Advantage

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Contents

Author
Mihai Pavel,
Western Division

Implementing new forest management principles in coastal British Columbia: case study 4

Abstract

The Forest Engineering Research Institute of Canada (FERIC) is conducting a series of case studies in coastal British Columbia of applications of new forestry principles that incorporate ecosystem-based management in a variety of site and stand conditions, retention levels, and harvesting systems. This report is the fourth in the series, and discusses retaining tree patches and individual trees in an old-growth stand that was manually felled and where log extraction was performed mainly with cable systems.

Keywords

Ecosystem-based management, Harvesting, Forest management, Productivity, Costs, Coastal British Columbia.

Introduction

Forest companies in British Columbia began implementing new forest management systems in the 1990s to better conserve biological diversity and ecosystem functions in managed forests (Hopwood 1991). Although different terminology was adopted among the various forest companies to describe the application of this new approach, "ecosystem-based management" is a widely used and generally accepted name for the new paradigm in forest management. A definition of ecosystem-based management tailored to the specifics of coastal British Columbia is "…an adaptive approach to managing human activities that seeks to ensure the coexistence of healthy, fully functioning ecosystems and human communities. The intent of this approach is to maintain those spatial and temporal characteristics of ecosystems such that component species and ecological processes can be sustained, and human wellbeing supported and improved" (Coast Information Team 2004a). The scientific basis of ecosystem-based management and a detailed description of its framework, purpose, and guiding principles are presented in Coast Information Team (2004a, c).

To provide its members with information on the operational challenges of implementing the new forest management principles specific to ecosystem-based management, FERIC is conducting case studies to document the application of this system at the cutblock level in a variety of site and stand conditions, retention levels, and harvesting systems. This study is the fourth in a series documenting the application of ecosystem-based management. It was conducted in an old-growth stand on northern Vancouver Island, in collaboration with Canadian Forest Products Ltd. (Canfor). The prescription for the study site called for retaining tree patches and a few individual trees. The cutblock was manually felled and log extraction was performed mainly using cable systems.

Objectives

The goal of this study was to assess the economic and operational feasibility of the harvesting methods used, in the context of stand-level objectives associated with ecosystem-based management. FERIC's objectives were to:

- Determine overall productivities and costs for all phases of the operation.
- Assess the impact of the retention level and pattern of dispersion of leave trees on the harvesting phases, and recommend improvements where appropriate.
- Assess site and residual stand conditions after harvesting.

Site and stand description

The study site is located approximately 7 km southeast of Woss, B.C., about halfway between the Nimpkish and Davie rivers. The cutblock is situated on private and Crown land within Tree Farm License 37. Ecologically, the area is within the montane very wet maritime Coastal Western Hemlock variant (CWHvm2) (Green and Klinka 1994). The logging map of the cutblock is presented in Figure 1.

Site topography is steep and broken, with slopes ranging from flat to 65% and averaging 55%. Soils are mainly fine textured, with a thin organic layer and occasional bedrock outcrops. The silviculture prescription identified the following soil hazard

