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TRIALS OF TWO HARVESTING SYSTEMS FOR SHELTERWOOD CUTTING IN SOFTWOOD STANDS

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Abstract

In an effort to reduce the high costs of partial cutting operations, such as shelterwood cuts, FERIC tested an innovative approach with two harvesting systems in softwood forests. The approach relied on conventional harvesting equipment that progressed through the harvest block using a work pattern that encompassed strips of two different widths that were either treated or left untreated. The results showed that the shelterwood objectives could be met at an acceptable cost.

Introduction

Commercial thinning and shelterwood regeneration cuts in softwood forests are generally more costly than clearcuts because of lower equipment productivity. These productivity decreases can be attributed to the lower volume harvested per hectare, to the increased travel required within the stand, and to interference from the residual stems. In October 1996, FERIC proposed an evaluation of a trail network with a specific spacing designed to minimize the amount of travel by the machines within the stand. Both a cut-to-length harvesting system and a full-tree system were tested during shelterwood cutting. Matériaux Blanchet Inc. (Amos, Que.) and Stone-Consolidated Corp. (Saguenay, Que., division) cooperated in the study. Harvesting equipment traditionally used in clearcutting was chosen for the study to permit the development of work techniques that the could be applied easily by the companies. The cut-to-length system observed north of Matagami comprised a Rottne SMV Rapid single-grip harvester equipped with Rottne harvester head (Figure 1) and a 16-tonne, six-wheeled Rottne SMV Rapid forwarder. The full-tree system comprised a Timberjack 618 feller-buncher (Figure 2) and a John Deere 640D cable skidder. These machines were working in the Monts Valins region (Saguenay, Que.).

Figure 1. The Rottne SMV Rapid single-grip harvester.

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Figure 2. The Timberjack 618 feller-buncher.

The project's goal was to study the impact of an innovative approach to shelterwood cutting on equipment productivity, on regeneration, and on soil protection. More specifically, the objectives were:

- to estimate the costs of the two systems in shelterwood cutting, both for the initial partial cut and for the final harvest, and
- to identify work techniques that would help to optimize equipment productivity in both systems.

Harvesting Method

The prescription for the proposed shelterwood regeneration cut required two stand entries. The first involved a partial cut to remove one-third of the stand's basal area so as to stimulate natural regeneration under the forest cover. The second stand entry, in which the remainder of the stand was removed, would normally take place once the regeneration was well established.

For the FERIC study, a trail network based on a 36-m-wide sequence of strips was initially established by flagging in the stand (Figure 3). During the first entry, the extraction trails (100% removal) were sufficiently wide (5 m) to permit temporary bunching of the wood as well as maneuvering by the equipment. Harvesting of 25% of the volume was performed in a pair of consecutive strips on each side of the extraction trails; the first of the paired strips was 5 m wide and the second was 8 m wide. A final 5-m strip was left untreated, and would serve eventually as an access trail during the second entry of the shelterwood cut. Because damage to the regeneration would be concentrated in this strip during the second entry, no particular effort would be made during the first entry to favor seedling establishment within this strip.

The width of the strips with the 25% removal intensity was determined based on the stand's density and the characteristics of the felling equipment (i.e., the accumulation capacity of the feller-buncher's head and the ability of the single-grip harvester to direct wood towards the main extraction trail). In the 5-m strips adjacent to the extraction trail, the harvester removed only the trees in its path so as to provide access to the adjacent 8-m strips; selection in the 8-m strips was done in proportion to the stand's basal area. With the single-grip harvester (Figure 3, at left), the length of the machine (5 m) and the reach of its boom (8 m) determined the depth of penetration for treating the 5-m and 8-m strips. With the feller-buncher, a complete treatment (Figure 3, at right) was possible by entering the 5-m and 8-m strips on secondary trails equivalent in

