

CORRESPONDENCE ANALYSIS AS A TOOL TOWARDS OPTIMIZING THE USE OF WHITE BIRCH IN THE PANEL INDUSTRY

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ABSTRACT

This study examines parts distribution for lumber sawn from conventional-length and short-length logs. Select, No. 1 Common, and No. 2A Common white birch lumber was simulation-processed using both rip-first and crosscut-first processing methods with a typical panel-industry cutting order. A white birch database was developed and used to simulate crosscut-first and rip-first rough mills and determine the effects of the species physio-morphological characteristics on yield.

ROMI-RIP and ROMI-CROSS simulations show that conventional-length lumber offers the greatest production flexibility because it is able to produce long and wide components. These components can be broken down into combinations of shorter length parts. Lumber from the short log sawmill produces a greater variety of components in order to maximize part yield from the lumber.

Correspondence analysis determined that lumber grade and processing method are the two variables explaining most of the variability in component production. Overall lumber type (from conventional-versus short log sawmill) contributed less among the sources of variability in the model. When component distri-

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butions were analyzed on a per grade basis, lumber type was more important than process choice in explaining component variability, for the highest and lowest grade lumber. For No. 1 Common lumber, the process explained relatively more of the variability in comparison to the other grades.

Keywords: White birch, short-length, conventional-length, rough mill, crosscut-first, rip-first, yield, cutting order, grade, comparative parts distribution, correspondence analysis.

INTRODUCTION

White birch (*Betula papyrifera*, Marsh.) is one of the last untapped hardwood lumber resources in North America. This statement is based on inventory statistics that indicate large timber volumes available for processing on a sustainable basis (Giguère 1998; MNRQ 1996). To date, the physical characteristics of the species made it an uneconomical candidate for lumber production, but today's technology and value-added marketplace could make further analysis of this resource worthwhile.

In a previous paper analyzing remanufacturing potential of white birch (Clément et al. 2004), yield was evaluated for a rip-first or crosscut-first rough milling according to four different cutting bills using a 5576 board ft (13.16 m³) white birch database. Two of the cutting bills were adapted from the USDA (Easy and Tough) (Steele et al. 1999), a third was selected from a Québec component manufacturer, and the fourth came from a furniture manufacturer producing panels for white birch tabletops.

Previous work has shown that lumber length has a direct effect on yield (Clément et al. 2004; Hamner et al. 2002; Wiedenbeck 1992). Wiedenbeck (1992) studied the impact of using short-length lumber in terms of yield and rough mill throughput. No significant yield difference was found using a casings cutting bill for crosscut-first or cabinet cutting bill when ripped-first. Throughput, in terms of parts processed per time unit, was higher for the short-length lumber when crosscut-first due to inherently easier material handling properties. No difference in processing speed was determined for rip-first processing.

When comparing the effects of length between short (7- to 8-ft), medium length (11- to 12-ft), and long (15- to 16-ft) NHLA-graded boards, Hamner et al. (2002) noticed a direct relationship between length and yield, when ripped-first using USDA Easy and USDA Tough cutting bills.

Clément et al. (2004) showed that conventional-length lumber had a higher yield than short-length lumber, except for No. 1 Common when ripping-first Furniture, USDA Easy, and USDA Tough cutting bills and when crosscutting first USDA Easy and USDA Tough cutting bills. The physical characteristics of the sample population also indicated that crosscut-first processing would generate a higher yield than rip-first due to the narrowness of the lumber and to the presence of crook, which corresponded to the findings of Wiedenbeck (2001).

One of the conclusions drawn from Clément et al. (2004) was that, although conventional-length lumber typically produces a higher yield than short-length lumber, short-length lumber can produce an acceptable and even comparable yield when the appropriate lumber grade and cutting bill are paired.

In order to better understand how to improve the yield and marketability of white birch, the objective of this study is to compare the distribution of part widths and lengths obtained when cutting conventional- and short-length white birch lumber in Select, No. 1 Common, and No. 2A Common grades. This lumber was processed using rip-first and crosscut-first rough milling and a local panel-industry cutting bill. The cutting bill was chosen from a plant producing a set of panel sizes on a continuous basis; this was done in order to determine what component distributions would be generated by the two sorts of wood when no restriction was imposed on the parts demanded.

METHODOLOGY

Sample material

A previously developed white birch database (Clément et al. 2004) consisting of 5576 board ft (13.16 m³) random width and length boards including 1157 bf of Selects, 911 bf of No. 1 Common, 871 bf of No. 2A Common conventional-

length, and 962 bf of Selects 970 bf of No. 1 Common, and 703 BF of No. 2A Common short-length lumber was used. Table 1 characterizes the database by indicating the total volume analyzed, average lengths, average widths, average maximum crook, and clear surface areas, along with associated standard deviations.

Rough mill processing

Rough mill processing was performed using the USDA ROMI-RIP (Thomas 1999) and ROMI-CROSS (Thomas 1997) simulators.

ROMI-RIP simulation parameters:

Arbor type: All-blades movable arbor with 6 spacings;

Kerf: 4 mm (0.157 in.);

Prioritization strategy: complex dynamic exponent (CDE) weights set at $L^{1.44} \times W^{1.22}$;

Part prioritization: never updated;

Parts Grade: C1F (pin knots, mineral streaks accepted on good side; good side defects plus sound knots and stain admitted on poor side);

Salvage cuts were made to three salvage-specific lengths in addition to the primary part dimensions.

