WOOD HARVESTING

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INCREASING VALUE AND FIBRE RECOVERY FROM COASTAL FORESTS BY MANUFACTURING LONGER LOGS

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Abstract

In 1994, International Forest Products Limited (Interfor) approached the Forest Engineering Research Institute of Canada (FERIC) to examine the feasibility of delivering long logs to the sortyard for further manufacture. FERIC conducted a field study at Interfor's Cleagh Creek Division. This report compares the productivities, costs, volumes, and recovered values of harvesting and delivering conventional-length and long logs to the sortyard.

Introduction

As a result of the fibre shortage and increasing harvesting costs, forest companies in British Columbia have examined their log handling procedures. In many operating areas, utilizing the timber resource to its fullest potential, both in volume and value of recovered wood, is critical to continued operations. The large size and value of logs harvested in coastal British Columbia indicate that potential gains from improved handling can be significant. In most coastal operations, logs are bucked at the stump after felling, on the landing, and at the log sortyard. The degree of log manufacture at each location is determined by common practice and is influenced by the location, equipment used, and timber characteristics. In interior British Columbia operations, delivery of long logs to the mill has been shown to reduce hauling costs and improve product quality, resulting in increased lumber recovery (Clark 1986). This concept—delivering the longest log possible to the location where bucking can be done under the best conditions—has not been tested by FERIC in coastal operations. Theoretically, if log manufacturing decisions are delayed until they are made by a log grader, in a safe working environment and with current information on the sawmill's requirements, then the log values should increase.

In 1994, Interfor approached FERIC to examine the feasibility of delivering long logs to the sortyard for further manufacture. FERIC conducted a field study on this topic in the winter of 1994/95 at Interfor's Cleagh Creek Division, near Port Hardy, British Columbia. The objectives for the field study were based largely on the study recommendations proposed in a paper on the topic (Briscoe 1994).This report presents the results of the study, and compares the productivities, costs, volumes, and recovered values of harvesting and delivering conventional-length and long logs to the sortyard.

Objectives

This study was developed to evaluate the effects of harvesting long logs on a coastal grapple yarding operation, by comparing the results of harvesting conventional-length logs with those of harvesting long logs. Specifically, the objectives were to:

- Determine the differences in the productivities and costs by phase, including: falling and bucking, yarding, loading, hauling, and unloading.
- Identify the effects on worker safety, particularly during the falling and bucking phase.

Keywords: Lumber manufacturing, Productivity, Costs, Coastal British Columbia, Long logs, Upgrading.

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- Determine the differences in log breakage and fibre recovery during the harvesting phase.
- Determine the differences in recovered value based on grade change.
- Determine the differences in recovery by measuring the waste left on the site after harvesting.
- Determine the differences in soil disturbance.

Site and Equipment Description

The 21-ha study block, located on the northwest coast of Vancouver Island, had a cruised volume of 22 300 m^3. Most of the original stand of sitka spruce (*Picea sitchensis* [Bong.] Carr.) and western red cedar (*Thuja plicata* Donn) was destroyed by a hurricane in the early 1900s. The site naturally regenerated with western hemlock (*Tsuga heterophylla* [Raf.] Sarg.), sitka spruce, and western red cedar. The average tree diameter was 50 cm at breast height, and the average tree height was 40 m. The stand also contained scattered old-growth spruce and cedar that survived the hurricane. The old-growth spruce trees averaged over 100 cm in diameter and over 50 m in height, while the old-growth cedar trees averaged over 100 cm in diameter and had "candelabra" tops.

The site was ideally suited for grapple yarding (Figure 1). The study block was divided into three treatment areas in order to compare long log harvesting with conventional harvesting. Two treatment areas were assigned to the conventional-length practice to compare uphill and downhill yarding. During harvest, a portion of the long log area was excavator-forwarded because the long yarding distance (approximately 250 m) and poor deflection made it inefficient for grapple yarding.

The equipment used in the study included a Madill 044 swing yarder with a grapple, a Madill 075 super-snorkel log loader, an old Hitachi UH122 excavator used as a mobile backspar, and a Kobelco 400 hydraulic log loader used to excavator-forward the logs.

Log Manufacturing Practice

Conventional-Length Logs

Interfor's standard procedures for manufacturing conventional-length logs involve hand falling and bucking stems to specific log lengths (Appendix I). Cutblocks are often felled months in advance of the yarding operation. The maximum length of a hemlock "gang" log is 16.7 m, with the majority of logs manufactured between 10.6 m and 14.5 m. For stems with butt rot, except for cedar stems, the fallers allow a minimum-length pulp log, add a preferred log length, then buck the stem to the combined length. Often three logs are manufactured from a stem.

