

GUIDELINES TO BETTER MATCH RESOURCE CHARACTERISTICS, CONVERSION TECHNOLOGY, AND PRODUCTS

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ABSTRACT

Average tree volume in Eastern Canada has shrunk from 170 dm³ in the 70s to 123 dm³ today. Over the same period, the wood consumption factor dropped from 5.6 m³/Mbf to 4.0 m³/Mbf. Some mills even do better than this and achieve factors approaching 3.5 m³/Mbf. The objective of this project was to generate performance indicators for Eastern Canadian mills while assessing the most recent sawing optimization techniques. In order to quantify the effect of resource characteristics on results, we identified distinct geographic areas, and the North American market served as reference for the economic analyses. Wood consumption factors and mill revenue were selected as the principal performance indicators; and the Optitek® sawing simulator was used to analyse different mill scenarios. It should be noted that resource characteristics have far less impact on results than lumber manufacturing techniques or the primary log lengths. Similar results were obtained for the various regions. Random mills should process the longest logs possible to maximize revenue. Small Log Processors are efficient equipment for small logs, but stud mills should have a Canter-Twin on its larger log line to achieve a satisfactory performance level. Optimization of primary and secondary breakdown operations significantly increases revenues in random mills while greatly reducing wood consumption factors. Curve sawing and optimized bucking further improve performance; these two techniques are complementary as the former does not cancel out the benefits provided by the latter. To be effective, optimized bucking needs to be integrated into a flexible sawmill that is capable of processing any length of logs to suit the market demand. A fully optimized sawmill, from bucking to trimming, can improve its revenue by 25% compared to the base case sawmill where only edging and trimming operations are optimized.

Keywords: Sawmill performance, optimized bucking, curve sawing, resource characteristics, wood consumption factor.

INTRODUCTION

Manufacturing industries have experienced major changes over the past decades. Information processing technology, artificial vision systems, and automation played a major role in promoting more efficient manufacturing processes. The lumber industry is no exception to this technological move forward, and softwood mill performance has made considerable gains over the past 30 years.

For a better understanding of the Eastern Canadian softwood lumber industry, one needs to be familiar with the factors used to measure sawmill performance. As a rule, mill performance is expressed through its wood consumption (m³/Mbf), i.e., the number of cubic meters of solid wood required to produce one thousand board feet of lumber. Some mills commonly used the Lumber Recovery Factor (LRF), which is conversely expressed as the number of board feet produced from one cubic meter of solid wood (fbm/m³). Note that one cubic metre equals 35.31 cubic feet. Below, Table 1 helps the reader to convert from one factor to the other.

These indicators illustrate the lumber volume recovery of a mill, but provide no clues as to its economic performance. Value recovery can be calculated as the sum of all revenues (lumber and by-products) generated from one cubic meter of solid wood. Value recovery has been receiving more and more attention in recent years as market requirements change, and mills manufacture a more diverse range of products. As a result, it has become increasingly difficult to compare performance levels on the sole basis of wood consumption factors.

The following is an overview of the softwood lumber industry over the past 30 years. Tree size decreased considerably over those 30 years. Stem volumes used to average 170 dm³ or more in the 70s. Stem volumes in mature softwood stands are currently estimated to average 123 dm³. From 5.6 m³/Mbf in the 70s, the wood consumption factor dropped to 4.5 m³/Mbf in the 80s, and it is now hovering around 4.0 m³/Mbf. Lumber recovery has been increasing consistently even though stem volumes were decreasing.

Table 1.—Conversion factors.

Wood Consumption Factor (m/Mbf)	Lumber Recovery Factor (fbm/m ³)	Lumber Recovery Factor (fbm/ft ³)
3.5	286	8.1
4.0	250	7.1
4.5	222	6.3
5.0	200	5.7

For example, many Eastern Canadian mills currently harvest forests where average stem volume may be as low as 115 dm³, which is equivalent to a 20 cm at breast height diameter. The most efficient mills are capable of wood consumption factors as low as 3.5 m³/Mbf. This shows that exceptional recovery levels are attainable when the conversion technology has been adequately adapted to the resource and to market demand.