ROMI-CROSS simulation parameters:

Primary yield maximization method: Crosscuts optimized for best length fitting to board features;

Kerf: 4 mm;

Prioritization strategy: complex dynamic exponent (CDE) weights set at $L^{1.44} \times W^{1.22}$;

Part prioritization: never updated;

Parts Grade: C1F (pin knots, mineral streaks accepted on good side; good side defects plus sound knots and stain admitted on poor side);

Salvage cuts were made to three salvage-specific lengths in addition to the primary part dimensions.

Cutting bill

A cutting bill was designed that simulated the creation of random-width fixed length components as they are used in the panel industry. The panel industry cuts fixed-length, random-width strips between 25 and 114 mm (1 and 4.5 in.), then proceeds with edge-gluing them together into specific-sized panels. This mode of operating assures a high yield because length is the only constraining factor. It should be noted that

TABLE 1. *White birch data base characteristics*

Grade	Volume (BF / m ³)	Number of Boards	Average Width (m)	Average Length (m)	Average Crook Max. (mm)	Clear Wood (%)
Conventional						
Select	1157 / 2.73	183	0.165 (0.040)	3.560 (0.258)	7.99 (5.2)	2.7 (4.3)
No. 1C	911 / 2.15	241	0.141 (0.032)	2.475 (0.415)	6.6 (3.8)	90.9 (7.6)
No. 2AC	873 / 2.06	235	0.140 (0.027)	2.456 (0.368)	7.2 (4.5)	89.3 (9.6)
Short-length						
Select	962 / 2.27	312	0.134 (0.030)	2.120 (0.246)	5.5 (3.8)	91.1 (7.6)
No. 1C	970 / 2.29	292	0.152 (0.032)	2.030 (0.405)	5.2 (3.3)	91.3 (9.8)
No. 2AC	703 / 1.66	350	0.124 (0.027)	1.490 (0.347)	4.5 (2.6)	90.9 (8.2)

Standard deviation in parentheses.

the CDE prioritization strategy emphasizes the cutting of longer lengths over shorter lengths.

The function allowing the definition of random-width panel cutting bills is available in ROMI-RIP 2.1 for data bases where measurements are in inches, but it was never implemented for metric data bases. Our data base having been developed in metric units, a purely random-width cutting bill could not be defined. We were not aware of this limitation when the data base was built. To bypass this shortcoming, a system was devised, in which the width range was divided into fifteen 6.35-mm ($\frac{1}{4}$ -in.) increments, between 25 and 114 mm (1 to 4.5 in.). According to Buehlmann (1998), small width spacings minimize the distortion that could occur when quantity is not a factor. Thus, the proximity of the different width ranges was small enough not to induce a bias on yield determination. An advantage of specifying random width in this manner is that it allows the components to be clearly identified and tallied according to size (width and length), thus enabling a graphical representation of the output.

Infinite demand of all combinations of the following widths and lengths was used. Widths of 25, 32, 38, 44, 51, 57, 64, 70, 76, 83, 89, 95, 102, 108, and 114 mm along with lengths of 445, 546, 749, 940, 991, 1041, 1092, 1143, 1245, 1372, and 1549 mm. The following length were salvage specific: 445, 546, and 749 mm.

To insure that the parts demand would be considered infinite/constant by the simulation software, parts required ("Quantity") was set to 999 for each size, and "Parts Priorities" were set to be adjusted every 10,000 bf in ROMI-RIP and 9999 bf in ROMI-CROSS. That is, the volumes were set so large that they would never be met and the part priorities would remain constant.

RESULTS

Yield

Table 2 shows the average yield for primary and salvage components and total average yield obtained from 20 simulation replications for 2 lumber types, 3 grades, and 2 processing methods using the Panel cutting bill. The number of

replications, 20, was based on standard deviation estimate obtained from preliminary yield simulations. It was determined using the following equation from Devore (1987):

$$n = \frac{(t_{\alpha/2, n-1} + t_{\beta/2, n-1})^2 s^2}{\delta^2}$$

where:

α = significance level set at 0.05

β = 1-Power of the test set at 0.10

δ = The acceptable difference between averages was set at 1%

Total yield

Figure 1 shows examples of board cutups obtained when using rip-first or crosscut-first processing on conventional-length or short-length lumber. From Table 2, it can be observed that the yield for conventional-length lumber was always significantly higher ($\alpha = 0.01$) than that for short-length lumber, although yield differences were small when processing No. 1 Common lumber—0.5% when ripped-first and 3.6% when crosscut-first. These small differences can be explained by examining the average length and width for No. 1 Common lumber in Table 1, where the sizes are relatively similar.

Total yield for crosscut-first rough milling was always significantly higher ($\alpha = 0.01$) than for rip-first processing. Wiedenbeck (2001) and Gatchell (1991) indicate that crosscut-first processing has a higher yield than rip-first when crooked and narrow lumber is used. Table 1 indicates that the boards contain crook and that their average width is small, which tends to explain the results.

Analyzing the yield results from primary and salvage parts provides additional insight into why crosscut-first rough milling had a higher total yield.

