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EVALUATION OF CUT-TO-LENGTH COMMERCIAL THINNING SYSTEMS WITH MANUAL FELLING AND PROCESSING

P. Meek*, J.-F. Gingras and R.H. Ewing*****

Abstract

In 1997, FERIC studied four commercial thinning operations based on manual felling and processing of the trees, and measured the productivities of the fellers and of the extraction equipment. The results suggest felling and processing costs of \$20 to \$25 per m^3 with an average volume per harvested stem of around 0.1 m^3; however, the costs were higher when harvesting smaller stems and in unfavorable weather. Piling of the logs remains an arduous task that reduces the productivity of the fellers, but the use of large-capacity forwarders permitted relatively low extraction costs.

Introduction

Commercial thinning is an increasingly important silvicultural treatment in eastern Canada, and the use of cut-to-length harvesting systems based on manual felling and processing has let many forestry companies develop their expertise in the application of this treatment. One justification for the choice of this approach to commercial thinning is that it does not require a strong commitment on the part of the contractor; in effect, the low investment in equipment and the high flexibility of the forwarders used in the system let foresters become familiar with the treatment without the constraints entailed by a high degree of mechanization. The use of manual felling and processing also promotes excellent stem selection so as to meet the demanding standards for commercial thinning, and the manual piling of logs adapts easily to interference from the residual stems. The shortage of equipment specially adapted to commercial thinning has often made manual thinning work a reasonable solution, and the development of this treatment has created jobs that do not require specialized training in certain regions.

As in all lightly mechanized operations, the productivity of the workers in this treatment is crucial in determining the overall cost. Within the context of the experimental program on commercial thinning conducted in Quebec, FERIC carried out operational research in 1997–1998 on the limits of Domtar Inc. near Val d'Or, Abitibi-Consolidated Inc. south of Roberval, Alliance Forest Products Inc. north of Mistassini, and Gaspesia Pulp and Paper Company Ltd. in the Gaspé region. These sites were chosen because the operations were conducted by local workers with experience in thinning and paid on a piecework basis. The evaluations described in the current report thus represent typical cut-to-length thinning operations with manual felling and processing.

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* Philippe Meek is a Senior Researcher, Eastern Division.
** Jean-François Gingras is a Program Manager, Eastern Division.
*** Roderick H. Ewing is a Researcher, Eastern Division.
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Description of the operations

All the commercial thinning operations that FERIC studied occurred on public land in Quebec and as a result, were subject to the regulations currently in force for this type of treatment. Typically, the operations took place in stands with good densities at least 15 years before maturity as defined in the management plan. The removal of 25 to 40% of the basal area was intended to increase the proportion of quality stems, increase the average DBH of the remaining stems by at least 5%, and leave at least 16 m²/ha of basal area.

Overall, the cutovers observed during FERIC's studies were on favorable terrain (CPPA class 2.1.1). The unmerchantable stems, particularly in the understory, did not interfere excessively with the work (density of unmerchantable stems of less than 5000/ha) even though a significant part of the work involved felling these stems. At Mistassini, precommercial thinning in the late 1970s created favorable conditions for the fellers; no brushing was required. As the data in Table 1 indicate, the characteristics of the treated stands were comparable. The thinning lowered the density of the stands by just over one-third after treatment, to around 1450 stems/ha, with a basal area of 25 m²/ha and a volume of 130 m³/ha for the spruce stands.

The fellers performed comparable work in all the operations FERIC visited, apart from the lack of prior marking of stems on two sites. After locating the stems to cut, fellers had to remove brush from their work area and perform directional felling in such a manner as to reduce the piling distance. Once the tree was on the ground, they immediately delimbed and bucked it, but only performed the piling (Figure 1) after several stems had been processed.

Figure 1 . Manual piling of logs.

