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THE EFFECTS OF LIVE-LIMB REMOVAL ON CLEARING-SAW PRODUCTIVITY

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Abstract

This report details the spacing (precommercial thinning) of three one-hectare blocks of Interior B.C. lodgepole pine and two one-hectare blocks of Coastal western hemlock during 1987 and 1988. Each block received four different treatments during spacing. A Husqvarna 165RX clearing saw was used. Pre- and post-spacing stand densities, clearing-saw productivity, and costs are reported.

Introduction

This project was undertaken in partial fulfillment of a Canada/British Columbia Forest Resources Development Agreement (FRDA) contract to document the survival and development of live limbs on cut stumps in 10- to 20-year-old lodgepole-pine and hemlock stands. The survival, subsequent growth, and potential competition of these remaining live limbs, whether left by mechanical strip-thinning machines or manual spacing methods, concern Coastal and Interior foresters. During 1987 and 1988, FERIC selected and spaced (precommercially thinned) three Interior lodgepole-pine (*Pinus contorta var. latifolia*) and two Coastal western-hemlock (*Tsuga heterophylla Raf. Sarg.*) stands, to densities specified by cooperators, using a clearing saw (Hosie 1979). Follow-up visits to each site were made in 1988 and these will be repeated in 1989 to monitor the survival and growth of the remaining live limbs. This report presents the results of the clearing-saw time and productivity study.

Study Method

Experimental blocks of one hectare each were laid out in the vicinities of Cranbrook, Princeton, Riske Creek, Eve River, and Beaver Cove (Figure A). Each block was divided into four quadrants for the following treatments:

- Low trim - cutting as low to the ground as possible and trying to remove all remaining live limbs.
- Low leave - cutting as low to the ground as possible and leaving all remaining limbs.
- High trim - cutting at a height of 30 cm and trying to remove all remaining live limbs.
- High leave - cutting at a height of 30 cm and leaving all remaining limbs.

The "trim" treatments were introduced to quantify the extra effort required to minimize the potential competition from surviving live limbs on the cut stumps. The trimming was done concurrently with the spacing treatment, using the clearing saw.

Study sites were chosen based on the frequency of live limbs at and below a height of 10 cm and the homogeneity of the stand. A height of ten centi-

Figure A. Locations of study sites.

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metres was considered the point closest to the ground at which the saw could work with maximum productivity. Working at this height ensured the saw required a minimum of sharpening. After site selection, four 0.25-ha blocks (50 m x 50 m) were established perpendicular to the slope. On a predetermined grid, randomly selected 0.05-ha plots were established in each block to determine stand density and species composition. Within these plots, one randomly selected quadrant was intensively measured. Tree species, stem diameter at ground height, and total tree height were recorded. Plot aspect, average slope over 25 m, and a visual slash assessment were noted as well.

After the stand information was collected for each of the four blocks, spacing treatments were randomly assigned and thinning began. Detailed timing information was collected for each block.

The Saw

The clearing saw used in this study was a 1987 Husqvarna 165RX (Figure B) fitted with a Maxi 225 clearing-blade (Figure C). The 65 cc displacement engine realized a cutting speed of 8000 to 8500 rpm at maximum power. The blade is 22.5 cm in diameter and is able to cut a 10-cm diameter tree in one pass. For larger trees, however, a two-cut or undercut method was used. The blade is easily sharpened with a 5.6-mm round file. The entire unit weighs 10.8 kg without fuel or carrying harness.

During the approximately 36 days the saw was operated, which included the training period, four blades were used. The only repair of note was the replacement of a handlebar which had snapped off at the control clamp. This was probably caused by repeatedly swinging the saw into the cut with too much force.

The Operator

A FERIC employee was trained with the assistance of videos and manuals. Also, field training was carried out at the University of British Columbia Malcolm Knapp Research Forest in Haney, B.C. where a staff member provided instruction in cutting and spacing techniques as well as maintenance strategy. This operator carried out the spacing activities at the Cranbrook, Princeton, Riske Creek, and Eve River study sites, while a second, less-experienced operator used the saw at the Beaver Cove site.