Primary parts

Yield in primary parts was significantly higher ($\alpha = 0.01$) for crosscut-first rough milling when processing conventional-length, Select,

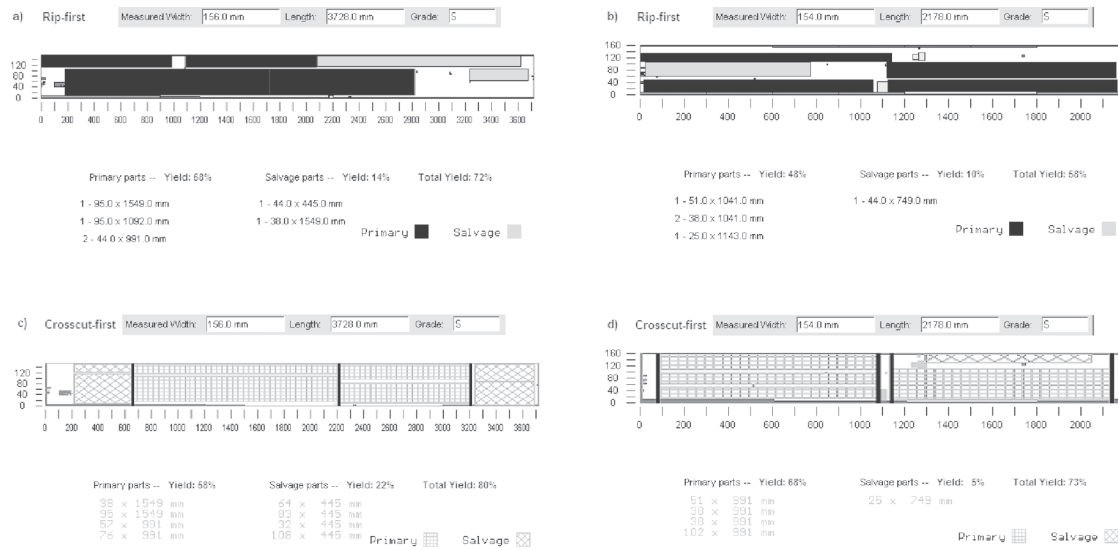


FIG. 1. Examples of cutup solution for a) rip-first on conventional-length lumber, b) rip-first on short-length lumber, c) crosscut-first on conventional-length lumber, and d) crosscut-first on short-length lumber. It should be noted that the dimensions in the conventional-length and short-length lumber examples are not to the same scale.

TABLE 2. Primary and salvage component yield results (%) by lumber type for Panel cutting bill processed by a rip-first or crosscut-first rough mill.

	Rip- first	Select		Rip- first	No. 1C		Rip- first	No. 2AC	
		Crosscut- first	<i>p</i> -value ^b		Crosscut- first	<i>p</i> -value ^b		Crosscut- first	<i>p</i> -value ^b
Primary									
conventional	64.4 (0.3)	66.8 (0.3)	0.000**	52.8 (0.5)	54.5 (0.6)	0.000**	47.3 (0.3)	46.8 (0.7)	0.014*
short-length	55.0 (0.5)	55.7 (0.5)	0.058	52.9 (0.6)	50.5 (0.7)	0.000**	37.3 (0.7)	35.9 (0.8)	0.000**
<i>P</i> -value ^a	0.000**	0.000**		0.399	0.000**		0.000**	0.000**	
Salvage									
conventional	7.4 (0.2)	11.4 (0.4)	0.000**	9.8 (0.3)	15.7 (0.3)	0.000**	10.2 (0.3)	17.2 (0.4)	0.000**
short-length	8.0 (0.4)	16.3 (0.6)	0.000**	9.1 (0.5)	16.2 (0.4)	0.000**	12.1 (0.4)	18.6 (0.7)	0.000**
<i>P</i> -value ^a	0.000**	0.000**		0.000**	0.000**		0.000**	0.000**	
Total									
conventional	71.8 (0.3)	78.3 (0.3)	0.000**	62.6 (0.5)	70.2 (0.6)	0.000**	57.5 (0.3)	64.0 (0.5)	0.000**
short-length	63.0 (0.5)	71.6 (0.5)	0.000**	62.1 (0.5)	66.6 (0.8)	0.000**	49.4 (0.6)	54.5 (0.6)	0.000**
<i>p</i> -value ^a	0.000**	0.000**		0.002**	0.000**		0.000**	0.000**	

Standard deviation in parentheses.

** Highly significant difference ($\alpha=0.01$)

* Significant difference ($\alpha=0.05$)

z-test *p*-value^a for comparison between conventional- and short-length lumber

z-test *p*-value^b for comparison between rip-first and crosscut-first

and No. 1 Common lumber. Rip-first rough milling had a significantly higher ($\alpha = 0.01$) yield when using short-length No. 1 Common lumber and No. 2A Common short-length lumber and was significantly higher ($\alpha = 0.05$) when processing No. 2A Common conventional-length lumber.

When ripped-first, the yield difference was not significant for No. 1 Common lumber. Although significantly different, the yield difference was only 4% when No. 1 Common lumber was crosscut-first.

Conventional-length lumber had a significantly higher ($\alpha = 0.01$) yield of primary parts, in the order of 10% on average, compared to short-length lumber for Select and No. 2A Common lumber (Table 2).

In all cases, the yield differences in primary parts were small between ripping-first and crosscutting first, ranging from 0.5% to 2.4%. The lower quality lumber grades (short-length No. 1 Common and all No. 2A Common) had a higher yield when ripped-first. These results indicate that both processing methods generate approximately the same primary parts yield when using a panel-industry cutting bill.

Salvage parts

Table 2 shows that short-length lumber yielded significantly higher salvage parts ($\alpha = 0.01$) than conventional-length lumber, although the yield differences were quite small, with the following exceptions: a) No. 1 Common, rip-first lumber where conventional-length lumber had a higher yield than short-length, and b) Select, crosscut-first lumber that had a 4.6% yield difference in favor of short-length lumber. The short-length lumber produced more salvage components because longer parts were prioritized in the primary operation. In this case, the residual lumber was too short to meet the primary components size requirements, which resulted in an increased amount of salvage components.

