Maximum value throughout the wood supply chain: the RAID concept*

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Abstract
Maintaining or enhancing value throughout the solid-wood supply chain, from the stump to the client facility, is essential to enable the forest industry to manufacture the highest-quality products. FERIC promotes the use of a concept known as RAID to achieve this objective: Reduce stem and log breakage; Allocate the right log to the right mill at the right time; Increase fiber and value recovery; and Decrease value losses during wood storage. This paper describes the results and applications of several FERIC research initiatives under each of these four axes of the RAID concept. Reducing breakage through best operating practices (full-tree equipment) and the use of swing-boom skidders are discussed. Allocating the best log resulting from appropriate bucking scenarios and product sorting is also described. Project results on maximizing value recovery by means of optimized bucking in both softwood and hardwood operations are also provided. The paper concludes with an overview of the benefits of wood storage under snow and the integration of wood storage parameters in the Opti-Stock model.

1. INTRODUCTION
Maintaining or enhancing value throughout the solid-wood supply chain, from the stump to the client facility, is essential to enable the forest industry to manufacture the highest-quality products possible. In recent years, the Forest Engineering Research Institute of Canada (FERIC) has maintained an extensive research program in the area of maximizing the fiber quality and value obtained from forest operations. This program has led to the development of new practical knowledge that has been synthesized and distributed through a variety of technology-transfer media, such as reports, best-practices guides, downloadable Flash presentations, spreadsheets, and more advanced software tools.

FERIC has developed the RAID concept to provide a framework that integrates these products to help managers ensure that their operations use best practices to maintain fiber quality and enhance value. RAID stands for the following components: Reduce stem and log breakage; Allocate the right log to the right mill at the right time; Increase fiber and value recovery; and Decrease value losses during wood storage. Because extensive literature already exists on the topic of the fiber quality obtained from woodlands operations, this paper will focus on the research results and applications developed by FERIC for use in eastern Canadian operations under each of the four components of the RAID concept.

Reduce stem and log breakage
Operating practices and equipment selection can have a huge and sometimes critical impact on quality by their effects on log or stem breakage or damage during any of the

harvesting and delivery phases. FERIC has conducted numerous studies of breakage during forestry operations, and the results obtained prior to 1998 were summarized by Favreau (1998).

During these studies, data were collected both on the levels of breakage occurring and on the impact of various operating techniques on these levels. This information was summarized in two downloadable Flash presentations designed to present best practices for operations using full-tree to roadside equipment. One presentation deals solely with feller-bunchers, recognizing that the machine working at the head of the production chain deserves the most attention. The other presentation covers skidding and roadside delimbing. The best practices covered by both presentations (available via the Solutions section of FERIC’s Web site, www.feric.ca) were designed to be easy for field staff to understand and implement.

For feller-bunchers, best practices to minimize stem breakage include:

- Replace or rotate damaged teeth immediately. Andersson (2003) found that during a winter operation, 29.5% of the stems showed butt damage that caused a volume loss; this proportion decreased to only 9.1% when operating the felling head with new saw teeth.
- Avoid exceeding the tree accumulator’s holding capacity prior to bunching.
- Avoid horizontal pressure between the crowns of cut trees held in the accumulator and the crown of the tree being cut.
- Avoid repositioning trees that have already been bunched on the ground.
- Work smoothly and avoid jerky maneuvers.

Skidding represents another harvesting phase in which breakage frequently occurs if care is not taken. Stems stressed during the felling phase can break completely if mishandled during skidding. For example, decking at roadside with grapple skidders is a major cause of breakage, whether as a result of traveling directly on the log decks or pushing stems from the side using the skidder’s dozer blade to make room for additional loads. In one study conducted by Légère (2001), 48% of the stems exhibited some form of damage resulting from these practices. He found that the number of stems showing some level of breakage could be reduced by half if skidders delivered the trees directly to the delimiters at roadside in an integrated system (also called "hot logging") that eliminates decking of stems by means of a "just in time" delivery system.

Recently, skidders equipped with grapples mounted on pivoting booms, such as the Morgan SX-706, have become more popular in eastern Canada (Figure 1). A recent study found that this technology could reduce stem breakage by 30% compared with using traditional grapple skidders because loads can be swung sideways onto the log decks at roadside, thereby eliminating the need to climb onto the log decks with the machine during unloading (Gingras and Plamondon 2005).
Favreau (1998) also reported that clammbunk skidders produced 25% fewer broken stems than grapple skidders in the same operation because these large-load machines typically do not climb over the piles at roadside.

Roadside delimbing of trees can also lead to significant breakage if operating practices are poor. Integration of the skidding and delimbing operations is the preferred option for the delimbing phase because it facilitates extraction of stems by the delimber. When trees are decked at roadside in a separate prior operation, they often become tangled and compressed, making it difficult for the delimber to pull out individual stems, resulting in breakage and fiber loss. In addition, care must be taken when operators choose to delimb multiple stems to increase their productivity, and when handling salvaged material such as fire- or insect-killed trees, which are highly susceptible to breakage.