In practice, here is how these trends have developed in the mills. Prior to 1980, optimized systems were very scarce in sawmills; log positioning and sawing patterns were essentially left to the operators' judgement. The first generation of optimizers appeared in the 80s; they were mostly trimmers and edgers using photocells to scan the lumber. It was only in the early 90s that mills gradually installed more efficient optimizers based on more powerful computers and more advanced scanning techniques using infrared or laser technology. Over the past 10 years, most mills have adopted guided saws, which has allowed them to reduce saw kerf as well as target sizes. Another significant factor has been the increasing presence of skilled labor as technicians and engineers were hired to deal efficiently with new technology.

This analysis of past years brings us to ponder the relative importance of recent technological developments and their potential impact on sawmill performance. In order to guide sawmill owners in future capital projects, we need to better understand relationships between wood supply characteristics, the technological sophistication of conversion equipment, and the range of products manufactured. Only a computer-based simulator can help us elucidate such relationships.

METHODS

Simulation Software

This study requires the use of a sawing simulation software. The Optitek® software developed by Forintek simulates the entire log breakdown on the basis of a geometrical description of timber supply. It can be used to model just about any conversion process currently found in industry, such as the different curve sawing techniques, bucking, primary and secondary breakdown optimization, edg-

ing and trimming or even planing operations. Optitek® can be used to simulate lumber production on the basis of key lumber dimensional characteristics, including wane, as a means of maximizing production value.

Resource

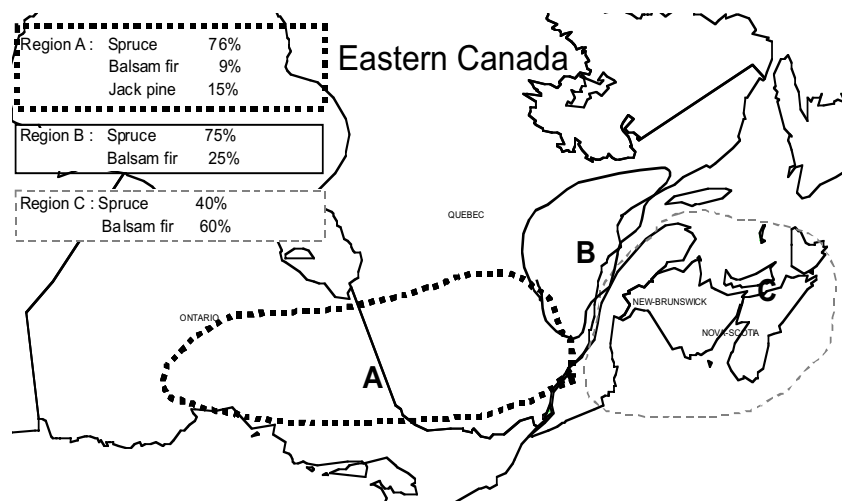
Three regions were defined to represent typical species distributions in the spruce-pine-fir (SPF) group in Eastern Canada; these were identified as regions A, B, and C, as shown in Figure 1. Region A covers northeastern Ontario and western Quebec; the species mix consists of 76% spruce (mostly black spruce), 15% jack pine, and 9% balsam fir. The Quebec North Shore makes up Region B, with a species mix of 75% spruce (white and black) and 25% balsam fir. As for Region C, it covers eastern Quebec and the Atlantic Provinces; balsam fir is predominant, with 60% of total volume, the remaining 40% being divided between black and white spruce.

The timber supply of these three regions was represented by six groups of sample stems derived from a database that includes some 3,400 trees measured by Forintek over a five-year period. In each of the three regions, two different populations were considered with respect to tree diameter. A majority of Eastern Canadian mills are sawing logs with average volumes ranging from 105 to 150 dm³. This was the range we used to define our representative samples so that most mills could related to one of the six groups. Each group was adjusted to 400,000 m³, which would be a typical timber supply level for an Eastern Canadian mill.

