Advantage

Restricted to FERIC Members and Partners Vol. 5 No. 28 July 2004

Contents

Substituting a skyline harvesting system on sites originally planned for helicopter harvesting: two case studies

Abstract

At the request of Ainsworth Lumber Company Limited, the Forest Engineering Research Institute of Canada (FERIC) monitored harvesting of two blocks in southwestern British Columbia that had originally been designed for helicopter harvesting but were converted to skyline harvesting. This report describes the planning and layout involved in the conversion; presents productivities and costs for falling, skyline yarding, and loading; compares these costs with those for helicopter harvesting; and makes suggestions for improvements.

Keywords

Skyline yarding, Cable yarding, Long line, Helicopter yarding, Madill 071 yarder, Acme 200 Pow'-R Block motorized slackpulling carriage, Intermediate supports, Hand falling, Harvest planning, Cost, Productivity, Clearcut, Irregular shelterwood, Partial cutting, British Columbia.

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Introduction

Although helicopter harvesting is expensive to conduct, in British Columbia it is often prescribed where logging-road construction is not economically feasible or environmentally viable. In an effort to minimize overall harvesting costs, forest companies are taking a closer look at using less expensive harvesting systems on these sites. One important consideration when examining the cost of harvesting systems is the stumpage rate. When stumpage is at the minimum value,[1] the higher costs of some harvesting systems cannot be offset. Two cutblocks within the operating area of Lillooet Division of Ainsworth Lumber Company Limited in southwestern British Columbia were initially designated and laid out for yarding by helicopter. Because stumpage assessed for both helicopter and cable methods was already at the minimum, Ainsworth Lumber asked FERIC to help determine the feasibility of substituting long-distance skyline systems on these blocks.

The specific objectives of FERIC's study were to:

- Document the changes necessary to convert the blocks from helicopter harvesting to skyline harvesting.
- For the skyline system, determine productivity and unit costs for falling, yarding, and loading.
- Compare the costs of skyline harvesting with those of helicopter harvesting.
- Identify any problems associated with substituting skyline harvesting for helicopter harvesting, and make suggestions for improving the process.

Site, stand, and silvicultural system

The two blocks were located in southwestern British Columbia approximately 160 km northeast of Vancouver, near the town of Lillooet.

[1] Generally, minimum stumpage is assessed when the appraised cost of harvesting is equal to or above the appraised value of the end product.

Figure 1. Block 1, clearcut with reserves. Approximate boundary (outlined), intermediate support trees (arrow), and previously logged area (foreground). The landing is behind the trees in the foreground of the photo.

Block 1: Clearcut with reserves

Block 1 (Figure 1) is located in the dry cold subzone of the Montane Spruce biogeoclimatic zone (MSdc) (Lloyd et al. 1990) between 1300 m and 1580 m elevation. Slope averages 55% and ranges from 35 to 75%; aspect is easterly. The net stand volume was 336 m^3/ha, and the stand was comprised of 94% Douglas-fir with minor components of spruce and lodgepole pine (Table 1). The average net tree volume was 0.74 m^3, and the average tree diameter was 36 cm. The silviculture prescription specified a clearcut with reserves, with 2–3 Douglas-fir trees/ha to be left as wildlife trees and as sources of future coarse woody debris.

Table 1. Descriptions of study blocks

	Clearcut block	Partial cut block
Original block size [a] (ha)	9	13
Net volume (m^3/ha)	336	386 [b]
Species composition		
Douglas-fir (%)	94	90
Spruce (%)	3	5
Lodgepole pine (%)	3	5
Stand density (no. trees/ha)	454	549 [c]
Tree diameter (cm)	36	35
Net volume/tree (m^3)	0.74	0.67
Total tree height (m)	27	Not avail.
Ground slope, range (average) (%)	35–75 (55)	45–75 (60)
Planned yarding distance (m)	200–725 [d]	200–530 [e]
Yarding over previously harvested area	Yes	No
Intermediate supports	Yes	No
Cross-stream yarding	No	Yes
Yarding direction	Downhill	Downhill

[a] Includes areas deleted from final harvesting plan.
[b] Planned harvest volume was 200 m^3/ha.
[c] Planned harvest was 200 trees/ha.
[d] Logs were yarded over a 200-m-wide area, located between the landing and the lower boundary of the block, that had been previously harvested.
[e] Logs were yarded over a riparian reserve zone and through an unharvested area (totaling 200 m wide) between the landing and the lower boundary of the block.

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ISSN 1493-3381

The nearest haul road was located 200 m slope distance below the clearcut block, and the area between the road and the lower edge of the study block had recently been harvested with a highlead system. New road construction was prohibited to protect mountain goat habitat; this block had therefore been designated for helicopter harvesting.

The new plan for skyline harvesting required downhill yarding and external horizontal yarding distances of 375–725 m, and that logs be yarded over the recently harvested area. A break in slope was situated at the boundary of the study block and the recently harvested area. The long yarding distances and the terrain break made intermediate supports necessary. Three skyline roads were required to harvest the clearcut block.

Block 2: Partial cut (Irregular shelterwood)

Block 2 (Figure 2) is located in the Okanagan very dry hot variant of the Interior Douglas-fir biogeoclimatic zone (IDFxh1) (Lloyd et al. 1990). Elevation extends from 900 m to 1200 m. The average slope within the block is 60% and ranges from 45 to 75%; the aspect is southerly. Net stand volume was 368 m^3/ha, and the stand was comprised of 90% Douglas-fir with minor components of spruce and lodgepole pine. The average net tree volume was 0.67 m^3, and the average tree diameter was 35 cm.

The area is adjacent to Highway 99 and is highly visible to tourists traveling between Whistler and Lillooet. As well, a recreation site is located directly across the highway from the block. A large creek with class S2 and S3 reaches[2] is located between the block and the landing. The area includes critical winter habitat for mountain goats.

Partial cutting was required on the steep terrain to accommodate silvicultural and visual quality objectives and helicopter harvesting had been prescribed.

