WOOD HARVESTING

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HARVESTING SECOND-GROWTH WESTERN HEMLOCK ON VANCOUVER ISLAND: PRODUCTIVITY, COST, AND PREDICTED LOG VALUE

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Abstract

In the winter of 1997, the Forest Engineering Research Institute of Canada (FERIC) monitored a harvesting operation on northern Vancouver Island. The study was requested and funded by Forintek Canada Corp. and was to determine the costs of harvesting a coastal second-growth western hemlock stand. The operation was also used to test a computer model developed by FERIC, to evaluate the accuracy of prediction for volume distribution by sort and species and total value of timber harvested.

Introduction

As forest companies harvest more coastal second-growth forests, further information is needed on harvesting methods and costs and on product values. At the request of its members and partners, the Forest Engineering Research Institute of Canada (FERIC) has conducted a series of harvesting studies in coastal second-growth forests (Andersson and Jukes 1995; Andersson and Young 1998; Young 1998) and developed a computer model to predict the economics of harvesting second-growth forests (Pavel and Young 1997).

Although information on log grades and values was obtained in some of these studies, the relationship between wood quality and mill output was not directly linked. In 1996 Forintek Canada Corp. initiated a project to study the relationships between the physical characteristics of second-growth western hemlock trees (*Tsuga heterophylla* [Raf.] Sarg.) and lumber quality and value. To obtain a more complete picture of the costs of producing lumber, Forintek asked FERIC to document the productivities and costs of harvesting one of its sample cutblocks. The cutblock was located within MacMillan Bloedel Limited's Port McNeill Division on northern Vancouver Island, and was harvested between December 1996 and May 1997. This report describes the harvesting study conducted by FERIC.

Objectives

The objectives of this study were to:

- Determine the actual phase and overall costs for the block by monitoring the falling, forwarding/yarding, and loading phases of the harvesting operation.
- Compare the log volumes and values of the actual harvest with those predicted by a computerized harvesting model developed by FERIC.

Site Description

The study site, located near Rupert Inlet, had a total area of 38.2 ha. Terrain was uniform and gentle; slopes ranged from 5 to 30% with a weighted average slope

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of 14%. Soils were predominantly well-drained sandy loams with minor occurrences of poorly drained, wet sites.

The stand had regenerated naturally following a severe windstorm in the early 1900s. It was thrifty and even-aged, consisting primarily of western hemlock with minor components of western red cedar (*Thuja plicata* Donn), Sitka spruce (*Picea sitchensis* [Bong.] Carriere) and amabilis fir (*Abies amabilis* [Dougl. ex Loud.]). A few large veteran western red cedar trees also remained after the windstorm. The total gross volume for the site was 1044 m^3/ha, with a net volume of 999 m^3/ha (Table 1). Diameters at breast height (dbh) of merchantable trees ranged from 12 to 70 cm and averaged 32 cm. The average gross volume per tree was 1.19 m^3.

The prescription for the site was to clear cut the current stand and then reforest the area with the same species, but with a slightly lower percentage of western hemlock. The management objective was to produce merchantable timber on a 70-year rotation.

System Description

The gentle terrain and well-drained soils favoured ground-based extraction, so manual falling with loader forwarding was the primary harvesting system used on the site. Trees were manually felled and bucked into specific log lengths by both company and contract fallers. Falling began in December 1996 and continued until March 1997. The fallers normally worked 6.5 hours per day, 5 days per week, but adverse weather conditions, especially high wind, occasionally reduced the shift length.

Primary extraction started in January 1997 using two John Deere 992D LC and one John Deere 992E LC hydraulic log loaders (Figure 1). The three machines were not on site continuously during this period, and occasionally worked on an adjacent block. The loaders either forwarded logs directly to roadside or to within 40–50 m of the road, where the logs were transferred to roadside by a Madill 075 super-snorkel mounted on a Madill 044 undercarriage (Figure 2). In April, a Madill 044 grapple yarder was also brought on site. A Hitachi EX 400 was used as a mobile backspar for the grapple yarder.

