WOOD HARVESTING

Technical Note TN-216 October 1994

# SHELTERWOOD HARVESTING IN COASTAL SECOND-GROWTH DOUGLAS-FIR

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## Abstract

A shelterwood harvest in a Coastal second-growth Douglas-fir stand in Southwestern British Columbia was completed in late 1993 using a Cypress 6280B swing yarder, rigged with a running skyline system. The Forest Engineering Research Institute of Canada (FERIC) monitored and filmed the harvesting activities to evaluate and document productivities and costs of the harvesting phases, and to describe influencing factors. The British Columbia Ministry of Forests will study vegetation, hydrology, wildlife, windthrow, and coarse woody debris as part of the trial.

## Introduction

Increasingly, clearcut harvesting methods are being challenged by the public for their impact on aesthetics, wildlife habitat, and other resource values. To gain more knowledge about the effects of partial cutting on timber and non-timber resources in the Coastal second-growth Douglas-fir stands of Southwestern British Columbia, Vancouver Forest Region (Forest Sciences Section) and the Sunshine Coast Forest District of the British Columbia Ministry of Forests (BCMOF), proposed to study shelterwood and extended rotation treatments in such stands, and to compare these treatments with clearcut and unharvested controls. Studies of vegetation (crop and non-crop), hydrology, wildlife, and coarse woody debris were to be conducted as part of the program.

A shelterwood trial was planned as a pilot study and demonstration site; harvesting was done in late 1993. At the request of the BCMOF, the Forest Engineering Research Institute of Canada (FERIC) monitored and filmed the harvesting activities. This report summarizes the results of both the FERIC productivity study and the BCMOF post-harvest residual tree and site disturbance surveys, while the video documents the harvesting activities.[1] The video has a broad audience focus, and was funded by the BCMOF's Alternative Silvicultural Systems Research Program. FERIC's study was supported in part by the Forestry Practices Component of the Canadian Forest Service's Green Plan.

## Objectives

The overall objective of the demonstration harvest was to gain research and operational experience with partial cutting, using conventional cable-yarding equipment, in a Coastal second-growth stand. FERIC's particular objective was to evaluate the operational aspects of the harvest, to determine the productivity and cost of the harvesting phases, and to describe the influencing factors. The BCMOF studies addressed aspects of soil microclimate, forest floor dynamics and nutrient release, understory light conditions, overstory mensuration, vegetation development, coarse woody debris dynamics, seedfall, regeneration, hydrology, and forest health. And, since the development of the demonstration block working plan, the BCMOF added a study of wind effects on residual trees. The BCMOF will be reporting on its components as the results are obtained.

[1] A video, entitled "Shelterwood Harvesting in a Coastal Second-Growth Forest, April 1994", is available from BCMOF, Vancouver Forest Region, Forest Sciences Section, or from FERIC's Head Office.

Keywords: Harvesting, Shelterwood, Systems, Clearcuts, Douglas-fir, Second growth, Productivity, Costs, British Columbia

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## Study Methods

Preharvest site and stand descriptions were obtained from BCMOF surveys and the Preharvest Silviculture Prescription. Post-harvest residual stand and site disturbance information was provided by the BCMOF from its post-harvest surveys.

FERIC mounted Servis recorders on the harvesting equipment to determine machine operating time. Records of crew time were provided by the contractor. Intermittently throughout the period of harvest, yarding cycles were timed with stop watches to quantify individual cycle elements. The BCMOF provided the harvested volume calculated from the weigh-scale data.

Using FERIC's standard costing formula (Appendix I), FERIC calculated harvesting costs per cubic metre by applying 1993 IWA labour rates and hourly machine costs against the total hours for crew and equipment and the scaled volumes from the block.

## Study Site

Situated within the Roberts Creek Study Forest on the Sunshine Coast (Figure 1), the study area was classified as Partial Retention for viewpoints at both the tidal water line and Highway 101 (British Columbia Ministry of Forests 1981). The 7.6-ha study block (Figure 2), located in the Coastal Western Hemlock Dry Maritime ecosystem (CWHdm), has a gentle slope of <10%.

