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Optimizing product sorting in mixedwood forests using a full-tree harvesting system

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Abstract

In cooperation with Groupe Savoie inc., FERIC conducted tests in New Brunswick during the summer of 2006 that were designed to establish the optimal way to separate and skid products with a full-tree system in mixedwood forests, while minimizing productivity losses. The results of a trial where hardwood species were sorted into separate bunches during the felling phase show that productivity losses during felling and skidding were offset by gains during delimbing and slashing at roadside, and also facilitated piling logistics at roadside. To maximize the benefits from separating the species, the skidder operator should as much as possible concentrate trips with the same product within the roadside piles. Furthermore, combining skidding and delimbing operations, when possible, makes the work at roadside that much easier.

Keywords:

Full-tree harvesting system, Mixedwood forest, Product sorting, Productivity, Costs.

Introduction

Mixedwood forests present special challenges when it comes to harvesting the multiple species and the many products they can yield. One major problem involves separating the products while minimizing the loss of machine productivity and ensuring sorting quality. This problem is compounded in areas harvested using full-tree methods since the numerous products entail significant productivity loss and take up considerable roadside space.

Groupe Savoie inc., which owns a hardwood sawmill in Saint-Quentin in northwestern New Brunswick, must process and sort up to 15 products at roadside using delimbers and slashers in a full-tree harvesting system. Operators of the slashers, the last machines in the system, experienced many problems due to the lack of space at roadside. The recent addition of another sort for pulpwood and pallet wood made work that much more difficult.

Figure 1. Sorting of species during felling.

In the summer of 2006, FERIC conducted tests where a first separation of species was done during felling to hopefully offset productivity losses attributable to sorting during subsequent delimbing and slashing (Figure 1). Although separating species during the felling phase is quite common in mixedwood operations, it is rarely used in this region. Furthermore, during the tests, the skidding and delimbing phases were integrated to provide even more piling space for the delimber.

The specific objectives of the study were to:

- Measure the impact of species separation by the feller-buncher on the total productivity of the system (felling, skidding, delimbing and slashing).
- Evaluate the potential benefits of a hot-logging operation (integrated skidding-delimbing) as regards the sorting and piling of products.
- Propose general improvements to work methods.

Test conditions

The tests were carried out in June 2006, some 20 km southeast of Saint-Quentin. The study area was a mixedwood stand composed mostly of hardwoods and dominated by small red maples often growing in clumps of sucker shoots. Softwoods accounted for less than 25% of stems in terms of density. Table 1 presents the overall results of the pre-harvest inventory which was typical of the harvesting conditions commonly encountered by Groupe Savoie.

Table 1. Pre-harvest inventory of test block

	Maple	Birch	Aspen	Spruce/Fir
Stems/ha	670	320	10	275
Average DBH (cm)	13.6	17.1	36.0	15.0
Basal area (m^2/ha)	10.4	8.0	0.8	5.6
Proportion (% of stems)	53	25	1	21

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The terrain was considered very favorable (CPPA class 1.1.1).

Regular harvesting equipment was used for the trial, i.e. a Prentice 630 feller-buncher, a John Deere 748 grapple skidder, an old ProPac delimber and a Hood 24000 slasher. Two sorting scenarios were examined:

Usual scenario:

- Felling without separation of species
- Skidding with piling at roadside
- Delimbing with separation of species (maple, birch, softwoods and aspen)
- Slashing and sorting of products, including separation of pulpwood and pallet wood (maple)

Modified scenario:

- Felling with separation of dominant hardwood species (maple in this case) into one pile and secondary species in another
- Skidding integrated with delimbing; final sorting of species by the delimber
- Slashing and sorting of products, including separation of pulpwood and pallet wood (maple)

Productivity studies were conducted using FERIC's standard detailed time-study techniques. Furthermore, the wood was measured and tallied at roadside so the two scenarios could be compared in terms of productivity and costs.

Results

Productivity was calculated using the stem volumes measured and then was standardized to an average of 0.120 m^3/stem so that both scenarios could be compared fairly.

Felling

Results from the productivity study are presented in Table 2.

Sorting reduced the feller-buncher's productivity by roughly 8%. This reduction was mostly due to the greater difficulty in accumulating stems of the same species in

Table 2. Feller-buncher results

	Without sorting during felling	With sorting during felling	Difference (%)
Observation time (PMH)	4.4	8.6	
Average volume/stem (m^3)	0.131	0.133	
Travel time (min/cycle)	0.003	0.009	
Stems/PMH	338	311	
Productivity (m^3/PMH)	44.4	41.4	
Adjusted productivity at 0.120 m^3/stem	41.1	37.8	-8

the felling head and a slightly greater need to move the machine before bunching. This result is similar to that obtained by Gingras and Godin (2001) and Gingras (1996).