The main characteristics of the six groups are summarized in Table 2. Geometry characteristics other than stem volume may affect volume recovery; they include sweep and taper. Taper was found to be heavier in Region B, particularly in group number 3. On the other hand, sweep was found to be lighter in Region C. In Region A, taper was slightly lower than average, particularly in group number 2. Wood density has a direct impact on revenue from by-products since they trade on a weight basis. Average density is determined by the species mix. Thus, average density is significantly lower in Region C, which has the highest proportion of fir, than the other two regions.

As for decay, it affects mostly lumber value. It also affects volume recovery, but this is rather difficult to quan-

Figure 1.—Resource distribution in Eastern Canada.



tify with any accuracy as some products, such as stud grade lumber, tolerate a fair amount of decay. For the purpose of this study, it was assumed that 1% of decay would reduce net lumber value by 1%. As a rule, balsam fir has more decay than other species, and this is reflected in our samples, with higher decay percentages in regions having higher proportions of fir.

Market and Product Description

Since the North American market has been the main outlet for Eastern Canadian softwood lumber for a number of years, it was used as the target market for this study. A standard product range was developed on the basis of sizes and grades defined by the National Lumber Grades Authority (NLGA); these products were defined according to nominal sizes, and grades were determined on the basis of wane rules. Lumber sizes are mill-set targets, and wane percentages were calculated against these target sizes. Wane tolerances were slightly larger than specified by NLGA to account for planing allowance. Our specifications were based on practical experience, which resulted in target sizes and wane tolerances being very close to those found in most Eastern Canadian sawmills.

- Range of products: 1x3, 1x4, 1x6, 2x3, 2x4, 2x6, 2x8 from 6 to 16 feet
- Target sizes: Thickness: 0.9 (1 inch boards), 1.7 (2 inches boards)
Width: 2.8, 3.8, 5.8, 7.8 (3 to 8 inches wide)
- Grades: Utility & better (1 inch board), Stud, No.2 & better, No.3

The price list (Table 3) used to calculate revenue from lumber sales was developed mostly on the basis of (Indec 1998) and (Random Lengths 1999 Yearbook), two reference documents compiled from prices obtained by Eastern Canadian sawmills on the North American market. In order to limit cyclical variations in lumber prices, we used averages for a five year period. We selected the Great Lakes market because it provided the most complete set of statis-

tical information on selling prices. Revenue of by-products, sawdust and chips were also considered. We used 100 CAN\$ per BDT (Bone Dry Tonne) for chips and 15 CAN\$ per BDT for sawdust.

Conversion Technologies

A typical sawmill layout was modelled with Optitek®. The virtual sawmill consisted of a single bucking station and two distinct saw lines. Edging and trimming operations remain fully optimized.

Four state of the art conversion technologies were selected for this study:

1. Optimized bucking (Merchandizer);
2. Optimized Canter-Twin at primary breakdown Double Length Infeed or End dogging system);
3. Optimized straight and curve sawing at the secondary breakdown (Cant optimizer);
4. Integrated Small Log Processor, SLP (shape sawing or natural curve sawing).

A dozen mill scenarios were created, combining the different conversion technologies and log length mix for stud and random mills. In all scenarios, production was simulated for the six different resource groups, which resulted in a total of 72 simulations.

1. Typical random mill, only edging and trimming are optimized.
2. Stud mill using two Small Log Processors to produce 8-foot lumber.
3. Stud mill using two Small Log Processors to produce 10-foot lumber.
4. Stud mill using one Small Log Processor and a Canter-Twin for larger logs to produce 8-foot lumber.
5. Stud mill using one Small Log Processor and a Canter-Twin for larger logs to produce 9-foot lumber.
6. Stud mill using one Small Log Processor and a Canter-Twin for larger logs to produce 10-foot lumber.
7. Random mill with optimized primary and secondary breakdown on both saw lines in straight sawing.