The silviculture prescription specified an irregular shelterwood with a combination of uniform and group removal. The objectives were to produce an irregular stem distribution,

Figure 2. Block 2, partial cut (irregular shelterwood). Madill 071 yarder and skyline corridors.

leave a cross section of diameter classes up to 72.5 cm, and, where operationally feasible, provide wildlife habitat by leaving trees >72.5 cm in diameter. Douglas-fir accounted for 45 m^2/ha of basal area, and of this a minimum of 18 m^2/ha were to be retained; all other species were to be harvested. Openings were limited in size to 2000 m^2 with maximum dimensions of 25 m up the hill and 80 m along the contour. In order to reduce visual impact, openings were designed to follow the contours.

Dry site conditions required the use of partial cutting to facilitate reforestation. The silviculture prescription required the logs to be fully suspended when yarding over the creek. Yarding was limited to narrow (10-m-wide) corridors through a 20–30 m riparian reserve zone adjacent to the creek and within a 100-m-wide timbered area between the landing and the creek. All yarding in this block was downhill and three skyline corridors were required. Horizontal yarding distance was as much as 530 m.

To minimize impacts on the goats, harvesting activities were permitted from May to November only.

Harvesting system, equipment, and crew

Trees were hand felled and bucked by four fallers from June to August. One to

[2] Fish streams and community watershed streams are classified S1 to S4. Class S1 streams are >20 m wide; S2 streams are >5 to 20 m wide, S3 streams are 1.5 to 5 m wide; and S4 streams are <1.5 m wide (BCMOF 1998).

Figure 3. Opening in the partial cut, approximately 20 m by 50 m.

Figure 4. Madill 071 yarder and Barko 450 loader working in partial cut block.

Figure 5. Acme 200 Pow'-R Block motorized slackpulling carriage.

three fallers worked per shift; an observer was on site for safety whenever a faller worked alone. In the partial cut block, the engineering crew located and marked the skyline corridors but the fallers measured and marked the openings. The long axis of each opening was oriented approximately perpendicular to the skyline corridors and following the contours; 20-m-wide openings (Figure 3) were alternated with 20-m-wide leave strips. Ainsworth Lumber believed falling would be safer and more efficient if the fallers selected the openings.

Yarding took place from June to August. In both blocks, yarding was conducted with a Madill 071 yarder (Figure 4) rigged as a standing skyline system. Smaller-than-usual lines, with extensions (Table 2), were required to enable the Madill to yard the long distances. The 21-kW Acme 200 carriage (Figure 5), which was equipped with a hydraulic "Pow'-R Block" slackpulling system with dual tension wraps, was chosen for its ability to pull slack uphill on steep slopes at long distances. The use of this type of carriage made it possible to yard long distances downhill plus yard laterally in the partial cut block, while the carriage's ability to pass intermediate supports was required for the clearcut block.

The harvesting contractor and crew had considerable experience using highlead and skyline systems. However, this was the first time they had tried downhill yarding at such long distances, and it was also the first time they had used an Acme motorized carriage.

Table 2. Wire rope specifications for yarder [a]

Line	Line size (mm)	Wire rope type	Drum capacity (m)	Line extensions (m)	Total length (m)
Skyline	25	Power pac	589	326	915
Mainline	16	Power pac	960	-	915
Haulback	16	Power pac	1 341	1 098	2 439
Strawline	11	EIPS	745	2 304	3 049
Guylines and utility line	16	EIPS	-	-	1 524
Slackpulling		Not required for this cable system			

[a] Based on consultant's recommendations.

The six-person yarding and loading crew consisted of a loader operator/foreman, hooktender, yarder operator, rigging slinger, chaser, and chokersetter. The loader operator/foreman rigged the intermediate supports and tail trees. Sorting and loading were done by a Barko 450 hydraulic loader with a butt-'n-top grapple (Figure 4).

Study methods

The falling contractor kept a log of daily activities. Because the fallers' records did not include the exact time to hike in and out of the blocks, this time was estimated. When an observer was on site to ensure safety, the observer's time was not considered in the cost and productivity calculations. FERIC met with the falling contractor at the site on a weekly basis to discuss falling progress and to obtain detailed information about non-productive time and working conditions. Ainsworth Lumber provided log scale volumes for both blocks and estimated the area and volumes that had been felled but not cable yarded. This information was used to estimate falling productivity and to determine the time distribution of falling activities. Detailed timing was performed on three of the four fallers over six days to determine average times for the falling cycle elements. The results for Faller No. 1, the only faller timed in both blocks, were compared for the two areas. Falling costs per cubic metre were estimated by applying the study productivities to the IWA's hourly rate for fallers including benefit loading and powersaw costs (Appendix I).

A Servis recorder installed on the yarder recorded operating and non-operating time within each scheduled shift. On a daily basis, the loader operator/foreman filled in forms to record the date, block, crew size, daily piece counts, and yarding time. He also recorded times ≥30 min for rigging changes, road and corridor changes, maintenance, mechanical delays, and other non-mechanical delays. This information was used to determine the scheduled machine hours (SMH), productive machine hours (PMH), yarding hours (YH), and time distributions. Along with Ainsworth Lumber's log scale data, these data were used to calculate yarding productivity. Detailed timing was performed for five days to determine average times for yarding cycle elements. Loader productivity was assumed to be equal to yarder productivity because the loader and the yarder always worked together.

Yarding and loading costs per cubic metre were estimated by applying the study productivities to hourly machine costs as determined by FERIC's standard costing method (Appendix II). The results were compared with helicopter harvesting costs that are representative of the area.

Results and discussion

Accommodating skyline harvesting

Ainsworth Lumber hired a skyline harvesting consultant to assess the blocks and recommend harvesting plans that would convert the sites from helicopter to long-distance skyline yarding. Potential tail trees, anchor stumps, and intermediate support trees were identified, and ground profiles were run in the field. Payload analyses were performed on the profiles to determine maximum turn sizes; this information was then used to estimate productivity and costs on each planned skyline road and corridor. The consultant made several recommendations including sizes and lengths of line for the yarder (Table 2), rigging supplies, minimum and maximum rigging heights for tail trees and intermediate supports, skyline pretensions for each skyline corridor and road, and, in the case of the partial cutting block, minimum corridor widths for lateral yarding.