Figure 1. John Deere 992D LC loader forwarding logs to roadside.

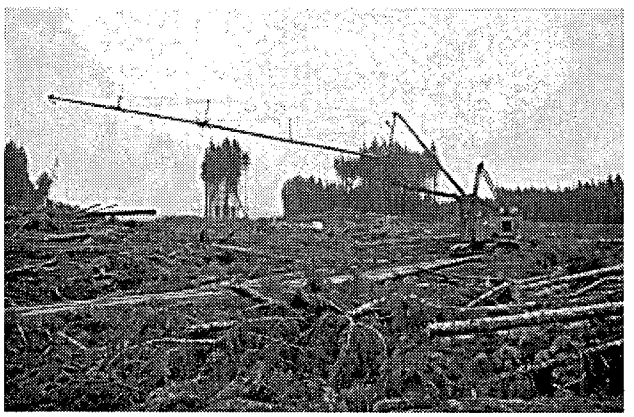

Figure 2. Madill 075 super-snorkel working in the block.

Table 1. Average Pre-harvest Stand Characteristics

	Species					
	Western red cedar	Western hemlock	Amabilis fir	Sitka spruce	Average	Total
Diameter at breast height (cm)	38.1	31.2	44.5	32.0	32.3	-
Total height (m)	32.1	39.2	35.8	35.2	38.4	-
Merchantable height (m)	23.9	32.1	31.5	28.2	31.5	-
Gross volume/tree (m^3)	1.09	1.15	2.30	1.06	1.19	-
Net volume/tree (m^3)	0.97	1.10	2.21	1.02	1.14	-
Trees/ha (no.)	50	745	36	47	-	878
Net volume/ha (m^3)	49	822	80	48	-	999

The loaders forwarded the logs to roadside using an up-and-down working pattern, as described in Andersson and Jukes (1995) (Figure 3). The loader first moved from the roadside to the cutblock boundary (out-turn), moving the logs from in front of the machine to alongside its path. At the end of the out-turn, the loader turned around and worked back towards the road (in-turn), shifting the logs that were within boom reach towards the road as it moved forward. Occasionally two loaders worked in tandem, passing logs from one to the other.

The average yarding distance (distance from backline to roadside) was 140 m, and ranged from 70 to 250 m. Trail construction was minimal during the forwarding operations. The favourable terrain allowed logs to be decked along the entire section of the haul road.

Loading and log hauling were done using any of the three forwarding loaders and company trucks. The logs were hauled to the company's sortyard in Port McNeill, approximately 24 km away.

Study Methods

To calculate the cost of harvesting, data on both manual fallers and machines were collected using shift-level techniques. Daily time sheets for the crew working on the site were used to determine total labour inputs, and to calculate the scheduled machine hours (SMH) spent by each machine in the block.

Hourly machine costs were calculated using FERIC's standard costing methodology, and labour costs were calculated using applicable coastal IWA labour rates (Appendix 1). These costs do not include supervision, profit, or overhead, and do not reflect the actual costs incurred by the company.

All logs from the site were scaled and graded by licensed scalers at the company sortyard. These logs included those from Forintek's sample of 63 trees. These sample trees were selected and marked by Forintek scientists, and then felled, forwarded and hauled to the sortyard by company crews and equipment during three days of operation. The volumes of the sample trees, as well as the labour and machine times required to recover them, are minor in relation to the rest of the harvesting operations and are therefore included in the calculation of overall harvesting costs presented in this report.