Skidding

The results of the skidding productivity study are presented in Table 3. It should be pointed out that the skidder worked in combination with the delimber (hot-logging operation) during the scenario with sorting during felling.

In the scenario where the wood was sorted during felling, the smaller sized bunches meant that the skidder operator had to assemble more bunches to make a load, thus increasing loading time. The productivity difference between the two scenarios was also impacted by the low productivity of the delimber, which resulted in the skidder sometimes having to wait to unload at the roadside landing when hot-logging was used. However, the skidder spent less time arranging the piles at roadside with its blade when hot-logging, therefore reducing the difference between the two scenarios. The difference between the two scenarios was considerably smaller at 300 m skidding distance than at 150 m because of the shorter waiting time at roadside. Figure 2 shows how the productivity of the skidder-delimber duo was affected by skidding distance.

With the equipment studied, the productivity of the skidder corresponded to that of the delimber up to roughly 200 m, since the skidder had no problem supplying the delimber. Beyond this distance, it was the delimber that had to wait for wood.

Table 3. Skidding results

	Without sorting during felling	With sorting during felling and integrated skidding-delimbing	Difference (%)
Observation (PMH)	3.7	6.1	
Volume/bunch (m^3)	1.46	1.15	
Bunches/trip	1.8	3.0	
Volume/trip (m^3)	2.6	3.4	
Loading time (min/cycle)	0.96	1.90	
Adjusted productivity (m^3/PMH) at a distance of 150 m and 0.120 m^3/stem	21.4	15.1*	-29
Adjusted productivity (m^3/PMH) at a distance of 300 m and 0.120 m^3/stem	13.6	12.9	-5

* Productivity during hot logging is that of the delimber, measured at 15.1 m^3/PMH during this test.

However, to reduce this delay, the skidder operator used the machine's excess production capacity when working within 200 m to bring wood closer to roadside. In general, the equilibrium point between the two phases will vary according to the potential productivity of the two machines.

Figure 3 shows the effect of sorting during felling on skidder productivity when it works independently of the delimber, i.e. not within a hot-logging operation. It should be noted that volumes per trip and travel speeds were standardized in this exercise.

It was found that the productivity of the skidder with wood sorted during felling was lower than when working with unsorted bunches. This was due to the additional time required to gather a full load with the smaller-volume bunches.

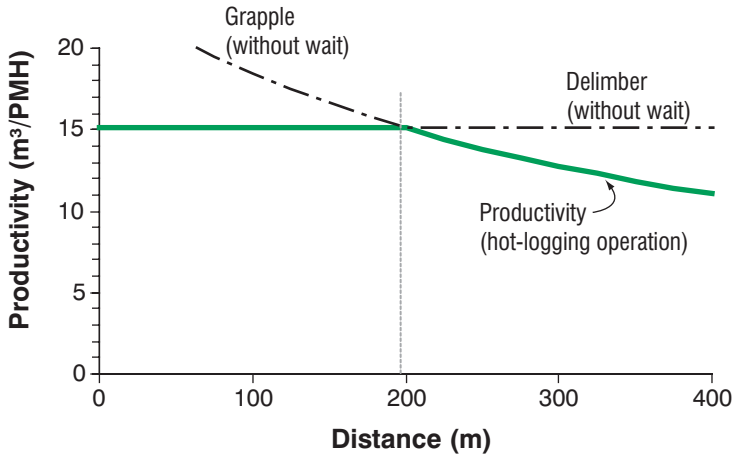

Figure 2. Productivity with sorting and integrated skidding-delimbing (in green).

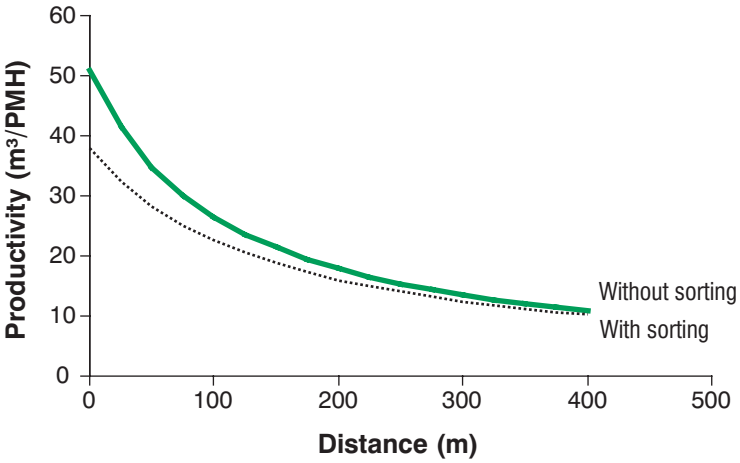

Figure 3. Skidding productivity with and without prior sorting.