Table 2.—Resource characteristics.

	Region A		Region B		Region C		Total
	1	2	3	4	5	6	
Group Number	1	2	3	4	5	6	Total
Volume (dm ³ /stem)	113	132	108	133	113	147	123
Spruce (%)	76	76	75	75	37	40	63
Jack pine (%)	15	15	-	-	-	-	5
Balsam fir (%)	9	9	25	25	63	60	32
Density (kg/m ³)	398	398	386	386	350	350	376
Decay (%)	1.6	1.6	2.4	2.4	4.8	4.8	2.2
Taper (cm/m)	0.92	0.89	1.05	1.00	0.92	0.97	0.96
Sweep (cm/m)	0.86	0.84	0.87	0.83	0.70	0.71	0.80

Table 3.— Lumber prices.

Nominal Size	NLGA Grade	Product Length							
		6'	7'	8'	9'	10'	12'	14'	16'
1x3	Utility & Better	140	140	200	-	200	275	275	285
1x4	Utility & Better	140	140	200	-	200	230	230	230
1x6	Utility & Better	200	200	200	-	200	220	220	230
2x3	Stud	150	268	281	281	-	-	-	-
2x3	No.2 & Better	-	-	-	-	281	284	341	352
2x3	No.3	150	200	250	-	250	250	250	250
2x4	Stud	150	297	387	401	395	-	-	-
2x4	No.2 & Better	-	-	-	-	395	411	436	490
2x4	No.3	150	200	327	-	327	327	327	327
2x6	Stud	150	150	367	363	434	-	-	-
2x6	No.2 & Better	-	-	-	-	434	418	439	456
2x6	No.3	150	150	282	-	282	282	282	282
2x8	No.2 & Better	-	-	350	-	430	430	430	430
2x8	No.3	-	-	316	-	316	316	316	316

Source: Indec 1998 and Random Length 1999, Del'd Great Lakes, in US\$/Mbf.

8. Random mill using one Small Log Processor for short logs (less than 10 feet) and optimized primary and secondary breakdown in curve sawing for larger logs.
9. Random mill using one Small Log Processor for short logs (less than 10 feet) and optimized primary and secondary breakdown in curve sawing for larger logs with the addition of optimized bucking
10. Random mill with optimized primary and secondary breakdown on both saw lines in curve sawing.
11. Random mill with optimized primary and secondary breakdown on both saw lines in straight sawing with the addition of optimized bucking.
12. Random mill with optimized primary and secondary breakdown on both saw lines in curve sawing with the addition of optimized bucking.

RESULTS AND DISCUSSION

The primary objective of this study was to generate performance indicators for Eastern Canadian sawmills according to their resource characteristics. Simulation results reveal that resource characteristics have less impact on sawmill performance than sawmill process and primary log lengths. Optimized bucking, primary and secondary breakdown optimization, curve sawing and proper use of Small Log Processors and Canter-Twins all contribute to increase lumber recovery (Fig. 2), but specifically sawmill revenue (Fig. 3). The various mill scenarios are presented by increasing revenue. Market preferences are such that optimized random mills yield higher revenues than any stud mill,

and that is true for all of the 6 resource groups. A close look at the graphics reveals that resource groups number 2, 4 and 6 give slightly higher revenues than the three other groups. This can be explained by the higher stem volumes of these first three groups. However, it is clear that all resource groups follow the same trend when technology increases. The revenue gap between the best and the worst group is in the range of 5.5% to 8.6% for any given scenario and the average is about 7%. The potential revenue increase from the first to the twelfth scenario is around 25%, roughly four times the gap between resource groups.

The second objective of the study was to compare various lumber manufacturing technologies, and to quantify their respective impact on mill performance. To do so, the mean wood consumption factor and mean sawmill revenue of the six resource groups were calculated for each scenario. Stud and random mill results were individually analysed.