The Sites

Three lodgepole-pine sites were selected in the Interior of B.C. and two western-hemlock sites were selected on Vancouver Island. Table 1 gives some

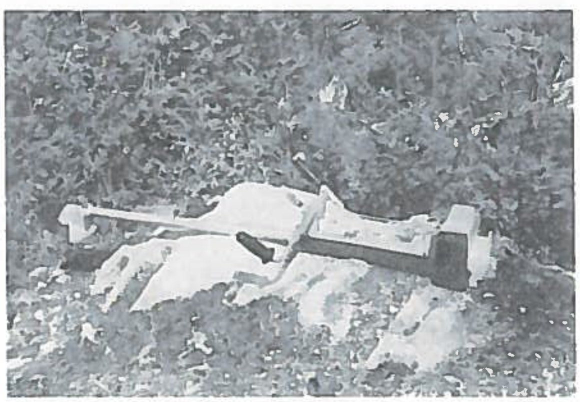

Figure B. Husqvarna 165RX clearing saw.

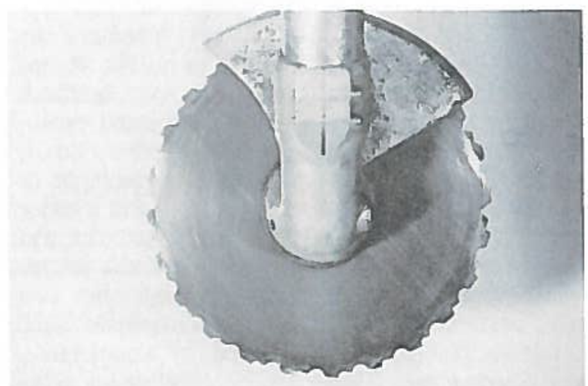

Figure C. Maxi 225 blade.

Table 1. Site Detail

Location	Ecological description[a]	Elevation (m)	Aspect	25-m slope (%)	Slash	Stand history
Interior						
Cranbrook	ESSFc	1646	SE	28	Light-medium	Wild fire 1973 Salvage logged 1974
Princeton	MSB1	1615	W	13	Light	Logged 1973 Drag scarified 1974
Riske Creek	SBSa	1250	Flat	4	Light	Logged 1973
Coastal						
Eve River	CWHb1	200	NW	16	Light-medium	Logged 1977
Beaver Cove	CWHb1	320	SSW	18	Medium	Logged 1977-78

[a] From Klinka et al 1984, and Utzig et al 1983, and provided by company or MOF personnel.

detail on the selected stands. Slash, in most instances, did not impede movement within the stand or severely affect the cutting. The slopes encountered posed no great problems, although the skid-trail cut-banks and fill slopes at the Cranbrook site did make movement and cutting somewhat onerous. Brush was a problem only at Beaver Cove where frequent dense clumps of huckleberry had to be cut to facilitate the spacing operation.

The Stands

Interior. The Cranbrook and Princeton stands were predominantly lodgepole pine (86% and 85% respectively), with minor components of Interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca* (Biessn.)), sub-alpine fir (*Abies lasiocarpa* (Hook.) Nutt.), and Engelmann spruce (*Picea engelmannii* Parry). The Riske Creek stand was 99% lodgepole pine. Table 2 shows the stand densities by treatment type. The Princeton stand was the least dense with an overall average of 11 450 trees/ha while the Cranbrook stand was the most dense with 31 075 trees/ha. The stand density on a treatment-block basis ranged from 9700 trees/ha in Princeton to 45 700 trees/ha in Cranbrook. As is typical in lodgepole pine, all three sites were clumpy.

Overall, the diameter and height ranges over the three sites were not broad. Average diameters at ground height were 2.0 cm to 2.5 cm while heights ranged from 1.2 m to 1.6 m. However, on a treatment-block basis, the ranges widened from 1.7 cm to 2.9 cm for diameter and 1.0 m to 1.8 m for height.

Coastal. The two Coastal sites were dominated by western hemlock (97%) with occasional Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), amabilis fir (*Abies amabilis* (Dougl.) Forbes), sitka spruce (*Picea sitchensis* (Bong.) Carr.) and western red cedar (*Thuja plicata* Donn). Table 2 shows Beaver Cove had an average of 36 275 trees/ha compared to 45 225 trees/ha in Eve River. The stand density, when taken on a treatment-block basis, ranged from a low of 27 600 trees/ha at Beaver Cove to a high of 54 000 trees/ha at Eve River.

