Advantage
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Contents



# Ability of three harvesting systems to limit rutting on a clay site

**Abstract**

FERIC compared three harvesting systems (full-tree, tree length, and cut-to-length) on a clay site in northwestern Quebec. None of the systems limited rutting to below the acceptable target level; however, cut-to-length harvesting (using a three-machine system) showed slightly better results than the other two systems.

**Keywords:**

Full-tree harvesting, Tree-length harvesting, Cut-to-length harvesting, Rutting, Soil disturbance, Clay soils, Feller-buncher, Stroke delimber, Processor, Shortwood forwarder, Grapple skidder.

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## Introduction

The target reductions in rutting that Quebec's Ministère des Ressources Naturelles (MRNQ) plans to impose in Quebec's Crown forests are leading companies to seek solutions applicable to certain sensitive clay sites that must be harvested in summer. In August 2000, FERIC and Norbord Industries Inc. (La Sarre panel division) conducted trials 35 km south of La Sarre to evaluate the costs and level of rutting associated with various approaches to harvesting. The full-tree harvesting system traditionally used by Norbord comprised a feller-buncher, a wheeled grapple skidder, and a roadside stroke delimber. We compared this system with a tree-length system using the same three machines, but based on at-the-stump delimbing and tree-length extraction, and with a cut-to-length system in which the feller-buncher was followed by a processor and a shortwood forwarder.

## Site conditions and study methodology

The study stand was composed primarily of aspen, with a density of 1275 trees/ha, a basal area of 33 $m^2$/ha, a mean DBH of 18.2 cm, and a mean volume of 0.26 $m^3$ per harvested tree. The trees were straight, with mostly small branches. Visibility in the understory was good. The stand was growing on a clay soil covered with a thin (10 cm) organic layer, but some lowlying areas had a siltier soil and a thicker organic layer. It rained to various degrees on each day of the study. The terrain was even, and slopes did not exceed 10% (CPPA classification 2(3).1.1).

The harvesting systems were studied side by side, each within two 320-m-long felling corridors. The various phases of the harvesting operation were timed and the level of rutting was surveyed once wood extraction was complete.

## Productivities

Table 1 presents the productivities of each phase in the three systems. With the John Deere 793D *feller-buncher*, the operator followed the normal work practices, but in the two corridors in which the processor worked, he bunched the wood at 90° to the trail rather than at the traditional 45° angle. The respective productivities of 72.5 and 73.7 m³/PMH did not differ significantly between the two methods of felling and bunching.

The Denis stroke delimber was mounted on a Komatsu PC 220LC carrier. *At-the-stump delimbing* was done by grasping the trees on one side the machine, delimbing them over the trail, and then piling the delimbed stems on the opposite side of the trail. The operator left the tops on the trail, lying roughly parallel to the trail. *Roadside delimbing* was performed at the landing once extraction was complete ("cold decking"). The terrain at the landing was very soft and often required the operator to build a carpet of stems to support the machine. The short duration of the observations limits our confidence in the estimated productivities: 33.4 m³/PMH on the felling corridors versus 37.5 m³/PMH at roadside.

The *processor* comprised a Marquis head mounted on a tracked Caterpillar 320 carrier. The operator of the processor followed the normal operating practice of delimbing the stems over the trail, then slashing them and piling the logs perpendicular to the trail. The tops were thus deposited across the trail. The productivity of 36.3 m³/PMH is at the high end of the range of values that FERIC has observed for roadside processors. The low branchiness of the stems undoubtedly compensated for the additional travel time required while working on the cutover.

The productivity of the six-wheel-drive Franklin 170 *shortwood forwarder*, with tracks on the rear bogies, was 20 m³/PMH. This is typical given the extraction distance and the study conditions. The productivity of the John Deere 648G *grapple skidder* (112-cm tire width) in both extraction modes was greater than that observed in other studies of aspen harvesting (Légère 2000; Plamondon and Godin, unpublished data). Although the full-tree extraction appeared more productive (52.8 m³/PMH) than the tree-length extraction (49.2 m³/PMH), this difference was largely attributable to unfavorable terrain conditions behind the tree-length landing that reduced the skidder's travel speed. The additional time required for piling at the tree-length landing was compensated for by a reduction in the time required to load the well-formed piles produced by the delimber on the cutover.

## Harvesting costs

Table 1 also compares the estimated direct harvesting costs for the three systems. These estimates do not include a profit margin, supervision, or other overhead charges. The unit cost for each phase was obtained by dividing the machine's direct hourly cost by the corresponding productivities obtained during our time studies. Since roadside slashing was not observed during FERIC's visit, we used a standard productivity and cost.