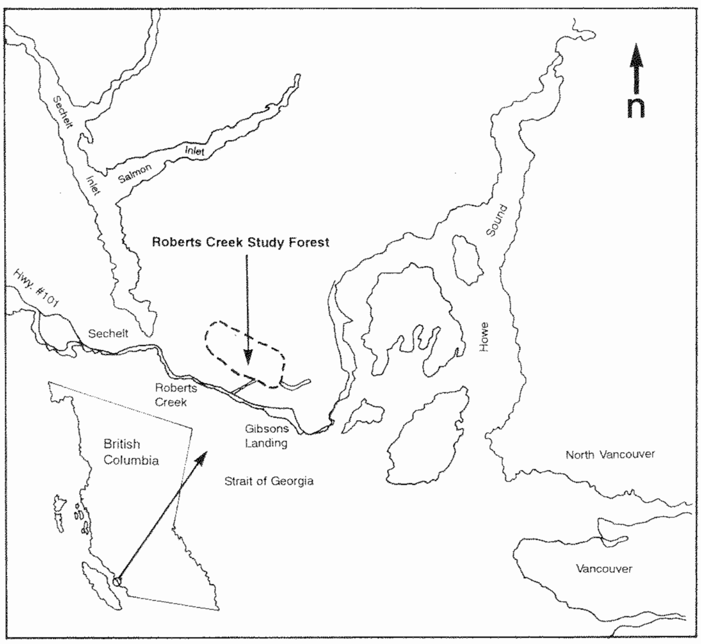


*Figure 1. Location of study site.*

The area is bounded by two creeks, and two ephemeral streams are within it. Numerous domestic water licences are located on Flume Creek which bounds the eastern side of the study block. Soils are predominantly well drained coarse textured glacial tills. A layer of compacted material 70-100 cm below the ground surface impedes root growth. Site sensitivity to compaction was identified as low to medium.

After a wildfire in the 1860's, some Douglas-fir remained, and the second-growth trees established themselves by natural regeneration (Figure 3). In the 1930's, shake cutters harvested both downed and standing cedar. By 1993, the stand was composed of 70% Douglas-fir, 20% western hemlock, and 10% western red cedar by volume, with 670 merchantable trees/ha, a total basal area of 85 $m^2$/ha, and a total volume of 1136 $m^3$/ha. Tree diameter ranged from 10- to 160-cm at breast height, with dominant trees reaching over 55 m in height.

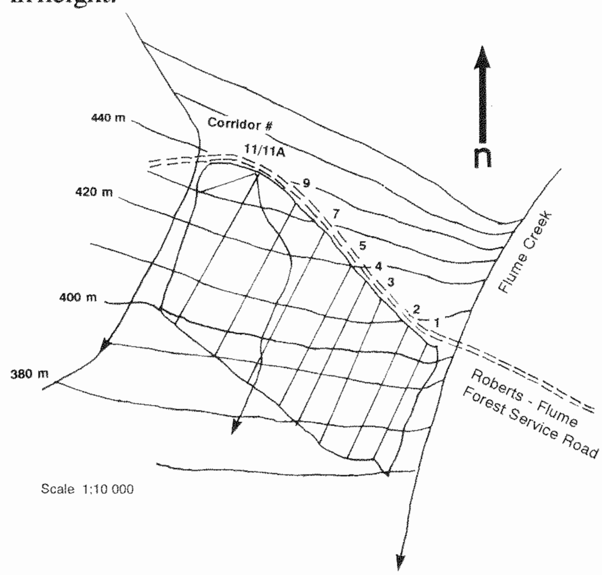


*Figure 2. Layout of study block. The eight corridors that were used are shown.*

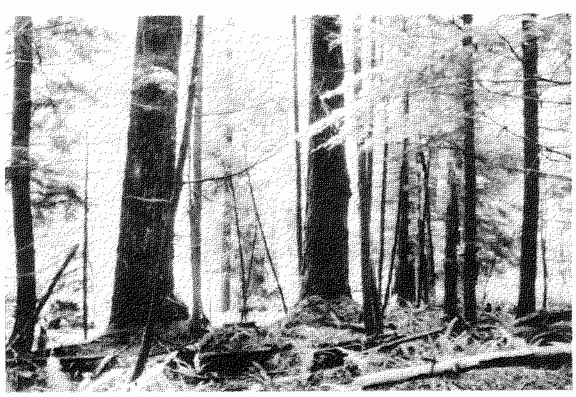

*Figure 3. Stand prior to harvest.*

## Silvicultural Prescription

The management objectives described in the Preharvest Silviculture Prescription are as follows:

- Following harvesting, and throughout the rotation of the new stand, maintain an overstory for wildlife and other resource values.
- Regenerate an even-aged stand of Douglas-fir and western red cedar, with a rotation between 90 and 120 years, for sawlog production.
- Maintain water quality by preserving the integrity of streams and other water courses within and near the treatment area.