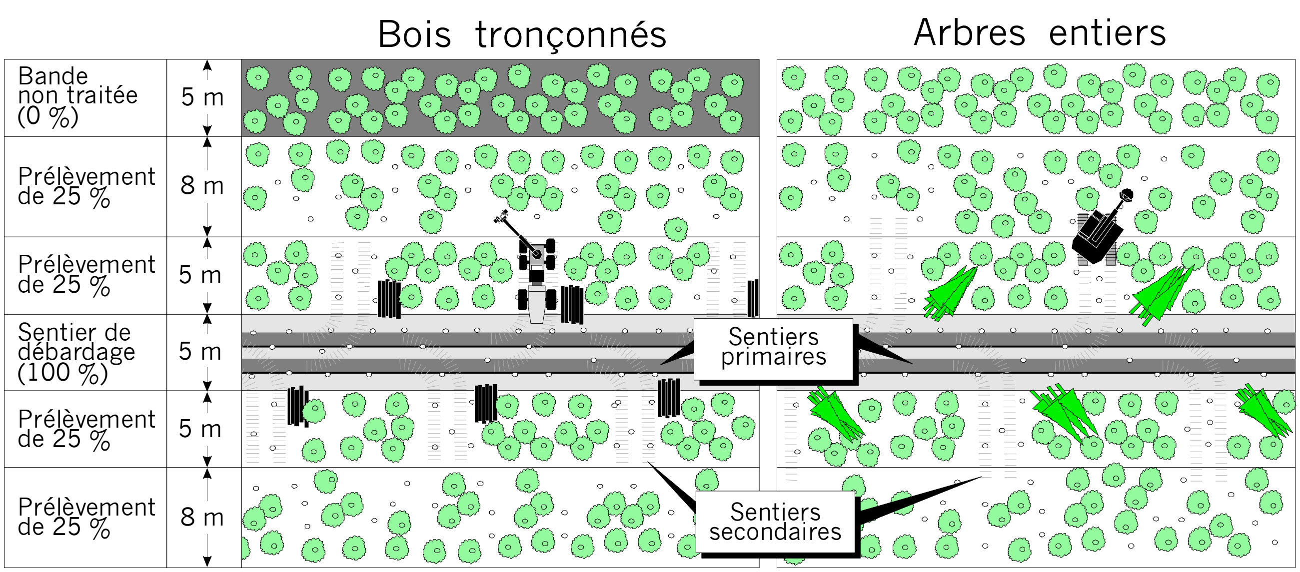

Figure 3. Diagram of the first entry with the cut-to-length system (at left) and the full-tree system (at right).

length to two lengths of the machine's tracks (8.6 m in total). In this manner, the operator could optimize the use of the felling head's accumulation capability, and this avoided the need for more than a single entry along the secondary trail. An average distance of 13 m between the secondary trails would provide the target removal intensity of 32% of basal area.

The untreated corridors that were reserved as a preferred means of access for the second stand entry were not actually used in this manner during the current trials. Instead, the conventional method of harvesting with protection of regeneration and soils was chosen to permit a productivity comparison with the results of the first entry of the shelterwood cut.

Description of the Study Conditions

Two black spruce stands on favorable terrain were chosen for the trials. The pre- and post-harvest conditions for both entries are presented in Table 1. The results indicate that the target removal intensity of 32% was nearly achieved with the cut-to-length sys- tem, whereas the removal intensity reached 48% in the full-tree block. The even-aged stand treated with the full-tree system featured a large number of stems that were 6 to 8 cm in dbh, whose presence may have influenced the operator during the selection of mer- chantable stems (10 cm dbh and up) in the 8-m strips. However, the degree of interference from the residual stems, including these small stems, was sufficiently high that it affected the feller-buncher's productivity in a similar way to a lower-intensity removal.

Productivity and Costs

Table 2 presents the productivities of the two felling machines for both stand entries. The single-grip harvester's productivity during the second entry was 11% greater than that in the first entry. This difference was largely due to the difference in average stem volume. It was also noted that work performed outside the main extraction trails during the first entry required slightly more travel than during the second entry. The difference in direct costs between the two entries was only $\$0.71/m^3$, which can be explained by the low amount of interference that the residual stand caused for the single-grip harvester.

The feller-buncher's productivity was 25% lower during the first entry than during the second, which led to an increase of $\$1.20/m^3$ in the direct costs. This difference arose from the increased amount of travel required during the first entry, despite the fact that the proposed work method had been designed to reduce travel by maximizing the use of the felling head's accumulating ability.

Table 3 summarizes the observations for the forwarding and skidding equipment during the two entries. The forwarder's productivity was 8% higher during the second entry, even though the volume per trip was slightly (4%) lower and the travel speeds were comparable in the two cases. The higher time per trip during the first entry was caused by a slightly longer loading time.

Table 1. Description of the study blocks

	Cut-to-length system		Full-tree system	
	First entry	Second entry	First entry	Second entry
Density (stems/ha)	1002	649	1300	750
Basal area (m^2/ha)	22.0	14.2	21.4	11.2
Removal (% of basal area)	35	100	48	100
Average volume per hectare (m^3/ha)	143	94	97	49
Stocking (%)				
Before the entry	74	69[a]	100	100[a]
After the entry	66	46[a]	96	74[a]
Terrain (CPPA class)	3(4).1.1		3.1.1(2)	

[a] Excluding the trails in the first entry.