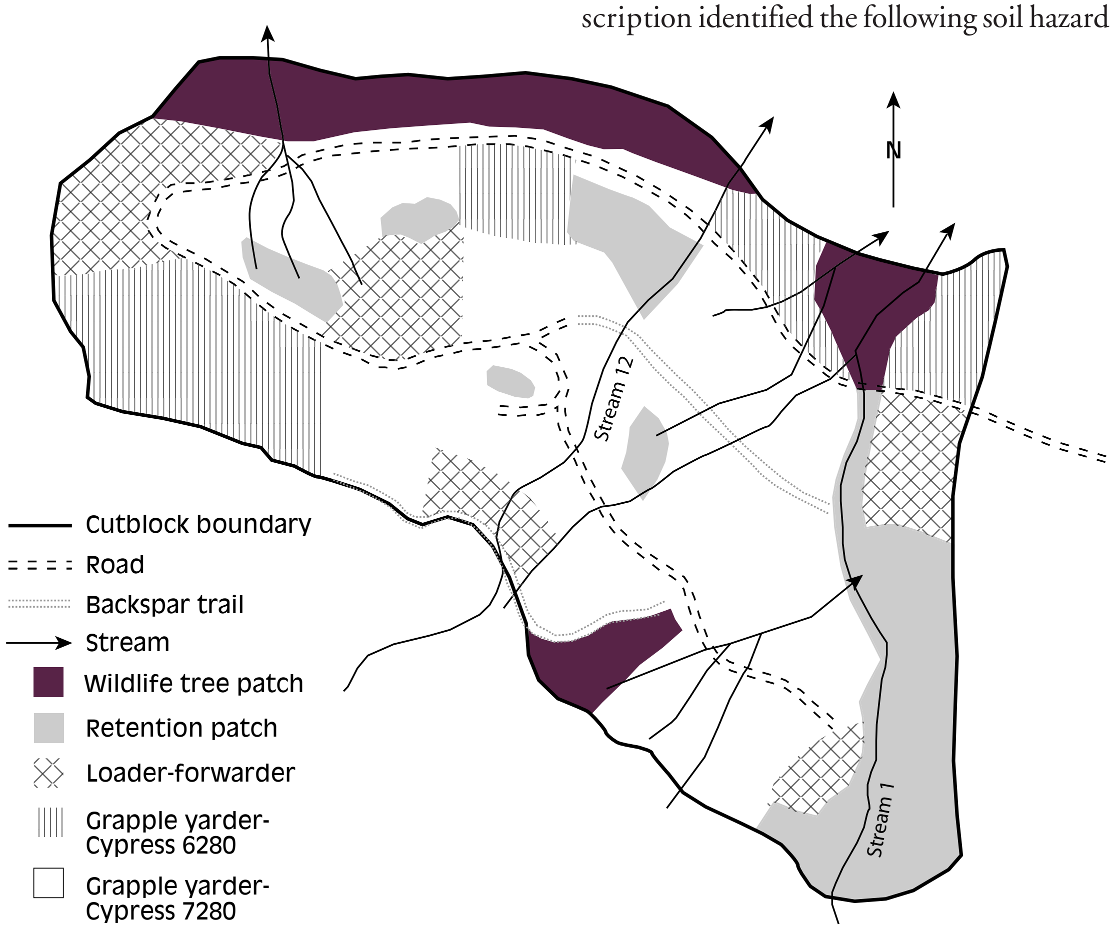

Figure 1. Logging map of the cutblock.

Forest Engineering Research Institute of Canada (FERIC)

Find us Online! www.feric.ca

Eastern Division and Head Office
580 boul. St-Jean
Pointe-Claire, QC, H9R 3J9
(514) 694-1140
(514) 694-4351
admin@mtl.feric.ca

Western Division
2601 East Mall
Vancouver, BC, V6T 1Z4
(604) 228-1555
(604) 228-0999
admin@vcr.feric.ca

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ratings: high for compaction and soil displacement, and very high for surface erosion. All streams identified within the cutblock are Class 6, except for Stream 1 (Figure 1) which is Class 5.[1] There are also numerous non-classified drainages within the cutblock.

The main site and stand characteristics are presented in Table 1. The stand was a typical coastal old-growth forest with a wide range of stem diameters and heights. It consisted primarily of western hemlock, yellow cedar, amabilis fir, and western red cedar, with scattered Douglas-fir and mountain hemlock.

Silviculture prescription

Canfor's Environment Policy commits the company to "practice forest management that recognizes ecological processes and diversity and supports integrated use of the forest" (Deal 2000). Canfor's coastal implementation plan for ecosystem-based management addresses natural disturbance processes, spatial and temporal landscape-level biodiversity, stand-level biodiversity, species-specific management, timber sustainability, and restoration. In the study block, prescribed retention consisted of three wildlife tree patches (WTPs) adjacent to the block with a total area of 5.1 ha, six retention patches (one adjacent to the block and five within the harvest area) with a total area of 6.3 ha, and nine individual trees distributed in the central part of the harvest area, between the retention patches (Figure 1). The silvicultural system applied in the block was the retention system. As the cutblock is located in a known scenic area, its Visual Quality Objective (VQO) is partial retention.

[1] The Fish-stream Identification Guidebook of the Forest Practices Code of BC (BC Ministry of Forests and BC Environment 1998) describes both Class 5 and Class 6 streams as non-fish streams. Class 5 streams have an average slope gradient of less than 20%, and Class 6 streams have an average slope gradient of more than 20%.