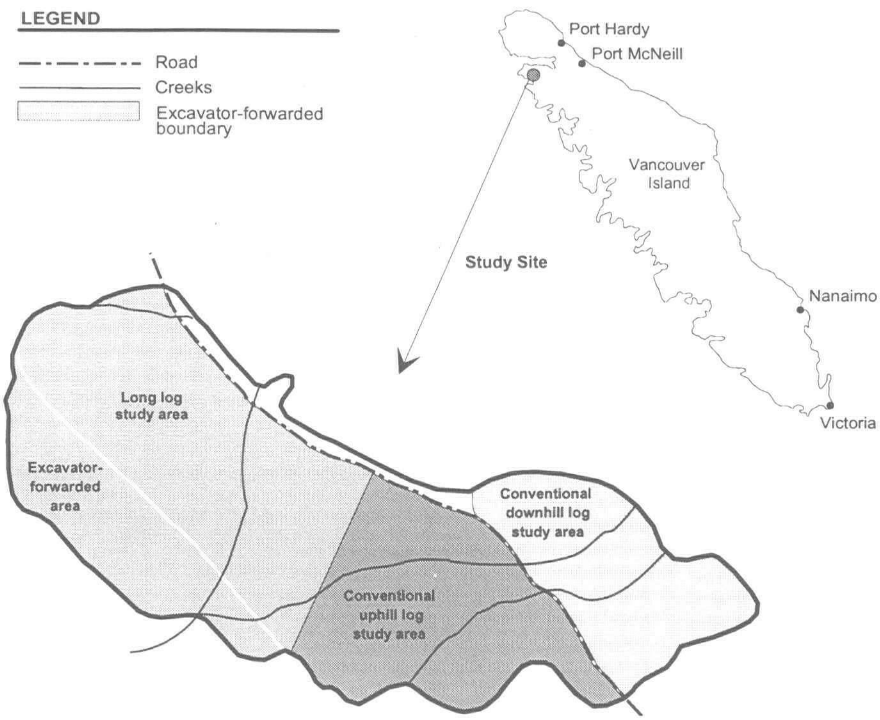

Figure 1. Study areas.

The logs were sent to two of Interfor's sawmills. The two sawmills—Fraser Mills and Western Whitewood—each have different specifications and requirements. The maximum log length that can be presented to Fraser Mills is 16.4 m, and the minimum top diameter is 40 cm. Western Whitewood can accept logs up to 21.2 m, with a minimum top diameter of 10 cm. Since eleven log grades and four species are harvested, there are over 80 bucking possibilities. Therefore, individuals responsible for log manufacture are faced with complex instructions and difficult decision-making tasks.

Long Logs

Occasionally, the fallers manufactured "boom stick" logs up to 20.6 m in length during normal operation. While this demonstrated that the system could handle long logs, it was not known how the operation would be affected if a larger proportion of long logs was produced. The new bucking specification for the long log study was determined by adding another log to the existing conventional-length log specification. Instead of making butt-rot allowances, the fallers were instructed to measure to one of the longer lengths. All other conventional bucking procedures, such as bucking to prevent breakage, and bucking large-diameter logs (i.e., butt diameter >100 cm) into short logs to prevent soil disturbance during yarding, remained the same. Interfor's main concern when harvesting long logs was operational safety during the bucking and yarding phases, and at the dryland sortyard.

Study Methods

On randomly selected days during the falling and bucking phase, FERIC measured and recorded the butt diameters of all trees felled, measured the top diameter and length of each log produced, and determined where and when breakage occurred. At the end of the falling and bucking phase, the falling contractor provided FERIC with the total faller-days worked on the study area.

Throughout the yarding phase, FERIC observed the operation and periodically collected detailed-timing data. FERIC observed the work cycles and recorded the duration of each cycle element by entering event codes into a hand-held data logger. For each cycle, additional data describing the species, butt-diameter classes, logs yarded, distances yarded, and breakages were also recorded. The data files were later transferred to a microcomputer for analysis. A representative sample of logs was hand-scaled to determine the log volume in each butt-diameter class.

During the truck loading phase, FERIC recorded loading times, log counts, and breakages for each of the treatment areas. By accompanying the truck drivers to the sortyard, FERIC was able to determine the times for each of the elements—loading, travelling to the sortyard, unloading, and returning empty—for each trip observed. In addition, FERIC was able to obtain the drivers' impressions of hauling long logs.

At the dryland sortyard, FERIC observed both conventional and long log loads being unloaded, spread, graded, bucked, and scaled. FERIC also solicited comments and impressions from all the workers at the sortyard regarding the delivery of long logs. All of the load scale summaries for the study block were obtained from the scalers for analysis. The log values and stumpage rates were obtained from the British Columbia Ministry of Forests, Valuation Branch[1] and Interfor.

After harvesting was completed, FERIC accompanied a waste and residue survey contractor to the study block to determine the merchantable volume left on the block and in the roadside piles. Since the contractor was required to establish only 5 plots over the whole area, FERIC established additional plots to compare the differences in each of the treatment areas.

The B.C. Ministry of Forests soil disturbance survey procedures (Curran and Thompson 1991) were used on the study block, and completed prior to the enactment of the B.C. Forest Practices Code; therefore, the results do not reflect current Code standards (British Columbia Ministry of Forests 1995). The road right-of-way to a maximum width of 30 m was excluded from the survey. Survey grid points were established at 50-m intervals, and random-bearing 30-m transect lines were located at each point. The soil condition was noted at 2-m intervals along the transect lines. Additional transect lines were located at 90 degrees to the original lines, and the soil condition was noted at 2-m intervals along these lines as well.

System costs were derived using FERIC's standard machine-costing methodology and using applicable coastal IWA labour rates (Appendix II). These costs do not include supervision, profit, nor overhead and may not reflect the actual costs incurred by the company.