The average diameter of all stems at Eve River was 1.6 cm, compared to 1.9 cm at Beaver Cove. Average heights were 1.6 m and 2.0 m respectively.

Table 2. Pretreatment Diameter, Height, and Stocking

Location	Species	Treatment	Average stems/ha	Average diameter (cm)	Average height (m)
Interior					
Cranbrook	Lodgepole pine (86%)	Low trim	24 500	2.2	1.6
		Low leave	24 500	2.5	1.8
		High trim	29 600	1.8	1.4
		High leave	45 700	2.1	1.6
Overall			31 075	2.1	1.6
Princeton	Lodgepole pine (85%)	Low trim	9 700	2.9	1.3
		Low leave	11 100	2.8	1.3
		High trim	12 200	2.5	1.2
		High leave	12 800	2.2	1.0
Overall			11 450	2.5	1.2
Riske Creek	Lodgepole pine (99%)	Low trim	19 100	2.0	1.3
		Low leave	16 200	2.0	1.2
		High trim	25 900	1.7	1.0
		High leave	16 800	2.5	1.5
Overall			19 500	2.0	1.2
Coastal					
Eve River	Hemlock (97%)	Low trim	51 400	2.1	2.0
		Low leave	54 000	1.5	1.7
		High trim	42 000	1.6	1.5
		High leave	33 500	1.4	1.4
Overall			45 225	1.6	1.6
Beaver Cove	Hemlock (97%)	Low trim	44 400	2.0	2.2
		Low leave	44 900	1.5	1.5
		High trim	28 200	2.4	2.2
		High leave	27 600	2.2	2.3
Overall			36 275	1.9	2.0

The Treatment

Before cutting was started at any of the locations, a backline was cleared to prevent cut stems from "hanging up" on the first pass. The operators worked across and up the slope. Fuelling and blade maintenance were carried out as required while general saw maintenance was done on a daily basis.

Interior. Table 3 gives the post-treatment density levels. At the Cranbrook and Riske Creek sites, the overall trees/ha averages of 1505 and 1330 adhere to the prescribed densities of 1500 and 1300 trees/ha. At Princeton, the target of 1500 trees/ha was missed by a wide margin with only 1275 trees/ha. The stand was clumpy and 15-20% of all trees had basal scars of unknown origin.

At two of the three sites, the sapling count exceeded that of the crop trees. For the purposes of the live-limb survival study, saplings were classified as all trees over 30 cm in height not designated as crop trees. In operational practice, only trees greater than 0.5 m in height and not designated as crop trees are counted as saplings.

The average stump heights were measured after treatment (Table 3). The target height of 10 cm or less was easily met at Princeton and Riske Creek for the "low" cutting phases. However, as stand density and slash increased, so did the stump heights; this is reflected in the Cranbrook data. The requirement was easily met for those cutting blocks where 30 cm was the target height.

Coastal. The crop-tree densities of 1050 and 900 trees/ha achieved at Eve River and Beaver Cove (Table 3) were close to the target densities of 1000 and 890 trees/ha.

As in the Interior studies, the sapling counts were large. Though not quantified, the number of saplings greater than 0.5 m in height in the hemlock stands was high. These saplings, less rigid than the pine, were bent over and buried by fallen trees and were not visible until the post-treatment plots were cleared.

The average stump heights in the hemlock stands were higher overall than in the pine sites. Greater slash loading and rougher ground surface made low stumps more difficult to achieve.

Table 3. Post-Treatment Stocking and Stump Heights

Location	Treatment	Crop trees (trees/ha)	Prescription (crop trees/ha)	Saplings > 30 cm high (trees/ha)	Average stump height (cm)
Interior					
Cranbrook	Low trim	1380	1500	1600	9.3
	Low leave	1500		1460	15.9
	High trim	1700		2240	30.8
	High leave	1440		4920	29.9
Overall		1505		2555	n/a
Princeton	Low trim	1246	1500	1090	8.5
	Low leave	1340		820	8.6
	High trim	1240		660	28.6
	High leave	1280		820	28.2
Overall		1275		850	n/a
Riske Creek	Low trim	1380	1300	680	6.6
	Low leave	1360		1160	8.9
	High trim	1380		840	33.8
	High leave	1200		1220	32.9
Overall		1330		975	n/a
Coastal					
Eve River	Low trim	984	1000	1170	16.0
	Low leave	1040		1180	17.3
	High trim	1260		1440	30.9
	High leave	920		1960	34.4
Overall		1050		1435	n/a
Beaver Cove	Low trim	980	890	680	19.5
	Low leave	920		2800	18.4
	High trim	800		1260	33.3
	High leave	900		1400	32.0
Overall		900		1535	n/a

Productivity

The figures in Table 4 have been adjusted to reflect the cutting time, i.e. cutting and moving time only, per hectare by location and treatment type.