Forwarding of logs from these commercial thinnings was done in the usual manner for clearcuts. However, travel and loading were slower because of interference from the residual stand. The equipment that FERIC studied differed considerably among the four cutovers. The CM2000 miniskidder with a custom-made trailer that FERIC observed at Val d'Or was well suited to a small-scale operation because of its small dimensions, its low load capacity, and its moderate purchase price. A John Deere 6200 tractor (Figure 2), with a custom-made trailer and a Patu boom, was observed at Roberval; it is often considered to reflect the minimum characteristics for performing professional work. The cab provides a safe environment, the payload is relatively large, and the machine is robust despite its low purchase price. At Mistassini, the contractor used a converted Timberjack 230 skidder as a forwarder with a payload of 5 tonnes. Last of all, a large-capacity (16-tonne) six-wheeled Fabtek 546B forwarder (Figure 3) was observed in the Gaspé region, working in a commercial thinning operation in a fir stand about 100 km from the site on which the fellers had been observed.

Table 1. Summary of stand conditions for the thinning operations

	Val d'Or	Roberval	Mistassini	Gaspé
Composition of stand	Jack pine	Black spruce	Black spruce	Black spruce
Density before treatment (stems/ha)	1460	2705	2400	2614
Basal area before treatment (m²/ha)	29	45	41	35
Standing volume before treatment (m³/ha)	187	188	215	173
Tree marking before the operation	No	No	Yes	Yes
Removal (% of the basal area)	45	38	39	33
Volume harvested (m³/ha)	79	61	79	50
Average diameter of the felled trees (cm)	15.7	12.5	14.1	12.4
Trail spacing (m)	17	23	25	25

Figure 2 . John Deere 6200 tractor equipped with a custom-built trailer and a Patu boom.

Figure 3. The Fabtek 546B shortwood forwarder.

Study Methods

FERIC's studies of feller productivity consisted of detailed time studies or shift-level studies. The time studies involved observing workers continuously and recording the number of trees felled, the number of logs produced, and the time devoted to the various elements of the overall work cycle; scaling a sample of the logs completed the data collection in this type of study. The shift-level studies were primarily used at Mistassini and in the Gaspé region, and did not require continuous presence of the observer. In these studies, groups of fellers were followed via logbooks in which workers recorded the times they devoted to the job. FERIC then counted the number of logs produced during the productive time and scaled log samples to calculate overall productivity. Brief detailed time studies let FERIC calculate the proportion of the total work cycle spent on each activity on these sites.

For the extraction phase, FERIC observed the time elements that comprised the work cycle (for round trips) via detailed time studies, and calculated the average volume per log by measuring a sample of logs. Using this information, the productivity was calculated in m^3/PMH (productive machine hour) for standardized average extraction distances of 150 m.

The assumptions used to calculate the direct hourly operating costs of the equipment appear in the Appendix. These assumptions reflect experienced workers with optimal equipment utilization and reasonable availability. The direct hourly costs for the skidders ranged from $43.65 to $75.98 per PMH. The hourly cost for fellers equipped with chain saws ($31.50/PMH) was calculated using the same assumptions for all the operations. These costs reflect only the direct operating costs, excluding supervision, profits, and other overhead.

Results

Table 2 presents the results of the productivity studies for the workers who performed the felling and processing. Productivities ranged from 0.67 to 1.52 m^3 per productive hour (PH). Certain felling and processing costs were clearly too high for the operation to be viable, but those below $25/$m^3$ could prove to be acceptable. Note that the operations with the highest average volumes per harvested stem had the best productivities, and that the experience of the fellers also varied considerably among groups in the study. For the Mistassini and Gaspé operations, the weather conditions (early winter) partially explain the moderate productivity of the fellers. In the Gaspé operation, the production of 1.22-m (4-foot) logs also helps to explain the lower productivity that FERIC observed.

A detailed examination of the work cycle (Table 3) reveals that delimbing and bucking the logs represented the longest phase of the work cycle in almost all the operations, and the piling phase took the next-largest amount of time. Thus, any attempts to reduce operating costs should prioritize these two phases. However, it's unlikely that the chain saw work performed by these skilled workers could become sufficiently more productive to significantly reduce costs. Moreover, manual piling of wood is physically demanding work that could not be made more productive without changes to the regulations that govern the distance between the trails. Under comparable conditions, it appears impossible to achieve significant cost reductions in these phases without at least some mechanization of the operation. Initial efforts to mechanize commercial thinning have thus focused on the processing or extraction phases. The use of a processor would combine the benefits of manual felling with a typically lower cost for processing the logs. Several commercially available processors are equipped with a winch that could be used to ease the backbreaking job of manual piling. In addition, forwarders adapted to manual thinning operations in Europe have a very long boom reach (up to 10 m) so that fellers can pile logs farther from the extraction trails.