The harvesting plan prescribed two harvesting entries. The first, in 1993, was intended to reduce stand density to a maximum of 90 shelterwood trees/ha, excluding the corridors dedicated to timber extraction. Healthy Douglas-fir and western red cedar trees were prescribed for retention. All western hemlock was to be removed because the species is not recommended in this ecosystem. Where suitable trees for retention did not exist, areas without leave trees were accepted. The relatively low number of residual trees was a compromise between two objectives: the retention of an adequate number of trees for aesthetics and other values; and the desire to regenerate Douglas-fir, which requires light for successful establishment and growth. Douglas-fir and cedar seedlings were to be planted to augment natural regeneration (completed in March 1994). Five to ten years after the 1993 harvest, a second harvest will reduce residual overstory to 20-30 trees/ha. Douglas-fir veterans will be reserved through both harvests to provide for biodiversity and wildlife habitat needs.

## Preharvest Surveys and Layout

The BCMOF contracted a detailed cruise to determine stand and site characteristics. Leave trees were selected— i.e. healthy Douglas-fir and western red cedar, dominant in the canopy—and marked with blue paint. Windthrow risk was a concern, and the dominant trees were considered the most windfirm. The stand was recruised after leave tree selection to verify that the post-harvest stand met the prescription. Deflection lines were run, and backspar trees were selected for each corridor. Yarding corridors were then located (again by contract). The corridors ranged from 180 to 230 m in length while the inter-corridor spacing ranged from 30 to 60 m (Figure 2). The licence document specified a 5-m corridor width.

## Equipment and Crew

Harvesting was competitively awarded through the Small Business Forest Enterprise Program. The successful bidder, T&T Trucking Ltd. of Sechelt, utilized a Cypress 6280B swing yarder rigged with a running skyline system (Figures 4 and 5). Backspar trees were rigged on each yarding corridor to improve yarding deflection. A Prentice 625 loader cleared the landing, decked the logs, and loaded the highway log truck.

The crew consisted of one full-time faller (assisted part-time by a second faller), two choker setters, a yarder operator, a chaser/bucker, and a part-time loader operator. Although the crew members were experienced, they had not worked in partial cutting prior to this trial.

## Operating Procedure

Two haulback blocks were hung at a 7-15 m height in the backspar tree. A third haulback block was positioned at the base of a tailhold tree located behind the backspar tree (Figure 5). The arrangement was prerigged by threading strawline extensions through the blocks to make corridor changes more efficient.

The operating procedure was to fall and then yard trees within the yarding corridor first, and then fall and yard the trees adjacent to the corridor on one side first and then the other side. Felling the corridors was straightforward, with stems aligned perpendicular to the road. No replacement of marked leave trees was necessary within the corridors. In some cases, the faller left 'rub' trees to protect leave trees from damage by cables or logs; these were removed during the last entry into the corridor. Stems were bucked and delimbed before yarding. However, stems were left full length if buck-