Table 1. Site and stand description

Site characteristics	
Elevation range (m)	600–850
Slope (%)	
Range	0–65
Average	55
Block area (ha)	
Retention patches	6.3
Wildlife tree patches (WTP)	5.1
Road right-of-way	6.1
Harvest area	28.4
Total	45.9
Maximum yarding distance (m)	200
Stand characteristics [a]	
Species composition (by volume)	53% western hemlock, 22% yellow cedar, 21% amabilis fir, 4% western red cedar
Net merchantable volume (m^3/ha)	764
Stand density (merchantable stems/ha)	291
Average net merchantable volume (m^3/tree)	2.62
Average dbh of live and dead potential trees (cm)	58.3
Average tree height (m)	40.1

[a] Based on cruise data supplied by Canfor.

The Silviculture Prescription specifies that the purpose of all WTPs is to provide a representative sample of the original stand to meet the legal requirements (BC Ministry of Forests and BC Environment 1995) for stand-level biodiversity and to contribute to Canfor's ecosystem management targets. The trees left standing in patches or as individual trees provide additional stand-level forest influence and act as a source of habitat, structure, and diversity within the regenerating stand. They also will represent a legacy of the harvested stand, and mitigate the visual impact of the cutblock. Leave trees and the boundaries of patches were marked. In addition to these retention features, seven bear dens were identified in the block (five in the northern WTP and two within the main harvest area) and were marked and protected.

Class 6 streams existing in the study site had narrow and shallow channels, low stream banks, and low debris transport potential. For the majority of these streams as well as for the non-classified drainages, falling and yarding across were acceptable, and no stream cleaning was planned. The only exception was Stream 12 (Figure 1), where the prescription allowed removal of only those stems that could be lifted without damage to the channel or the bank, and any unstable accumulations of introduced logging debris had to be cleaned. The Class 5 stream (Stream 1) was located within a WTP and no measures to protect the stream banks and debris management were required.

Figure 2. Cypress 7280 yarder and mobile backspar working in the upper (southern) part of the block.

Harvesting system and equipment

Douglas-fir poles were selectively harvested in the late fall of 2002, prior to the conventional harvest. In the main harvest area, trees were manually felled, delimbed, and topped at the stump. Bucking was performed whenever operational and safety conditions allowed it. High-value trees (especially yellow cedar) were marked to be protected during extraction.

Logs in the proximity of the road were extracted by two Madill 075 super snorkels equipped with 20-m booms. The snorkels decked most logs parallel to the road, but where the site permitted, logs were decked perpendicular to the road. In flat areas, logs were loader-forwarded (Figure 1) to the roadside by a Komatsu PC 300 HD hydraulic log loader. The loader-forwarder moved the logs in swaths and travelled on a rubber mat made of used tires. The machine also built backspar trails and was used to forward logs to the yarders in low-deflection areas.

The majority of wood extraction was performed by Cypress 7280 and Cypress 6280 swing yarders equipped with grapples. The 7280 yarder used a mobile backspar for approximately one-half of its yarding time (Figure 2), and the 6280 yarder used a mobile backspar for about one-third of its yarding time. For the rest of the time, the yarders were stump-rigged. Both machines performed uphill and downhill yarding, and decked wood parallel to the road in steeper areas, or perpendicular to the road where the site permitted.

Log decks produced by yarders were steep and extended relatively far up the hill, especially on steep terrain. To assist with deck clearing, a Cypress 7675 line loader was brought on site and a landing man (or "second loader") assisted this machine. The line loader helped reduce the dimensions of the decks, assisted with log manufacturing (i.e., laid logs on the road to be processed by the landing man), and loaded trucks (Figure 3). As log manufacturing was labour intensive, the landing man for the yarder also assisted with this work. The line loader continued after yarding was finished to reduce the large log decks, until all logs were within the reach of a hydraulic loader. Loading was completed by a Madill 3800 B hydraulic log loader. The landing man for this loader also performed some log manufacturing at the roadside.

Logs were hauled by off-highway trucks 9 km to the nearest reload station.

Figure 3. Cypress 6280 yarder and line loader working in the lower (northern) side of the block.