Stud Mill Performance

Using two Small Log Processors, a stud mill can achieve wood consumption factors close to 4.3 m³/Mbf when processing 10-foot logs. However, Canter-Twins are mandatory for larger log conversion, indeed, the addition of a Canter-Twin boosts revenue by 8.5 % while reducing the consumption factor to 3.73 m³/Mbf.

Log length has a significant impact on mill revenue, with longer logs clearly generating greater revenue (Fig. 4). In a stud mill equipped with a Canter-Twin, revenue goes up by 1.1% when log lengths increase from 8 to 9 feet, and by another 1.3% when lengths go from 9 to 10 feet. For the same mill, the consumption factor usually increases rise with longer logs; the increase between 8- and 10-foot

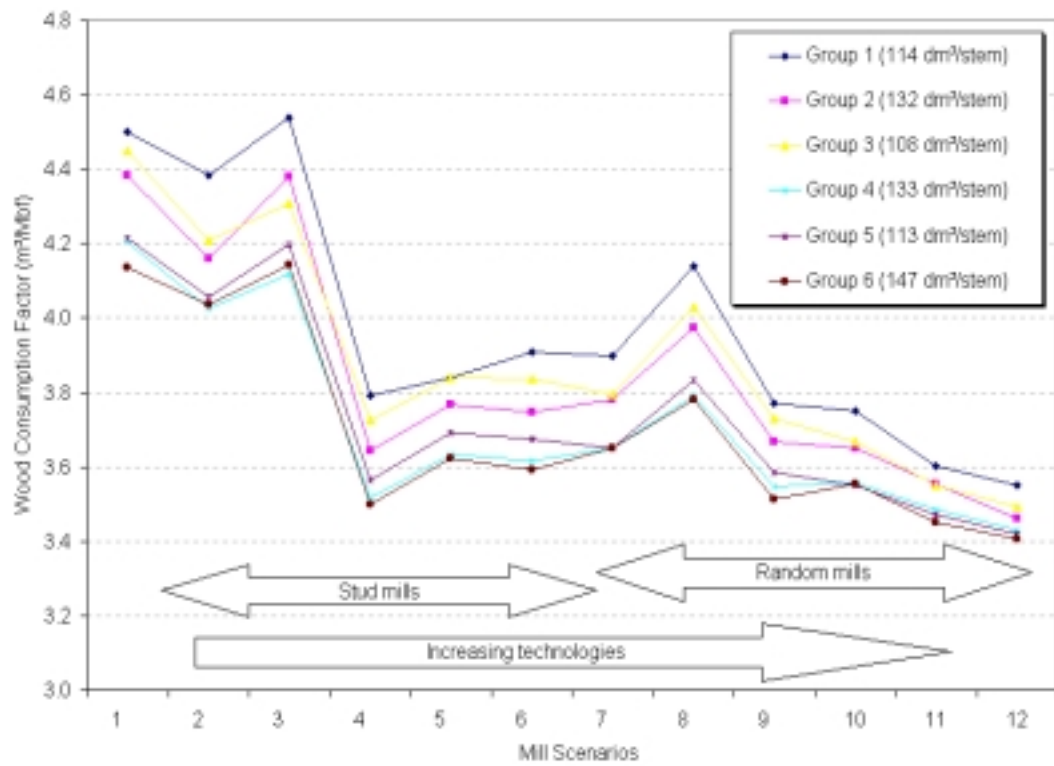


Figure 2.—Impact of resource and technology on lumber recovery.

