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Using mechanized systems to harvest second-growth forests in coastal British Columbia: productivity and costs of a processing operation

Abstract

The Forest Engineering Research Institute of Canada (FERIC) monitored the processing phase of a clearcut harvesting operation on Vancouver Island. This report is part of FERIC's overall study on the operational and economic feasibility of using mechanized systems for clearcut harvesting of coastal second-growth stands on steep slopes. Two previous reports presented the results of the felling and extraction phases.

Keywords

Coastal British Columbia, Second-growth, Processing, Costs, Productivity.

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Introduction

As forest companies in coastal British Columbia harvest more second-growth stands, opportunities to use mechanized harvesting systems often arise. Feller-bunchers, processors, loader-forwarders, and skidders—if used appropriately—offer opportunities to reduce harvesting costs with acceptable site impacts. At the request of its members, FERIC has been investigating the use of this equipment in coastal second-growth stands.

In the spring of 2002, TimberWest Forest Corp.'s Cowichan Woodlands Operation and Honeymoon Bay Operation undertook a series of trials to investigate the feasibility of using mechanized systems for clearcut harvesting on steep slopes. FERIC monitored the trials to determine the operational and economic feasibility of these systems. Because of the scope of this study, the results are presented in several "Advantage" reports. Two previous reports presented the results for the mechanized felling and extraction

operations (Kosicki and Dyson 2003, 2004). This report presents the results for the processing phase.

Objectives

The primary goal of this study was to assess the economic and operational feasibility of using mechanized systems for clearcut harvesting on steep slopes. The objectives of this report on the processing phase were to:

- Determine overall productivities and costs for roadside processing.
- Evaluate processors as components of roadside harvesting systems.
- Compare results of hot and cold processing options.¹

¹ In a "hot processing" system, extraction and processing phases occur simultaneously, and the supply buffer between these phases is generally small. In a "cold processing" system, processing usually starts after the extraction phase has been completed, and the supply buffer between both phases is generally large.

Harvesting systems

An overview of harvesting systems and equipment used in this project is shown in Table 1. Both manual and mechanized felling with feller-bunchers were used. Depending on block layout and terrain, stems were extracted with loader-forwarders or swing yarders. At roadside, the stems were decked for hot or cold processing by dangle-head processors.

Description of sites and stands for processing operation

Processing operations were observed on three study blocks (Blocks B, C, and D). Descriptions of these blocks are given in Kosicki and Dyson (2003, 2004).

Study methods

FERIC observed the processing operation and collected shift-level and detailed-timing data. Shift-level data for the processing phase were collected in study blocks B, C, and D, and consisted of datalogger charts and operators' reports about daily production and major delays (>15 min/occurrence). Processing cycles were detail-timed at frequent intervals throughout the study period. In Block B, the detailed-timing study focused on cold processing of loader-forwarded stems, and in Blocks C and D on hot processing of grapple yarded stems. Net volumes were obtained from TimberWest's scale records. Hourly processor costs were calculated using FERIC's standard costing methods (Appendix I).

Table 1. Harvesting systems and equipment

Cutblock	A	B	C	D
Harvesting system	Clearcut, cold deck	Clearcut, cold deck	Clearcut, hot deck	Clearcut, cold and hot deck
Felling equipment	Madill T2200 feller-buncher with intermittent low-speed circular saw ^a	Tigercat 860 feller-buncher with high-speed circular saw ^a	Feller-buncher	Manual
Extraction equipment	Snorkel, loader-forwarders, swing yarder	Madill 144 yarder, uphill and downhill yarding ^a	Cypress 7280 yarder, uphill yarding ^a	Cypress 7280 yarder, downhill yarding ^a
		Madill 3800 loader-forwarder ^a	Loader-forwarders	
Processing equipment	Madill 3800 carrier with Waratah processing head	Madill 3800 carrier with Waratah processing head ^a	Madill 3800 carrier with Waratah processing head ^a	Madill 3800 carrier with Waratah processing head ^a

^a Monitored by FERIC in shift-level and detailed-timing studies (Kosicki and Dyson 2003, 2004).