The consultant's analyses showed that portions of the blocks would be difficult or impossible to yard from existing roads with the proposed cable system. Some deletions were necessary, which substantially reduced the volume available for cable yarding. Other logistical changes were also needed as harvesting progressed.

In the clearcut block, turn size in the southwest corner (Figure 6) would be very small (about half of the average payload for the rest of the block). To improve the harvesting economics, this 2.5-ha area was removed from the planned cable harvest area. During yarding of the middle skyline road, the tail tree was pulled over. Because no suitable large trees were available beyond the block boundary, the area could not be cable yarded, and about 1100 m^3 of felled wood was re-designated for helicopter yarding. Deletion of this area reduced the maximum yarding distance in the block to 500 m (Figure 6).

In the partial cut block (Figure 7), two landings had already been built outside the block boundary for helicopter harvesting, one for landing logs and one for servicing the helicopter. The consultant chose the lower landing to situate the yarder in order to maximize payloads, and the yarding corridors

Figure 6.
Map of Block 1, clearcut with reserves, showing implementation of the new harvesting plan.

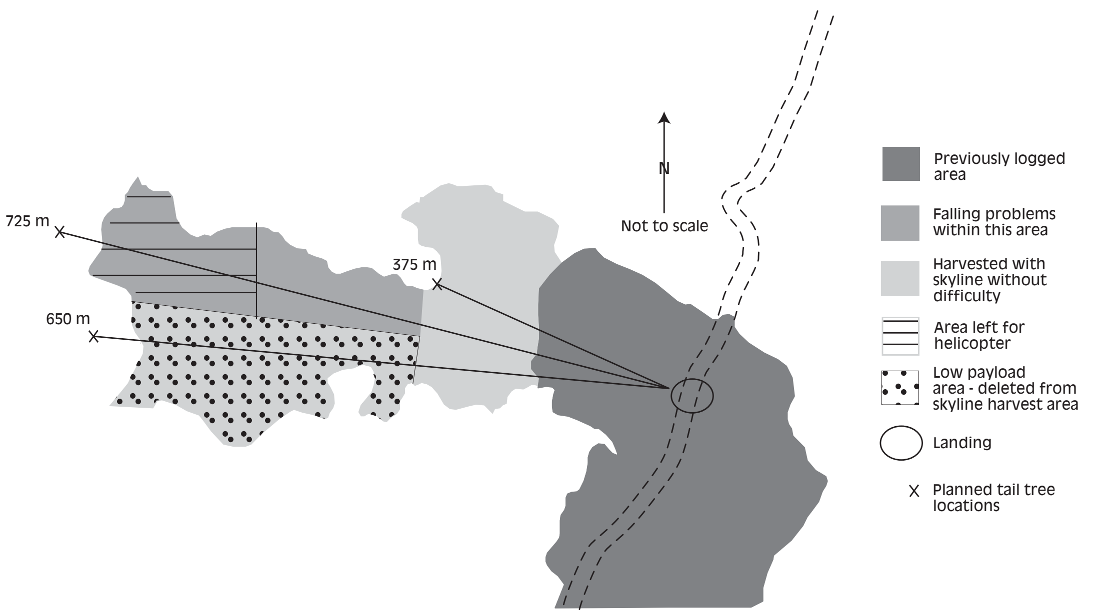
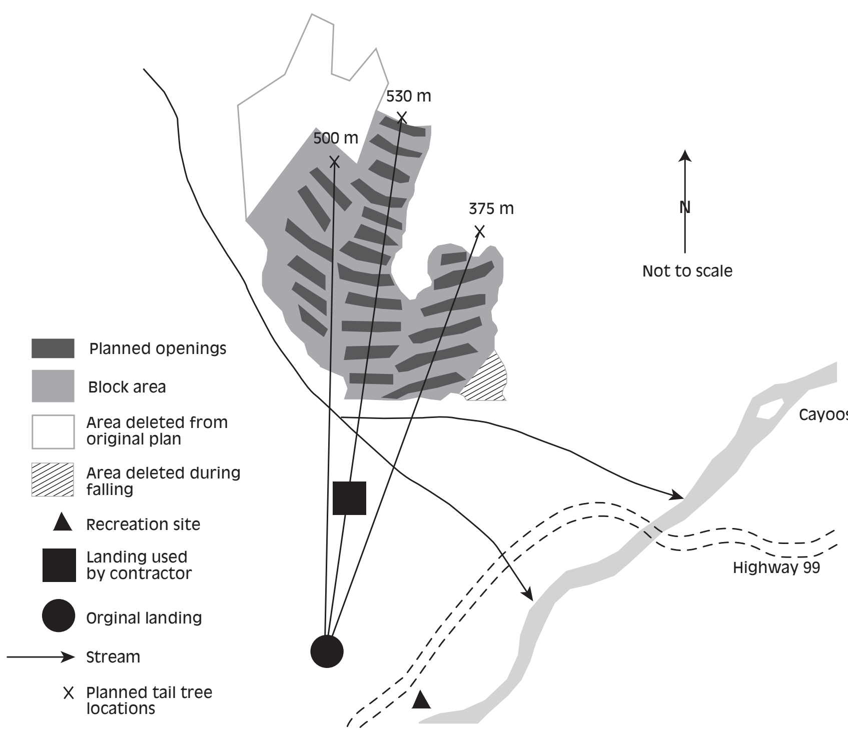


Figure 7.
Map of Block 2, partial cut, showing changes to the harvesting plan.



were laid out accordingly. Instead, the contractor decided to use the upper landing to shorten the yarding distances and because deflection from this location was good and payloads were adequate. However, the corridors did not converge at the upper landing and the yarder had to be re-aligned at each corridor change. During the planning stage, a 5-ha area in the northwest corner of the partial cut block was determined to be inoperable for the skyline system and was deleted. This area was later yarded by helicopter. Also, during falling, it was determined that the southeast corner of the partial cut block could not be yarded as laid out, so this portion of the block was removed from the harvesting plan before it was felled.