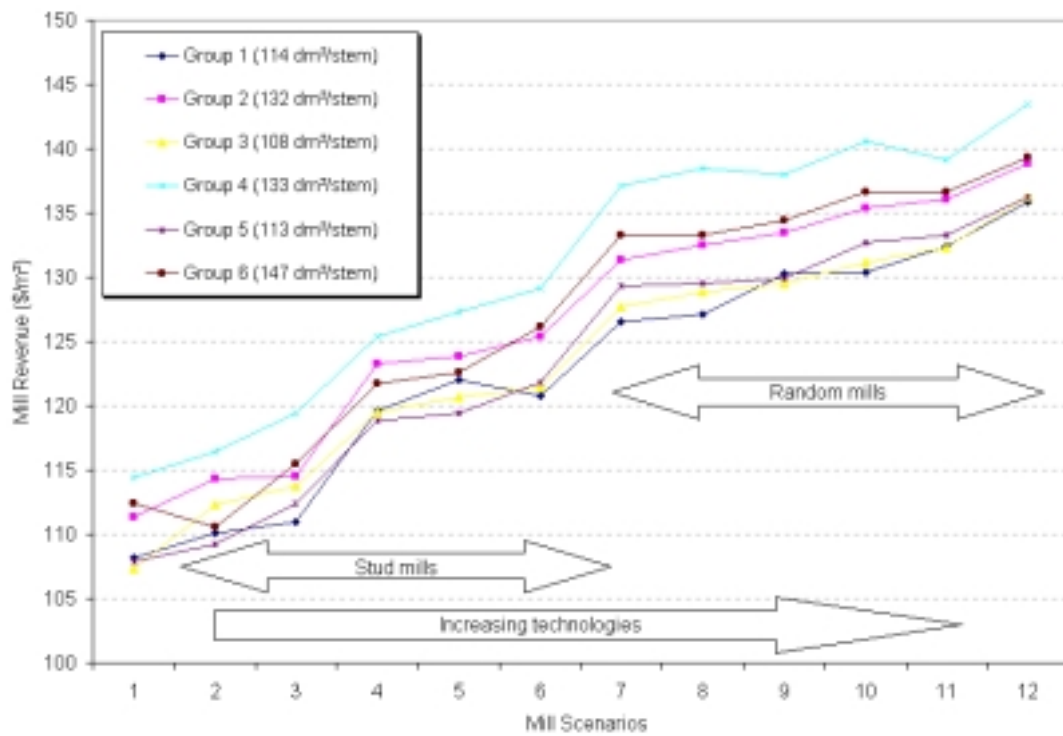


Figure 3.—Impact of resource and technology on mill revenue.

logs is about 3%. This, however, does not hold true with 9 foot logs; 9-foot lumber is not manufactured in all products; consequently, when mills cut 9-foot logs, a number of pieces are systematically trimmed to 8 feet, which causes a significant trim loss. For this reason, the 9-foot log scenario does not generate a lower consumption factor than the 10-foot log scenario. However, the prime value earned on 9-foot studs fully compensates volume losses.

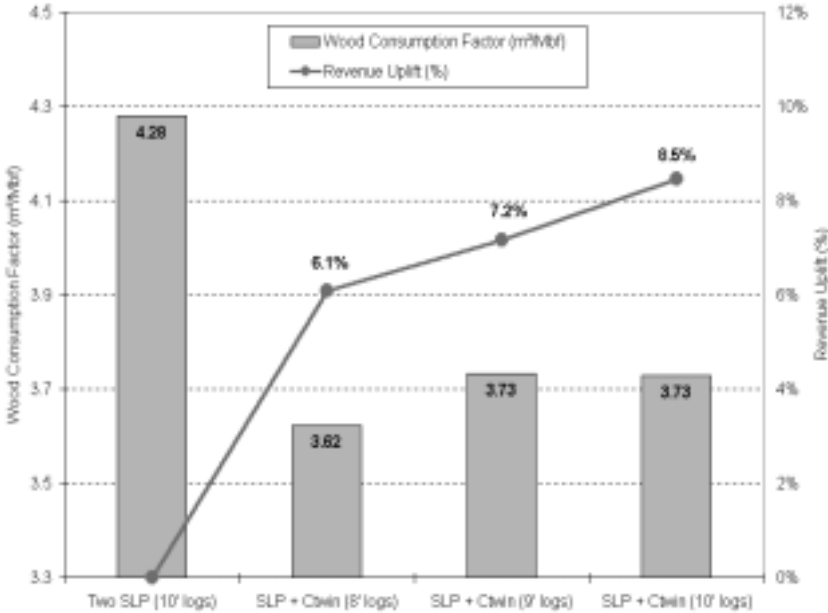


Figure 4.—Impact of conversion technology and log length on stud mills.

