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HARVESTING ECONOMICS: SEVEN CASE STUDIES OF COASTAL HIGHLEAD YARDING

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Abstract

This is the first report in a series of studies based on a joint project between the Forest Engineering Research Institute of Canada (FERIC) and the Department of Harvesting and Wood Science, Faculty of Forestry, University of British Columbia. This cooperative project was funded by FERIC, University of British Columbia, and the Natural Sciences and Engineering Research Council of Canada. The report discusses seven case studies of cable yarding with Madill 009 highlead yarders. The studies were conducted on Vancouver Island, British Columbia in 1988.

Introduction

This report describes a series of highlead yarding studies conducted for the Harvesting Economics Project of the Forest Engineering Research Institute of Canada (FERIC). Average production figures are presented, and the influence of stand conditions, log size, yarding distance, and terrain on productivity and cost are discussed.

Loggers usually estimate logging costs for each phase of their operation (falling, skidding, yarding, and loading) by averaging costs for a broad range of timber and terrain conditions. The disadvantage of using costs that are determined in this manner is that they are averages only. While a given average cost may seem satisfactory, a breakdown of costs for specific parts and sites may reveal individual cost situations that are not profitable (Adams 1965). In order to determine the ideal harvesting system for individual stands of timber, information about the productivity and cost of alternatives is required. The influence of such variables as piece size, stand density, yarding distance, terrain, and equipment-labour mix on harvesting costs must be known and related to the stands to be logged in the future. To provide this information, the Harvesting Economics Project was initiated by FERIC member companies in 1983. Previous FERIC studies have addressed the handfalling and grapple yarding of Coastal old-growth and second-growth timber (MacDonald 1987 and 1988; Peterson 1987 and 1988).

The data collected for this report were obtained by taking on-site detailed measurements of seven highlead yarding operations (Figure 1) on Vancouver Island, B.C. Four studies were carried out near Port McNeill, and three were undertaken in the vicinity of Lake Cowichan. Data were collected as part of a cooperative project that was jointly funded by the Natural Sciences and Engineering Research Council of Canada, the University of British Columbia, and FERIC.

Study Methods

Detailed-timing data were collected using MEMO hand-held microcomputers. To gather data by piece size, individual pieces were scaled and numbered with paint prior to yarding. Detailed terrain information was also gathered for each site.

Keywords: Cable logging, Highlead, Cable yarders, Machine evaluation, Time study, Productivity, Costs, Economic analysis, Old growth, Madill 009 Highlead Yarder.

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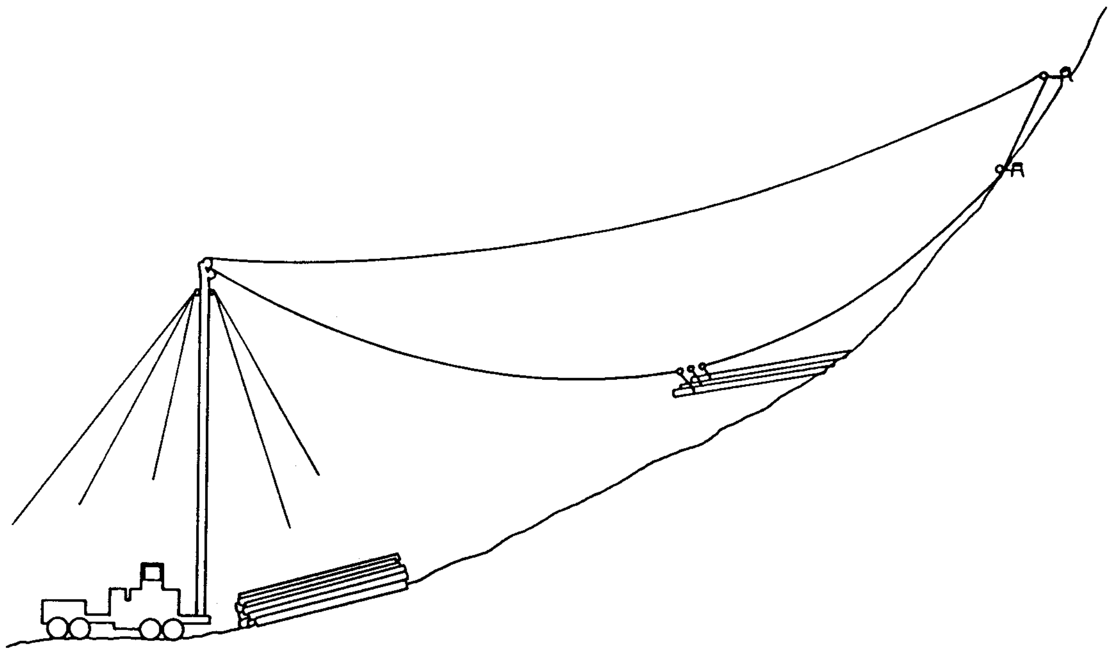

Figure 1. Typical highlead yarding setup.