In the partial cut block, corridors had to be created through the 100 m of timber that stood between the landing and the lower boundary of the block.

Falling

Shift-level study

In the clearcut block, 19 shifts and 45 mandays were required to fell 2992 m³. The average shift length was 7.6 h, including time to hike in and out of the block. Productivity was 57.1 m³/6.5-h manday.

For the partial cut block, 14 shifts and 29 mandays were required to fall 1189 m³. Average shift length was 6.8 h and productivity was 39.2 m³/6.5-h manday (Table 3).

Falling in the southwest corner of the clearcut block was complicated by a change in block boundary such that the area created was too narrow and steep for two fallers to cut trees safely (see the 725-m road in Figure 6). Instead, one worker felled the trees and the other bucked and limbed them. This required a lot of coordination between the fallers to ensure safe conditions. Often one faller was idle while waiting for the other to complete his task, and productivity was reduced as a result.

For the clearcut block, moving equipment, fuel, and oil into the block, and cutting an access trail, took an additional 90 min of hike in/out time over the first two days of falling.

Fallers were paid for time to hike into the block but not for time to hike out. However, all time, including all hiking time, was used to calculate productivity and costs. Two-way hiking time was 19% of the total time for the clearcut block and 9% for the partial cut block (Figures 8 and 9).

Including hiking time in the data increased the fallers' average shift length to more than the standard 6.5 h/shift. If all the hike in/out had been done within the 6.5-h

Table 3. Falling productivity

	Clearcut block	Partial cut block
Felled volume (m³)	2992	1189
Scheduled man hours (SMH)	340.9	197.3
Productive man hours (PMH)	208.0	140.0
Mandays worked (no.)	45	29
Average shift length (h)	7.6	6.8
Productivity		
(m³/manday [a])	57.1	39.2
(m³/SMH)	8.8	6.0
(m³/PMH)	14.4	8.5

[a] Based on a 6.5-h/shift.

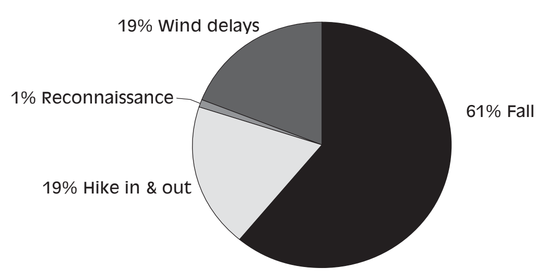


Figure 8. Falling time distribution, clearcut.

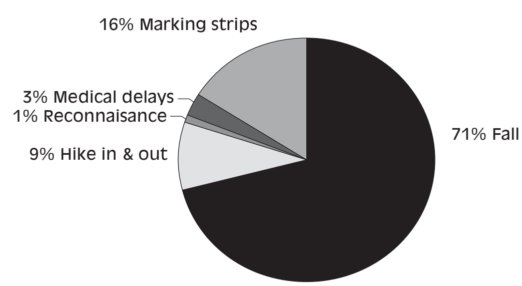


Figure 9. Falling time distribution, partial cut.

period, then more mandays would have been needed to complete the work. FERIC estimated that falling would have taken an extra 9.6 mandays for the clearcut block and an extra 1.5 mandays for the partial cut block; this would have reduced productivity to 54.8 m^3/manday and 39.0 m^3/manday, respectively.

For the clearcut block, 19% of the time was taken up by wind delays. No wind delays were recorded for the partial cut block. On days when the fallers went home early due to high winds, the time remaining in the shift was recorded as wind delay. This occurred on 6 days and ranged from 0.5 to 5 h/occurrence. Two full days were also lost due to wind when the crew came to the site but were unable to work.

For both blocks, delays occurred when fallers went to check on the safety of their partners. These delays could have been shortened or eliminated if all fallers had been equipped with two-way radios.

For the partial cut block, measuring and marking the openings and leave strips required 2 shifts and 5 mandays of faller time. During falling, a faller discovered that one corridor was not straight, resulting in a delay.

Table 4. Falling: detailed timing

	Faller No. 1 only	
	Clearcut block (min/tree)	Partial cut block (min/tree)
Falling cycle elements		
Move between trees	0.44	1.10
Cut bush	0.57	0.32
Cut tree	0.74	0.89
Wedge tree	0.15	0.13
Buck/limb tree	0.68	3.35
Operational delays <15 min [a]		
Refuel powersaw	0.27	0.34
File chain, repair powersaw	0.12	0.16
Move equipment or fuel	0.24	0.32
Miscellaneous [b]	0.05	0.13
Total falling cycle time	3.26	6.74
Ground slope (%)	45–60	65–90
Sample size (trees)	113	25

[a] Prorated over cycles timed.
[b] Includes buck windfall, rest break, fall snag (non-merchantable), wait for partner, wind delay, cut stump, and cut trail.

Detailed-timing study

During the detailed timing study, Faller No. 1 felled a total of 138 trees in both blocks. Analysis of the data (Table 4) showed that average falling time per tree was much longer for the partial cut block (6.74 min) than for the clearcut block (3.26 min). Average move time between trees was higher for the partial cut than for the clearcut likely due to the steeper ground and lower stand density in the partial cut. The steeper ground and the additional bucking required to facilitate yarding from the corridors and openings may have influenced the longer bucking/limbing times observed for the partial cut. Fallers spent almost twice as much time cutting brush (i.e., to access the base of a tree) in the partial cut than in the clearcut because the partial cut block contained many small saplings.

Yarding

Shift-level study

Clearcut block

A total of 31 shifts were required to yard 1892 m^3; average shift length was 8.7 h. Productivity averaged 61.0 m^3/shift worked (56.3 m^3/8-h shift) (Table 5). Hourly productivity averaged 8.7 m^3/PMH and 7.0 m^3/SMH. Average turn size was 2.9 pieces or 2.2 m^3/turn.