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Results and discussion

Overview of processing operations

Processing operations in the study blocks were performed from mid-May to late July 2002. In all study blocks, roadside processing of loader-forwarded and/or grapple yarded stems was done with Waratah HTH624 processor heads (Figure 1) mounted on Madill 3800 carriers. Table 2 presents the technical specifications for these machines. Depending on block layout and decking conditions, cold and/or hot processing systems were used (Table 3). The processors were operated by TimberWest crews and scheduled to work five days per week on a double-shift (Blocks B and C) or single-shift basis (Block D).

Shift-level study

The shift-level study was based on shifts with complete records (scheduled and productive machine hours, volume processed, etc.). Shifts with incomplete records were excluded from evaluation.

In Block B, only cold processing of loader-forwarded and grapple yarded stems was done. The shift-level study was based on records for 26 productive shifts, or 197 h. Table 3 summarizes shift structure, productivity in cubic metres per productive machine hour (m^3/PMH) and scheduled machine hour (m^3/SMH), and cost in $\$/\text{m}^3$.

Shift lengths ranged from 6.3 to 8.3 h and averaged 7.6 h. For the monitoring period, availability and utilization were 94 and 88%, respectively. Almost all mechanical delays were caused by problems related to hydraulic components.

The total volume processed in Block B during the monitoring period was 9531 m^3 . For single shifts, the processing productivity of loader-forwarded stems varied from 45 to 79 m^3/PMH and averaged 56 m^3/PMH . Because of more difficult handling of grapple yarded stems decked below the road, processing of grapple yarded stems was less productive. For single shifts, it varied



Figure 1. Waratah HTH624 processing head.

Table 2. Technical specification for the Madill 3800 carrier and Waratah HTH624 processing head

Description	
Madill 3800 carrier	
Engine	Cummins 6CTA 8.3
Power (kW)	194 @ 2200 rpm
Max. boom reach (m)	11.8
Lift capacity at 9-m reach (kg)	8780
Track dimensions (m)	3.60 wide, 5.18 long
Travel speed (km/h)	up to 4.5
Mass (kg)	39 500
Waratah HTH624 processing head	
Maximum delimbing diameter (mm)	640
Maximum diameter saw cut (mm)	780
Mass (kg)	3 414
Measuring and control system	Logrite

from 47 to 65 m^3/PMH , and averaged 52 m^3/PMH . For a utilization rate of 88%, these average productivities translated into 49 and 46 m^3/SMH for the loader-forwarded and grapple yarded stems, respectively.

The overall processing productivity of loader-forwarded and grapple yarded stems in Block B was 55 m^3/PMH and 48 m^3/SMH , respectively. At an hourly machine rate of \$140.37/ SMH (Appendix I), the average cost of processing was \$2.92/ m^3 . Processing of loader-forwarded stems was slightly less expensive than processing of grapple yarded stems (\$2.86/ m^3 and \$3.05/ m^3 , respectively).

In Block C, because of limited decking area, only hot processing of uphill yarded stems was done (Figure 2). A small number of loader-forwarded stems from an adjacent

Table 3. Shift-level summary and productivity for the Madill 3800/ Waratah HTH624 processor in study blocks B, C, and D

Description	Block B	Block C	Block D
Extraction method	forwarding and yarding	grapple yarding	grapple yarding
Processing method	cold	hot	cold and hot
Productive shifts (no.)	26	9	7
Productive machine hours (PMH) (h)	173.0	62.7	45.0
Mechanical delays (MD) (h)	11.9	not available	5.0
Non-mechanical delays (NMD) (h)	11.9	not available	11.5
Total all delays	23.8	10.8	16.5
Scheduled machine hours (SMH) (h)	196.8	73.5	61.5
Average shift length (h)	7.6	8.2	8.8
Utilization (PMH/SMH) (%)	88	85	73
Availability [(SMH-MD)/SMH] (%)	94	not available	92
Stems (no.)	10 030	3 486	3 916
Total volume (m ³)	9 531	3 521	1 723
Average volume (m ³ /stem)	0.95	1.01	0.44
Productivity			
stems/PMH	58	56	87
stems/SMH	51	47	64
m ³ /PMH	55	56	38
m ³ /SMH	48	48	28
Hourly machine cost (\$/SMH)	140.37	140.37	140.37
Cost (\$/m ³)	2.92	2.92	5.01

Figure 2. Hot processing in Block C. Stems grapple yarded with a Cypress 7280 (in the background) were processed by a Waratah HTH624/Madill 3800 and decked for hot loading by a Madill 3800 loader (in the foreground).



area was cold processed during longer breaks in yarding activities (e.g., moving and repairing the yarder). All processed stems were decked for hot loading. The results for nine shifts with a full set of processing records are shown in Table 3.