To test the prediction capabilities of its second-growth harvesting model, FERIC installed additional prism cruise plots to increase sampling intensity to 1 plot per hectare. The cutblock consisted of two timber types. Since falling had already started when FERIC

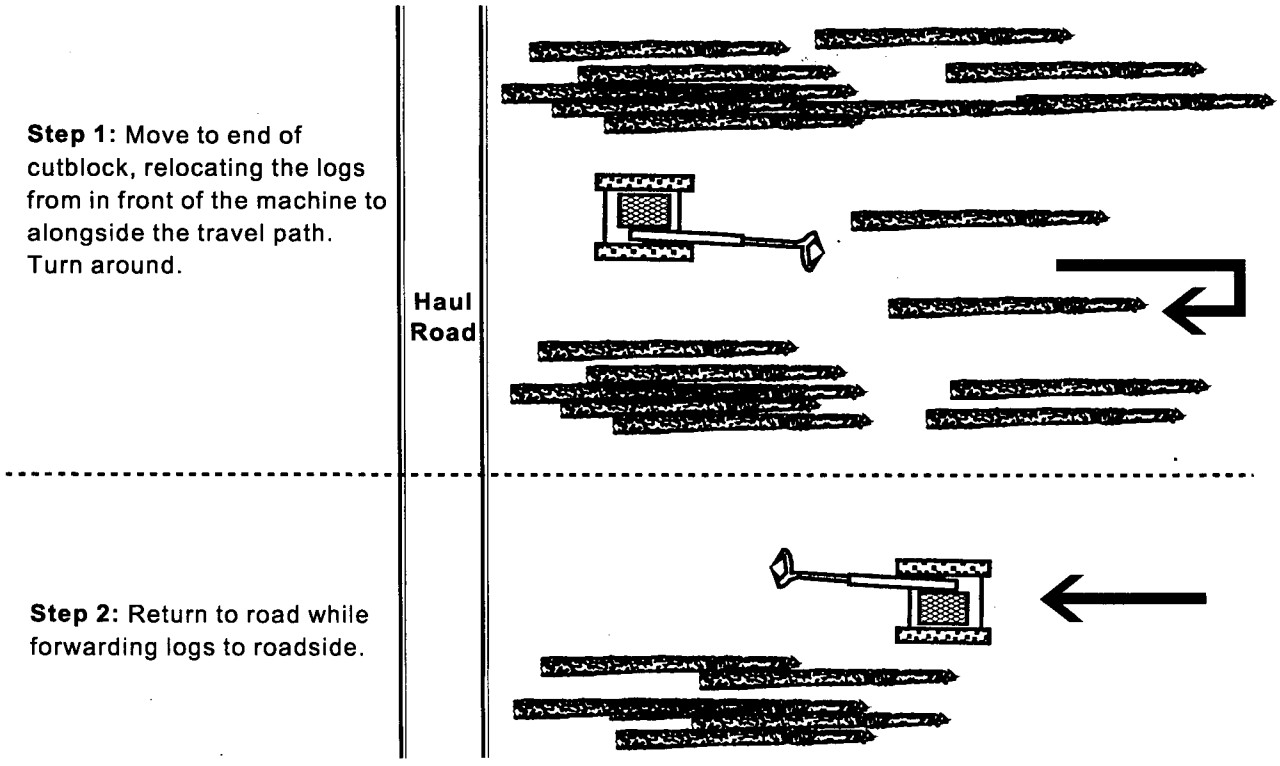

Figure 3. Loader forwarding pattern.

arrived on site, the desired number of plots was obtained only in one of these timber types. For the second timber type, the company's cruise data at an intensity of 1 plot per 3 hectares were used. Therefore, to test the accuracy of the prediction, a combined cruise (the company's and FERIC's) was used as input.

At the time this test was performed, the model could only predict log grades for western red cedar, western hemlock and Douglas-fir. For this reason, amabilis fir and Sitka spruce were analyzed as Douglas-fir.

Results and Discussion

A total of 447 loads of logs, consisting of 60 403 logs and 40 421 m^3, was harvested from the site. Table 2 summarizes the labour and machine times for the harvesting operation.

The average productivity for fallers (both company and contract) was 143 m^3/day. Table 3 summarizes the volume extracted by each machine.