Results

Falling

The falling phase occurred from October to December 1994. A total of 142 falling shifts was required with 3 to 8 fallers working per shift. On several days, the

[1] Effective April 1, 1995, the name of the Valuation Branch was changed to the Revenue Branch.

crew was unable to complete their shifts due to strong wind conditions. Based on the scaled volume, the average faller-day productivity was 126 m³/shift. Unfortunately, the falling contractor was unable to provide a complete distribution of the faller-days worked in each of the treatment areas, so comparisons between treatments could not be made on a shift-level basis.

During this phase, FERIC accompanied fallers to different falling locations for a total of 12 days. The average productivity was 136 m³/day in the long log area, while the productivity in the conventional area was 119 m³/day (Table 1). Faller productivity improved because fewer cuts were required as fewer logs were produced from the stems—on average, 1.63 logs were produced from conventional-length stems and 1.45 logs were produced from long-log stems. Many of the stems were between 30–40 m in merchantable length and both a long and a short log were cut (Figure 2). The fallers were instructed to cut the short log from the butt rather than from the top to reduce the risk of breakage and fibre losses during yarding. The large-diameter stems (>100 cm) were bucked to conventional log lengths to prevent the butts from gouging into the soil during the yarding phase, and to allow the grapple yarder to handle the logs easily. The average length and volume per log in the long log area was 15.6 m and 2.0 m³, respectively; in the conventional area, logs had an average length and volume of 11.8 m and 1.6 m³, respectively. Even though the priority in the long log area was to cut as many long logs as possible, only 28.6% of the logs manufactured were longer than 16.7 m.

Figure 2. Faller bucking in long log study area.

Very little log breakage resulted during falling because the terrain of the study area was relatively flat—only the southern portion had slopes over 35%—and only a small percentage of the stand contained large old-growth trees. Breakage due to falling was only counted when the broken top contained a merchantable log (diameter >20 cm). In both study areas, less than 10% breakage during falling was noted. In the long log area, the fallers manufactured short logs if they felt that the logs might break when hit by subsequently felled trees. During the detailed observation period, less than 1.5% of the felled trees hit and broke logs on the ground.

Yarding

Shift-level study. After falling of the study block was completed, a Madill 075 super-snorkel loader with a 27-m reach yarded the logs close to the road. On the lower side of the road edge, all logs within 40 m were yarded and decked by the super-snorkel, while only a 20-m strip on the top side was yarded. In total, 2 693 m³ of logs were yarded by the loader (Table 2). In the long log area, the Kobelco hydraulic excavator log loader forwarded the logs to within 180 m of the road. The excavator-forwarded logs had both tops and butts facing the road and were decked to a height of 4 m. In mid-January of 1995, a Madill 044 swing yarder equipped with a grapple arrived on the study block and yarded a total of 15 247 m³ of logs over 50 shifts (Figure 3). The swing yarder worked approximately 8 productive hours/shift and averaged 305 m³/shift. A total of 29 shifts was spent yarding the conventionally bucked logs, while 21 shifts were required to yard the long log area. Even though the average yarding distance in the long log area was greater than in the conventional area, the productivity for the long log area was 315 m³/shift, whereas productivity for the conventional area was 297 m³/shift—a difference of 6%.

Table 1. Falling Comparison

Treatment	Average production (m³/shift)	Long logs produced[a] (%)	Average logs/stem (no.)	Average volume/log (m³)	Average length/log (m)	Stem breakage during falling (%)	Breakage from felled trees (%)
Conventional	119	5.8	1.63	1.6	11.8	9.3	1.4
Long log	136	28.6	1.45	2.0	15.6	10.0	1.0

[a] Longer than Interfor's maximum acceptable log length of 16.7 m.

Table 2. Shift-Level Yarding Summary

	Conventional			Long Log	Swing	Log	
	Downhill	Uphill	Total	Uphill	yarder	loader	Total
Volume yarded (m^3)	3 254	5 370	8 624	6 623	15 247	2 693	17 940
Shifts (no.)	10	19	29	21	50		
Productivity (m^3/shift)	325.4	282.6	297.4	315.4	304.9		

Table 3. Detailed Timing of Grapple Yarding Operations

	Conventional		Long log	
	Downhill	Uphill	Uphill	Total
Average operating conditions				
Time (h)	22.0	19.7	15.8	57.5
Cycles (no.)	769	574	440	1 783
Logs (no.)	839	684	543	2 066
Volume (m^3)	866	705	631	2 202
Average yarding distance (m)	100	85	113	
Broken tops (no.)	58	50	118	226
Occurrences of yarding breakage (no.)	28	39	56	123
Average productivity				
Volume/h	39.4	35.8	39.9	38.3
Logs/h	38.1	34.7	34.4	35.9
Volume/cycle	1.1	1.2	1.4	1.2
Logs/cycle	1.1	1.2	1.2	1.2

Figure 3. Madill 044 swing yarder with long log.

Detailed-Timing Study

Detailed-timing studies were conducted periodically during the yarding phase. A total of 2 202 m^3 of logs were yarded during 57.5 h of detailed-timing observations (Table 3). In addition to comparing long log yarding with conventional yarding, FERIC also compared downhill and uphill yarding. The downhill yarding required stump rigging of the tail blocks, but the productivity was not affected because the road changes were relatively fast. In addition, more volume was left for the grapple yarder on the upper side of the haul road than on the lower side.