More dramatic differences in salvage yield were obtained when comparing rip-first and crosscut-first rough mills, as indicated in Table

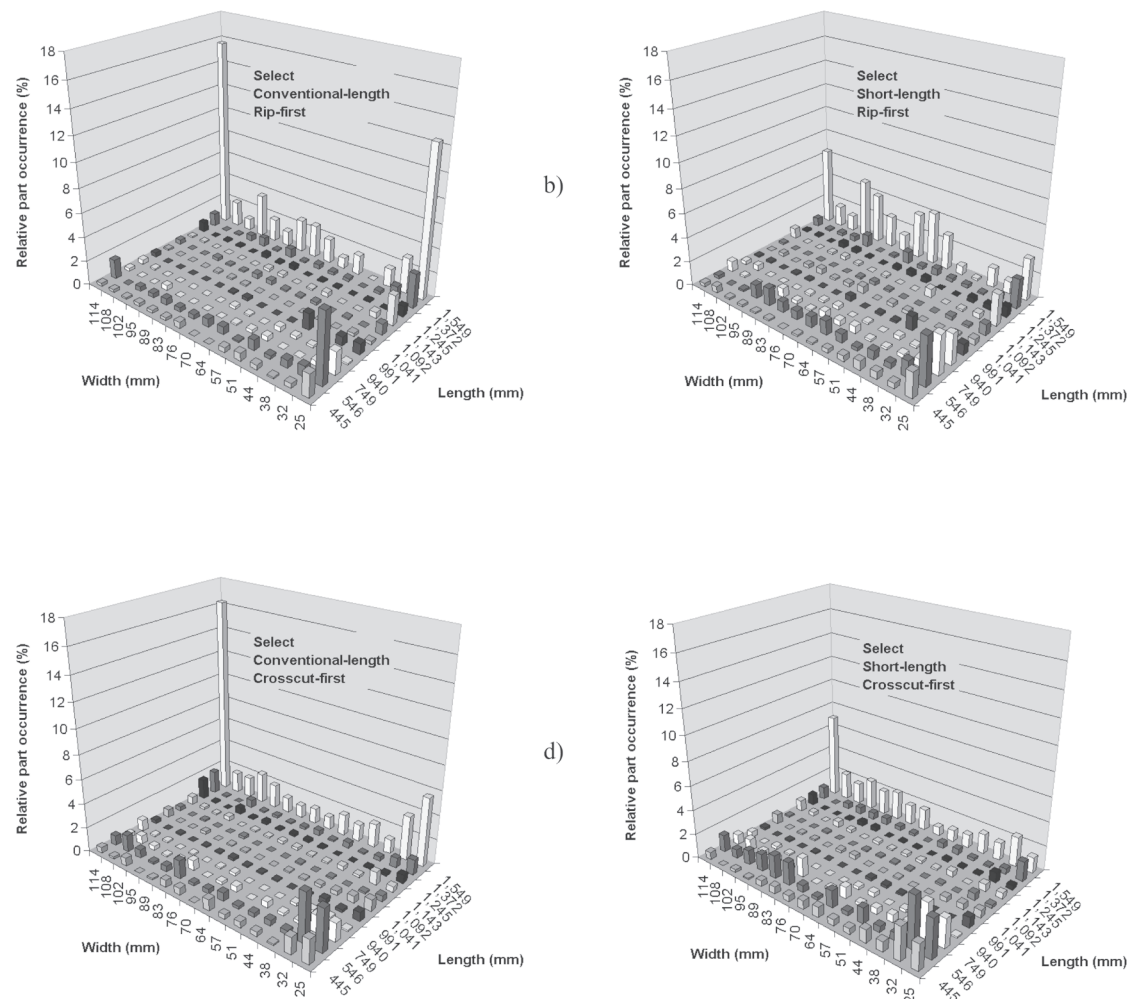
2. A factor contributing to the higher salvage yield obtained with crosscut-first lies in the logic of the cutting process. With crosscut-first, maximum width components are prioritized, whereas in rip-first, maximum length components are given priority. When these respective logics are applied to narrow crooked lumber, shorter wide components are obtained when crosscutting-first, whereas long and narrow components are obtained when ripping-first (Gatchell 1991; Wiedenbeck 2001). Because this cutting bill had short, salvage-specific, component-lengths (445 mm, 546 mm, and 749 mm), the crosscut-first simulation program used them to increase yield significantly ($\alpha = 0.01$) between 4 and 8.3% compared with rip-first processing.

Part size distribution

Figures 2, 3, and 4 show the part distribution, in terms of relative frequency for the different lengths and widths that were produced using a Panel cutting bill for conventional- and short-length Select, No. 1 Common, and No. 2A Common lumber that was ripped-first and crosscut-first.

Conventional- vs. short-length.—In Figs. 2, 3, and 4 it can be seen that yield in conventional-length lumber allows the production of long components (1549 mm). Also, in all figures there is a peak in salvage components at 546 mm. The component distribution was even between 51 mm and 108 mm with peaks at 25, 38, and 114 mm. This last peak, at 114 mm, consisted mostly of long and wide components, especially from conventional-length lumber, which points to maximum component manufacturing flexibility.