Falling, forwarding/yarding, and loading costs were estimated at \$11.54/m^3 (Appendix 1).

Table 4 presents the actual and predicted volumes by species and sort. Also, results produced using company cruise data and the BCMOF cruise compilation program are included in this table; these results present only total volumes by species for the entire block.

This is the third testing of the model and it produced the least accurate results, mainly because only a small cruise sample was taken from one of the timber types in the block. Based on the previous tests, the program is expected to overestimate value, but by no more than 5%. However, in this case an overestimate of 10% in value was obtained.

Table 3. Volume Extracted by Machine Type

Machine type	Volume extracted (m^3)
Loaders	
Directly from right-of-way	1 043
Forwarded directly to road	15 025
Forwarded to super-snorkel	14 000
Grapple yarder	3 655
Super-snorkel	20 698 [a]

[a] Part of this volume was within the super-snorkel's reach, close to the road; the rest was forwarded by the loaders.

As with the previous tests, the best result was obtained for the most representative species of the block. In this case, this was western hemlock which represented 90% of total volume and for which volume and value were overestimated by 2% and 7%, respectively. The distribution of western hemlock volume by sort is presented in Figure 4. A statistical analysis performed for western hemlock showed that for all sorts, actual and predicted volumes are the same.

Good results were also obtained for western red cedar, which represented 6% of total volume. The prediction was poor for amabilis fir and Sitka spruce, together representing 4% of total volume, because the model could not analyze these species and therefore treated them as Douglas-fir. The total predicted volume for these two species was almost twice the harvested volume. This suggests these species are non-uniformly distributed (in pockets) throughout the block, and the small sample taken from one of the two timber types was partly responsible for the poor prediction.

The total volume predicted by the BCMOF cruise compilation program was 95% of actual volume. Prediction was also good for western hemlock and western red cedar but very poor for amabilis fir and Sitka spruce.

Table 2. Summary of Total Labour and Machine Times

Phase	Days	Hours
Falling	282.3	1835.0
Yarding		
Grapple yarding - machine only	9.5	76.0
- three-person crew	28.5	228.0
Loader forwarding - machine & operator	83.9	671.2
Super-snorkelling - machine & operator	34.8	278.4
Loading - machine only	62.5	500.0
- labour (operator & second loader)	62.5	500.0
Excavating (building backspar trails) - machine & operator	5.0	40.0

Table 4. Volume Per Hectare by Species and Sort - Predicted vs. Actual

Species and Sort	Volume (m^3/ha) Actual	Predicted by model	Cruise compilation
Western hemlock			
Saw log	213	296	-
Gang	553	515	-
Chip & saw	102	90	-
Utility	1	0	-
Pulp	73	56	-
Total volume	942	957	822
% of actual volume	-	102	87
% of actual value [a]	-	107	-
Western red cedar			
Saw log	3	0	-
Gang	21	24	-
Chip & saw	11	16	-
Utility	13	8	-
Pulp	13	7	-
Total volume	61	55	49
% of actual volume	-	90	80
% of actual value [a]	-	103	-
Amabilis fir & Sitka spruce			
Saw log	7	3	-
Gang	40	79	-
Chip & saw	0	0	-
Utility	0	0	-
Pulp	0	9	-
Total volume	47	91	128
% of actual volume	-	194	272
% of actual value [a]	-	169	-
Total block volume	1050	1103	999
% of actual block volume	-	105	95
% of actual block value [a]	-	110	-

[a] Based on data provided by MacMillan Bloedel's Port McNeill Division.