The studies were conducted over a period of six months, between February and July 1988. During this period, detailed information was gathered on 505 pieces. More general production data were collected on an additional 1294 pieces. Piece volumes were derived from on-site measurements taken by field technicians.

All mechanical and operational delays were recorded and then converted to determine productivity in terms of 8-h shifts. The machine utilization levels used were those observed during timing. Costs were estimated by FERIC and are not actual costs of the cooperating companies (Appendix I).

Site and System Description

Case Studies 1-4 were located on northern Vancouver Island near Port McNeill, B.C., and Case Studies 5-7 were located on southern Vancouver Island in the vicinity of Lake Cowichan, B.C. Table 1 provides site information.

In all cases, the old-growth stands were handfelled and processed at the stump according to falling and bucking rules issued by the company. Logs were yarded to landings and immediately loaded onto the off-highway trucks and hauled to the unloading points.

Operating specifications for the yarders are shown in Table 2. Yarding on all areas was done with Madill 009 highlead yarders. Pieces were yarded to roadside and decked for loading. Case Studies 1 and 2 were yarded with Machine #1, Case Studies 3 and 4 were yarded with Machine #2, while Machine #3 yarded Case Studies 5, 6, and 7.

Case Studies 1-4 took place in old-growth stands, composed mainly of hemlock and balsam species, on four separate locations. The slopes of the yarding roads in Case Study 1 ranged from 40 to 110%, and the terrain was broken by major rock bluffs and creek draws. The logging chance (yarding deflection, obstacles, terrain, falling pattern, etc.) on Case Study 1 was classed as poor because of the presence of rock bluffs and gullies. Case Studies 2-4 were considered to have a moderate logging chance; slopes ranged from 25 to 85%.

Case Studies 5-7 took place on the same location. The stand was composed mostly of hemlock, balsam, and cedar species. Yarding road slopes ranged from 15 to 85% and averaged 50%. The terrain was classed as even to rolling with ridges. The ridges ran up and down the slope as well as along the top of the slope. Rock outcrops were present throughout the area; these influenced yarding operations and the movement of chokermen when setting chokers.

In Case Study 5, timber was yarded downhill (slightly across the slope), along a ridge, with an average yarding road slope of 30%. The logging chance during this period was considered moderate. The logging chance for Case Study 6, where timber was yarded across the slope, was very poor because of two ridges running up and down the slope. In addition, the 70% side slope caused many turns to slide down the slope, thus creating hangups. Rechoking of logs was often necessary, and many chokers and logs broke because of hangups on stumps and rock outcrops. The logging chance for Case Study 7 was considered moderate to poor. Timber was yarded uphill and slightly across the slope. The yarding deflection for Case Study 7 could have been improved if the tower had been located closer to the break in the slope.

Table 1. Site Descriptions

Description	Case Study 1	Case Study 2	Case Study 3	Case Study 4	Case Study 5	Case Study 6	Case Study 7
Falling methods	Hand felled	Hand felled	Hand felled	Hand felled	Hand felled	Hand felled	Hand felled
Stand type	Old growth	Old growth	Old growth	Old growth	Old growth	Old growth	Old growth
Yarding direction	Downhill	Downhill	Downhill	Downhill	Downhill	Across slope	Uphill
Yarding slope							
Range	40-110%	30-75%	30-85%	25-80%	15-65%	40-85%	30-60%
Average	60%	45%	45%	40%	30%	55%	45%
Aspect	Southwest	North	West	West	Northwest	North	North
Terrain	Broken/gullied	Gullied	Rolling/gullied	Rolling/gullied	Rolling/ridge	Gullied/ridge	Even/broken
Exposed rock	10-20%	0-10%	10-20%	10-20%	10-15%	10-15%	10-15%
Underbrush	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Obstacles	Rock bluffs	Gullies	Rock bluffs	Rock bluffs	Rock outcrops Stumps (2 m)	Rock outcrops Stumps (2 m)	Rock outcrops Stumps (2 m)
Volume/ha (gross)	620 m^3	700 m^3	1 027 m^3	1 027 m^3	687 m^3	687 m^3	687 m^3