Expressing productivity in terms of PMH does not give a complete picture of a skyline system's productive yarding capacity. Set-up, tear-down, and road and corridor changes are included in PMH; these times can account for a substantial proportion of total productive time for skyline yarding, and they can vary greatly between sites and between crews, depending on the crew's experience and competence. Yarding hours (YH) is therefore a better measure of a skyline system's productive yarding capacity because set-up, tear-down, and road and corridor changes are excluded. For the clearcut block, the skyline system's yarding productivity averaged 15.2 m³/YH.

Walking the machine into the block and rigging-up for the first time took 5 shifts. Rigging up was difficult owing to the long yarding distance and steep slopes. The contractor attempted to pull the strawline to the end of the block with a helicopter, but the line was too heavy and the helicopter had to release the line before it reached the tailhold. The rigging crew then had to untangle the strawline and pull it manually to the tailhold. It was also necessary to install haulback and skyline extensions. Finally, poor alignment between the intermediate support, the yarder, and the tail tree caused the carriage to fall off the jack whenever it tried to pass the intermediate support, so the contractor had to select and rig another tree for the intermediate support.

The contractor also experienced numerous rigging-related delays during yarding. The haulback line broke twice, and two tail trees, the skyline anchor, and a haulback anchor failed in separate incidents, resulting in 29.3 h of delay time. As well, another broken haulback and another tailhold failure were included in road-change times. These incidents were not classified as delays by the yarder operator because the roads were not re-rigged after the failures. (The unyarded wood remaining on one road was later yarded by helicopter.)

In addition to these rigging problems, the contractor experienced 23.0 h of mechanical delays for a total downtime of 52.3 h or 19% of total time. The two road changes took an average of 18 h or two shifts each.

Due to these many problems, long rig-up times, and the small volume yarded, only 46% of all time (or 14 shifts) (Figure 10), was spent yarding logs.

Overall, the proportion of total working time spent yarding on the clearcut block was low, resulting in low productivity. The volume available to yard per road was too small relative to the time spent rigging each road, because of the recently harvested area between the road and the block, the deletion of the area with inadequate payload on the southernmost road, and the decision after the tailhold failed to leave the remaining felled and bucked timber on one yarding road for helicopter harvesting.

Yarding downhill over the slope break at the lower boundary of the block resulted in the mainline dragging on the ground and rubbing on logs near the break.

Leaving wildlife trees at the prescribed level posed no problems to yarding.

Partial cut block

In the partial cut block, a total of 15 shifts were required to yard 1189 m³. The average shift length was 8.8 h. Productivity averaged 79.3 m³/shift worked (71.8 m³/8-h shift).

Table 5. Yarding: productivity, shift-level study

	Clearcut block	Partial cut block
Yarded volume (m³)	1892	1189
Scheduled time (SMH) (h)	269.0	132.5
Productive time (PMH) (h)	216.8	131.5
Yarding hours (YH) (h)	124.3	102.5
Shifts worked (no.)	31	15
Average shift length (h)	8.7	8.8
Average crew size (no. people)	5.8	5.9
Average turn size (m³/turn)	2.2	1.8
Productivity		
(m³/shift [a])	56.3	71.8
(m³/SMH)	7.0	9.0
(m³/PMH)	8.7	9.0
(m³/YH)	15.2	11.6

[a] Based on an 8.0-h/shift.

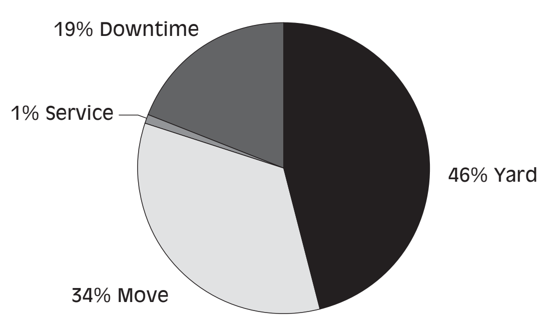


Figure 10. Yarding time distribution, clearcut.

Hourly productivity averaged 9.0 m^3/PMH, 9.0 m^3/SMH (only 1 h of mechanical downtime was recorded), and 11.6 m^3/YH. Average turn size was 2.6 pieces or 1.8 m^3.

Rigging up for the first time took only 9 h for the partial cut block because no problems were encountered and intermediate supports were not required. The two corridor changes averaged 10 h each. Seventy-seven percent of the time was spent yarding logs in this block (Figure 11).

Overall productivity per SMH was higher for the partial cut block than for the clearcut block, but productivity per YH was lower, even though the average yarding distance was shorter in the partial cut block.

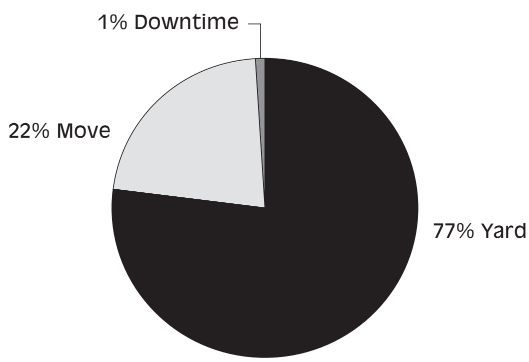


Figure 11. Yarding time distribution, partial cut.

Although the openings and leave strips in the partial cut block were to be approximately 20 m wide, a post-harvest survey (Figure 12) showed that the width of the 28 openings ranged from 7 to 26 m (average 16 m), and that the width of leave strips averaged 25 m. The length of the openings ranged from 10 to 82 m (average 37 m), and the overall size ranged from 100 to 1400 m^2 (average 600 m^2). Corridor widths ranged from 7 to 28 m (average 15 m). The total area of the corridors and openings was 2.7 ha, which was only 21% of the original 13-ha block. An additional 0.2 ha of corridor was cut in the area below the block to facilitate yarding between the landing and the block.

The average opening size in the partial cut block was within the maximum allowable size stated in the silviculture prescription. Even the largest opening was smaller than the maximum prescribed size (200 m^2). This yarding system was very successful in creating the prescribed small openings and preventing a negative visual impact from the highway. However, because the openings were smaller than prescribed, less volume was harvested than planned and costs were therefore higher.