Short-length lumber has a similar distribution, but appears to produce more scattered distributions and tends to produce shorter cuttings. As with conventional-length lumber, mostly narrow components were produced; however, fewer wide parts were produced. The shift in production from longer and wider to shorter and narrower components is attributable to smaller dimensions and to the presence of more frequent



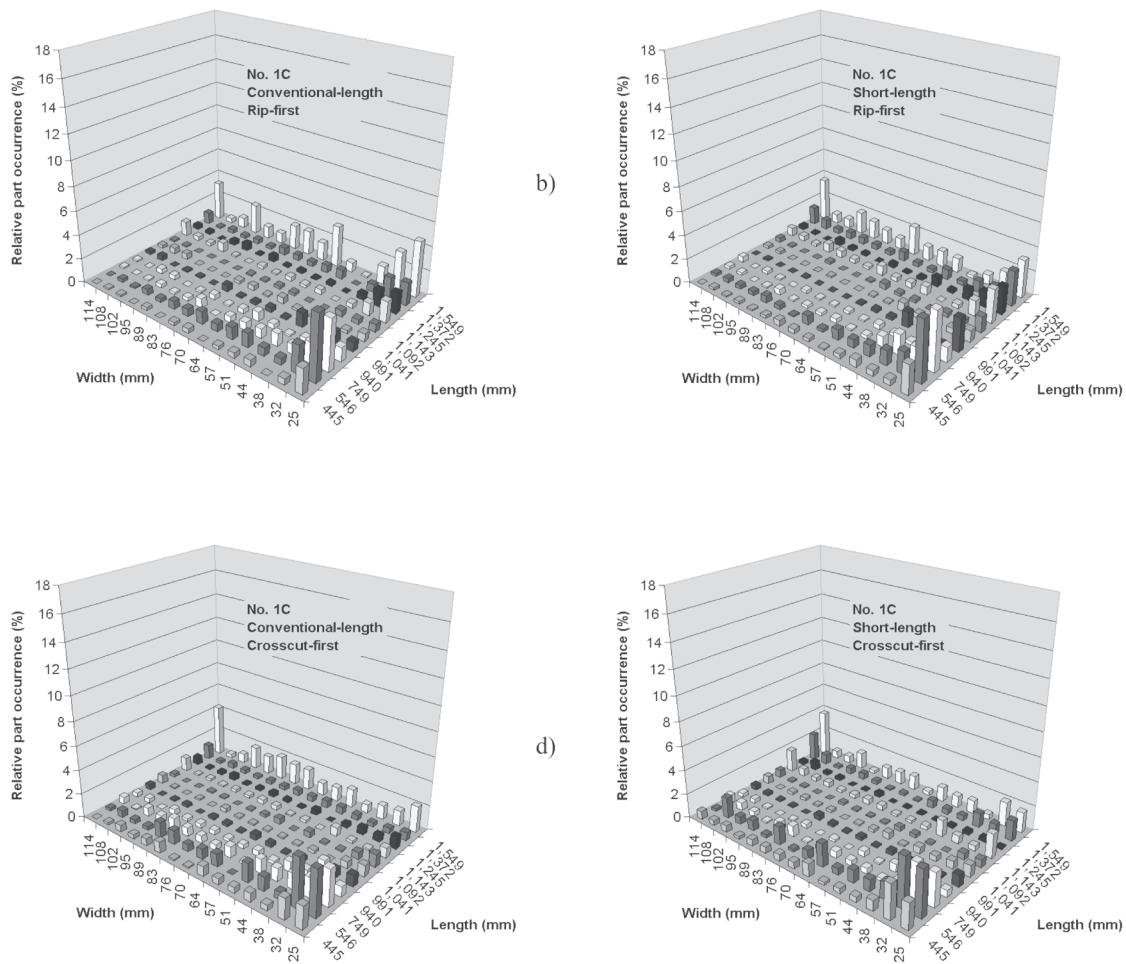


FIG. 3. Part distribution for No. 1C grade lumber with a) Conventional-length, rip-first, b) Short-length, rip-first, c) Conventional-length, crosscut-first, d) Short-length, crosscut-first.

Conventional-length No. 2A Common lumber (Fig. 4a,c) produced components following similar trends as Select and No. 1 Common grade lumber but with less amplitude in the largest and longest components. Short-length lumber (Fig. 3b,d), however, had a peak at 1143 mm in length instead of 1549 mm. This is explained by looking at the average board length (Table 1) that is only 1490 mm, which prevents the production of any of the longest components. The parts produced, therefore, were mostly narrow with few wide components produced at all. This indicates that No. 2A Common grade lumber in this case

should be used for shorter and narrower components only.

Rip-first vs. crosscut-first.—The rip-first operation tries to place all the defects in the narrowest strips in order to produce the longest cuttings. The crosscut-first operation produces the widest components by cutting out defects at appropriate lengths. The logic of these processes results in patterns that show well in Figs. 1, 2, and 3. The rip-first rough mill produces long and narrow components. The crosscut-first rough mill has a similar component distribution although skewed towards slightly shorter and wider components,