Allocate the right log to the right mill at the right time

Maintaining undamaged logs or tree-length stems during the logging operation is critical, but directing the right product to the right mill at the right time is also important in maximizing fiber quality. The reality of today’s harvesting operations is that operators are responsible for producing a wide diversity of products to meet a similarly wide range of specifications, for a large number of customer mills and delivery schedules. These logistics may be further influenced by economic parameters such as the need for just-in-time delivery and the need to restrict inventory levels. Although satellite merchandizing yards are used in some parts of eastern Canada (especially for hardwoods), the majority of product sorting takes place during the actual harvesting operation. In some cases, sorting is concentrated in a single phase, such as roadside delimbing, whereas in other cases, it is spread throughout the production chain. FERIC has conducted a number of sorting studies over the years to identify optimal sorting scenarios.

Table 1 presents the productivity losses (%) measured during these studies, as a function of the number of sorts versus producing only a single product. This information was generated
by pooling a number of results from studies by FERIC and other researchers (Bjurulf 1992; Brunberg and Arlinger 2001; Gingras 1996; Gingras and Godin 1997, 2001; Gingras and Soucy 1999; Gingras and Favreau 2002).

Table 1. Effect of sorting on machine productivity (% loss compared with one product).

<table>
<thead>
<tr>
<th>Number of products separated</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feller-bunchers</td>
<td>5–10</td>
<td>9–11</td>
<td>15</td>
<td>n.a.</td>
</tr>
<tr>
<td>Harvesters and processors</td>
<td>1–4</td>
<td>2–8</td>
<td>3–12</td>
<td>4–16</td>
</tr>
<tr>
<td>Forwarders</td>
<td>3–8</td>
<td>8–13</td>
<td>12–20</td>
<td>16–27</td>
</tr>
</tbody>
</table>

To optimize the delivery of properly sorted logs and stems to the right mills, FERIC has developed computer software to help its members compare harvesting and delivery scenarios. One of these tools, called Interface-Map, allows users to import digitized maps to produce harvesting and transportation simulations based on actual spatial and forestry data for the various blocks to be harvested. Figures 2 and 3 provide screenshots from the software using a hypothetical supply situation.

![Interface-Map screen capture showing cut-blocks, road lay-out and product exit points.](image)
Figure 3. *Interface-Map* screen capture showing summary of cost analysis per product for selected cut blocks.

*Interface-Map* allows users to allocate the product volumes coming from various blocks to various possible destinations using different routing scenarios and to compare overall delivery costs for these scenarios. In addition, an optimization feature called *MaxTour* has recently been added to this software (Gingras 2005). This module determines haul routes by combining the loads available during a given transportation period and in a given region. This logistics tool minimizes the distances traveled by empty trucks.

**Improve recovery**

Currently, there is tremendous pressure on the fiber supply in eastern Canada because of a combination of factors, including a reduction in allowable cuts in some jurisdictions, an increase in mill capacity and demand, and increasing amounts of productive land being withdrawn from fiber production for alternative uses. Ironically, the opposite situation prevails in western Canada, where large volumes of timber from stands damaged by the pine beetle are flooding the market. This fiber shortage is forcing companies to invest considerable energy in maximizing fiber recovery from every harvested hectare and minimizing any waste. FERIC is actively cooperating with the forest industry to develop techniques for recovering additional fiber from harvesting operations.

In addition to efforts to increase fiber volumes, efforts are being made to enhance value recovery during harvesting to reduce the financial impact of decreases in the available volumes. Bucking decisions, for example, can dramatically affect grade and value recovery in both softwoods and hardwoods. To improve bucking practices, FERIC has produced a guide targeted at the owners and operators of cut-to-length machines to help them decrease the variation in log lengths and more easily meet the required log specifications. Produced in Flash, this downloadable tool consists of a 15-minute self-running presentation that covers the following topics:
• Definitions.
• Factors affecting length- and diameter-measurement accuracy.
• Maintenance tips to ensure high accuracy consistently.
• Verifying actual log dimensions.
• The calibration process.
• Setting log-length targets and parameters.

Today’s cut-to-length heads do more than measure lengths and diameters. They have become sophisticated merchandizing devices with advanced stem-shape predictors and bucking optimizers. These systems show great potential for improving both volume and value recovery. Sondell (1995) and Sondell et al. (2002) provided good reviews of the bucking-optimization systems provided by mainstream harvesters. In a recent FERIC–Forintek study, Corneau et al. (2005) compared the value gains from optimized bucking of softwoods using a cut-to-length harvester computer with that of a full 3-D scan on a sawmill’s infeed deck. Although the sawmill system provided the optimal bucking solutions, the 2-D predictions provided by the harvester optimizers improved value recovery at a much lower cost than the major investment required for inline scanning at sawmills. The net savings represented CAD $1.40/m³ compared with the investment in optimization at the mill.