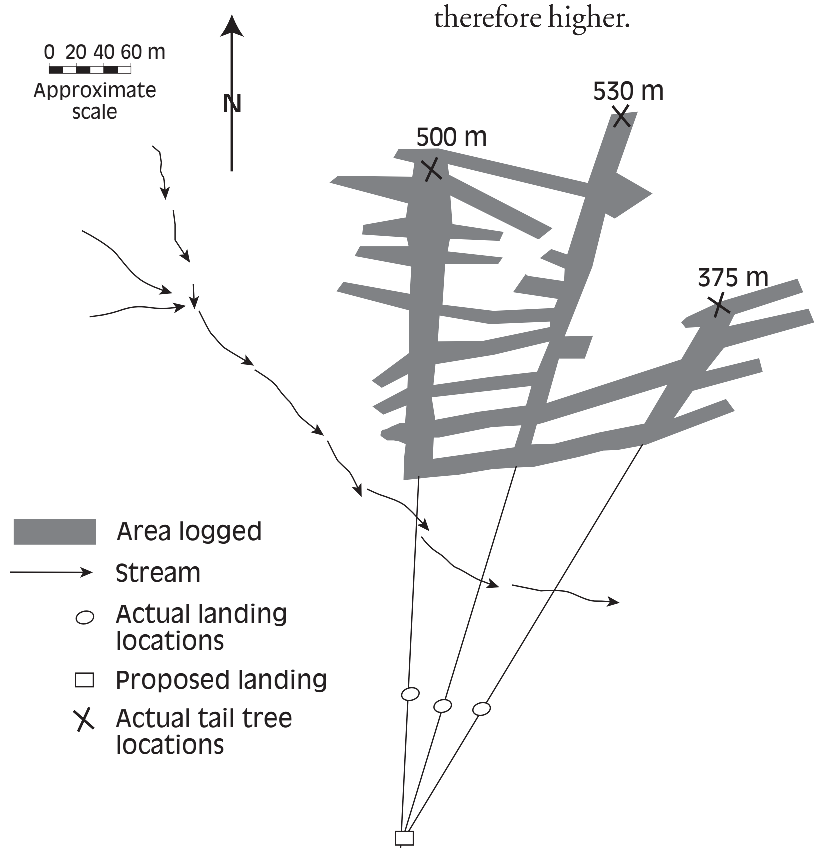


Figure 12. Actual logged area in Block 2, partial cut.

Detailed-timing study

Detailed timing was performed on the clearcut block for 9.6 h over 3 days and 70 cycles, and on the partial cut block for 9.6 h over 2 days and 101 cycles (Table 6). Outhaul and inhaul times were standardized to 400 m slope distance using average inhaul and outhaul speeds to compare the two blocks.

All cycle elements except breakout time were shorter for the partial cut block. Breakout time was longer for the partial cut where the lateral yarding distances were greater than for the clearcut. Inhaul and outhaul speeds were slower for the clearcut block, where intermediate supports were used.

The proportion of time in delays was very similar, at 6% for the clearcut and 4% for the partial cut. Most of the delay time was due to hang-ups or resetting chokers.

The overall average cycle time at the standardized distance of 400 m was 12% shorter for the partial cut compared with the clearcut. This difference may reflect the crew becoming more familiar with the carriage and long-distance yarding, rather than support the notion that yarding in a partial cut is faster.

Projected costs for re-engineered helicopter harvesting blocks

Table 7 presents estimated harvesting costs for the two study blocks and compares these with typical helicopter-harvesting costs

Table 6. Yarding: summary of detailed-timing

	Clearcut block	Partial cut block
Time (min)	577	576
Cycles (no.)	70	101
Average yarding cycle elements (min/cycle)		
Outhaul (standardized [a])	1.36 (1.17)	0.88 (1.05)
Drop chokers to ground	0.32	0.23
Hook [b]	1.74	1.44
Breakout [c]	0.45	0.52
Inhaul (standardized [a])	1.65 (1.36)	1.09 (1.29)
Unhook	0.92	0.86
Delays <15 min	0.41	0.20
Total cycle time (min/cycle) (standardized [a])	6.85 (6.37)	5.22 (5.59)
Average inhaul speed (m/min)	293	309
Average outhaul speed (m/min)	343	382
Yarding study, average parameters (range)		
Slope yarding distance (m)	479 (100–562[d])	331 (216–480)
Lateral yarding distance (m)	2 (0–8)	13 (0–42)
Height of carriage at hook point (m)	13 (5–19)	15 (4–31)
Turn size (no. logs/turn)	2.7 (1–4)	3.1 (1–5)
Piece size (m^3) [e]	0.76	0.71
Volume yarded/cycle (m^3) [f]	2.05	2.2

a Standardized to 400 m slope distance using the average inhaul and outhaul speeds.
b Includes lateral out, setting chokers, and getting in the clear.
c Includes freeing the logs, lateral in, and raising turn to the carriage.
d Turns yarded between 100 and 200 m were "clean-up turns" to pick up pieces dropped in the previously harvested area.
e From shift-level study.
f Calculated from turn size and piece size.

Table 7. Harvesting costs, based on actual productivity in the study: summary

	Clearcut block ($/m³)	Partial cut block ($/m³)
Harvesting phase		
Falling	8.83	12.87 [a]
Yarding	42.99	33.70
Helicopter for set-up [b]	0.79	1.26
Loading	21.90	17.17
Total	74.51	65.00
Estimated future costs [c]	47.68	69.30 [c]
Local helicopter harvesting rate [d]	60.00	

[a] Fallers spent 16% of the time measuring and marking openings, which equates to $2.06/m³.

[b] Estimated time of 1 h/block @ $1500/h.

[c] The estimated future costs for a partial cut are higher than the costs for the block in the study because the estimated yarding delay time (11%) is higher than the reported yarding delay time (1%).