Study methods

Shift-level data were collected consisting of Servis recorder charts, daily report forms, and operator time cards. Data were summarized to develop machine and phase productivity and cost. Volumes were obtained from company records. FERIC also conducted detailed timing to gain insight into various phases of the logging process for a subsequent comparison with other study sites. Stand and site conditions at the end of the harvesting operation were assessed visually. Machine costs were calculated using FERIC's standard costing methodology (Appendix I) and do not reflect the actual cost of the equipment or operation.

Figure 4. View of the residual stand – group retention.

Results and discussion

The total volume extracted from the block was 21 592 m^3, consisting of 17 654 m^3 in the harvest area, 3 829 m^3 of right-of-way, and 109 m^3 of poles. Figures 4 and 5 illustrate the area after harvesting was completed.

Figure 5. View of the residual stand – dispersed retention.

Estimated machine productivities and costs are presented in Table 2. The volumes harvested by each machine could not be determined accurately, and some logs were handled by more than one machine, so the machine productivities presented here should be considered only as approximate.

Leave patches and individual leave trees were dispersed at relatively large distances and did not pose difficulties for manual fallers. Falling productivity was 93.0 m^3/6.5-h shift at a cost of \$3.90/m^3. The super snorkels were an important component of the harvesting system in this block, as they created favourable conditions for subsequent grapple yarding. The two snorkels were identical machines and worked in a similar pattern. Both machines spent considerable portions of their operating time decking logs and moving along the road. Separation of wood moved by each machine was not possible, so the data for this phase were pooled. The combined productivity of the snorkels was 38.3 m^3 per productive machine hour (PMH), at a cost of \$7.59/m^3. The loader-forwarder extracted approximately 1 200 m^3 to the roadside. The productivity

Table 2. Harvesting productivity and cost

Machine	Shifts (no.)	Average shift length (h)	Scheduled machine hours (SMH)	Productive machine hours (PMH)	Utilization (%)	Volume harvested (m^3)	Productivity (m^3/SMH)	Productivity (m^3/PMH)	Cost $/SMH	Cost $/$m^3$
Falling [a]	190	6.5	1235	852	69	17 654	14.3	20.7	55.79	3.90
Extraction										
Super snorkel [b]	16	8.4	134	107	80	4 100	30.6	38.3	232.11	7.59
Loader-forwarder [c]	3	8.6	26	23	88	1 200	46.2	52.2	150.40	3.26
Loader-forwarder [d]	4	8.6	34	30	88	-	-	-	150.40	4.26
Yarder - Cypress 7280 [e]	34	8.1	274	233	85	6 728	24.6	28.9	363.17	14.79
Yarder - Cypress 6280 [f]	34	8.1	274	211	77	5 626	20.5	26.7	304.19	14.81
Loading										
Line loader	43	8.6	371	330	89	9 462	25.5	28.7	248.62	9.94
Hydraulic loader	18	8.3	149	98	66	8 192	55.0	83.6	193.80	3.52
Total [g]	-	-	-	-	-	-	-	-	-	23.49

[a] Falling includes delimbing and limited bucking. Utilization was determined based on time cards and limited observations in the field. Manual falling wages are based on the 2004–2007 IWA Coast Master Agreement, and include 38% wage benefit loading.
[b] Data were pooled for the two machines.
[c] Includes time spent by loader-forwarder to move wood to the roadside.
[d] Includes time spent to forward wood to the grapple yarders and to build backspar trails. Costs are applied against the volume moved by the machine to the roadside.
[e] Includes costs for a mobile backspar used for approximately one-half of its operating time.
[f] Includes costs for a mobile backspar used for approximately one-third of its operating time.
[g] For extraction and loading, the costs were weighted by the volume handled by each machine.

achieved (based only on volume moved to the roadside) was 52.2 m^3/PMH, and the cost was \$3.26/m^3. The loader-forwarder was also used to move wood to within reach of the grapple yarders in areas of poor deflection and to build backspar trails. The costs associated with these activities were also included in the total cost of the operation (Table 2).

The two swing yarders harvested the majority of the cutblock volume. The Cypress 7280 yarder used a mobile backspar more than the 6280. It also worked in areas with shorter yarding distances, and yarded wood forwarded and aligned by the loader-forwarder. However, this yarder spent more time rigging, and sometimes also had to make long moves within the cutblock. Overall, the 7280 achieved a productivity of 28.9 m^3/PMH and a cost of \$14.79/m^3.