In hardwoods, improper bucking decisions have a much greater financial impact than in softwoods because of the tremendous difference in value between low and high log quality classes. With this in mind, FERIC has actively cooperated with Michigan Technological University in the development of training software called HW Buck that helps operators to improve their bucking of hardwoods (Pickens et al. 1993). This Windows software permits a variety of customizations to suit local conditions, log rules, log grades, and market prices (Figure 4). In field trials, FERIC found that value recovery losses originating from poor bucking patterns could reach 40% of the full potential value (Hamilton 2006).
Decrease value losses due to storage

Efforts made to minimize quality losses can be erased quickly by prolonged or improper storage of wood in the forest or at the mill. Although more and more mills try to balance fiber deliveries with mill consumption in order to reduce inventories, hauling is not feasible in many areas because of adverse weather or load-restriction periods during the spring thaw. In addition, the increasing frequency of forest fires and insect infestations creates surges of salvage volume that often exceed a mill's capacity. Therefore, large wood inventories remain a reality for many forestry operations.

To minimize the decrease in wood quality that occurs during storage and its effects on costs, FERIC has developed a decision-support model called Opti-Stock. The objective of this tool is to help managers determine the optimal storage duration under their specific operating conditions. Using information obtained from field studies and published literature, this spreadsheet-based model accounts for the interactions among several variables to predict the cost associated with variations in wood storage duration (Favreau 2001). Figure 5 illustrates the main components of the model, as well as a total cost that integrates all the parameters as a function of storage duration.

The Opti-Stock model groups costs into four categories that respond differently to storage duration. Logistics represents the cost to ensure a steady flow of wood to the mill (i.e., having sufficient harvesting and transportation capacity). This cost increases rapidly as storage time approaches zero because of the tremendous capacity that must be added to prevent the risk of any
wood shortages. Financial and operating costs increase linearly with storage duration and include pulp bleaching, inventory, insurance, treatment of mill effluents, and mill energy consumption. Product yield costs increase with storage duration because process yield decreases with increasing fiber dryness, and these costs include fiber loss during debarking, lumber yield, and pulp yield. Transportation costs are the only ones that diminish with increasing storage duration because less water is hauled as wood dries. The four individual cost components are combined to produce a total cost curve whose minimum cost value identifies the optimal storage period, and the graph shows the evolution of total costs over time.

Inevitably, some wood storage is required in most forestry operations. From a quality perspective, every effort must be made to prevent the quality degrades that result from this storage, mainly as a result of moisture loss, fungal staining, and (at more advanced stages) checking, rot, and insect attack. Gingras and Sotomayor (1992) discussed the variation in moisture of standing, felled, and stored softwood logs and stems as a function of storage duration and examines various storage implications. One protection strategy that has been around for centuries but that has been only recently applied to roundwood is storage under snow. Pioneered in Finland, the technique has now been tested and implemented operationally in several eastern Canadian operations with the assistance of FERIC (Nader 2003). The technique involves burying large volumes of roundwood under snow during the winter months and covering this snow with an insulating layer that typically comprises organic material such as bark, sawdust, or debris. These piles are then opened in mid- to late summer as fresh wood is required. Figure 6 illustrates the March and August temperature differences between a control pile and a pile stored under snow in one FERIC trial.

![Temperature difference in piles stored under snow and control piles.](image)

The snow-covered piles in this test systematically remained at or below 0°C. This greatly reduces the risk of discoloration of the stored wood and attack by insects. In fact, the moisture content of wood stored under snow actually increased as a result of snowmelt during the summer. Nader (2005) found that storage under snow is thus a relatively inexpensive alternative to the use of sprinklers and other water-based storage techniques.
2. CONCLUSION

Managing operations by means of the RAID concept ensures that best practices are used to deliver the highest-quality raw material to the client. Reducing breakage and damage to logs, allocating the right log to the right mill, improving volume and value recovery, and decreasing value losses due to storage are all key strategies for maximizing the quality of the fiber delivered from harvest operations.

We have seen that a combination of best operating practices and the right equipment can minimize breakage and damage levels, even in full-tree to roadside logging systems. Also, optimized log allocation will increasingly prove to be an important operational parameter in eastern Canadian operations. In this context, appropriate advance planning using software such as Interface-Map and tools such as onboard computers in harvesting machines will help to optimize product merchandizing and sorting and will help to establish appropriate delivery schedules. Improving both volume and value recovery through optimized merchandizing is key to improving the financial situation of the forest industry. Finally, we discussed how tools such as Opti-Stock and techniques like storage under snow can reduce the risk of quality downgrades as a result of wood storage.

Company managers should review their chain of operations in light of the RAID concept to optimize all phases of their operations and avoid jeopardizing wood quality in any phase. FERIC has produced decision-support information and tools to assist company managers in this assessment.

3. LITERATURE CITED