Table 2. Operating Specifications: Madill 009 Highlead Yarder

Description	Machine #1 (Case Studies 1 & 2)	Machine #2 (Case Studies 3 & 4)	Machine #3 (Case Studies (5, 6, & 7)
Model year	1974	1973	1974
Engine	Cummins KTA 389 kW (525 HP)	Caterpillar 1693 267 kW (360 HP)	Caterpillar 1693 267 kW (360 HP)
Carrier	4-axle rubber-tired	4-axle rubber-tired	4-axle rubber-tired
Tower height	27.4 m (90 ft)	27.4 m (90 ft)	27.4 m (90 ft)
Fuel capacity	2 250 L	2 250 L	2 250 L
Number of guylines	6	6	8
Machine weight	45 249 kg	45 249 kg	46 000 kg
Line speed at mid-drum			
Mainline	262 m/min	262 m/min	262 m/min
Haulback	707 m/min	707 m/min	707 m/min

Results and Discussion

Detailed-Timing Results

Table 3 summarizes both the machine timing and productivity data for all seven case studies. Productive time ranged from 79 to 91% of the total time, with a combined average of 89%. Little downtime resulted from mechanical problems (3% of total time) during the study periods. A summary of non-productive time is shown in Appendix II.

Within the four phases of yarding, setting chokers (choke) accounted for the largest portion of the yarding turn time, and varied considerably depending on yarding chance and safety conditions. The crews used two, and occasionally three, chokers during the study periods. The choke element ranged from 50 to 65% of total yarding phase time, with a combined average of 57%. The average time per turn to set chokers ranged from 3.1 to 4.8 min. The longest choke time occurred when yarding across the slope; gravity pulled the turns downhill, causing chokers and logs to wrap around stumps, boulders, and unyarded timber. This resulted in slow inhaul time and the need to rechoke turns to avoid choker and log breakage. Steep terrain, uneven footing, and the lay of logs also increased choke time because the crew required more time to walk to safe observation points.

Inhaul time was the second largest yarding phase category with a 19% combined average time. Inhaul time per turn varied from 15 to 22% of total time. It was observed to depend on yarding distance, yarding deflection, obstacles, and safety.

Table 3. Timing Summary

Phase	Case Study 1 min	Case Study 1 %	Case Study 2 min	Case Study 2 %	Case Study 3 min	Case Study 3 %	Case Study 4 min	Case Study 4 %	Case Study 5 min	Case Study 5 %	Case Study 6 min	Case Study 6 %	Cast Study 7 min	Cast Study 7 %	Combined min	Combined %
Productive time																
Yarding	918.9	84	1 638.7	80	935.8	75	415.7	75	299.4	74	849.9	78	372.9	86	5 431.3	79
Yarding road changes	82.3	7	187.5	9	130.7	10	20.3	4	70.6	17	133.2	12	60.9	14	685.5	10
Subtotal	1 001.2	91	1 826.2	89	1 066.5	85	436.0	79	370.0	91	983.1	90	433.8	100	6 116.8	89
Nonproductive time																
Mechanical	56.9	5	92.8	4	25.0	2	62.8	11	9.6	3	-	-	-	-	247.1	3
Other	41.5	4	142.0	7	165.4	13	55.9	10	25.5	6	102.8	10	1.7	<1	534.8	8
Subtotal	98.4	9	234.8	11	190.4	15	118.7	21	35.1	9	102.8	10	1.7	<1	781.9	11
Total scheduled machine time	1 099.6	100	2 061.0	100	1 256.9	100	554.7	100	405.1	100	1 085.9	100	435.5	100	6 898.7	100