The Cypress 6280 yarder worked mostly in areas with longer yarding distances. While this resulted in less time spent on rigging, occasionally cycle times were longer because of poor visibility at the back ends of the yarding roads. The 6280 achieved a productivity of 26.7 m^3/PMH and a cost of \$14.81/m^3.

For both yarders, road change times ranged from 10 minutes, when the guylines were slacked and the machine repositioned a few metres, to about 1.5 hours, when the yarder had to move long distances and rig again at the new position.

Apart from usual mechanical and organizational delays encountered in this type of operation, productivity of both yarders was affected by the terrain, as the machines spent considerable time decking the logs in steep areas. Weather conditions also adversely affected productivity; on occasion, fog prevented the equipment from working and productivity was reduced when snow was present on logs. Finally, poor visibility at the end of yarding roads also affected yarding productivity.

The line loader was well suited to this harvesting operation, particularly when the log decks created by the grapple yarders were very high and extended far uphill beyond the reach of the hydraulic log loader. The line loader achieved a productivity of 28.7 m^3/PMH at a cost of \$9.94/m^3. The productivity of the hydraulic loader was not affected by the prescription applied in this block, but the machine was occasionally idle when there were no trucks to load. The hydraulic loader achieved a productivity of 83.6 m^3/PMH and the cost of loading was \$3.52/m^3.

The total cost of the falling and extraction phases (weighted by the volume handled by each machine in different phases) was \$23.49/m^3. Field layout took an additional 10 person-days of work, compared to a clearcut, to select and delimit the retention patches and individual trees. The incremental cost of field layout was estimated at \$0.13/m^3.[2]

Minimal soil disturbance was observed in the block after harvesting was completed. A total of 14 trees sustained visible damage, either through bark removal or shallow gouging; these were single trees or trees on the margins of the retention patches. Damage to residual trees occurred when they were hit by other trees during falling or during extraction. No blowdown was observed in the cutblock within the first few months after logging was completed.

As visual quality was important for this site, a view of the block from the highway is presented in Figure 6. The VQO for this cutblock was met with the existing harvest layout.

An indirect comparison with other FERIC studies suggests that productivities and costs achieved in this study are similar to those achieved in clearcuts performed in similar conditions (Araki 1994; Forrester 1995; Pavel 1998).

Summary and conclusions

This study focused on quantifying the operational effects of an ecosystem management prescription on harvesting costs and productivities within an old-growth stand on northern Vancouver Island. In the study block, prescribed retention consisted of three WTPs with a total area of 5.1 ha, six retention patches with a total area of 6.3 ha, and nine individual trees.

Trees in the block were manually felled and delimbed, and limited bucking was performed at the stump where it was safe to do so. Log extraction was performed with two super snorkels, a loader-forwarder, and two swing yarders equipped with grapples. Loading was performed by a hydraulic loader and a line loader, which also assisted in the yarding phase. Productivities achieved by individual machines in this study block were estimated because the precise volume that was handled by each machine could not be determined, and sometimes the same wood was handled by more than one machine. The total cost of the harvesting phases was \$23.49/m^3 (on the truck). Field layout took 10 person-days more than for a clearcut, at an added cost of \$0.13/m^3.

Results indicate that the prescription had relatively little impact on the cost of the operation, as compared to a clearcut.

Figure 6. View of the block from the highway.

2 Engineering costs are based on 10 person-days of an Engineering Crewman IV. The wages are based on the 2004–2007 IWA Coast Master Agreement, and include 38% wage benefit loading.

Implementation

Based on the findings of this study, the following recommendations should be considered to increase the overall efficiency and success of the harvesting phases of ecosystem-based management operations:

- Effective engineering (layout and load path analysis) is critical to ensure good yarding performance with cable systems. Utilization of mobile backspars and good selection and delineation of backspar trails can significantly reduce rigging time and increase productivity.
- The profitability of the operation could be enhanced by marking the very high value logs to ensure careful extraction.
- Utilization of super snorkels is very helpful in steep terrain as they create good conditions for subsequent yarding.
- When yarding in steep terrain and with little room to deck logs, a long-boom line loader can reduce the size of decks and, if necessary, assist with log manufacturing. Hauling may need to be done concurrent with yarding, as decking space is often very limited.