All of the long log study area was uphill yarded. Because the excavator-forwarded log decks were piled perpendicular to the haul road, the yarding engineer had difficulty grappling logs, which caused more breakage (the logs should have been placed at a slight angle to make a larger target). The topography of the long log area provided less deflection than the conventional area, and this also contributed to an increase in yarding breakage. The increase in yarding productivity for the long log area is attributed to log size, as the logs/h and logs/cycle were not significantly different for conventional and long log uphill yarding.

Table 4 summarizes the distribution of the timing elements. Although the percentages of total time for elements vary slightly, the actual outhaul, hook, and inhaul times for the conventional uphill and downhill yarding were the same. The average outhaul and inhaul times for the long log area were greater than for the conventional area because average yarding distances were longer in the long log area. The hook time was shorter in the long log area because there were larger targets for the grapple. Decking time was longer for uphill yarding because the fill portion of the road was very steep, and logs had to be placed carefully.

Table 4. Detailed Timing of Yarding Operations

Elements	Conventional—downhill yarding					Conventional—uphill yarding					Long log—uphill yarding				
	Total time (min)	Occurrences (no.)	Time/ occur. (min)	Time/cycle (min)	Time/cycle (%)[a]	Total time (min)	Occurrences (no.)	Time/ occur. (min)	Time/cycle (min)	Time/cycle (%)[a]	Total time (min)	Occurrences (no.)	Time/ occur. (min)	Time/cycle (min)	Time/cycle (%)[a]
Outhaul	302.13	734		0.41	23.3	224.86	563		0.40	19.2	222.18	384		0.58	25.8
Hook	283.96	734		0.39	22.2	219.65	563		0.39	18.7	136.17	384		0.35	15.6
Inhaul	394.45	734		0.54	30.7	305.77	563		0.54	25.9	268.01	384		0.70	31.1
Unhook[b]	6.80	11	0.62	0.01	0.6	1.30	11	0.12	0.00	0.1	0.00	0		0.00	0.0
Deck[b]	67.57	88	0.77	0.09	5.1	134.63	150	0.90	0.24	11.5	85.28	76	1.12	0.22[b]	9.8
Move[b]	42.85	18	2.38	0.06	3.4	77.65	7	11.09	0.14	6.7	32.68	5	6.54	0.09[b]	4.0
Move backspar[b]	23.47	2	11.74	0.03	1.7	75.08	6	12.51	0.13	6.3	32.42	6	5.40	0.08[b]	3.6
Spot[b]	21.99	15	1.47	0.03	1.7	37.73	23	1.64	0.07	3.4	18.56	14	1.33	0.05[b]	2.2
Rehook[b]	26.43	45	0.59	0.04	2.3	42.38	72	0.59	0.08	3.8	40.52	37	1.10	0.11[b]	4.9
Delay[b]	120.73	54	2.24	0.16	9.1	53.45	35	1.53	0.09	4.3	27.54	8	3.44	0.07[b]	3.1
Subtotal	1 290.38	734		1.76	100.0	1 172.50	563		2.08	100.0	863.36	384		2.25	100.0
Sumtime[c]	29.31	35	0.84			11.13	11	1.01			83.8	56	1.50		
Total time															
(min)	1 319.69	769				1 183.63	574				947.16	440			
(hours)	21.99					19.73					15.79				
Volume (m^3)	866					705					631				

[a] Differences due to rounding.
[b] These timing elements did not occur on every cycle, but the values shown are the averages applied to all cycles.
[c] Total cycle time from outhaul to unhook when individual element times were missed.

Backstops were built to prevent the logs from slipping down the hill.

Table 5 compares similar yarding conditions summarizing cycles of 20 to 150 m yarding distance. The yarding of the excavator-forwarded logs was also removed from the comparison. The yarding productivity for the long log area was 23% higher than for the conventional uphill area because of the larger logs, and therefore greater volume/cycle. Less time was required to inspect the yarded area for missed logs between yarding road changes. Also, fewer small tops or broken pieces had to be recovered because the top portion of a stem was attached to the long log.

Loading and Hauling

FERIC observed 53 trucks being loaded during the study period (Figure 4). The average loading time for long logs was 5 min less than for conventional logs because fewer logs were required for a full load (Table 6). Average payload increased by 16 m^3 (19%) because of the larger volume per log. There was also a slight decrease in the unloading time for the long logs. The increase in breakage attributed to loading long logs occurred mainly when a log was picked up by the top instead of the butt. Travel time to the sortyard increased because the extra load volume and weight slowed the truck on corners and adverse grades. In total, the 4-min reduction in a 3-h cycle (Table 6) is not significant. The payload increase was the most notable difference. FERIC was unable to determine the effects on truck maintenance or fuel consumption. While these factors probably increased on a per trip basis for hauling long logs, fewer trips would be required to haul the same total volume; therefore, the overall cost may be reduced.

Dryland Sortyard

FERIC did not measure productivity changes at the dryland sortyard, but discussed the effects of the long logs on sortyard activities with the log scalers and buckers. They observed no increases in log breakage at the sortyard. However, the long logs created a safety consideration at the sortyard. All the people at the sortyard had to be aware that these logs had a longer sweep and that, therefore, the hazard zone was larger. The log scalers may have spent more time grading the individual logs, but they probably spent less time scaling long log loads because fewer logs per load had to be measured.