Delimbing

Table 4 presents the results of the productivity study for the delimber.

Although fairly low overall, the delimber's productivity is a bit higher in the scenario with sorting (+ 5%). This improvement can be explained by a slightly faster time to load stems (less tangled piles) and a higher proportion of the same species in the pile. It is even possible to increase delimbing productivity without hotlogging as long as the skidder concentrates trips of the same species within the roadside piles.

Skidding integrated with delimbing provides the added benefit of fewer broken stems and facilitates the management of the delimbing residues, i.e. the branches can be easily returned to the cutover or piled into windrows to be recovered for biomass.

Slashing

Figure 4 shows the Hood slasher used by Groupe Savoie and Table 5 presents the productivity study results.

During the time study, the productivity of the slasher increased greatly be-

Table 4. Delimber results

	Without sorting during felling	With sorting during felling and integrated skidding-delimbing	Difference (%)
Observation time (PMH)	6.5	10.5	
Average volume/stem (m^3)	0.121	0.114	
Stems/PMH	118	128	
Productivity (m^3/PMH)	14.4	14.5	
Adjusted productivity at 0.120 m^3/stem and a skidding distance of less than 200 m	14.4	15.1	+5

Figure 4. Hood 24000 slasher.

cause of the better concentration of species within the pile as a result of sorting during felling, with a gain of 19% compared to the scenario without sorting. This gain was attributable to a shorter average handling time (loading, unloading and piling) when the piles formed by the delimber had a better species concentration. In addition, the stems were easy to access since they were neatly piled (no diagonal piling requiring re-handling).

Cost analysis

Table 6 compares the production costs for each scenario using the productivity observed during the study and standardized to 0.12 m³/stem. The estimated direct hourly costs of machines were obtained using the normal FERIC hypotheses and do not necessarily represent the contractors' actual costs.

It can be seen that the scenario with sorting resulted in a small savings of

Table 5. Slashing results

	Without sorting during felling	With sorting during felling	Difference (%)
Observation time (PMH)	2.6	3.0	
Average volume/stem (m³)	0.091	0.110	
Average handling time (min/cycle)	1.42	1.10	
Stems/PMH	155	163	
Productivity (m³/PMH)	14.2	17.9	
Adjusted productivity at 0.120 m³/stem	15.4	18.4	+19

Table 6. Production costs for both scenarios

Phase	Hourly cost ($/PMH)	Cost without sorting during felling ($/m³)	Cost with sorting during felling and integrated skidding-delimbing ($/m³)	Difference ($/m³)
Felling	148	3.37	3.67	0.30
Skidding (at 200 m)	106	5.92	6.97	1.05
Delimbing	119	8.28	7.90	(0.38)
Slashing	96	6.21	5.20	(1.01)
Total				(0.04)

roughly $0.04/m³. The loss in productivity during felling and skidding were offset by gains achieved during delimbing and slashing at roadside. Since this method also facilitated the new pulpwood /pallet wood sort, the company has made it a general policy to sort species during felling in all its full-tree operations.

Implementation

The results of this study suggest that sorting hardwood species into separate bunches during felling improves the productivity of the roadside operations (delimbing and slashing) and makes it easier to maintain sorting quality. The productivity losses observed during felling and skidding are fairly low and should be offset by gains during delimbing and slashing.

To gain optimal benefit from this practice, the skidder operator should make as many trips as possible with one group of species before changing to the next so as to better concentrate volumes of species within the pile. It is this concentration that makes the delimber and slasher's job easier.

Delimbing integrated with skidding is also desirable since it reduces stem breakage, makes it easier to load the delimber, improves the management of delimbing residues and facilitates the creation of higher piles at roadside (Figure 5). However, even in situations where this integration is difficult to achieve, the skidding of successive loads of the same species will lead to more homogenous piles at roadside, which is still beneficial for the delimber and slasher.

It is also possible to combine both methods: the skidder supplies as much as possible the delimber in a hot-logging operation, but also uses its excess production capacity to cold deck reserves of wood to delimb should a mechanical problem arise with one of the machines.

It is then the delimber operator's turn to facilitate the slasher's job by further consolidating volumes of the same species within the pile and avoiding putting cross piles on top of the main pile. This is made possible by the prior sorting of species during felling and the successive skidding of bunches the same species.

Figure 5. Skidding integrated with delimbing.

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