[d] Included falling, yarding, bucking, and loading (Dave Rennie, Operations Superintendent Lillooet Division, Ainsworth Lumber Company Limited, Lillooet, BC; personal communication, December 19, 2002).

for similar sites and conditions in the area. The study costs are based on the actual shift-level productivity results for this study and include all the delays and non-falling and non-yarding activities described earlier. In this scenario, estimated falling costs were $8.83/m³ for the clearcut block and $12.87/m³ for the partial cut block, and yarding costs were $42.99/m³ for the clearcut and $33.70/m³ for the partial cut. Total costs—including falling, yarding, loading, and helicopter time for set-up—were $74.51/m³ for the clearcut and $65.00/m³ for the partial cut. The typical rate for helicopter harvesting in the area was $60/m³ at the time of the study, which included falling, yarding, bucking, and loading; however, this rate may be a little low for a partial cut.

The decision to substitute cable harvesting for helicopter harvesting required that the skyline system be adapted to the site conditions, e.g., to accommodate long-distance downhill yarding and intermediate supports on the clearcut block, and to accommodate long-distance downhill yarding, cross-stream yarding, and partial cutting prescription on the partial cut block. Not unexpectedly, because these were the very first sites to be harvested by the company with this modified cable system, several major delays occurred, most of which were attributed to lack of experience with harvesting under these particular conditions. As a result, the falling and yarding productivities in this study were lower and costs were higher than the company and the contractors had hoped, especially for the clearcut block. However, as the results for the partial cut block indicate, the loggers were able to adapt quickly and find effective solutions to most of the difficulties experienced on the first block. It is therefore reasonable to expect that delays should decrease and that productivities and costs should improve as more experience is gained.

Using the study's shift-level information and productivity results as a basis, FERIC estimated that future harvesting costs for the study conditions could be reduced to $47.68 for a clearcut and $69.30/m³ for a partial cut.[3] These adjusted costs compare favourably with average helicopter harvesting costs of $60/m³ in the area at the time of the study. In fact, Ainsworth Lumber reported that the skyline contractor was routinely producing 170–200 m³/day in similar sites and stands three months after finishing this study.[4] Ainsworth Lumber is now realizing savings of $20–25/m³ by converting helicopter blocks to long-distance skyline blocks.[5]

Conclusions

FERIC conducted a study in southwestern British Columbia that followed the planning and harvesting of a clearcut block and a partial cut block which were originally planned for helicopter harvesting and were

[3] The assumptions used to generate expected costs can be obtained from the author.

[4] Peter Scharf, Area Manager, International Forest Products Limited, Terrace, BC (formerly with Lillooet Division, Ainsworth Lumber Company Limited); personal communication, August 2003.

[5] Dave Rennie, Operations Superintendent, Ainsworth Lumber Company Limited, Lillooet, BC; personal communication, August 2003.

then converted to long-distance skyline harvesting. FERIC documented the layout changes associated with the conversion; and determined productivities and costs for falling, yarding, and loading. Finally, by factoring out some of the unusual events that occurred during this study, FERIC estimated future skyline harvesting costs, and compared these adjusted costs with helicopter harvesting costs typical for the area.

Mistakes in planning, small block sizes, high set-up costs, and start-up problems associated with adapting the cable configuration to the particular conditions of this study site resulted in lower productivity and higher costs than necessary. However, as experience in substituting cable harvesting for helicopter harvesting is gained, productivities and costs should improve. Although actual overall skyline harvesting costs were $74.51/m³ for the clearcut block and $65.00/m³ for the partial cut block, FERIC estimates that it would be feasible to achieve overall harvesting costs of $47.68/m³ and $69.30/m³ respectively for similar clearcut and partial cut blocks. These adjusted costs compare favourably with typical helicopter harvesting costs of $60/m³ for similar sites and conditions.

Although helicopter harvesting may be a quick and simple solution for harvesting difficult sites, it may not always be the most economical alternative, especially when stumpage rates are at minimums. As stumpage rates change so may the lowest-cost method of harvesting. While skyline systems require a higher level of expertise and more detailed planning, potential cost savings warrant their consideration by forest companies and harvesting contractors. Ainsworth Lumber is now realizing savings of $20–25/m³ by converting helicopter blocks to long-distance skyline blocks.

It is important to consider whether environmental, silvicultural, and visual quality goals can be achieved by substituting a cable system for a helicopter system. If these objectives can be met, implementation of a well-planned cable system may reduce overall log costs including stumpage. As this study demonstrated, changing to a new system can be difficult, but productivity improves as experience is gained.

Implementation

Based on observations made during the study, and on the study's outcomes, FERIC has compiled a number of suggestions for assisting forest companies implementing skyline harvesting. Many of these suggestions are good practices for any skyline system, regardless of whether one is converting from helicopter harvesting. The suggestions are grouped by area of responsibility; some overlap occurs, so all parties need to communicate and work together to make the operation successful.

Planners

- A thorough investigation is necessary to determine the operational feasibility of the harvesting system. Include an evaluation of the amount of wood available and of the effects of deleting any area that cannot be harvested by the proposed system. Ensure the harvestable wood volume is sufficient on each skyline road or corridor to economically justify the set-up times. The time to set up a skyline system and the time to change corridors or roads can vary greatly by location; more complex situations will require greater volumes of wood to make the operation economically viable. Avoid areas where the entire skyline corridor or road cannot be harvested, such as yarding over previously harvested ground and leave areas.
- In partial cuts, employ block layout personnel rather than fallers to measure and mark the openings because their hourly cost is usually lower. Ensure these people are properly trained regarding falling safety issues.

Layout personnel

- Engineering of skyline systems must be conducted to a high standard, especially in complex situations such as those involving partial cuts and intermediate supports.
- To improve falling and yarding productivity in partial cuts, ensure that layout is precise; all yarding corridors must be straight and correctly located before falling starts, and intermediate support trees, tail trees, and landings must be properly aligned. Ensure corridors line up with the yarder's position, especially if corridors are narrow. Consider using GPS to improve the accuracy of corridor location. Ensure openings are large enough or spaced closely enough to allow two or more fallers to work independently in the block, but within easy reach of each other in the event of an emergency.
- Because skyline yarding develops much higher line stresses than other cable systems, ensure primary anchors and backup anchors are strong enough to permit the system to operate safely and with sufficient payloads.