Among the other elements of the work cycle, brushing was important in only one of the four operations FERIC visited (Gaspé). This element can be critical in terms of the selection of the stands to be treated because a high density of unmerchantable stems, as is the case in poorly developed fir stands, can compromise the viability of the operation. Conversely, in tended stands such as those at Mistassini, the low density of unmerchantable stems frees the feller to concentrate on producing logs. No technique would permit the treatment of dense stands without either increasing the cost or compromising the quality of work.

Table 4 presents the results of the studies of the extraction equipment. It is clear that the productivity of the forwarders was proportional to their payload capacity, as extraction costs tended to decrease with increasing forwarder size despite the higher purchase prices and operating costs for the bigger machines. As the forwarders had comparable travel speeds, large payload capacity was crucial. The use of a large-capacity forwarder such as the Fabtek appears preferable, since its efficiency is less affected by long extraction distances. These large forwarders generally require slightly wider trails than the smaller machines, but this typically does not compromise the goal of meeting the regulations that limit coverage of the site by extraction trails. The detailed work cycle analysis also revealed that the Fabtek forwarder was more efficient than the others at loading (Table 5) because of its high boom speed and large grapple capacity. The forestry trailers and the 5-tonne forwarder had smaller, less-productive loaders.

Table 2. Results of observations of the felling and processing phase

	Val d’Or	Roberval	Mistassini	Gaspé
Log length (m)	2.54	3.00	2.54	1.22
Study duration (productive hours, PH)	4.7	15.3	29.4	109.2
Average volume (m³/stem)	0.097	0.100	0.072	0.052
Productivity				
stems/PH	15.7	13.0	10.8	12.9
m³/PH	1.52	1.30	0.78	0.67
Direct hourly cost ($/PH)	31.50	31.50	31.50	31.50
Wood cost ($/m³)	20.72	24.23	40.38	47.01

Table 3. Details of the work cycle of the fellers

	Val d’Or		Roberval		Mistassini		Gaspé	
	min/m³	%	min/m³	%	min/m³	%	min/m³	%
Time element								
Travel	2.9	7	3.9	9	2.3	3	8.0	9
Brushing	5.7	14	3.0	6	0.0	0	8.9	10
Felling	5.4	14	4.8	10	9.9	13	8.9	10
Delimbing and bucking	13.3	34	21.5	47	24.6	32	29.5	32
Piling	8.3	21	9.9	21	29.9	39	18.8	21
Operational delays	3.9	10	3.1	7	10.2	13	16.1	18
Total	39.5	100	46.2	100	76.9	100	90.2	100

Table 4. Results of the forwarding observations for average distances standardized at 150 m

	Val d'Or	Roberval	Mistassini	Gaspé
Forwarder used	CM2000	John Deere 6200	Timberjack 230 (5 tonnes)	Fabtek 546B
Log length (m)	2.54	3.00	2.54	2.54
Study duration (PMH)	7.5	3.7	13.8	2.8
Load size (m^3)	1.3	3.3	4.0	18.2
Productivity (m^3/PMH)	3.5	5.4	5.6	23.4
Direct hourly cost ($/PMH)	43.65	43.94	60.30	75.98
Wood cost ($/$m^3$)	12.47	8.14	10.77	3.25