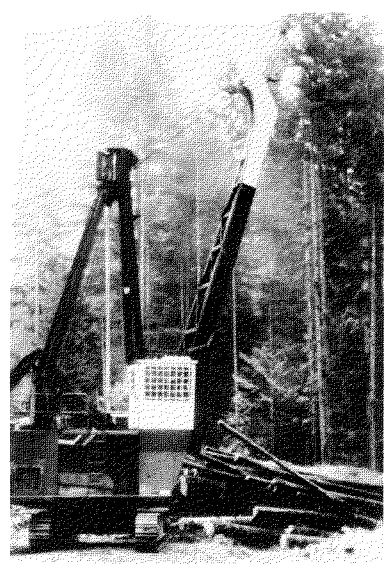

*Figure 4. Cypress 6280B swing yarder.*

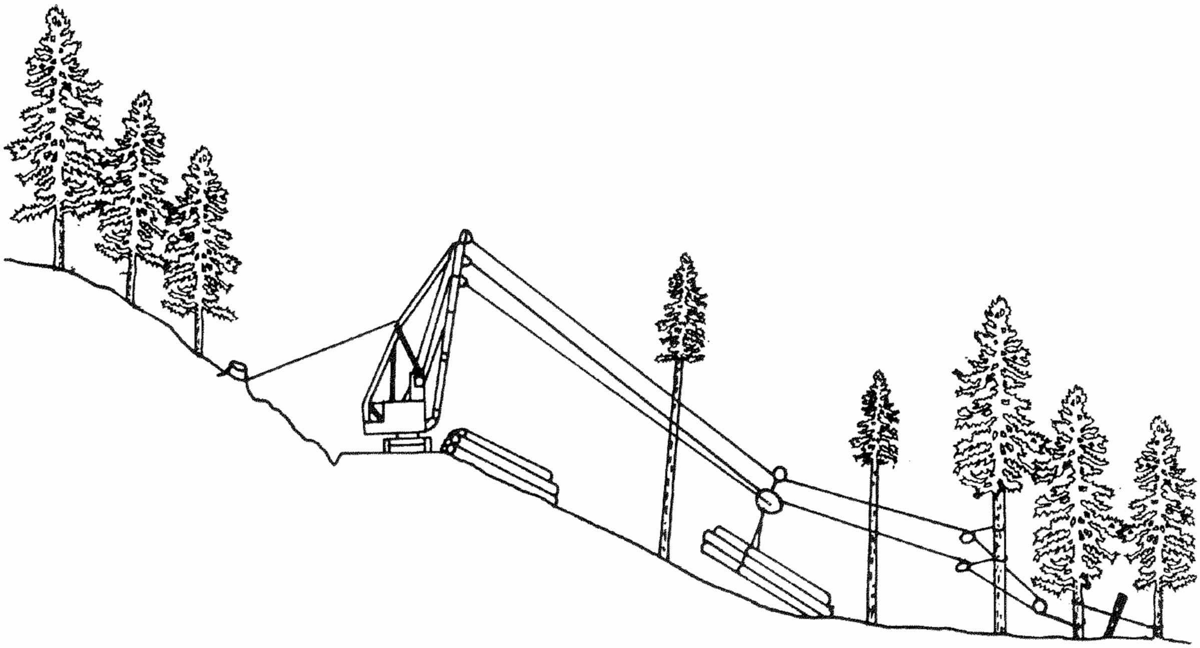

*Figure 5. Running skyline system used in the study.*

ing meant the furthest log could not be reached with chokers. When the sides of the corridors were felled, the faller directed the stems in a herringbone fashion, using wedges to control the falling direction. If, for safety or other reasons, the faller needed to fall a marked tree within these side areas, another tree of a similar size, species, and quality was left.

This work procedure required the yarder to move frequently. Because the yarding crew and faller had to be separated by at least two tree lengths for safety, at least one inactive corridor was needed between the corridor being yarded and any being felled. To minimize the duration of the frequent machine moves, three corridors were maintained with prerigged backspar trees and guyline stumps.

*Figure 6. Cypress 6280B swing yarder placing logs to the side of the machine.*

No landings were constructed in this operation. The swing yarder was positioned on the road at the end of the corridor. The yarder's swing capability allowed the operator to land logs to the side, rather than directly in front of the machine (Figure 6). In some cases, protective plastic barrels were wrapped around leave trees near the top of the corridor to protect them during yarding and decking activities.

Usually four chokers were attached to a 15-m dropline extending from a simple carriage. The carriage was the top section of a regular yarding grapple with the grapple jaws removed (Figure 7). At roadside, the chokers were unhooked and the loader moved the logs into decks for loading. The loader operator also positioned long logs for safe bucking.