	Case Study 1	Case Study 2	Case Study 3	Case Study 4	Case Study 5	Case Study 6	Cast Study 7	Combined
Yarding phase summary								
Minutes/turn								
Outhaul	0.7	0.4	0.4	0.5	0.5	0.7	0.6	0.5
Choke	3.7	3.3	3.1	4.0	3.6	4.8	4.1	3.6
Inhaul	1.6	1.1	0.8	1.2	0.9	1.6	1.2	1.2
Unhook	1.4	1.3	1.0	0.7	1.1	0.6	0.4	1.0
Total	7.4	6.1	5.3	6.4	6.1	7.7	6.3	6.3
Yarding road change (min/occ.)								
Range	2.9-27.8	8.2-53.5	7.6-25.8	20.4	24.3-46.3	10.6-67.4	17.1-22.7	2.9-67.4
Average	16.5	14.4	11.9	20.4	35.3	33.3	20.3	17.6
Yarding piece size (gross vol.)								
Range (m^3/log)	0.33-18.07	0.16-24.24	0.10-12.43	0.10-12.43	0.08-7.93	0.10-9.01	0.13-11.0	0.08-24.24
Average (m^3/log)	2.83	3.63	2.07	2.07	1.46	2.00	1.64	2.59
Total no. logs yarded	254	561	359	180	129	216	100	1 799
Total no. turns	125	266	177	64	49	110	59	850
Average no. logs/turn	2.0	2.1	2.0	2.8	2.6	2.0	1.7	2.1
Average volume/turn (m^3)	5.75	7.66	4.20	5.82	3.84	3.93	2.78	5.48
Yarding distance (m)								
Average	198.5	125.3	97.0	157.2	120.5	159.1	136.6	136.3
Maximum	300.0	255.0	160.0	240.0	190.0	250.0	185.0	300.0
Logs/8-h shift	110.9	130.7	137.1	155.8	152.9	95.5	110.2	125.2
Volume/8-h shift (m^3)	313.8	474.4	283.8	322.5	223.2	191.0	180.7	324.3
Total equipment cost/8-h shift [a]	$1 905.28	$1 905.28	$1 905.28	$1 905.28	$1 905.28	$1 905.28	$1 905.28	$1 905.28
Cost per log	$17.18	$14.58	$13.90	$12.23	$12.46	$19.95	$17.29	$15.22
Cost/m^3	$6.07	$4.02	$6.71	$5.91	$8.54	$9.98	$10.54	$5.88

[a] Interest costs are excluded.

Unhook time per turn was the third largest yarding phase category. It varied from 6 to 21% of yarding time, with a combined average of 16%. This time was observed to vary with decking patterns, number of logs per turn, and landing layout. The lowest average unhook time of 0.4 min/turn occurred with Case 7. Case 7 also had the lowest average number of logs per turn at 1.7.

Outhaul times per turn were consistent at 7-9% of yarding turn time.

Yarding road change time (move tailblocks) ranged from 2.9 to 67.4 min/occurrence. Average times per case study ranged from 11.9 to 35.3 min/occurrence, with a combined average of 17.6 min/occurrence. There were a total of 39 yarding road changes observed during the study. This averages out to approximately one yarding road change for every 3 h of scheduled machine time, or one change for every 2.5 h of productive machine time.

The yarded piece sizes shown for Case Studies 1-4 are based on marking and scaling of logs by a field crew prior to yarding. In Case Studies 5-7, logs were marked prior to yarding and then scaled when they arrived at the dryland sortyard. Scaling and log marking was done only in areas to be immediately yarded. As such, they may not be representative of the total setting, but are considered to be representative for the periods studied.

Each crew consisted of six men (hooktender, yarding engineer, rigging slinger, chaser, and two chokermen). The labour rates used in the cost analysis are 1989 International Woodworkers of America-Canada (IWA) rates plus 35% burden (Appendix I). Machinery costs, based on information obtained from equipment and supplies distributors, have been estimated by the authors using a standard FERIC owning, repairing, and operating formula. Costs such as supervision, overhead, crew transportation, and equipment transportation are not included. Also, interest costs are excluded from the machinery costs reported in the text, but are calculated in Appendix I.

Costs per log varied from \$12.23 to \$19.95. Case Study 4 had the lowest cost per log, mainly because it recorded the largest number of logs per turn, at 2.8, and the largest number of logs per shift, at 155.8. The highest cost per log was associated with Case Study 6; this case had a poor logging chance, the highest total time per turn, and the lowest number of logs per shift.

The highest costs per m^3 occurred in Case Studies 5-7. In these cases, log sizes were small, a low number of logs were yarded per turn, and logging chances were moderate to poor. Case Study 7 had the highest cost per m^3 at \$10.54; the average log size was small (1.6 m^3), the number of logs yarded per turn was low (1.7), the logging chance was moderate to poor with the highest combination of choke and inhaul yarding phase times (85%). The lowest cost per m^3 occurred in Case Study 2, with a high average log volume of 3.63 m^3 being the main reason.

Conclusions

Setting chokers accounted for the largest portion of yarding turn time. Across-slope yarding caused the most problems, i.e. hangups, broken chokers, and broken logs.

Logging chance (yarding deflection, obstacles, terrain, falling pattern, etc.) had a direct effect on yarding costs and productivities. Generally, case studies with a moderate logging chance had lower costs, while case studies with a poor logging chance had higher costs.

Yarding cost per log varied from \$12.23 to \$19.95. The case study with the lowest cost per log had the highest number of logs per turn, at 2.8. The case study with the highest cost per log averaged 2.0 logs per turn and had a poor logging chance.