Table 5. Details of the forwarder work cycles

	Val d'Or		Roberval		Mistassini		Gaspé	
Forwarder used	CM2000		John Deere 6200		Timberjack 230 (5 tonnes)		Fabtek 546B	
	(min/m^3)	(%)	(min/m^3)	(%)	(min/m^3)	(%)	(min/m^3)	(%)
Time element								
Travel empty	2.7	16	2.5	22	1.1	10	0.2	7
Loading	4.7	28	3.3	30	4.0	37	1.4	54
Travel to load	1.2	7	0.9	8	0.7	6	0.2	8
Travel loaded	3.0	18	1.9	17	1.3	12	0.2	8
Unloading at the landing	4.0	23	2.4	21	3.2	30	0.6	23
Operational delays	1.4	8	0.2	2	0.5	5	0.0	0
Total	17.0	100	11.2	100	10.8	100	2.6	100

Conclusions

The commercial thinning operations that FERIC visited permitted assessments of worker productivity in the felling and processing phase. In half the cases, productivity was sufficient to make the operation economically viable, provided that the extraction phase was efficient. It appears that large extraction equipment can provide better productivity than that of machines with small or average capacity. Adequate planning will minimize the effects of unfavorable operating conditions, whereas the use of an inadequate forwarder leads to systematic productivity losses that cannot be overcome. Shortwood forwarders used in commercial thinning operations with manual felling and processing should have, in addition to high payload capacity, a loader with a long reach, capable of reaching logs piled relatively far from the extraction trail. The physical effort demanded for assembling the piles would be lower, and the resulting productivity gains for the fellers would also reduce the costs of this phase and provide more flexibility in stand selection.

The instructions given to the workers should be adjusted to suit the objectives of the thinning treatment; for example, without appropriate instructions, they may undertake time-consuming and expensive brushing work to clear the understory, when doing so will have virtually no impact on the treatment quality. Thus, training and instruction of the workers for appropriate stem selection and felling becomes an important success factor.

Finally, it should be noted that the costs of a fully mechanized commercial thinning operation are typically less than those of operations with manual felling and processing. However, because of its flexibility, a manual system has many potential uses, particularly as a complement to mechanized operations.

Recommendations for implementing a commercial thinning operation based on a cut-to-length system with manual felling and processing:

- Limit the treatment to stands that offer favorable conditions: a sparse understory, flat and firm terrain, and a high average stem volume.
- Select a shortwood forwarder with high payload capacity (8 tonnes and up) equipped with a long-reach loader.
- Use a trail network with narrow spacing to improve feller productivity.
- Train workers and instruct them in the goals of the treatment to improve the operation's chances of success.

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Appendix
Assumptions used in the calculation of direct hourly costs for the equipment in the studies

	Chain saw	CM2000	John Deere 6200	Timberjack 230 (5 tonnes)	Fabtek 546B
Assumptions					
Machine life (years)	1	3	5	5	5
Scheduled hours (SH)/year	2000	2000	4000	4000	4000
Purchase price ($)	1600	35 000	61 000	180 000	275 000
Resale value ($)	0	3500	6100	18 000	27 500
Licensing ($/year)	0	500	500	500	500
Insurance ($/year)	100	1400	2440	7200	11 000
Interest rate (%)	10	10	10	10	10
Utilization rate (%)	85	85	85	85	85
Lifetime repair costs ($)	200	10 000	54 900	162 000	275 000
Fuel consumption (L/PMH)	1	5	10	10	12
Fuel cost ($/L)	0.50	0.50	0.50	0.50	0.50
Oils and lubricants ($/PMH)	0.38	1.00	1.00	1.00	1.00
Operator cost ($/SH)	25.00	25.00	25.00	25.00	25.00
Fixed costs					
Cost/PMH ($)	1.09	8.77	5.30	15.36	23.39
Cost/SH ($)	0.93	7.46	4.51	13.06	19.88
Variable costs					
Cost/PMH ($)	1.00	5.46	9.23	15.53	23.18
Cost/SH ($)	0.85	4.64	7.85	13.20	19.70
Labor costs					
Cost/PMH ($)	29.41	29.41	29.41	29.41	29.41
Cost/SH ($)	25.00	25.00	25.00	25.00	25.00
Total cost					
Grand total per PMH ($)	31.50	43.65	43.94	60.30	75.98
Grand total per SH ($)	26.78	37.10	37.35	51.26	64.58