*Figure 7. Carriage used in the operation.*

*Table 1. Distribution of Yarding Cycle Time*

| | Average time per element | | | | | Total cycle (min) | Average yarding distance (m) | Averages pieces (no.) | Samples (no.) |
|---|---|---|---|---|---|---|---|---|---|
| | Outhaul (min) | Hook-up (min) | Inhaul (min) | Unhook (min) | Delay (min) | | | | |
| Corridor | 0.91 | 3.18 | 1.01 | 0.91 | 0.23 | 6.24 | 103 | 4.4 | 104 |
| Between corridors | 0.89 | 3.15 | 1.09 | 1.07 | 0.19 | 6.39 | 139 | 4.0 | 280 |
| All samples | 0.90 | 3.16 | 1.07 | 1.03 | 0.20 | 6.36 | 129 | 4.1 | 384 |

## Results

The yarding cycles were timed with corridor yarding differentiated from intercorridor, or edge, yarding (Table 1). Overall, cycle time averaged 6.36 min, with an average yarding distance of 129 m. Piece size, determined from the sortyard scale, averaged 0.9 $m^3$. Differences between the two types of yarding were not great for any element of the cycle. Unhook was 20% greater (0.16 min) for the edge wood than for the corridor wood, but the reason was not obvious. The corridor yarding averaged 4.4 pieces/cycle, compared to 4.0 for the edge wood. Because edge wood was more dispersed, especially during clean-up, the number of pieces per cycle decreased.

The production from the first corridor was excluded in the shift-level results because it was considered a practice site. Therefore, rather than the total harvest volume of 6590 $m^3$, a volume of 6151 $m^3$ was used in the productivity and cost calculations (Table 2). A total of 41 faller shifts, 30 yarder shifts, and 33 loader shifts were required to harvest the 6151 $m^3$, resulting in overall productivities of 150 $m^3$/shift for falling and 205 $m^3$/shift for yarding. The yarder was used an average of 6.25 h/shift in the primary yarding function and 1.31 h/shift in rigging and changing corridors. The highway logging truck hauled 3-4 loads/day, with an average of 49 $m^3$/load.

Table 3 summarizes the production costs by phase. (See Appendix I and II for machine and labour cost calculations.) Using 1993 IWA labour rates, the falling phase cost \$2.53/$m^3$ and the combined yarding and loading phases cost \$15.59/$m^3$, for a total harvesting cost of \$18.12/$m^3$, on the truck.

## Post-Harvest Surveys

The BCMOF conducted post-harvest surveys of residual trees and site disturbance. A total of 57 trees/ha were left on site, with a basal area of 31 $m^2$/ha and a volume

*Table 2. Summary of Productivity*

| | |
|---|---|
| Production ($m^3$) | 6151 |
| Shifts | |
| Faller (no.) | 41 |
| Yarder (no.) | 30 |
| Productivity | |
| Falling ($m^3$/shift) | 150 |
| Yarding ($m^3$/shift) | 205 |
| Yarding (no. cycles/shift) | 54 |
| Distribution of yarder time | |
| Yarding (h/shift) | 6.25 |
| Rig backspars, change yarding roads (h/shift) | 1.02 |
| Repair cable (h/shift) | 0.26 |
| Wait for wood (h/shift) | 0.22 |
| Warm-up, maintenance (h/shift) | 0.25 |
| Total (h/shift) | 8.00 |

*Table 3. Harvesting Costs: Summary*

| Description | Shifts (no.) | Cost ($) | Cost ($/$m^3$) |
|---|---|---|---|
| Labour | 171.5 | 49 078 | - |
| Yarder | 30.0 | 39 120 | - |
| Loader | 33.0 | 23 232 | - |
| Total cost | | 111 430 | |
| Falling labour | | | 2.53 |
| Yarding and loading | | | 15.59 |
| Total harvesting cost | | | 18.12 |

*Figure 8. Site following harvest.*

of 262 $m^3$/ha (Figure 8). However, a storm in December 1993 blew down 69 trees within the block. The fallen trees were distributed throughout the block and all fell in roughly the same direction. This reduced the standing tree density to 48 trees/ha, with a basal area of 28 $m^2$/ha and volume of 223 $m^3$/ha.

Seventy-four residual trees were sampled for damage. Three had basal scars, one had bark abrasion from the cables and one had a broken top. This incidence of residual tree damage is low. Microsite surveys showed 68% intact forest floor, 6% mineral soil substrate, 8% slash, less than 1% potentially detrimental site disturbance, and 17% other (e.g. fine slash, bedrock etc.).