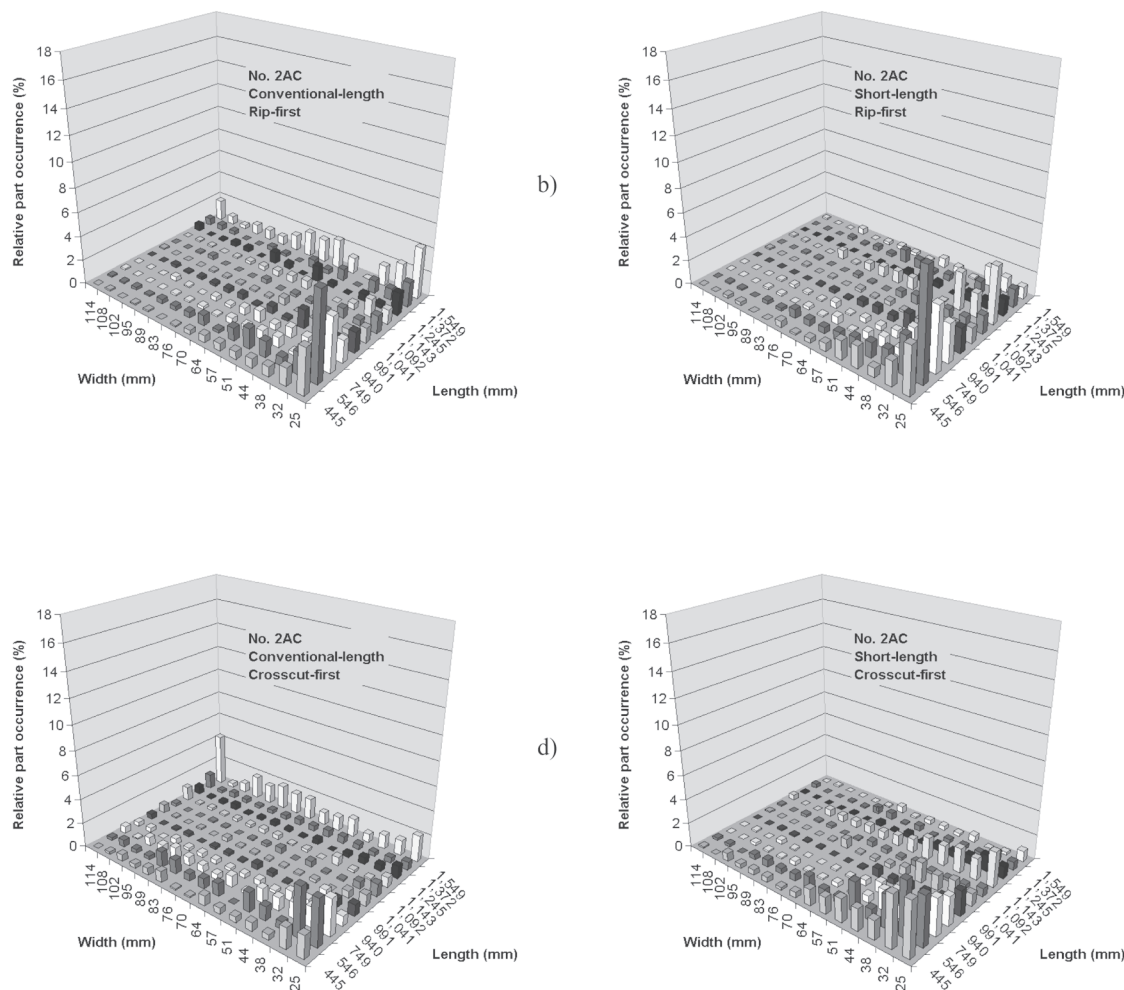


FIG. 4. Part distribution for No. 2AC grade lumber with a) Conventional-length, rip-first, b) Short-length, rip-first, c) Conventional-length, crosscut-first, d) Short-length, crosscut-first.

with a peak at 546 mm, which is a salvage-specific width. This result confirms observations from the previous section about additional production of salvage parts when cross-cutting.

In the case of Select grade lumber (Fig. 2a,b), there are no defects such as knots, bark pockets, or decay; however, the boards in the data base generally showed some degree of crook (Table 1). Therefore, when ripping-first Select grade lumber, long and narrow components were produced due to the shape of the board. When cross-cutting lumber, shorter components are favored because the cross-cut process maximizes the

width of the cuttings. In the case of Select grade lumber (Fig. 2c,d), where there are no defects except for crook, a crosscut-first rough mill will produce wider and shorter components.

The presence of defects directly affects scatter. In No. 1 Common lumber (Fig. 3), the scatter increases into multiples of lengths that fit into average board length. One can observe that in order to cut around the defects, a rip-first or a crosscut-first rough mill must produce a greater variety of components.

A rip-first rough mill (Fig. 3a,b) favors the production of narrow components in general,

and produces long components to maximize yield. A crosscut-first rough mill (Fig. 3c,d) produces various-sized components, but favors wide and short components. No. 2A Common boards have the same component-distribution trend as the other grades. Owing to the increased occurrence of defects, the components produced when ripped-first (Fig. 4a,b) are mostly narrow and cover the whole range of lengths. The component spread when crosscut-first (Fig. 4c,d) remains scattered, with wide components produced overall.

Correspondence analysis

Correspondence analysis was used to model how the 12 different combinations of variables (3 grades \times 2 processing methods \times 2 lumber types) affect the part distribution ($n-1 = 11$ dimensions). This method of analysis is an exploratory and descriptive technique, which uncovers, and describes graphically, the relationships between the dimensions in large contingency tables (Clausen 1998). It should be noted that if a dimension represents less than 9.09% ($1/(n-1) \times 100$) of the whole systems variability, then it is considered random in nature. Correspondence analysis was selected because of its ability to provide a quantitative assessment of the sources of variation among a distribution of components among a table of 15 widths and 11 lengths (Figs. 2 to 4), within specified ranges.

The analysis was performed on a single simulation run of the entire white birch data base (5574 bf in 1613 boards of select, No. 1 Common, and No. 2A Common). Only one run was required owing to the comparative nature of the analysis.