Table 2. Productivity summary for the felling equipment

	Cut-to-length (single-grip harvester)		Full-tree (feller-buncher)	
	First entry	Second entry	First entry	Second entry
Study duration (PMH)	5.7	5.7	10.1	8.2
Average volume (m^3/stem)	0.171	0.188	0.100	0.097
Productivity				
stems/PMH	101	102	235	324
m^3/PMH	17.3	19.2	23.5	31.4
Estimated hourly rate ($/PMH)	125.31	125.31	111.87	111.87
Direct cost ($/$m^3$)	7.24	6.53	4.76	3.56

Table 3. Productivity summary for the extraction equipment (average extraction distance standardized at 150 m)

	Cut-to-length (shortwood forwarder)		Full-tree (cable skidder)	
	First entry	Second entry	First entry	Second entry
Study duration (PMH)	5.0	7.0	4.3	8.5
Average volume (m^3/trip)	18.4	17.7	4.2	4.4
Productivity (m^3/PMH)	24.5	26.5	15.6	16.2
Estimated hourly rate ($/PMH)	98.57	98.57	76.16	76.16
Direct cost ($/$m^3$)	4.02	3.72	4.88	4.70

In the full-tree system, the cable skidder's productivity was about 4% higher during the second entry, primarily because the volume per trip was slightly higher. The total cycle time was also a bit shorter as a result of the decreased loading time and decreased travel permitted by a better concentration of stems in the second entry.

Overall, the impact of the trail layout on extraction costs was low (less than $0.30/$m^3$ for both systems).

The total direct harvesting costs for the cut-to-length system were $11.26/$m^3$ during the first entry and $10.25/$m^3$ during the second; thus, the incremental cost of using the shelterwood method was $1.01/$m^3$. With the full-tree system, the costs were $9.64/$m^3$ and $8.26/$m^3$, respectively, for the first and second entries; thus, the additional cost for using the shelterwood method was $1.38/$m^3$.

Note that the experimental nature of these trials and their short duration did not permit the most appropriate comparison of the costs of the first entry with those of a conventional clearcut. The costs of the second entry are assumed to approximate those of a conventional harvest with protection of regeneration and soils, although the stand density within the experimental setup at the second entry was lower than would normally be expected and these costs may have been overestimated.

Impact on Regeneration and Soils

The compatibility of the proposed approach with the regeneration and soil protection objectives was evaluated after each entry for the two systems. The first entry led to stocking decreases of less than 10% (Table 1). The wide spacing between the trails and the limited travel by the felling machines beyond the main extraction trails minimized these losses. During the second entry, stocking decreased by 26% with the full-tree system and 23% with the cut-to-length system. These losses are typical for such an operation and indicate that the trail network established during the first entry was compatible with the objective of protecting regeneration.

Soil disturbance surveys after the first entry indicated that less than 2% of the cutover had exposed mineral soil. This supports the assumption that travel by the machinery was controlled. However, it could be necessary to perform some understory site preparation to meet the seedbed requirements of certain species. The levels of soil disturbance after the second entry were comparable to those of a conventional harvest with protection of regeneration on similar sites.

Conclusions

The harvesting operations with FERIC's proposed trail spacing showed that the costs of the first entry were acceptable for shelterwood cutting in softwood forest. Use of the proposed trail network was implemented with no particular difficulty thanks to a trail spacing design that accounted for the characteristics of the harvesting equipment. The selection of stems in softwood stands was relatively easy, and this increased the chances of meeting the treatment objectives. The cut-to-length system provided ideal characteristics for partial cutting because the machines, which were of European origin, had been designed specifically for this type of operation. The use of a tracked single-grip harvester could also be possible provided that the cab's rear overhang would not affect trail width. The use of full-tree harvesting equipment for the shelterwood cut was particularly interesting since this equipment is widespread and the wood produced could be easily integrated with that produced by clearcutting. Over a longer period, optimization of the work techniques could further decrease the costs and better define limitations related to site conditions and night work. However, indirect costs such as flagging and block layout, equipment transportation, and design of the road network for large-scale partial cutting have not been included in this analysis.

Acknowledgments

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APPENDIX

Assumptions Used in the Calculation of Hourly Rates[a]

	Rottne SMV Rapid		Timberjack 618	John Deere 640D
	Single-grip harvester	Shortwood forwarder	(feller-buncher)	(cable skidder)
Economic life (years)	5	5	5	7
Scheduled hours (SMH/year)	4 000	4 000	4 000	2 000
Purchase price ($)	530 000	430 000	452 000	200 000
Salvage value ($)	53 000	43 000	45 200	20 000
Licensing ($/year)	50	50	50	50
Insurance ($/year)	21 200	17 200	18 080	8 000
Interest rate (%)	10	10	10	10
Utilization rate (%)	80	85	85	90
Lifetime repair costs ($)	583 000	430 000	452 000	180 000
Fuel consumption (L/PMH)	16	12	31	14
Fuel price ($/L)	0.50	0.50	0.50	0.50
Oils and lubricants ($/PMH)	2.00	1.50	2.15	1.00
Wages and benefits ($/SMH)	25.00	25.00	25.00	25.00
Fixed machine costs ($/PMH)	47.62	36.36	38.22	26.10
Variable machine costs ($/PMH)	46.44	32.80	44.24	22.28
Labor costs ($/PMH)	31.25	29.41	29.41	27.78
Total cost ($/PMH)	125.31	98.57	111.87	76.16

[a] These rates cover only operating and maintenance costs for the equipment, excluding transport and supervision costs, profits and other overhead.