The highest cost per m^3 occurred in case studies combining small log size, low number of logs per turn, and moderate to poor logging chances. The lowest cost per m^3, \$4.02, occurred in a case study having the highest average piece size (3.63 m^3) and a moderate logging chance.

An overall summary report will be prepared at a future date. This summary report will review all FERIC studies done to date, deal with specific log information (marginal log analysis), and discuss what is required in future studies.

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Appendix I

Machine Cost Analysis: Madill 009 Highlead Yarder

OWNERSHIP COSTS	
Purchase price (P)	$435 000
Salvage value (S), (30% of P)	130 500
Expected life (yr)	15
Hours per year (h)	1 440
Interest rate (I), %	13.5
Insurance rate (Ins), %	2
Average investment (AVI) = (P + S)/2	$282 750
Loss in resale value ($/h) = (P - S)/(yr • h)	$14.10
Interest ($/h) = (I • AVI)/(h/yr)	$26.51
Insurance ($/h) = (Ins • AVI)/(h/yr)	$ 3.93
Subtotal ownership costs ($/h)	$44.54
OPERATING AND REPAIR COSTS	
Wire rope cost (W)	
Mainline, 427 m of 32-mm @ $488/30 m	$6 950
Haulback, 1 036 m of 22-mm @ $270/30 m	$9 330
Strawline, 1 128 m of 11-mm @ $107/30 m	$4 020
Line life (LL), h	1 800
Rigging cost (Rc)	$3 500.00
Rigging life (Rl), h	7 200
Choker cost (C)	$136.72
Choker use (#/yr)	216
Fuel consumption (L/h)	36
Fuel cost ($/L)	$0.37
Annual repair and maintenance cost (R)	$31 500
Wages ($/h)	
Hooktender	$20.02
Yarding engineer	$18.37
Rigging slinger	$18.00
Chaser	$17.00
Chokerman (2)	$16.83
Wage benefit loading (%)	35
Line cost = (total W)/LL	$11.28
Rigging cost = (Rc/Rl)	0.49
Choker cost = (C) • (#/yr)/h	20.51
Fuel cost = (L/h) • ($/L)	13.32
Lube and oil cost = 10% • fuel cost	1.33
Repair and maintenance cost = R/(h/yr)	21.88
Labour cost[a] ($/h)	151.32
Subtotal operating and repair costs ($/h)	$220.13
TOTAL COST	
Ownership costs	$44.54
Operating and repair costs	220.13
Total cost ($/h)	$264.67
Total cost/h, excluding interest	$238.16

[a] Operating labour costs consist of the 1989 IWA hourly rate for a particular job plus 35% for fringe benefits. The machine operator and hooktender rate includes 0.7 of an hour at overtime rate for machine servicing.

Appendix II

Summary of Delays

Description	Case Study 1 # occ.	1 min	2 # occ.	2 min	3 # occ.	3 min	4 # occ.	4 min	5 # occ.	5 min	6 # occ.	6 min	7 # occ.	7 min	Combined # occ.	Combined min	Combined %
Mechanical																	
Maintenance	3	9.3	2	5.8	-	-	1	38.2	1	1.2	-	-	-	-	7	54.5	7
Warm-up	3	47.6	4	87.0	2	25.0	1	24.6	1	8.4	-	-	-	-	11	192.6	25
Subtotal	6	56.9	6	92.8	2	25.0	2	62.8	2	9.6	-	-	-	-	18	247.1	32
Other																	
Miscellaneous [a]	2	3.1	8	40.5	5	8.0	2	2.5	4	18.2	6	30.8	-	-	27	103.1	13
Operator	2	1.3	-	-	-	-	-	-	1	0.4	1	0.5	-	-	4	2.2	<1
Rigging [b]	15	35.9	42	101.5	33	157.4	10	53.4	6	5.0	19	60.2	1	1.7	126	415.1	53
Safety [c]	3	1.2	-	-	-	-	-	-	4	1.9	5	11.3	-	-	12	14.4	2
Subtotal	22	41.5	50	142.0	38	165.4	12	55.9	15	25.5	31	102.8	1	1.7	169	534.8	68
Total	28	98.4	56	234.8	40	190.4	14	118.7	17	35.1	31	102.8	1	1.7	187	781.9	100

[a] Occurrences such as replace radios, send out water, send out saw, etc.
[b] Occurrences such as add, replace, and remove chokers; remove bull hook and shackles; etc.
[c] Wait for someone other than chokerman to walk out of danger area.

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