Recommendations for emulating natural disturbance patterns for various natural disturbance types are presented in the Biodiversity guidebook of the Forest Practices Code of BC (BC Ministry of Forests and BC Environment 1995) and other publications (Harvey et al. 2003; Coast Information Team 2004b). Other recommendations for implementation of ecosystem-based management, especially for the planning and layout phase, are presented in the previous three reports in this series (Pavel 2004a, b, c). Failing and Gregory (2003) present the most common mistakes when using forest biodiversity indicators to make forest management decisions, and refer to the specific conditions in British Columbia. Evaluations of the esthetical value of retention trees, through their volume, physical appearance, and location, are presented in BC Ministry of Forests (1997, 2002) and Tönnes et al. (2004). Zeide (2001) presents a critique of ecosystem-based management as a new forest management paradigm.

Given the complexity of natural systems, new tools termed "environmental decision support systems (EDSS)" are being developed to assist in implementation of complex prescriptions. Nute et al. (2004) review the state of the art in this domain and describe a system and general framework for implementing ecosystem-based management. The authors acknowledge the complexity of the problem and note that any forest management application needs to incorporate ecological, social, and legal conditions specific to each region. Apart from these, practical applications prove that experience and common sense are particularly important when designing ecosystem-based management prescriptions. However, both experience and common sense are traditionally known to be extremely difficult to incorporate in any decision support system (Feigenbaum 1979).

Ecosystem management is still in its early stages of application, so it is important that each block be considered as an experiment, and the experience gained at each site be used to refine prescriptions and techniques for future blocks. The concept of adaptive management (i.e., refining future prescriptions based on existing experience) and assessment of landscape level implications are important as the forest industry learns to implement these new techniques.

FERIC continues to monitor other harvesting trials implementing new forest management principles, to present its members with current information on the prescriptions, operating practices, and harvesting productivities and costs of these new approaches.

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Appendix I

Machine costs

	Swing yarder with grapple (70–75 tonne) (3-man crew)	Swing yarder with grapple (55–60 tonne) (3-man crew)	Super snorkel (70–75 tonne)	Cable loader (70–75 tonne) (2-man crew)
OWNERSHIP COSTS				
Total purchase price (P) $	1 450 000	1 000 000	1 200 000	1 100 000
Expected life (Y) y	12	12	12	12
Expected life (H) h	17 280	17 280	17 280	17 280
Scheduled hours/year (h)=(H/Y) h	1 440	1 440	1 440	1 440
Salvage value as % of P (s) %	30	30	30	30
Interest rate (Int) %	6.0	6.0	6.0	6.0
Insurance rate (Ins) %	3.0	3.0	3.0	3.0
Salvage value (S)=((P•s)/100) $	435 000	300 000	360 000	330 000
Average investment (AVI)=((P+S)/2) $	942 500	650 000	780 000	715 000
Loss in resale value ((P-S)/H) $/h	58.74	40.51	48.61	44.56
Interest ((Int•AVI)/h) $/h	39.27	27.08	32.50	29.79
Insurance ((Ins•AVI)/h) $/h	19.64	13.54	16.25	14.90
Total ownership costs (OW) $/h	117.64	81.13	97.36	89.25
OPERATING COSTS				
Wire rope (wc) $	32 000	30 000	9 000	7 000
Wire rope life (wh) h	1 440	1 440	1 440	1 440
Rigging & radio (rc) $	12 500	12 500	0	12 500
Rigging & radio life (rh) h	5 760	5 760	0	5 760
Fuel consumption (F) L/h	50.0	50.0	40.0	40.0
Fuel (fc) [a] $/L	0.54	0.54	0.54	0.54
Lube & oil as % of fuel (fp) %	10	10	10	10
Track & undercarriage replacement (Tc) $	72 500	50 000	60 000	55 000
Track & undercarriage life [b] (Th) h	8 640	8 640	8 640	8 640
Annual operating supplies (Oc) $	10 000	10 000	0	0
Annual repair & maintenance (Rp) $	95 000	70 000	90 000	85 000
Shift length (sl) h	8.0	8.0	8.0	8.0
Wages [c] $/h				
Operator	27.34	27.34	28.09	27.34
Labourer No. 1	26.62	26.62	0.00	24.28
Labourer No. 2	23.62	23.62	0.00	0.00
Total wages (W) $/h	77.58	77.58	28.09	51.62
Wage benefit loading (WBL) %	38	38	38	38
Wire rope (wc/wh) $/h	22.22	20.83	6.25	4.86
Rigging & radio (rc/rh) $/h	2.17	2.17	0.00	2.17
Fuel (F•fc) $/h	27.00	27.00	21.60	21.60
Lube & oil ((fp/100)•(F•fc)) $/h	2.70	2.70	2.16	2.16
Track & undercarriage (Tc/H) $/h	4.20	2.89	3.47	3.18
Operating supplies (Oc/h) $/h	6.94	6.94	0.00	0.00
Repair & maintenance (Rp/h) $/h	65.97	48.61	62.50	59.03
Wages & benefits (W•(1+WBL/100)) $/h	107.06	107.06	38.76	71.24
Total operating costs (OP) $/h	238.27	218.21	134.75	164.24
TOTAL OWNERSHIP AND OPERATING COSTS (OW+OP) $/h	355.91	299.35	232.11	253.49