Grade Scaling

In January 1995, a log manufacturing policy change by Interfor affected the original study objectives. The receiving sawmills reduced the maximum acceptable

Table 5. Comparison of Productivity between 20 and 150 m Yarding Distance

	Conventional		Long log
	Downhill	Uphill	Uphill
Time (h)	15.75	18.13	8.27
Volume (m^3)	594.0	664.5	372.9
Cycles (no.)	636	551	295
Logs (no.)	694	639	346
Average yarding distance (m)	90.5	81.6	92.1
Productivity (m^3/h)	37.71	36.65	45.09
Time/cycle (min)	1.49	1.97	1.68
Cycles/h	40.38	30.39	35.67
Volume/cycle (m^3)	0.93	1.21	1.26
Logs/cycle (no.)	1.1	1.2	1.2

Table 6. Loading and Hauling Summary

	Conventional	Long log
Loads (no.)	29	24
Volume (m^3/load)	84.4	100.7
Logs (no./load)	72.2	51.7
Loading time (min/load)	50.3	45.4
Hauling (min/load)	69.6	73.9
Unloading time (min/load)	18.4	16.4
Return time (min)	50.0	50.0
Total cycle time (min/load)	188.3	185.7
Broken logs (%)	1.8	2.8

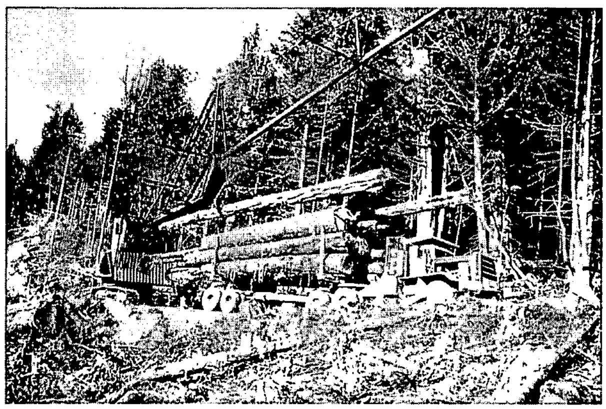

Figure 4. Madill 075 log loader with long log load.

log length to 16.7 m, although Western Whitewood had previously accepted logs up to 21.2 m. Since all of the falling had been completed by the end of December 1994, all the long logs had to be remanufactured at the dryland sortyard. The scalers at the sortyard were instructed to merchandize high-grade logs and sawlogs to the longest possible preferred length according to the conventional bucking specifications (Appendix I). They were also instructed to maximize the number of sawlogs with a 40-cm top diameter, taking into account the preferred lengths.

The grades and values of the wood from the study block are summarized in Table 7. There were 104 different log grades identified in the study. The table shows the prorated value of the logs using the February 1995 average log sale values obtained from the B.C. Ministry of Forests, Valuation Branch. The average value of the logs produced in the long log treatment increased by $26.25/m^3, compared to the conventional treatment. Generally, the long log wood had higher grade values. The largest differences were a 25% increase in the grade "H" long logs over conventional-length logs, and a 62% decrease in grade "J" long logs compared to conventional-length logs.

Table 8 illustrates the differences in average log values when all the cedar was removed from the analysis (the bucking specifications for cedar in the conventional and long log treatments were the same). A comparison with Table 7 shows that the average log value in the long log treatment increased by an additional $4.06 to $30.31/m^3 over the conventional treatment, and the percentage of "H" grade increased an additional 3%.

Table 9 summarizes the value of the scaled volume that ended up in the burn piles. Even though remanufacturing the 21.2-m logs to 16.7-m lengths should have created more waste, there was an overall reduction in volume loss. The 93.3 m^3 of waste from the long log study represented a 1.1% loss based on the total volume harvested in the long log area, while the 156 m^3 of waste for the conventional study was 1.6% of the total volume harvested in the conventional area. Table 10 shows the stumpage that would have been paid for the waste in the burn piles. A savings of approximately $0.18/m^3, or $3 229, would have been realized if all the stems had been manufactured into long logs.

Waste Survey

FERIC established a total of 13 waste assessment plots in addition to the 5 that were established by the waste survey contractor (Table 11). Most of the billable waste occurred when the faller bucked a broken stem at a desired length rather than at the break. One plot in the excavator-forwarded area had many broken pieces because the excavator used waste material as corduroy to support the machine weight. FERIC did not survey any of the landing debris piles, as the contractor measured 4 of the 14 piles and found only an additional 2 m^3/ha of billable waste and 4.1 m^3/ha of waste for cut control purposes.