Loggers

- All fallers should be equipped with two-way radios.
- Where hiking distances are long, consider transporting fallers to the falling site by helicopter.
- If yarding payloads permit, consider limbing and bucking the stems at the landing rather than on the hillside.
- Leave some extra tail and intermediate support trees standing in case replacements are needed.
- Ensure all anchors are adequately installed and tied back such that they can withstand the forces of skyline harvesting.
- Pre-rig as much as possible to reduce the downtime for set-up and corridor and road changes.
- Using a helicopter to pull the strawline can be fast and economical (Palmer 1998). Make sure the helicopter's capacity is sufficient for the intended load with allowances for drum friction and possible hangups. When pulling cable uphill, tie off the cable before it is released from the helicopter. If pulling the cable off the drum is not feasible, the helicopter can place bundles of coiled strawline at intervals along the yarding corridor or road instead.

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Acknowledgements

The author gratefully acknowledges the cooperation of Bill DeGraff, Barry Gilmore, and Jim Carey of BDG Falling Contracting; Kelly Beattie and the yarder crew of Hillside Harvesters Limited; Peter Scharf of International Forest Products Limited (formerly with Lillooet Division, Ainsworth Lumber Company Limited); Dave Rennie, of Lillooet Division, Ainsworth Lumber Company Limited; and Wayne Van Damme of Acme Manufacturing, Inc.

Appendix I

Falling costs

	Falling costs ($/SMH)
Faller's wages [a]	48.79
Wage benefit loading at 40%	19.52
Powersaw costs [b]	9.23
Total cost [c]	77.54

[a] IWA rate for coastal British Columbia, effective June 15, 2002.
[b] Includes powersaw, repairs, gas, oil, and falling supplies.
[c] Excludes transportation, supervision, overhead, profit, and risk.

Appendix II

Machine costs [a]

	Yarder, Madill 071, used	Carriage, Acme 200, new	Hydraulic log loader, 30 000-kg class, new
OWNERSHIP COSTS			
Total purchase price (P) $	175 000 [b]	80 000 [c]	500 000
Expected life (Y) y	5	5	5
Expected life (H) h	8 880	8 880	8 880
Scheduled hours/year (h)=(H/Y) h	1 776	1 776	1 776
Salvage value as % of P (s) %	20	20	25
Interest rate (Int) %	9.0	9.0	9.0
Insurance rate (Ins) %	2.0	2.0	2.0
Salvage value (S)=((P•s)/100) $	35 000	16 000	125 000
Average investment (AVI)=((P+S)/2) $	105 000	48 000	312 500
Loss in resale value ((P-S)/H) $/h	15.77	7.21	42.23
Interest ((Int•AVI)/h) $/h	5.32	2.43	15.84
Insurance ((Ins•AVI)/h) $/h	1.18	0.54	3.52
Total ownership costs (OW) $/h	22.27	10.18	61.59
OPERATING COSTS			
Wire rope-total (wc) $	68 400 [d]	-	-
Wire rope life-average (wh) h	2 530 [e]	-	-
Rigging & radio (rc) $	31 400 [f]	-	-
Rigging & radio life (rh) h	8 880	-	-
Other equipment (oc) $	13 700 [g]	-	-
Other equipment life (oh) h	3 552	-	-
Fuel consumption (F) L/h	17.0	1.0	27.0
Fuel (fc) $/L	0.44	0.44	0.44
Lube & oil as % of fuel (fp) %	10	10	10
Track & undercarriage replacement (Tc) $	22 500	-	30 000
Track & undercarriage life (Th) h	6 000	-	5 400
Annual operating supplies (Oc) $	32 000 [h]	-	-
Annual repair & maintenance (Rp) $	43 800 [i]	3 500	68 000
Shift length (sl) h	8	-	8
Total wages (W) $/h	127.43 [j]	-	25.39
Wage benefit loading (WBL) %	40	-	40
Wire rope (wc/wh) $/h	27.04	-	-
Rigging & radio (rc/rh) $/h	3.54	-	-
Other equipment (oc/oh) $/h	3.86	-	-
Fuel (F•fc) $/h	7.48	0.44	11.88
Lube & oil ((fp/100)•(F•fc)) $/h	0.75	0.04	1.19
Track & undercarriage (Tc/Th) $/h	3.75	-	5.56
Operating supplies (Oc/h) $/h	18.02	-	-
Repair & maintenance (Rp/h) $/h	24.66	1.97	38.29
Wages & benefits (W•(1+WBL/100)) $/h	178.40	-	35.55
Total operating costs (OP) $/SMH	267.50	2.45	92.47
TOTAL OWNERSHIP AND OPERATING COSTS (OW+OP) $/SMH	289.77	12.63	154.06

[a] Costs exclude taxes, freight, crew transportation, first-aid coverage, fire protection, supervision, profit and overhead, and are not the actual costs incurred by the contractor. Annual costs for repairs and maintenance were estimated by FERIC. [b] Purchase of used machine for $100 000 plus $75 000 for refurbishing. [c] US$51 500, Dec 2002. C$ 1.55 = US$1.00. [d] Includes wire rope with extensions for yarding up to 900 m. [e] Weighted average. Life varies by line type: skyline and mainline (2 y @ 1776 h/y), haulback and strawline (1 y @ 1776 h/y), guylines and utility lines (5 y @ 1776 h/y). [f] Rigging includes tree jacks, climbing gear, line spooler, blocks, and misc. hardware and tools. Portable radios (5 @ $1000 each). [g] Powersaws, saw winches, saw wire cutters, straps, hooks, and shoes. [h] Chokers, rock anchors, powersaw fuel, and misc. supplies. [i] For yarder ($35 000), powersaws, powersaw winches, cutters, radios, etc. [j] IWA rates for coastal British Columbia, effective June 15, 2002, for long-line yarding: operator, hook & rig, rigging slinger, chaser, and chokersetter.