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**Table 1. Comparison of the total direct harvesting costs (n.a. = not applicable)**

| | Estimated direct hourly cost ($/PMH) | Cut-to-length | | Tree-length | | Full-tree | |
|---|---|---|---|---|---|---|---|
| | | Productivity ($m^3$/PMH) | Cost ($/$m^3$) | Productivity ($m^3$/PMH) | Cost ($/$m^3$) | Productivity ($m^3$/PMH) | Cost ($/$m^3$) |
| Feller-buncher | 115 | 72.5 | 1.60 | 73.7 | 1.60 | 73.7 | 1.60 |
| Processor | 125 | 36.3 | 3.40 | n.a. | — | n.a. | — |
| Forwarder | 80 | 20.0 | 4.00 | n.a. | — | n.a. | — |
| Delimber | 110 | n.a. | — | 33.4 | 3.30 | 37.5 | 2.90 |
| Grapple skidder | 85 | n.a. | — | 49.2 | 1.70 | 52.8 | 1.60 |
| Slasher | 80 | n.a. | — | 24.0 | 3.30 | 24.0 | 3.30 |
| Total direct cost ($/$m^3$) | | 9.00 | | 9.90 | | 9.40 | |

The cut-to-length harvesting system provided the lowest cost of the three systems; thus, it could represent an interesting alternative to the tree-length and full-tree systems. However, before being adopted, it merits additional study with branchier trees, which are more characteristic of the company's annual fiber supply. The tree-length harvesting system was $0.50/$m^3$ more expensive than the full-tree harvesting system, which represents a 5% increase excluding the costs incurred by treating the delimbing areas. The majority of this difference was attributable to the delimbing phase; longer-duration studies and a more detailed examination of the operating-cost assumptions for a delimber adapted to working on the cutover would provide a better assessment of this cost difference. The other source of differences in the total cost resulted from the lower productivity of tree-length extraction, which was attributable in large part to the terrain conditions.

## Rutting

The operational objective was to limit rutting deeper than 20 cm to 20% or less of the total trail length. Ruts less than 4 m long were not included in this total. Based on the full block depth (320 m), none of the three systems met this target. Table 2 summarizes our observations of rutting after the harvesting operation was complete. The presence of ruts was insignificant after the passage of the harvester, delimber, or processor.

Table 2 also presents the length of trail (starting from the back of the block) at which the threshold of 20% rutting would have been respected if extraction had been limited to this distance. The results show a slight advantage for the shortwood forwarder. The similarity of the results for the tree-length and full-tree skidding suggests there was no difference between these two modes of extraction.

**Table 2. Survey of rutting**

| | System | | |
|---|---|---|---|
| | Cut-to-length | Tree length | Full-tree[a] |
| Proportion (%) of the 320-m trail length with ruts | 33 | 42 | 43 |
| Length of trail that met the criterion for <20% rutting (m) | 250 | 210 | 220 |

[a] Data for a single corridor; the other corridor was excluded because it was narrower than normal in several places and did not undergo the same level of traffic.

## Implementation

At a similar nominal static bearing pressure (an estimated 58 kPa for the loaded forwarder's rear bogie versus 65 kPa for the loaded skidder's rear axle), the cut-to-length system produced somewhat less rutting than the longwood systems, yet still didn't meet MRNQ's objectives. However, the shortwood forwarder did not have to change trails or widen the trails to retain mobility, which sometimes happened with the skidder. This superior mobility could help operators to conform with regulations on the proportion of the site occupied by extraction trails in operations based on harvesting with protection of regeneration and soils. An eight-wheel-drive forwarder could offer even better results and should also be considered.

Extraction of the wood by the grapple skidder required around 2.3 times as many trips as the shortwood forwarder required for the same amount of wood per corridor. The implications of this reduced travel frequency for soil compaction and poplar regeneration were not considered during our study, but there could certainly be an impact on both.

The study was unable to establish a correlation between a specific number of passages and the appearance of ruts. Differences in soil texture (for example, in the occasional zones with siltier textures) and in the thickness of the organic layer could have led to the appearance of ruts after only a few trips, particularly given that the soils were saturated with water at the time of the study.

In zones with a humus layer greater than 10 cm deep and in very wet zones with a siltier texture, the felling pattern should be modified to minimize the number of extraction trips, for example by using secondary trails to reach parts of the site. This would obviously increase supervision time, but represents a first step that should be investigated before considering other, more expensive solutions.

More observations will be required before we can confidently determine the cost difference between at-the-stump and roadside delimbing. The treatment of roadside delimbing debris should also be considered as part of the cost of the full-tree system. However, depositing the delimbing debris on the extraction trail did not appear to reduce the amount of rutting. This can be partially attributed to the fact that the debris left by the delimber lay nearly parallel to the trail rather than perpendicular, as was the case for debris produced by the processor.

The distance at which the critical rutting threshold was reached suggests that, under the study conditions, the extraction distance would have to be reduced by around 30% to meet the objective of a maximum rutting level of 20% in the trails. The adoption of such a scenario would increase the road construction and maintenance cost by around 40%. This provides managers with an idea of the level of additional cost that could be acceptable when considering the use of other potential solutions rather than reducing the extraction distance. These alternatives include the use of specialized equipment such as tracked or wide-tire skidders with low ground pressure, or even halting operations or relocating them to other sites during prolonged rainfall.

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