## Discussion

The BCMOF supervised the operation closely and communicated well with the contractor and crew. The crew was instructed on the requirements of partial cutting, and overall harvesting proceeded effectively.

The falling phase is critical to the success of yarding, both in terms of production and in maintaining a low incidence of damage to residual trees. Falling quality was good in this trial. The faller was successful at consistently aligning stems for efficient yarding. Occasionally a tree fell in the wrong direction, or the faller decided that a stem was best yarded from the next corridor, but these situations were uncommon.

The contractor lacked experience in tree climbing, resulting in inefficiencies in rigging the backspar. However, with the exception of one corridor, deflection was adequate and site-disturbance levels were therefore low. On Corridor 11 (Figure 3), a short, steep slope break 75 m from the road created a deflection problem; the leading ends of logs were pulled into the soil and a trench was excavated. The contractor raised the blocks in the backspar tree, but some dragging and gouging still occurred. This demonstrates the need for deflection surveys on each yarding corridor, and the need to follow survey recommendations when placing tailblocks in backspar trees, if site disturbance is to be minimized.

In partial cut areas, with repeated entries, backspar trees must be available at re-entry. This can be an important consideration in the layout and selection of residual trees.

With partial cutting, more rigging hardware (i.e. straps, blocks, shackles, and strawline) is necessary than with clearcut harvesting in order to reduce moving and rigging time. In this study, the prerigging of the backspar trees reduced corridor change times. In some cases, the contractor also prerigged the guyline stumps and this further reduced set-up time.

The carriage arrangement used for yarding was more successful than anticipated. The contractor simply unshackled the grapple legs from the yarding grapple and used the grapple's closing line as a dropline for the chokers. Because the winch drums on the Cypress 6280B yarder were all interlocked, the carriage could be "spotted" along the corridor and locked in place by applying both the haulback and mainline drum brakes. Lateral yarding to the corridor was done with the grapple closing-line drum (or dropline drum in this configuration) (Figure 7). Through the combination of ample drum braking capacity and drum interlock, the carriage did not shift position during lateral yarding. This feature is very important for cable yarding in partial cuts so as to minimize residual stand damage and to facilitate lateral yarding. Pulling the dropline out required physical effort, but the ground and slope conditions on this block were favourable and the choker setters did not find the task too onerous. However, if this system was applied on steeper slopes, some type of slack-pulling carriage would be necessary to maintain yarder production. The potential for residual tree damage would increase as well because the logs would have a tendency to roll. The yarder experienced downtime for cable repair; the contractor suggested cable wear was greater in this application than when grapple yarding in clearcuts.

The swing capability of the yarder allowed it to land logs efficiently at roadside because it could swing them up onto the road for the loader rather than having them accumulate immediately in front of the yarder. The loader was able to deck or spread the logs without delaying the yarder.

The loader was under utilized during the operation because it could have handled a larger volume than was produced. However, it was a necessary component of the system. The capacity of the yarder was greater than the production of one faller, as shown by the total number of shifts for each (Appendix II). Although the yarder's utilization was high overall, it experienced some downtime when wood was not available for yarding. A constraining factor was the necessity of leaving an inactive corridor between yarding and falling. Because partial cutting was a new technique to the contractor and BCMOF supervisors, this aspect was not fully considered when harvesting began. In the last week of harvest, the active corridors were at one end of the block, and some extra moving resulted. If the corridors had been felled in a slightly different order, the number of corridors on the site would have been adequate to maintain the appropriate clearances; delays due to falling/yarding interference would have been avoided. Having either a larger operating area, or being able to log both sides of the road, would give more flexibility in positioning equipment and crew. Smaller patch sizes with this type of partial cutting may be less efficient when the need to maintain a safe distance between fallers and yarding crew is considered.

With partial cutting there is an assumption that cable-yarding productivity will be lower than with clearcutting. Although FERIC is presently completing studies of clearcut cable yarding with chokers in Coastal second growth, the results are not yet available for comparison. However, FERIC did evaluate a Cypress 7280B swing yarder grapple working in second growth on Vancouver Island (Peterson 1988). In this operation, a Hitachi UH-14 mobile backspar was used to simplify yarding-road changes and to improve deflection. Piece size averaged 0.89 $m^3$ and productivity averaged 261 $m^3$/shift. The smaller Cypress 6280B at Roberts Creek had an average piece size of 0.9 $m^3$ and an average productivity of 205 $m^3$/shift. The cycle times averaged 1.53 min and 6.34 min for the 7280B and 6280B respectively; however, the per-piece cycle times were more comparable, at 1.18 and 1.55 min/piece. These productivities appear to be very similar considering that yarding-road changes would be much longer for the partial-cutting situation.

