Advantage

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Contents

Concentrating removal in patches to improve manual thinning productivity

Abstract

Motor-manual thinning operations can represent an important source of work for forestry workers and a source of fiber for companies, but they remain more expensive than fully mechanized operations. FERIC studied three approaches based on concentrating the removal of stems to improve the productivity of motor-manual thinning, and found that this approach could significantly decrease wood costs.

Keywords:

Commercial thinning, Manual operations, Concentrated removal, Productivity.

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Introduction

Many natural stands and plantations are now being thinned manually, thereby providing employment and extending the work season for forestry workers; this is an important consideration in certain regions of Canada. However, human fellers remain more sensitive than machines to stand conditions such as tree size, the degree of branchiness, the distance between extraction trails, the density of unmerchantable stems, the steepness of the terrain (Figure 1), and weather conditions. These factors greatly influence productivity.

Between 1997 and 1999, FERIC monitored three manual thinning operations in which the high densities of unmerchantable stems to be removed significantly decreased productivity. The studies took place during late summer and fall on the limits of Coopérative Laterrière (in 1997 and 1998, 70 km south of Alma, Que., in the Parc des Laurentides), the Association Coopérative Forestière de St-Elzéar (in 1998, 100 km north of Bonaventure, Que.), and Tembec Industries Inc.'s Nouvelle Division (in 1999, 20 km north of Carleton, Que.). The objective of the studies was to develop alternative block layouts that would improve working conditions for the fellers at each location and thus increase their productivity.

Figure 1. A trail on moderately steep terrain, with dense unmerchantables in the leave strip.

System descriptions

In the normal two-phase Alma operation, fellers cleared the trails first, selected and felled trees in the leave strips, and winched out the stems perpendicular to the trail using a cable skidder. The bunched full-tree stems were then delimbed and slashed by a Metal Marquis DS1000 stroke-fed processor mounted on a Kobelco SK115 excavator. The processed bolts, ranging from 2.1 to 3.0 m in length, were forwarded to the landing by a six-wheel-drive Timberjack 1010 forwarder.

The Bonaventure operation consisted of manual felling, delimbing, bucking, and piling of 2.4-m pulpwood and 3.6-m sawlogs at the trail's edge. A TreeFarmer C4 skidder converted into a forwarder extracted the wood to a secondary haul road, but was not operating during FERIC's study. The Carleton operation resembled the Bonaventure operation, but only produced 2.4-m pulpwood. The forwarding phase, which used a Fabtek FT548B eight-wheel-drive forwarder, was not monitored.

Work methods

After the 1997 Alma evaluation (the normal approach), the fellers modified their working method to reduce the non-productive time spent cutting unmerchantable stems. Instead of treating 100% of the leave strip uniformly (Figure 2, left), the new method concentrated a higher-intensity removal (targeting 50% of the basal area) in only 50% of the area using a checkerboard layout (Figure 2, right). This new method required less felling of unmerchantables, and thus reduced the non-productive time. The few stems left standing in the thinned zone interfered less with winching of stems to the trail's edge than in the normal approach. In both methods, the distance between extraction trails was 45 m; trails occupied 13% of the total area, and the maximum winching distance was 20 m.

In the Bonaventure operation, two work techniques were studied. In the first, three fellers used their normal approach, which involved clearing the extraction trail and thinning within the leave strips on either side in a single pass (Figure 3, left). The fellers delimbed the trees, bucked them to length, and manually piled the processed wood along the trails with the help of hand tools (hooks and tongs). In the second scenario ("concentrated removal"), three other fellers created alternating treated and untreated 100-m² squares along the extraction trails at 10-m intervals (Figure 3, right). Basal area removal in the treated squares was targeted at 50%. The trails, all of which ran upslope, occupied 16% of the total area of the site (an average trail width of 3.7 m) in the normal operation, versus 19% in the operation with concentrated removal (an average trail width of 4.5 m). In both cases, the distance between extraction trails was 25 m.

In the Carleton operation, FERIC also studied two different thinning methods. The normal approach involved removing about 22% of the basal area in a 10-m wide strip on both sides of the extraction trail (Figure 4, left). FERIC proposed a more

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practical alternative ("concentrated removal") that consisted of removing 44% of the basal area in 40-m² patches (4×10 m) established in a checkerboard fashion along the extraction trails at 4-m intervals (Figure 4, right). Both methods left a 4-m wide unthinned strip between extraction trails spaced 28 m apart, with an average trail width of 3.7 m (13% trail occupancy).