The resulting 2-D plots are expressed in terms of dimensions, which in turn, must be interpreted to allow for the representation of one of the variables under analysis. Figure 5 shows the overall relationships among the 12 parameters in the 2 main dimensions. Dimension 1 explains most of the systems variability at 35.03%. This dimension can be interpreted as representing the lumber grade since all Select grade observations are on the far right of the axis defined as Dimension

1, No. 1 Common scores are in the center, and No. 2A Common scores on the left. Dimension 2 explains an additional 18.21% of the system's variability and can be seen as representing the processing method since all rip-first observations are located on the upper part and all crosscut-first on the lower part of the graph. Grade and processing method combined explain 53.24% of the systems variability; however lumber grade, by definition, should be the main factor affecting the component production variability. Since it is to be expected that different grades will produce different part distributions, the following analysis reiterates the correspondence analysis procedure within each grade to see what dimensions emerge as explanatory variables.

Relationship to component distribution

Lumber grade, processing method, and lumber type.—By removing grade as a variable, we reduce the total number of variables to 4 (2 processing methods \times 2 lumber types). Thus, Dimension 1 is considered random if it represents less than 33.33%, and the system (the contribution of the two first dimensions) is deemed random if it represents less than 66.67% of the variability. Figures 5, 6, and 7 show correspondence analysis graphs for each grade.

For Select grade lumber (Fig. 6), Dimension 1 explains 46.73% of the variation and can be interpreted as the processing method. Dimension 2 can be taken to represent lumber type and explains 36.43% of the variation by itself. Combined, these two dimensions explain 83.16% of the variability in Select grade lumber, which is considered a satisfactory explanatory model.

When examining Dimension 1 of Fig. 6, one observes that rip-first rough milling is on the positive side of the axis, which means that a rip-first rough mill produces more narrow (25 mm in width) and long (1549 mm in length) components. The cross-cut rough mill, on the other hand, produces more wide parts (114 mm in width) and salvage-specific components (445, 546, and 749 mm in length). The choice of rip-first or crosscut-first rough milling plays a

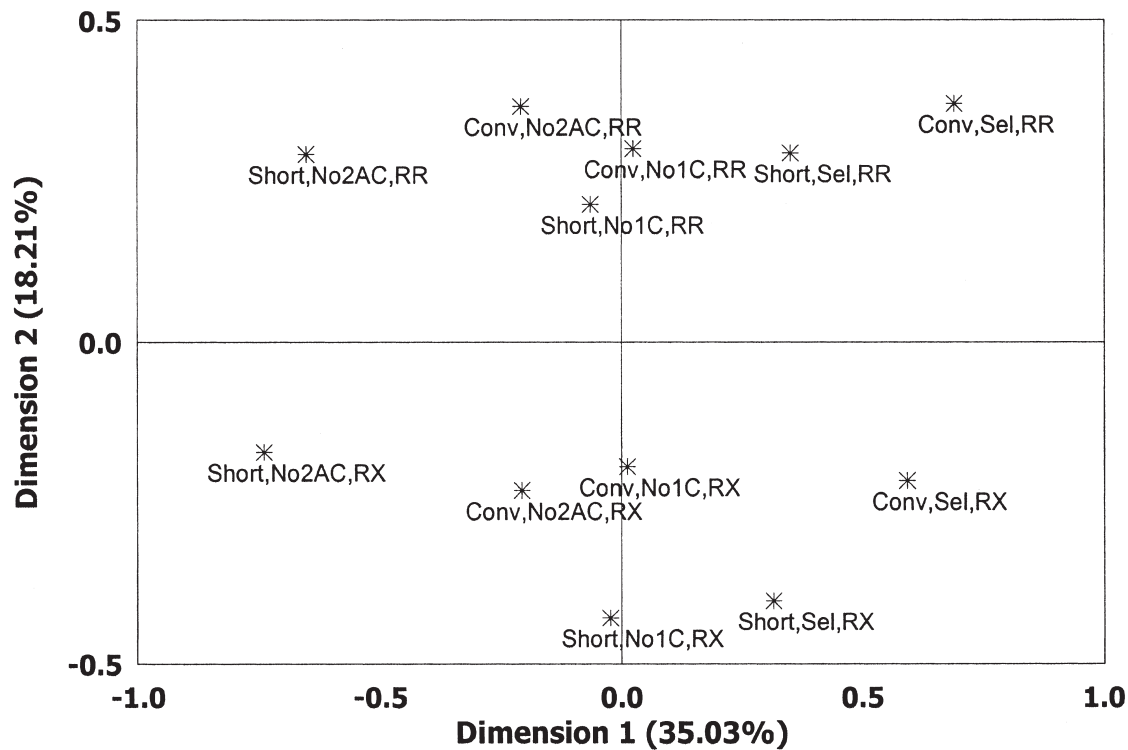


FIG. 5. Correspondence analysis scatter plot for lumber grade, processing method, and lumber type.

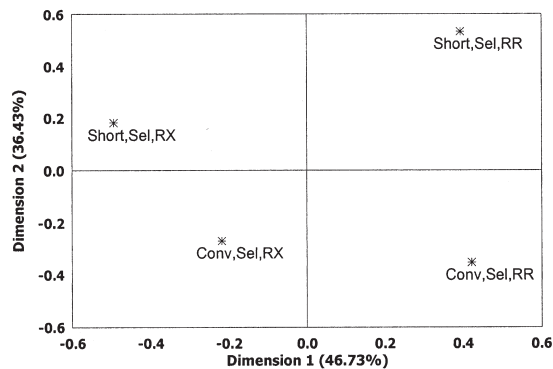


FIG. 6. Correspondence analysis between lumber type and processing method for Select lumber.

