</sub> inches.

For gang-rip-first rough mills that cut parts wider than 3 inches on an occasional to frequent basis, the best strategy for keeping yield up and lumber costs down is to note differences in lumber width from one supplier to the next. Significant differences in the distribution of lumber widths among suppliers have been measured. In an unpublished

1996 Forest Service study, the percentage of dry, red oak boards at least 8 inches wide from five mills ranged from 7 to 27%, while the percentage of boards less than 5 inches in width ranged from 8 to 26%. These widths were for mixed-grade lumber made up of similar percentages of Uppers and No. 1, 2, and 3 Common boards at each mill.

Processing efficiency is important when comparing lumber dimensions. From a material handling standpoint, it is easier to handle short and narrow lumber than longer or wider lumber in manual operations. Even so, productivity usually is greater when processing wider, longer lumber than when processing narrower, shorter lumber of the same quality. However, the difference in productivity is not as great as with automated systems. Processing short and narrow lumber with automated systems can be more problematic and less efficient because there are fewer board feet in each piece of lumber. For many automated systems, processing gaps (e.g., space between boards passing through work stations) lead to lower machine utilization rates when processing short and narrow lumber. In a gang-rip-first rough mill, efficiency losses associated with loading the rip saw's infeed conveyor (repositioning the fence) can be a problem when using short lumber. Similarly, narrow lumber occupying a machine that processes lumber in a linear direction is less productive on a volume-per-hour basis than when wider lumber (e.g., gang-rip saw, planer, moulder, automated chopsaw) is processed.

Literature Cited:

- Buehlmann, U., J.K. Wiedenbeck, and D.E. Kline. 1998. Character-marked furniture: potential for lumber yield increase in rip-first rough mills. *Forest Products Journal* 48(4):43-50.
- Buehlmann, U., J.K. Wiedenbeck, and D.E. Kline. 1999. Character-marked furniture: potential for lumber yield increase in crosscut-first rough mills. *Forest Products Journal* 49(2):65-72.
- Gatchell, C.J. and R.E. Thomas. 1997. Within-grade quality differences for 1 and 2A Common lumber affect processing and yields when gang-ripping red oak lumber. *Forest Products Journal* 47(10):85-90.
- Gatchell, C.J., R.E. Thomas, and E.S. Walker. 1999. Effects of preprocessing 1 Common and 2A Common red oak on gang-rip-first rough-mill dimension part yields. *Forest Products Journal* 49(3):53-60.
- Steele, P.H., J. Wiedenbeck, R. Shmulsky, and A. Perera. 1999. The influence of lumber grade on machine productivity in the rough mill. *Forest Products Journal* 49(9):48-54.
- Wiedenbeck, J. 1992. The potential for short length lumber in the furniture and cabinet industries. Virginia Polytechnic Institute and State University, Blacksburg, VA. 255 p. Ph.D. dissertation.
- Wiedenbeck, J. and E. Thomas. 1995. Don't gamble your fortunes – focus on rough mill yield. *Wood & Wood Products* 100(7):148-149.