Study conditions

Table 1 presents the pre- and post-treatment stand conditions for the block layouts described in this report for two of the three operations. The Alma sites in both 1997 and 1998 were on firm terrain with low ground roughness and variable to moderate slopes (CPPA terrain classification 2.1.3). The stand contained 72% balsam fir and 28% spruce, and a dense understory of unmerchantable stems (5000 to 10 000 stems/ha) hampered felling and winching. The prescription was to remove 30% of the basal area and to selectively harvest overmature remnant spruce left after a previous harvest. Trees had not been marked for removal.

At Bonaventure, slopes ranged up to 30% (CPPA terrain classification 2.1.3). Stands contained 69% balsam fir and 31% spruce, and the thinning prescription was to remove approximately 30% of the basal area and to harvest all unmerchantable stems (living or dead). Marked trees were not to be cut.

The Carleton site was firm and slightly uneven, with gentle to moderate slopes (CPPA terrain classification 2.1.2). The stand contained 82% balsam fir, 2% spruce, and 16% hardwoods. Trees were marked for removal, and the lack of a suitable market meant that the hardwood component was "cut to waste". Unfortunately, the survey results did not accurately depict actual removals and are thus not presented in Table 1.

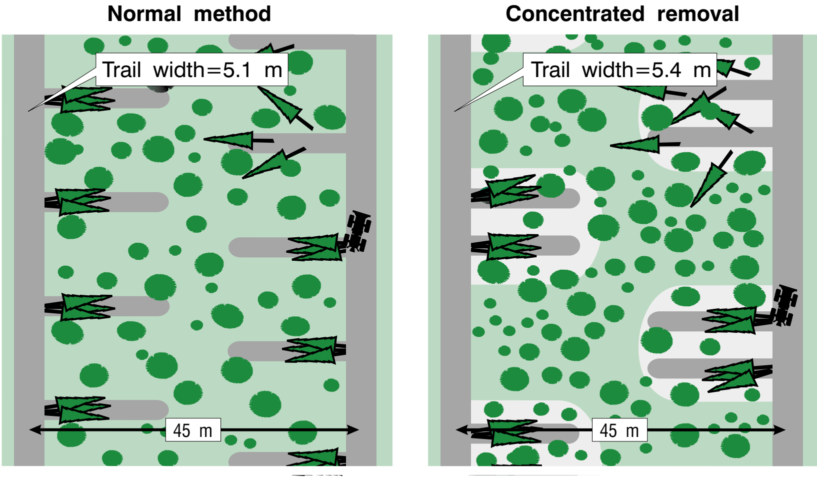

Figure 2. Layouts used in the Alma operation.

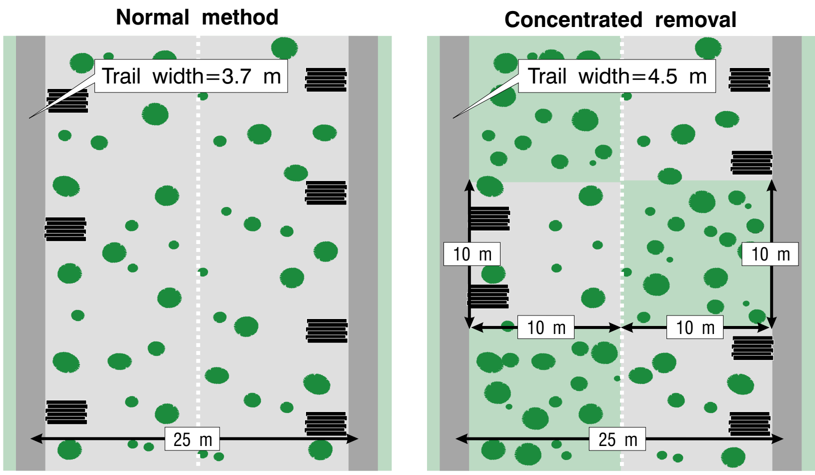

Figure 3. Layouts used in the Bonaventure operation.