Shift lengths ranged from 5.5 to 8.5 h and averaged 8.2 h. The total volume processed during the monitoring period was 3 521 m³. The overall processing productivity was 56 stems and 56 m³ per PMH. For a utilization rate of 85%, this translates into 47 stems and 48 m³ per SMH. Several

factors contributed to this relatively high processing productivity. The most important factor was a good balance between number of stems in yarded cycle loads and the processor's production capabilities. Yarded stems were processed immediately, usually before the next yarded load arrived at the roadside. This prevented accumulation of stems and facilitated grappling of the stems for processing. Another important factor was that the processed logs could be placed directly on the road for hot loading instead of being decked beside or below the road. A supply of cold decked stems nearby allowed the processor to continue working during yarder downtime and maintain high overall productivity. A final contributing factor was the large volume of 1.01 m³/stem. For an hourly rate of \$140.37/SMH (Appendix I), the processing cost in Block C was \$2.92/m³.

In Block D, the stems were grapple yarded downhill and decked. The majority of the stems was cold processed and only a small number of stems was hot processed.

The results for seven shifts are shown in Table 3. The total volume processed during these shifts was 1 723 m³. The processor achieved very high productivity in numbers of stems per hour (87 stems/PMH and 64 stems/SMH), but because of a very low average volume of 0.44 m³/stem, the average processing productivity of 38 m³/PMH (28 m³/SMH) was well below productivities achieved in Blocks B and C. For an hourly machine rate of \$140.37/SMH (Appendix I), the processing cost was \$5.01/m³.

Detailed-timing study

The detailed timing was performed on cold processing of loader-forwarded stems in Block B, and on hot processing of grapple yarded stems in Blocks C and D. The results of these studies are summarized in Table 4.

The lowest average processing time (0.79 min/stem) and the highest productivity (72 m³/PMH) were recorded in Block B. This high productivity can be attributed to the cold processing of loader-forwarded stems piled in long decks easily accessible to the processor. The productivity of 72 m³/PMH agreed well with the average

shift-level productivities of 69 m³/PMH determined for shifts on which the detailed timing was conducted.

In Block C, the average processing time of 1.04 min/stem included 0.16 min of interaction time between the swing yarder and processor. For an average volume of 1.01 m³/stem, the processing productivity of 58 m³/PMH in this detailed-timing study was almost identical with the productivity of 56 m³/PMH in the shift-level study (Table 2).

In Block D, the average processing time was 1.16 min/stem. For an average volume of 0.44 m³/stem, the productivity of hot processing was 21 m³/PMH. This productivity was much less than the average productivity of 38 m³/PMH based on the shift-level study that was done primarily in a cold processing system.

Conclusions

The results of the processing study suggest that a Waratah HTH624 dangle head processor on a Madill 3800 carrier is a suitable processing combination for roadside harvesting in second-growth forests in coastal

Table 4. Summary of detailed timing for the Madill 3800/ Waratah HTH624 processor in Blocks B, C and D

Description	Block B	Block C	Block D
Extraction method	forwarding	yarding	yarding
Processing system	cold	hot	hot
Productive time (min)	745	539	329
Productive machine hours (PMH)	12.4	9.0	5.5
Total cycles (no.)	940	317	284
Average cycle time (min)	0.79	1.04	1.16
Distribution of cycle time (%)			
Processing	81	74	80
Delays	7	11	15
Interaction with yarder	0	15	5
Other	12	0	0
Total stems (no.)	940	517	261
Average volume (m ³ /stem)	0.95	1.01	0.44
Logs produced (no.)	1 830	828	313
Logs per stem (no.)	1.9	1.6	1.2
Total volume (m ³)	893	522	115
Productivity			
stems/PMH	76	57	47
m ³ /PMH	72	58	21

British Columbia. This combination can effectively process loader-forwarded and grapple yarded stems in both cold and hot processing systems.