During the study period, yarding and falling could not be done on three days due to wind. This downtime must be expected with partial cutting because it is hazardous for crews to work under standing trees that may have broken branches caught in their crowns.

Eleven corridors were identified in the initial layout, but the BCMOF felt these were too closely spaced and removed too much of the stand. The number of corridors was therefore reduced to seven. When harvesting was done, an eighth corridor was used (Corridor 4, Figure 3) because the contractor felt it was necessary due to the width and topography between Corridors 3 and 5. In this additional corridor, the BCMOF specified that leave trees within the yarding path had to be replaced by substituting approximately the same number of trees that would otherwise have been cut adjacent to the corridor. On Corridor 11, a portion of the bench near the road could not be accessed and a tree adjacent to the side of the block was rigged to remove this wood. Not all of the backspar trees that had been identified during layout were used. The contractor preferred using trees forward of the boundary and made some substitutions in consultation with the BCMOF. In one case a relatively small tree was used as the backspar. During the yarding of the wood adjacent to this corridor, an additional support was rigged to provide stability for the backspar.

It is uncertain what role wind will play in the future stability of the residual stand. The combination of great tree height and shallow depth of root masses on the site was considered a major factor in the windfall that occurred in December 1993. After that windfall event, the BCMOF initiated a research project to evaluate the influence of wind on the residual trees in this partial-cutting treatment.

When planning for a specific number of residual trees, factors that may reduce prescribed spacing must be considered. Even when residual tree substitution is required, some trees within felled areas are likely to be knocked down by subsequent falling, and substitution in place will not be possible. Substitution for corridor trees is usually not required, and these trees must be deducted from final counts as well. If corridors are flagged prior to tree marking, then adjustments can be made to leave more trees between corridors. Finally, windfall will almost inevitably occur. A factor of 10-25% may need to be added to accommodate losses that may occur after the trees are marked.

## Conclusion

The BCMOF identified the Roberts Creek Study Forest as a locale to research, demonstrate, and develop alternative silvicultural systems in Coastal mainland ecosystems. This demonstration harvest was undertaken to gain operational experience in applying a partial cutting system in an area where clearcutting has been the principle cutting pattern in the past. FERIC was asked to monitor and film the harvesting operation.

A Cypress 6280B swing yarder, rigged with a running skyline system, yarded a 7.6-ha shelterwood treatment block within the Coastal Western Hemlock Dry Maritime ecosystem. Although the crew was not experienced in partial cutting, the members were motivated and interested in obtaining new skills. Good supervision and



communication, an excellent stand in terms of quality, and good terrain and operating conditions also contributed to a successful operation.

Stand density was reduced from 670 merchantable trees/ha to 57 trees/ha, with 874 $m^3$/ha removed. Falling productivity was 150 $m^3$/shift, and yarding productivity was 205 $m^3$/shift. This resulted in a total production cost of \$18.12/$m^3$ on the truck.

Planning is an important phase that must be done thoroughly to minimize problems during harvest. A detailed preharvest survey is necessary to determine the structure of the stand so that an effective silvicultural prescription can be created.

Operationally, falling is the most critical phase because the placement of stems directly affects yarding productivity and leave-tree damage. When falling and yarding are done concurrently, a safe distance must be kept between workers; this requires planning the sequence of corridors to reduce downtime. Debris caught in the crowns of residual trees poses a risk for both yarding and falling crews, and windy days will therefore result in downtime. The continuing role of wind will be monitored, and future entries and treatments should consider the influence of wind at the time of harvest planning.

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## Acknowledgments


The author appreciates the cooperation of Brian D'Anjou, Forest Sciences, Vancouver Forest Region, BCMOF; Mike Whitehouse, Sunshine Coast Forest District, BCMOF; and Bill Trousdell, T&T Trucking Ltd., and his crew. The project was supported by the BCMOF's Alternative Silvicultural Systems Research Program, and the Forest Practices Component of the Canadian Forest Service's Green Plan.