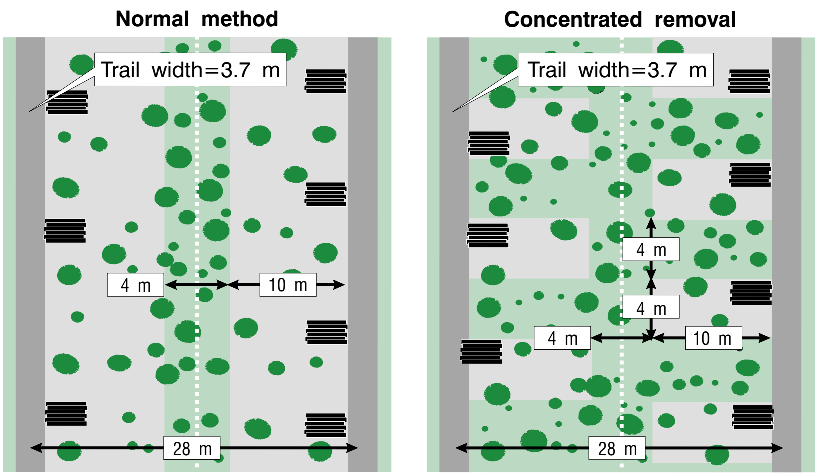

Figure 4. Layouts used in the Carleton operation.

Table 1. Pre- and post-treatment stand conditions

	Alma (Coop. Laterrière)						Bonaventure (Coop. St-Elzéar)					
	Normal			Concentrated removal			Normal			Concentrated removal		
	Before	After	Diff. (%)	Before	After	Diff. (%)	Before	After	Diff. (%)	Before	After	Diff. (%)
Density (stems/ha)												
Merchantable	1610	1010	–37	2530	1540	–39	2830	1890	–33	2830	1660	–41
Unmerchantable	–[a]	–	–	–	–	–	8080	0	–100	8080	3310	–59
Basal area (m^2/ha)	28.1	19.2	–32	37.3	25.9	–31	37.6	25.2	–33	37.6	23.9	–36
Merch. volume (m^3/ha)	165	114	–31	169	128	–24	169	107	–37	169	109	–36
Average diameter (cm)	14.9	15.6	+5	13.7	14.7	+7	13.0	13.0	0	13.0	13.5	+4
Average volume (m^3/stem)	0.102	0.113	+11	0.066	0.083	+26	0.060	0.056	–7	0.060	0.065	+8

[a] Not measured at Alma, but varied between 5000 and 10 000.

Productivity and costs

Table 2 compares the two methods used in the Alma operation. Productivity more than doubled (from 2.6 m^3/PMH to 5.5 m^3/PMH) by concentrating removal. The 70% increase in stems/PMH, combined with a 25% larger average stem volume, halved the estimated felling and winching cost in this treatment ($12.30/$m^3$ versus $26.00/$m^3$). For a feller using the normal method, cutting unmerchantable stems (brushing) represented the most time-consuming aspect of the work, at 48% of the total cycle time (versus only 27% in the concentrated removal method). With concentrated removal, the time spent felling increased to 29% of cycle time (from 18%); similarly, the skidder operator spent substantially less time brushing, and more time operating the skidder.

Processor productivity averaged 8.0 and 9.8 m^3/PMH (134 and 114 stems/PMH) in the conventional and concentrated-removal operations, respectively, with corresponding average tree volumes of 0.060 and 0.086 m^3. With an estimated direct operating cost of $65/PMH for the DS1000 processor, processing costs averaged about $8.15/$m^3$ and $6.70/$m^3$, respectively. The Timberjack 1010 forwarder's productivity

Table 2. Summary of productivities and time elements in the Alma operation

	Normal method	Concentrated removal
Study duration (PMH)	18.9	22.3
Volume/stem (m^3)	0.076	0.095
Productivity		
Stems/PMH	34	58
m^3/PMH	2.6	5.5
Work cycle time elements	(%)	(%)
Feller		
Walking	11	13
Brushing	48	27
Felling	18	29
Waiting for skidder	6	11
Choking	3	6
Operational delays	14	14
Total	100	100
Cable skidder operator		
Skidder operation (maneuvering and winching)	29	36
Brushing	16	3
Choking	26	35
Unchoking	8	10
Waiting for feller	7	5
Operational delays	14	11
Total	100	100

averaged 15 m^3/PMH. With an estimated direct operating cost of $88/PMH, forwarding costs averaged about $5.90/$m^3$. The total cost for slashed wood at roadside thus amounted to approximately $40/$m^3$ for the conventional method and $25/$m^3$ with concentrated removal. Note that all costs represent direct costs only, and exclude transportation, supervision, and overhead.