[a] Diesel fuel unit price as per a quote from Freight Carriers Association of Canada for August 2004.
[b] Assumes tracks are only replaced once over the life of the machine, except for the backspar.
[c] Wage rates are as per 2004 rates outlined in the current IWA Coast Master Agreement.

Appendix I – continued

	Hydraulic loader (40–45 tonne) (2-man crew)	Hydraulic loader (35–40 tonne)	Used mobile backspar
OWNERSHIP COSTS			
Total purchase price (P) $	585 000	535 000	30 000
Expected life (Y) y	6	6	5
Expected life (H) h	10 800	10 800	7 200
Scheduled hours/year (h)=(H/Y) h	1 800	1 800	1 440
Salvage value as % of P (s) %	25	25	0
Interest rate (Int) %	6.0	6.0	6.0
Insurance rate (Ins) %	3.0	3.0	3.0
Salvage value (S)=((P•s/100) $	146 250	133 750	0
Average investment (AVI)=((P+S)/2) $	365 625	334 375	15 000
Loss in resale value ((P-S)/H) $/h	40.63	37.15	4.17
Interest ((Int•AVI)/h) $/h	12.19	11.15	0.63
Insurance ((Ins•AVI)/h) $/h	6.09	5.57	0.31
Total ownership costs (OW) $/h	58.91	53.87	5.10
OPERATING COSTS			
Fuel consumption (F) L/h	30.0	30.0	10.0
Fuel (fc) [a] $/L	0.54	0.54	0.54
Lube & oil as % of fuel (fp) %	10	10	10
Track & undercarriage replacement (Tc) $	48 500	38 000	0
Track & undercarriage life [b] (Th) h	5 400	5 400	0
Annual repair & maintenance (Rp) $	78 000	71 000	5 000
Shift length (sl) h	8.0	8.0	8.0
Wages [c] $/h			
Operator	25.90	25.90	0.00
Labourer No. 1	24.28	0.00	0.00
Total wages (W) $/h	50.18	25.90	0.00
Wage benefit loading (WBL) %	38	38	0
Fuel (F•fc) $/h	16.20	16.20	5.40
Lube & oil ((fp/100)•(F•fc)) $/h	1.62	1.62	0.54
Track & undercarriage (Tc/H) $/h	4.49	3.52	0.00
Repair & maintenance (Rp/h) $/h	43.33	39.44	3.47
Wages & benefits (W•(1+WBL/100)) $/h	69.25	35.74	0.00
Total operating costs (OP) $/h	134.89	96.52	9.41
TOTAL OWNERSHIP AND OPERATING COSTS (OW+OP) $/h	193.80	150.40	14.52

[a] Diesel fuel unit price as per a quote from Freight Carriers Association of Canada for August 2004.
[b] Assumes tracks are only replaced once over the life of the machine, except for the backspar.
[c] Wage rates are per 2004 rates outlined in the current IWA Coast Master Agreement.