Random Mill Performance

In random mills, optimization of primary and secondary breakdown operations increases revenue by about 19%.

Wood consumption drops from 4.32 m³/Mbf to 3.74 m³/Mbf. The addition of curve sawing technology increases lumber recovery by 3.2% bringing the wood consumption to 3.62 m³/Mbf, while sawmill revenue goes up by 2.7%.

Optimized bucking cranks up the performance of the optimized random mill, and works quite well with curve sawing; it generates further lumber recovery and income. Revenue increases by 3.7% and 3.6% respectively with straight and curve sawing, while the consumption factor goes down to 3.52 m³/Mbf with straight sawing and to 3.46 m³/Mbf with curve sawing. It should be mentioned that the efficiency of optimized bucking is conditional on the availability of two flexible production lines, both having the capability of processing the full range of log lengths (8 to 16 feet) because this optimized bucking tends to generate some short

large diameter logs as well as long small diameter logs. In fact, merchandizer consider resource characteristics to cut the whole stem for the most valuable solution based on updated lumber prices.

A random mill that wants to improve its conversion process step by step, should adopt curve sawing prior to bucking optimization to get better return on investment. The capital cost of the bucking optimizer is relatively high compared to a curve sawing gang edger, and the benefits are pretty much the same (Fig. 5).

With these results, we are in a position to address the third objective of the study, and to demonstrate that the Eastern Canadian resource has the potential to permit consumption factors as low as 3.5 m³/Mbf, generating up to 135 dollars per cubic metre of income on the North American market based on the 1998–1999 economic situation. A mill achieving this goal would produce 114 million board feet of lumber from 400,000 m³ of timber supply.

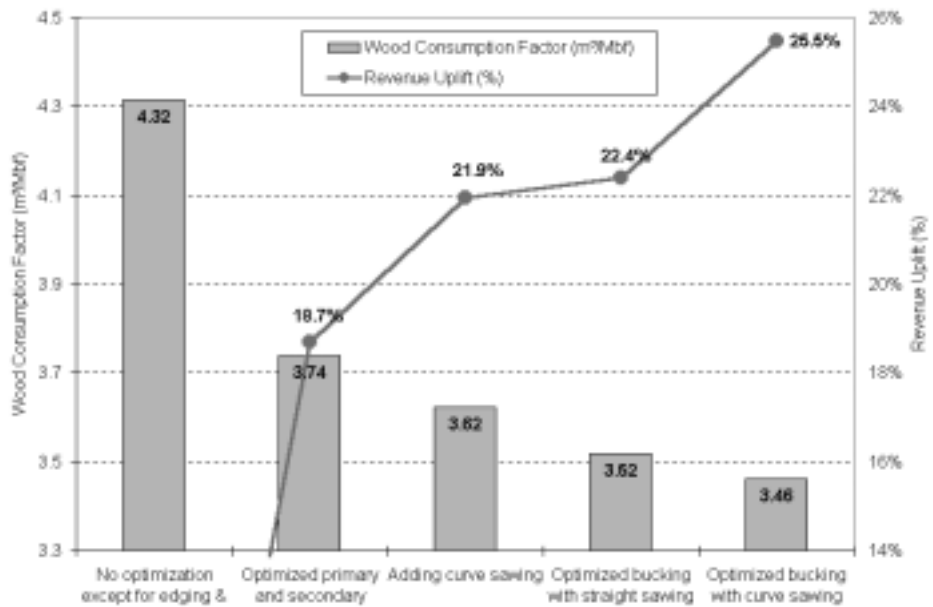


Figure 5.—Impact of conversion technology on random mills.

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