Table 3 compares the two methods used in the Bonaventure operation. The normal and concentrated-removal treatments were adjacent to each other and had similar pre-treatment stand characteristics, although the average volume per stem harvested was somewhat higher with concentrated removal during the actual study. The larger volume per stem in the latter method (0.053 vs. 0.063 m^3, respectively) and the greater number of stems harvested per PMH (+12%) increased productivity by approximately 30%. The resulting estimated "cut and pile" cost was 23% lower with concentrated removal ($30.30/$m^3$ versus $39.20/$m^3$). The proportions of cycle time spent walking and brushing were identical in both methods, but when converted to time per m^3, walking and brushing times decreased by 31 and 24%, respectively, in the thinned 100-m^2 patches because the work was concentrated within a smaller area.

Table 4 compares the two methods used in the Carleton operations. As at Bonaventure, the two treatments were applied in adjacent parts of the same stand. The detailed timing studies showed no significant difference in overall performance between the two methods in either productivity or estimated "cut and pile" cost ($22.20/$m^3$). Had the density of unmerchantable stems in the study blocks been higher (similar to that at Bonaventure), concentrated removal would likely have provided some advantages over the normal treatment despite the added time required for layout.

Table 3. Summary of productivities and time elements in the Bonaventure operation

	Normal method		Concentrated removal	
Study duration (PMH)	10.2		8.7	
Volume/stem (m^3)	0.053		0.063	
Productivity				
Stems/PMH	16		18	
m^3/PMH	0.85		1.10	
Work cycle time elements (feller)	**%**	**min/m^3**	**%**	**min/m^3**
Walking	4	3	4	2
Brushing	18	12	17	9
Felling	14	10	11	6
Delimbing and bucking	36	25	45	24
Piling	28	20	23	12
Operational delays	0	0	0	0
Total	100	70	100	53

Table 4. Summary of productivities and time elements in the Carleton operations

	Normal method		Concentrated removal	
Study duration (PMH)	12.7		11.4	
Volume/stem (m^3)	0.066		0.069	
Productivity				
Stems/PMH	22		22	
m^3/PMH	1.5		1.5	
Work cycle time elements (feller)	**%**	**min/m^3**	**%**	**min/m^3**
Walking	5	2	5	2
Brushing	15	6	14	6
Felling	12	5	12	5
Delimbing and bucking	40	16	39	17
Piling	14	6	15	6
Operational delays	14	6	15	6
Total	100	41	100	42

Implementation

All three approaches based on alternating treated and untreated patches can make manual thinning more efficient by concentrating the work within small, designated areas (Figure 5), thereby reducing walking and the number of merchantable and unmerchantable stems to be handled.

Figure 5. A 100-m² cut block with 50% basal area removal.

- This approach would be particularly advantageous in stands with a high density of unmerchantable stems. In such stands, past studies of fully mechanized thinning operations have shown that leaving untreated areas adjacent to treated areas produces wood at a reasonable cost and that the treatment quality falls within acceptable norms. The present study showed that concentrating removal represents a viable alternative to the normal manual methods.
- Where the fellers had used concentrated removal for almost a year (Alma), their productivity had increased. In the Bonaventure and Carleton operations, the fellers were inexperienced with concentrated removal using 100-m² and 40-m² patches, and productivity will likely increase as their familiarity with the new methods increases.

By minimizing the physical effort required of fellers, managers can improve the productivity of manual thinning and make the treatment more economically viable:

- The use of hand tools by fellers (Bonaventure) improved their efficiency in handling and piling bolts.
- Fellers minimized the effort required to pile heavy 3.6-m sawlogs by felling the trees towards the trail and partially crosscutting them. In this approach, the feller cut only partway through the stem, and the forwarder operator drew the prepared stem to the trail's edge and then snapped off the individual logs using the grapple. (This approach may have affected sawlog quality adversely.) Managers could further reduce the physical effort required of the fellers by using forwarders with long-reach booms capable of reaching wood piled farther from the extraction trail.
- Use narrow forwarders to reduce the width of the extraction trails, thereby permitting a decrease in the distance between trails; this, in turn, would reduce the distance fellers must walk to create wood piles. Alternatively, extracting wood from the leave strip to trailside using cable skidders would minimize the physical effort required of the feller, but would likely increase the total operating cost.

Stems of poorer quality are generally removed in a normal thinning (100% treatment); however, if only 50% of the surface area of a stand is thinned, the poorer-quality stems remaining in the untreated area will compromise the stand's overall quality somewhat.

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