## Appendix I

## Machine Costs: Cypress 6280B Grapple Yarder and Prentice 625 Hydraulic Loader

| | Cypress 6280B grapple yarder | Prentice 625 hydraulic loader |
|---|---|---|
| OWNERSHIP COSTS | | |
| Total purchase price (P) $ | 800 000 | 350 000 |
| Expected life (Y) y | 12 | 8 |
| Expected life (H) h | 17 280 | 11 520 |
| Scheduled hours per year (h)=(H/Y) h | 1 440 | 1 440 |
| Salvage value as % of P (s) % | 30 | 30 |
| Interest rate (Int) % | 12.0 | 12.0 |
| Insurance rate (Ins) % | 3.0 | 3.0 |
| Salvage value (S)=((P•s/100) $ | 240 000 | 105 000 |
| Average investment (AVI)=((P+S)/2) $ | 520 000 | 227 500 |
| Loss in resale value ((P-S)/H) $/h | 32.41 | 21.27 |
| Interest ((Int•AVI)=((P+S)/2) $ | 43.33 | 18.96 |
| Insurance ((Ins•AVI)/h) $/h | 10.83 | 4.74 |
| Total ownership costs (OW) $/h | 86.57 | 44.97 |
| OPERATING COSTS | | |
| Wire rope (wc) $ | 11 000 | 0.00 |
| Wire rope life (wh) h | 1 800 | 0.00 |
| Rigging and radio (rc) $ | 13 000 | 0.00 |
| Rigging and radio life (rh) h | 5 700 | 0.00 |
| Fuel consumption (F) L/h | 35.0 | 30.0 |
| Fuel (fc) $/L | 0.38 | 0.38 |
| Lube and oil as % of fuel (fp) % | 15 | 15 |
| Annual operating supplies[a] (Oc) $ | 9 000 | 0.00 |
| Annual repair and maintenance[b] (Rp) $ | 66 666 | 43 750 |
| Shift length (sl) h | 8.0 | 8.0 |
| Wire rope (wc/wh) $/h | 6.11 | 0.00 |
| Rigging and radio (rc/rh) $/h | 2.28 | 0.00 |
| Fuel (F•fc) $/h | 13.30 | 11.40 |
| Lube and oil ((fp/100)•(F•fc)) $/h | 2.00 | 1.71 |
| Operating supplies (Oc/h) $/h | 6.25 | 0.00 |
| Repair and maintenance (Rp/h) $/h | 46.30 | 30.38 |
| Total operating costs (OP) $/h | 76.23 | 43.49 |
| TOTAL OWNERSHIP AND OPERATING COSTS[c] (OW+OP) $/h | 162.81 | 88.46 |
| Excluding interest $/h | 119.47 | 69.50 |

[a] Operating supply cost for the yarder is an estimate of choker requirements.
[b] Annual costs for repairs and maintenance were estimated as 80% of purchase price divided by expected life.
[c] These costs are based on FERIC's standard costing methodology for determining machine ownership and operating costs. These costs do not include supervision, profit, or overhead, and are not the actual costs for the contractor or company studied.



## Appendix II

## Labour Costs

| Crew[a] | Hourly rate[b] ($) | Shift (h/day) | Shifts (no.) | Cost ($) |
|---|---|---|---|---|
| Yarder operator | 29.66 | 9 | 33 | 8 809 |
| Landing bucker | 29.66 | 9 | 30 | 8 008 |
| Hooker | 28.86 | 9 | 35 | 9 091 |
| Loader operator | 28.07 | 9 | 6.5 | 1 642 |
| Choker setter[c] | 25.57 | 9 | 26 | 5 983 |
| Faller | 44.02 | 8 | 41 | 14 438 |
| Saw allowance | | | 41 | 1 107 |
| Total cost | | | | 49 078 |

[a] The crew often performed tasks not described by their job titles. However, the rates did not change by task. For example, the yarder operator and hooker spent weekend time preparing backspar trees, and a day cleaning ditches and tidying the site after yarding was complete.
[b] Hourly rate is based on IWA July 15, 1993 rates, with 35% for fringe benefits.
[c] A choker setter was not available for all the yarding shifts.