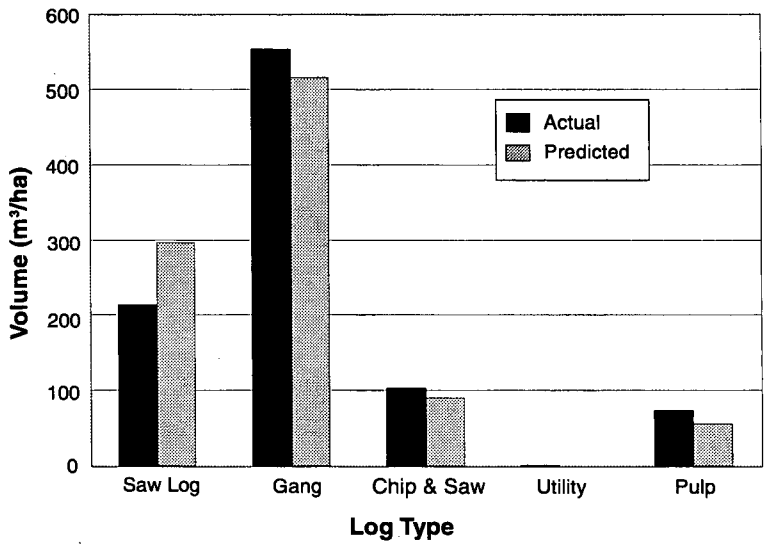

Figure 4. Actual and predicted volumes for western hemlock.

Summary and Conclusions

The objectives of this study were to calculate the costs of harvesting a second-growth western hemlock stand and to test the accuracy of log values predicted by a computer model developed by FERIC. The study block was a gentle, well-drained site on northern Vancouver Island. The stand consisted primarily of western hemlock with minor amounts of western red cedar, Sitka spruce and amabilis fir.

The harvesting operation consisted of manual falling and loader forwarding either directly to roadside or to within reach of a super-snorkel. Although site conditions did not make it essential, a grapple yarder also worked on the site for a brief period. Harvesting operations began in December 1996 and were completed in April 1997. A total volume of 40 421 m^3 was harvested from the site. Based on FERIC's standard costing methodology, the cost of harvesting the cutblock (consisting of falling, forwarding/yarding, and loading operations) was \$11.54/m^3. FERIC's computer model produced good results for the entire block and for western hemlock (the dominant species in the stand) when compared to the actual outcomes. Inaccurate values were produced for the secondary species existing in the block, particularly for amabilis fir and Sitka spruce, because the cruise sample was insufficient for one timber type, and FERIC's computer model was not designed to predict log grades for these species.

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Disclaimer

Appendix I

Harvesting Cost Summary

Operating phase or system	Description	Shifts (no.)	Shifts (SMH)	Cost ($/SMH)	Cost ($)	Cost ($/m³) [a]
Falling (manual)	Labour	282.3	1 834.9	49.57	90 958	2.25
	Saw allowance [b]	282.3	-	-	7 622	0.19
Total falling		-	-	-	98 580	2.44
Yarding						
Grapple yarding	Labour	33.5	268.0	87.19	23 367	0.58
	Madill 144	28.5	228.0	236.24	53 863	1.33
	Mobile backspar	28.5	228.0	14.89	3 395	0.08
	John Deere 992D	5.0	40.0	139.36	5 574	0.14
	Saw allowance	28.5	-	-	770	0.02
Loader forwarding	Labour	83.9	671.2	33.51	22 492	0.56
	John Deere 992D or John Deere 992E	83.9	671.2	139.36	93 538	2.31
Super-snorkelling	Labour	34.8	278.4	33.51	9 329	0.23
	Madill 075	34.8	278.4	191.41	53 289	1.32
Total yarding		-	-	-	265 617	6.57
Loading	Labour	62.5	500.0	65.24	32 620	0.81
	John Deere 992D or John Deere 992E	62.5	500.0	139.36	69 680	1.72
Total loading		-	-	-	102 300	2.53
Total labour cost		-	-	-	-	4.43
Total machine cost		-	-	-	-	7.11
Total harvesting cost		-	-	-	-	11.54

[a] Based on a total block volume of 40 421 m³.
[b] Saw allowance of $27.00/shift for each faller and landingman.