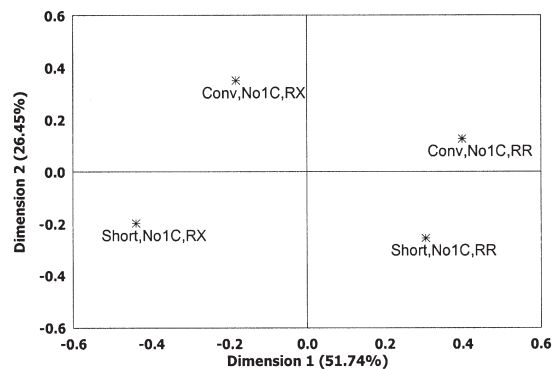


FIG. 7. Correspondence analysis between lumber type and processing method for No. 1 Common lumber.

greater role in determining the part distribution than does lumber type when Select grade lumber is processed.

Analysis of Dimension 2 indicates that conventional length Select lumber produces essentially either long (1549 mm) and wide (114 mm), or long (1549 mm) and narrow (25 mm) compo-

nents in the primary operation. The salvage operation produces short (546 mm) and narrow (25 mm) components. Short-length lumber has much more scatter and produces a wide range of components without any clear concentration. These observations are confirmed by looking at the component distribution (Fig. 2).

The variation in No. 1 Common lumber (Fig. 7) is explained at 51.74% by Dimension 1. This dimension can be interpreted as representing the processing method. Dimension 2 explains only 26.45% of the variation and can be interpreted as representing lumber type. Once combined, both dimensions explain 78.19% of the variability. The lesser importance of Dimension 2 is not surprising when the database characteristics are examined in Table 1. The differences between the two types of No. 1 Common lumber were of 7% in width and only 22% in length when compared to width differences of 23% and 13%, and length differences of 68% and 65% for Select and No. 2A Common grades, respectively.

When looking at the component distribution for Dimension 1 in Fig. 7, production of 25-mm- and 32-mm-wide and 1549-mm-long components was favored in the rip-first rough mill. Crosscut-first rough milling produced more 114-mm-wide components and salvage components. These patterns can be observed in Fig. 3. There was little difference in the production of components between conventional-length and short-length lumber. This was expected, since Dimension 2 had little contribution to the explanation of variability in component distribution.

In Fig. 8, Dimension 1 explains 46.30% of the system's variability. This dimension can be interpreted as explaining the influence of lumber type on variability when No. 2A Common lumber is processed. Dimension 2 explains 37.73% of the variability and can be seen as representing the processing method. Combined, these factors explain 84.03% of the variability within this grade. The importance of the lumber source is explained by examining the data base characteristics for No. 2A Common lumber in Table 1. The difference in length is markedly important, especially since the average length of the boards was less than the maximum cutting bill length.

In this case, Dimension 1 in Fig. 8 represents the lumber type. Conventional-length No. 2A Common lumber produces more than average long (1549 mm) components, whereas short-length lumber produces short (25, 32, 38, and 44 mm in width) components. With rip-first, Di-

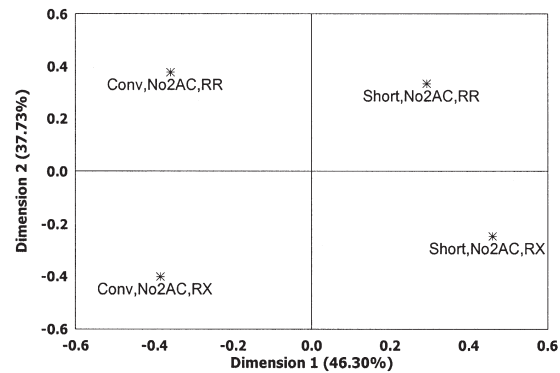


FIG. 8. Correspondence analysis between lumber type and processing method for No. 2A Common lumber.

mension 2 produces mostly narrow (25 mm in width) components. Likewise, crosscut-first with Dimension 2 produces more scatter and a wider range of component sizes, including salvage parts. These observations are confirmed when looking at Fig. 4.

CONCLUSIONS

The Panel cutting bill allowed us to observe the components distribution when no quantity limitations are imposed. Rip-first processing produces more of long narrow components, while crosscut-first produces relatively more of wide components. When rip-first and crosscut-first processing were compared, it was noticed that the crosscut-first rough mill produced wider components, generated a more scattered output, and produced more salvage components.

Conventional-length lumber produced longer and wider components than short-length lumber. This result was expected because the conventional-length lumber was of larger dimensions and offered a greater number of part-size combinations that could be fitted into each board.

Correspondence analysis indicated that lumber grade explained more than 35% of the part-size distribution variability. This was to be expected since the grading system was created for the purpose of sorting higher from lower yielding boards. It does confirm, though, that correspondence analysis is capable of detecting

the effect of a key factor on component yield. When correspondence analysis was performed on the lumber on a per grade basis, lumber type came out to be more important in explaining component variability, especially with the highest and lowest grade lumber. For No. 1 Common lumber, the process explained the variability relatively more than wood type. It must be noticed that No. 1 Common lumber from the two wood types had more dimension similarities when compared to the two other observed grades.

An important finding from this research was that it would be possible to use lumber of lower cost or quality when a specific product mix of known distribution is to be produced. Correspondence analysis could then be a powerful tool to be used to model the best match between a resource of known characteristics, the appropriate processing method and specific cutting bills. This tool in the future could be used by component manufacturers to assist in process design and resource procurement.

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