The greatest processing productivity may be expected when processing loader-forwarded stems decked in continuous windrows with an easy access from the road and sufficient room for decking processed logs. For the working conditions observed in Block B, this yielded productivities of 56 m³/PMH. For cold processing of grapple yarded stems, processing productivity was less, averaging 52 m³/PMH. For processing of loader-forwarded and grapple yarded stems, the average productivity was 48 m³/SMH at a cost of \$2.92/m³.

In Block C, where a hot processing system was used for grapple-yarded stems, the processing productivity was 48 m³/SMH at a cost of \$2.92/m³. These results are identical to those for the cold processing system in Block B, and suggest that the hot processing system can be efficient even if unavoidable delays result from interaction between the yarder and processor.

The lowest average productivity of 28 m³/SMH for hot and cold processing combined was recorded in Block D. Although the processing productivity in number of stems per scheduled machine hour was the highest in the three study blocks, the small average volume of 0.44 m³/stem means the hourly productivity was 28 m³/SMH. At an hourly machine cost of \$140.37/SMH (Appendix I), the processing cost in Block D was \$5.01/m³.

Implementation

During the observed processing operation, FERIC identified conditions for successful and effective use of the Waratah HTH624 processor head on the Madill 3800 carrier:

- If the haul road system and terrain permit unobstructed and safe decking of loader-forwarded and/or grapple yarded stems, a cold processing system is advantageous. It will eliminate interaction between the extraction and processing phases and will allow all machines to maximize their productivities.
- Hot processing of grapple yarded stems is operationally feasible and, under certain conditions, may be highly productive. However, because yarding productivity varies with distance and other factors while processing productivity is relatively stable, production losses in processing are unavoidable and hot processing systems should be used only when necessary (e.g., limited decking area for yarded stems, safety requirements, need to minimize the duration of the total harvesting time).
- If a hot processing system is used, try to minimize potential production losses in the processing phase by having a supply of cold-decked stems nearby for the processor to work on if the yarder is idle.

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Appendix I

Machine costs, \$/scheduled machine hour (SMH) ^a

	Madill 3800 carrier	Waratah HTH624 processing head
OWNERSHIP COSTS		
Total purchase price (P) \$	550 000	250 000
Expected life (Y) y	5	5
Expected life (H) h	20 000	20 000
Scheduled hours/year (h) = (H/Y) h	4 000	4 000
Salvage value as % of P (s) %	30	30
Interest rate (Int) %	5.0	5.0
Insurance rate (Ins) %	2.0	2.0
Salvage value (S) = ((P • s)/100) \$	165 000	75 000
Average investment (AVI) = ((P + S)/2) \$	357 500	162 500
Loss in resale value ((P-S)/H) \$/h	19.25	8.75
Interest ((Int • AVI)/h) \$/h	4.47	2.03
Insurance ((Ins • AVI)/h) \$/h	1.79	0.81
Total ownership costs (OW) \$/h	25.51	11.59
OPERATING COSTS		
Fuel consumption (F) L/h	40.0	-
Fuel (fc) \$/L	0.75	-
Lube & oil as % of fuel (fp) %	10	-
Track & undercarriage replacement (Tc) \$	30 000	-
Track & undercarriage life (Th) h	29 000	-
Annual operating supplies (Oc) \$	5 000	1 000
Annual repair & maintenance (Rp) \$	82 000	40 000
Shift length (sl) h	8.5	-
Total wages (W) \$/h	26.80	-
Wage benefit loading (WBL) %	35	-
Fuel (F • fc) \$/h	30.00	-
Lube & oil ((fp/100) • (F • fc)) \$/h	3.00	-
Track & undercarriage (Tc/Th) \$/h	1.03	-
Operating supplies (Oc/h) \$/h	1.25	0.25
Repair & maintenance (Rp/h) \$/h	20.50	10.00
Wages & benefits (W • (1 + WBL/100)) \$/h	36.18	-
Prorated overtime (((1.5 • W - W) • (sl - 8) • (1 + WBL/100))/sl) \$/h	1.06	-
Total operating costs (OP) \$/SMH	93.02	10.25
TOTAL OWNERSHIP AND OPERATING COSTS (OW + OP) \$/SMH	118.53	21.84

^a The costs used in the study are not the actual costs incurred by the company or contractor, and do not include indirect costs such as crew and machine transportation, overhead, profit, and risk.