Table 7. Grade and Value Summary [a]

Grade	Conventional				Long log			
	Volume (m^3)	Ratio [b] (%)	Average value [c] ($/m^3)	Value ($)	Volume (m^3)	Ratio [b] (%)	Average value [c] ($/m^3)	Value ($)
D	113.1	1.2	416.54	47 111	148.4	1.8	410.48	60 915
E					6.6	0.1	565.75	3 734
F	319.7	3.3	324.89	103 867	418.4	5.0	310.11	129 750
G	119.7	1.2	413.95	49 550	110.2	1.3	413.95	45 617
H	2 996.1	31.2	177.77	532 617	3 436.9	41.2	193.23	664 112
I	585.9	6.1	139.99	82 020	823.7	9.9	156.17	128 637
J	2 553.7	26.6	83.27	212 647	1 560.7	18.7	84.03	131 146
K	224.5	2.3	99.83	22 412	130.6	1.6	99.83	13 038
L	145.9	1.5	85.67	12 499	192.7	2.3	85.67	16 509
M	102.8	1.1	64.56	6 637	126.1	1.5	64.56	8 141
U	1 167.2	12.2	71.05	82 930	636.1	7.6	69.95	44 495
X	918.6	9.6	68.83	63 227	492.4	5.9	67.53	33 252
Y	348.9	3.6	69.17	24 133	261.3	3.1	67.38	17 606
Total	9 596.1	100.0	129.18	1 239 650	8 344.1	100.0	155.43	1 296 952

[a] From truck load summaries obtained from Interfor.
[b] Differences due to rounding.
[c] Average value is the prorated value of all species in the specific grade category obtained from the B.C. Ministry of Forests, Valuation Branch's coast average log value for April 1, 1995.

Table 8. Log Value with Cedar Removed

Grade	Conventional Volume (m³)	Conventional Ratio [a] (%)	Conventional Average value ($/m³)	Conventional Value ($)	Long log Volume (m³)	Long log Ratio [a] (%)	Long log Average value ($/m³)	Long log Value ($)
D	113.1	1.4	416.54	47 111	130.1	1.8	459.04	59 721
E					6.6	0.1	565.75	3 734
F	302.0	3.6	332.66	100 463	377.3	5.2	322.92	121 838
G	119.7	1.4	413.95	49 550	110.2	1.5	413.95	45 617
H	2 655.5	31.9	184.83	490 816	3 206.8	44.2	197.95	634 786
I	499.9	6.0	146.94	73 455	751.7	10.4	161.40	121 324
J	2 369.0	28.4	83.88	198 712	1 455.3	20.1	84.36	122 769
K	0.5	<0.1	99.83	50	2.8	<0.1	99.83	280
U	1 051.9	12.6	74.27	78 125	523.6	7.2	75.60	39 584
X	885.3	10.6	70.30	62 237	449.1	6.2	70.57	31 693
Y	333.2	4.0	69.96	23 311	237.5	3.3	70.09	16 646
Total	8 330.1	100.0	134.91	1 123 830	7 251.0	100.0	165.22	1 197 992

[a] Differences due to rounding.

Table 9. Value of Logs in Burn Pile at Dryland Sortyard

Grade	Conventional Volume (m³)	Conventional Log value ($/m³)	Conventional Total ($)	Long log Volume (m³)	Long log Log value ($/m³)	Long log Total ($)
F	1.3	324.89	422	0.2	324.89	65
G	0.3	413.95	124			
H	3.1	177.77	551	1.9	177.77	338
I	6.1	139.99	854	4.8	139.99	672
J	2.5	83.27	208	2.8	83.27	233
K	0.5	99.83	50			
L	0.5	85.67	43			
M	4.3	64.56	278	5.3	64.56	342
U	28.4	71.05	2 018	7.5	71.05	533
X	55.5	68.83	3 820	34.6	68.83	2 382
Y	53.6	69.17	3 708	36.2	69.17	2 504
Total	156.1		12 076	93.3		7 069

Table 10. Waste Billing Paid

	Conventional Volume (m³)	Conventional Stumpage rate ($/m³)	Conventional Total ($)	Long log Volume (m³)	Long log Stumpage rate ($/m³)	Long log Total ($)
Grades F–X	102.5	46.19	4 734	57.1	46.19	2 637
Grade Y	53.6	0.25	13	36.2	0.25	9
Billing	156.1		4 747	93.3		2 646
Average waste cost		0.50[a]			0.32[a]	

[a] Average waste cost is the waste billing prorated by the volume produced in each study area.

Soil Disturbance

A total of 45 soil disturbance grid points were established over the study block (Table 12). The long log area experienced more soil disturbance because of the poorer deflection, longer yarding distance (more turns per yarding road), and larger logs. The disturbances classified as heavy were primarily created by the logs as they were being dragged to the yarder. FERIC observed the yarding engineer placing logs in dry creek crossings and in wet areas to protect the site from excessive soil displacement or rutting. Prior to a yarding road change, these logs and any debris were removed.

Costs

In order to illustrate the magnitude of the savings that might have been realized if long logs had been harvested in the conventional area, FERIC compared the estimated costs of harvesting the entire study block using each method. Since the Madill 044 is no longer made, FERIC used a purchase price of $1.0MM for the Madill 044 in this comparison (Appendix II). The falling and bucking cost was calculated as $367/shift; the yarding cost was $2 540/10-h shift; the loading cost was $2 525/10-h shift; and the trucking cost was $1 250/10-h shift. The unloading, scaling and dryland bucking costs were assumed to be unchanged with the change in log length. In addition to the increase in log value for the study block, Table 13 illustrates the savings that could have been realized. If long logs had been manufactured for the entire study block, it is estimated that the log value would have increased by 20% ($26.25/m^3), the harvesting cost would have reduced by 8% ($1.93/m^3), and the waste billing would have reduced by 36% ($0.18/m^3). Individual harvesting phases showed estimated cost reductions of 12, 6, and 15% for falling, yarding and loading, and hauling, respectively. The total potential cost savings, or value increase, is estimated to be 22% ($28.47/m^3).