Interior. The cutting time per hectare was generally related to stand density and difficulty of treatment. Princeton, with the lowest number of trees per hectare, was cut the fastest followed by Riske Creek (Figure D) and Cranbrook both of which had higher initial densities. In Cranbrook, low leave took slightly longer than low trim when only cutting time is considered. This was the first block the operator treated in the study. The 11.7 h/ha for the low-trim block in Princeton is higher than expected and nothing in the data reveals the reason. One possible explanation is that the very stony soil, with little or no duff layer, contributed to increased wear on the blade and in the process of removing the live limbs from the stumps, the blade became dull. Though the blade was filed whenever the saw was refuelled, it could have been used in a dull condition for some time between fuel stops. The low initial stocking of the block (9700 trees/ha) plus the basal scarring mentioned earlier could have made the crop-tree selection process more time consuming.

Holmsen[1] has studied an experienced crew in the B.C. Cariboo working in lodgepole-pine stands ranging from 10 000 to 15 000 trees/ha. The productivity achieved by this crew was 6.7 h/ha under conditions similar to those found in Princeton. Hedin (1982) reported a productivity level of 17 h/ha in a 20 300 trees/ha lodgepole pine/spruce stand in Alberta with inexperienced operators. The stocking and terrain features were quite similar to those at Riske Creek. Riley (1973), working with an inexperienced crew, calculated production at 9.7 h/ha in a stand averaging 13 165 trees/ha. Though initial, and probably final (post-spacing), stand densities vary between these studies, the productivities at Princeton and Riske Creek are acceptable considering a moderately experienced person operated the clearing saw.

Coast. The two Coastal sites are difficult to compare because two operators with different levels of experience did the work. The generally higher initial densities plus increased slash loading in the hemlock at Eve River did slow production considerably compared to the Interior stands. Tight basal branching on the young hemlock trees made it difficult to approach the boles with a clearing saw. The longer branches interlocked and this increased hang-ups and impeded visibility (Figures E and F). The effect of these latter two features can be illustrated by comparing the high-leave blocks in Cranbrook with those in Eve River. The former had an initial stocking of 45 700 trees/ha and took 18.6 h/ha to cut, whereas the latter had a lower initial stocking of 33 500 trees/ha and took 33.9 h/ha to cut (Table 4). Table 5 illustrates this even more clearly with 35.2 trees/min in Cranbrook versus 15.1 trees/min in Eve River. The Beaver Cove data, when compared to Eve River, illustrate the difference between what an inexperienced operator and one with a few weeks on the job can achieve.

Holmsen[2] reported clearing-saw productivity of 33.6 h/ha in a Vancouver Island hemlock stand of 30 500 trees/ha density. The crew members were experienced spacers but relatively unfamiliar with the clearing saws. The same crew in the same stand achieved a

Figure D. Clearing-saw spacing on study site at Riske Creek.

Table 4. Cutting Time per Hectare[a] by Location and Treatment Type (h)

Treatment type	Interior			Coastal	
	Cranbrook	Princeton	Riske Creek	Eve River	Beaver Cove
Low trim	23.4	11.7	10.0	38.4	52.1
Low leave	28.1	5.7	6.0	33.8	41.8
High trim	35.5	18.5	21.3	41.0	47.6
High leave	18.6	5.4	6.0	33.9	45.5

[a] Cutting and moving time only for the 0.25-ha quadrants x 4 to give total cutting and moving time only for one hectare.

[1] Sylvi D. Holmsen, FERIC Technical Note, in preparation.

[2] See Note 1.

Figure E. Western-hemlock study site at Eve River.

Figure F. Clearing-saw spacing on study site at Beaver Cove.