Table 11. Waste Survey Summary

Area	Plots (no.)	Billable waste (m^3)	Cut control allocation (m^3)
Conventional	6	15.7	16.1
Long log	7	9.5	12.2
Weighted average		12.4	14.0
Contractor summary	5	10.7	15.7

Discussion

Falling and Bucking

The improvement in safety was probably the most important advantage of bucking stems into the longer lengths. The hazard was reduced because the faller spent less time walking back and forth on the stems to measure and make grading decisions. The number of bucking occurrences was also reduced in the long log area. During this study, it became apparent that 55 different conventional log lengths was too many to manufacture. Long log manufacturing had only 20 possible log lengths. Except for the large-diameter stems, any log length cut at the stump could have been merchandised into an acceptable log at the dryland sort. Harvesting long logs permits the sortyard to change bucking specifications to capture higher log values, without experiencing volume losses.

Table 12. Soil Disturbance Survey

Area	Grid points	Disturbance depth class: Undisturbed	0–5 cm	5–10 cm	>10 cm	Total sample points
Long log						
Yarded						
(no.)	16	245	124	63	48	480
(%)		51.0	25.8	13.1	10.0	100
Excavator forwarded						
(no.)	7	132	54	10	14	210
(%)		62.8	25.7	4.8	6.7	100
Conventional						
(no.)	22	546	89	19	6	660
(%)		82.7	13.5	2.9	0.9	100

Table 13. Summary of Productivity and Costs

	Conventional		Long log				
	Productivity (m^3/shift)	Cost (\$/m^3)	Productivity (m^3/shift)	Cost (\$/m^3)	Savings (\$/m^3)	Total volume (m^3)	Total reduction in cost (\$)
Falling	119	3.08	136	2.70	0.38	17 940	6 817
Yarding	297	8.55	315	8.06	0.49	15 247	7 471
Loading	351	7.19	373	6.77	0.42	17 940	7 535
Trucking [a]	85	4.62	100	3.87	0.75	17 940	13 455
Total		23.44		21.40	2.04		35 278
Waste billing		0.50		0.32	0.18	17 940	3 229
Log value		129.18		155.43	26.25	17 940	470 925
Total					28.47		509 432

[a] Trucks averaged three loads per shift, but the loads were hauled from several blocks.

In order to improve yarding efficiency, fallers bucking at the stump should manufacture the short log from the butt. To minimize the billable waste, the fallers should buck through the middle of the break, or possibly not buck at all and let the bucker at the dryland sortyard manufacture the log. Instead of bucking, more attention could be spent on delimbing. This would help reduce log breakage and improve recovery as merchantable logs would be more visible to the yarding engineer.

Yarding

Under the conditions observed in this study, the yarding phase is not adversely affected if long logs are yarded. Since productivity increases, the yarding engineer may be able to take more care in preventing breakage and soil disturbance while maintaining conventional log production levels.

The logs should be yarded by the butt whenever possible. This also reduces soil disturbance in the yarding road and reduces loading breakage at roadside. The yarding engineer should be encouraged to sort the small-diameter and short logs from the large logs, and place them on top of the roadside deck or to one side. This would reduce log breakage, as small-diameter logs and short logs are often crushed by the weight of large logs. Loading logs of different butt diameters and lengths simultaneously can also increase breakage because the balance point on each log is different.

FERIC observed many unmerchantable logs being brought close to the road before being discarded as waste by the yarding engineer. Although this is common grapple yarding practice, the hooktender could play a more active role in the yarding phase by identifying unmerchantable pieces as they are picked up. The hooktender should have some log grading training to ensure that all merchantable volume is utilized without unnecessarily handling cull logs.

Loading

Whenever possible, the loader should load from the front of the logging truck, with the butts facing forward, to minimize breakage. If loading from the rear is required, the grapple legs should be widened to provide a greater fulcrum area to reduce breakage. Any necessary delimbing at roadside should be done manually by the "second loader", instead of by the loader operator using the grapple to remove branches.

Trucking

The truck drivers indicated that the increase in payload did not affect the handling performance of their trucks on the road. However, triaxle trailers may distribute the weight better and provide better stability and/or increase payloads.

Sortyard Grading and Bucking

Ideally, log grading and bucking should be done at the last possible stage before manufacturing the log at the converting mill. Because logs of different grades are delivered to different mills, some manufacturing is necessary before delivery. Longer logs delivered directly to the sawmill would reduce manufacturing costs at the sortyard. In this study, the scaler became the log merchandiser of long logs and there was a significant increase in log grade values. If the logs were manufactured at the sawmill using computer-assisted technology, the gains would probably have been more dramatic.

If broken stems were manufactured at the sortyard, less waste may have been billed at the logging site.

Ideally, all of the fibre should be delivered to the sortyard or mill site, and any material not suitable for lumber or veneer could provide hog fuel or chips.

Conclusions

FERIC conducted a long log study during the winter of 1994/95 at Cleagh Creek near Port Hardy, B.C., in cooperation with Interfor. The study showed that manufacturing logs 21.2 m in length at the stump could realize an increase in log value of 20% ($26.25/m^3), while reducing harvesting and trucking costs by 8% ($1.93/m^3). The amount of waste generated at the dryland sortyard was reduced from 1.6 to 1.1%, and reduced the waste billing to the company by 36% ($0.18/m^3).

The study showed that all of the harvesting phases would realize productivity increases and cost reductions. Falling costs were reduced by 12%, yarding and loading by 6%, and trucking by 15%.

Harvesting long logs could reduce bucking hazards because bucking activity is reduced. When yarding, loading, and sorting long logs, workers must recognize the increased hazard zone and, if adopted as a standard procedure, safety instructions should be reviewed.

The study block was an easy site for grapple yarding with little potential for log breakage. Differences in residue and waste between the conventional and long log areas were not significant in this study and are unlikely to be an important consideration. However, the soil disturbance percentages were higher in the long log area than in the conventional area because of the increased number of turns close to the excavator-forwarded area, and the poor deflection present in the long log area.

This study demonstrated the potential of long log harvesting. In order to determine where this technique is most appropriate, more information on difficult sites is needed for grapple yarding, conventional highlead yarding, and especially skyline systems.

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Disclaimer

Appendix I

Interfor Bucking Specifications [a]

	Conventional specifications						Long log specifications					
Hembal												
Clear—top diameter 24”+	54’8”	43’	41’4”	35’	27’	21’	70’	68’4”	64’	62’4”	62’	
Sawlog—top diameter 16”+	54’8”	52’	48’	45’	41’4”	69’	68’4”	66’	65’	61’5”	59’	
	38’	34’5”	31’5”	27’	21’							
Gang—top diameter 8”+	55’3”	47’3”	41’	34’	21’		68’3”	62’				
Cedar												
Sawlog—top diameter 15”+	40’10”	36’10”	34’10”	32’10”			40’10”	36’10”	34’10”	32’10”		
Gang—top diameter 6”+	49’3”						49’3”					
Cypress												
Sawlog—top diameter 15”+	41’	34’	27’	21’			41’	34’	27’	21’		
Gang—top diameter 6”+	24’	14’					24’	14’				
Spruce												
Highgrade—top diameter 30”+	41’	34’	27’	21’			68’	62’				
Sawlog—top diameter 14”+	54’8”	45’	38’	32’	27’	21’	70’	68’	65’	64’	62’	59’
Gang—top diameter 6”+	53’	44’	35’	27’	18’		62’					
Douglas-fir												
Clear—top diameter 30”+	41’	34’	27’	21’			68’	62’	61’			
Sawlog—top diameter 14”+	54’8”	41’4”	38’	34’5”	31’5”		69’5”	66’				
Gang—top diameter 6”+	53’	44’	35’	27’	18’		62’					

[a] Using imperial units, where ’ = feet and ” = inches.

Appendix II

Equipment Cost Summary

	Madill 044 swing yarder	Madill 075 log loader
OWNERSHIP COSTS		
Purchase price (P) ($)	1 000 000	1 350 000
Expected life (Y) (y)	10	10
Scheduled hours/year (h)	2 000	2 000
Expected life (H)	20 000	20 000
Salvage value as % of P (s) (%)	20	20
Insurance rate (Ins) (%)	1.5	1.5
Interest rate (Int) (%)	12	12
Salvage value (S) = (P•s/100) ($)	200 000	270 000
Average investment (AVI) = (P+S)/2 ($)	600 000	810 000
Loss in resale ((P-S)/H) ($/h)	40.00	54.00
Insurance cost (AVI•Ins/100)/h ($/h)	4.50	6.08
Interest cost (AVI•Int/100)/h ($/h)	36.00	48.60
Total ownership costs (OW) ($/h)	80.50	108.68
OPERATING AND REPAIR COSTS		
Wire rope cost (wc) ($)	11 000	5 000
Wire life (wh) (h)	1 000	1 000
Daily shift length (sl) (h)	10	10
Annual repair and maintenance (Ar) = (% of P) (%)	80	80
Fuel consumption (F) (L/h)	50	40
Fuel cost (fc) ($/L)	0.45	0.45
Lube and oil as % of fuel (fp) (%)	10	10
Wages (W) ($/h)	65.86 [a]	43.82 [b]
Wage benefit loading (WBL) (%)	35	35
Wire rope cost (wc/wh) ($/h)	11.00	5.00
Repair and maintenance (P•Ar/100/H) ($/h)	40.00	54.00
Fuel costs (F•fc) ($/h)	22.50	18.00
Lube and oil ((F•fc)•fp/100) ($/h)	2.25	1.80
Wages and benefits (W•(1+WBL/100)) ($/h)	88.91	59.16
Prorated overtime ((((W•1.5)-W)•(sl-8)•(1+WBL/100))/sl) ($/h)	8.89	5.92
Total operating and repair costs (OP) ($/h)	173.55	143.88
TOTAL OWNERSHIP AND OPERATING COSTS [c] (OW+OP) ($/h)	254.05	252.56

[a] Includes operator, hooktender, and rigging slinger.
[b] Includes operator and second loader.
[c] These costs are based on FERIC's standard costing methodology for determining machine ownership and operating costs. They do not include supervision, profit, nor overhead, and are not the actual costs incurred by the company studied.