Table 5. Cutting Time: Stems/min by Location and Treatment

Treatment type	Interior			Coastal	
	Cranbrook	Princeton	Riske Creek	Eve River	Beaver Cove
Low trim	15.3	10.5	28.2	21.4	13.7
Low leave	12.8	26.2	38.0	25.5	16.4
High trim	12.0	9.2	18.5	16.0	9.2
High leave	35.2	32.8	39.8	15.1	9.3

rate of 17.1 h/ha using chain saws. Ross (1982) estimated 20 h/ha in stands of 25 000 trees/ha and 34.5 h/ha in stands of 50 000 trees/ha in Nova Scotia, leaving 3 000 trees/ha as crop trees. Though the species were different, the tree size, tree characteristics, and operating conditions were similar to those found on Vancouver Island. Based on this documented information, clearing-saw productivity would have to be almost doubled to be competitive with that achieved by operators using chain saws.

Costs

The hourly operating costs for the Husqvarna 165RX clearing saw listed in Table 6, including the operator, were calculated using the standard FERIC costing formula.

Table 7 gives the costs per hectare by location and treatment type. Assuming that the most desirable treatment would be low trim, the costs range from $235/ha to $545/ha in the Interior pine stands, and from $895/ha to $1215/ha in the Coastal hemlock stands.

Table 6. Cost Analysis for Husqvarna 165RX Clearing Saw

Ownership costs: Input	
Purchase price (P)	$900
Salvage value (S), (20% of P)	$180
Expected life (yr)	1
Expected life (h)	1500
Interest rate (I), (%)	11
Insurance (Ins), (%)	3
Ownership costs: Results	
Average investment (AVI) = (P + S)/2	$540.00
Loss in resale value = (P - S)/h	$0.48/h
Interest = (Int x AVI)/(h/yr)	$0.03/h
Insurance + (Ins x AVI)/(h/yr)	$0.01/h
Operating and repair costs: Input	
Hourly fuel consumption (L/h)	1.0
Fuel cost ($/L)	$0.75
Annual operating cost (O)	$200
Annual repair & maintenance cost (R)	$250
Wages (W), ($/h)	$16.11[a]
Wage benefit loading (WBL), (%)	35
Operating and repair costs: Results	
Hourly fuel cost = (L) x ($/L)	$0.75/h
Operating cost = O/(h/yr)	$0.13/h
Repair & maintenance cost = R/(h/yr)	$0.17/h
Labour cost = (W) x [1 + (WBL/100)]	$21.75/h
TOTAL Operating and Repair Costs	$22.80/h
Total costs: Results	
Loss in resale value	$0.48/h
Insurance	$0.01/h
Operating and repair costs	$22.80/h
Total equipment cost (excluding interest)	$23.29/h
Total equipment cost (including interest)	$23.32/h

[a] Forestry Crewman I rate.

Table 7. Cost by Location and Treatment[a]

Treatment type	Interior			Coastal	
	Cranbrook ($/ha)	Princeton ($/ha)	Riske Creek ($/ha)	Eve River ($/ha)	Beaver Cove ($/ha)
Low trim	545	275	235	895	1215
Low leave	655	135	140	785	975
High trim	830	430	495	955	1110
High leave	435	125	140	790	1060

[a] Total equipment cost excluding interest.

Conclusion

The negative effects of live-limb removal on clearing-saw productivity are apparent. High stumps with numerous live limbs are unacceptable because of potential nutrient and water competition to the selected crop trees. High stumps increase the proportion of stumps with live limbs. Trimming the remaining live limbs from those stumps reduces worker productivity severely. Cutting to obtain low stumps and leaving the live limbs generally gives productivity similar to high-leave cutting, but results in a lower proportion of stumps with live limbs on them and fewer limbs per stump. Cutting low stumps, with live-limb removal, is slower than low leave but results in less potential competition for the crop trees. Ultimately the forester is faced with selecting one of the low stump options. The long-term FRDA study of the survival and growth of these residual limbs will provide some answers as to their potential competitiveness. If the die-back of these limbs is high enough to justify the low-leave technique of cutting, then the dollar savings during treatment could be substantial. However, if the potential for survival and growth of the remaining live limbs is high, then the additional expense incurred in trimming them to protect the investment in the selected crop trees is justified. The forester may also choose to postpone thinning treatment until the canopy has closed, and limb die-back occurs.

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