HARVESTING & PROCESSING

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EFFECT OF FALLING TECHNIQUES ON GRAPPLE YARDING SECOND-GROWTH TIMBER

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Summary and Conclusions

The objective of this study was to compare the grapple yarding of feller-director bunched and unbunched wood. The study was done at Weyerhaeuser Forest Products Company's Vail Operation, near Olympia, Washington.

FERIC monitored a Washington 108 swing yarder in three areas for seven days in March, seven days in August, and two days in September 1986. Costs in these areas ranged from a low of $1.66/m³ to a high of $3.11/m³ (Canadian dollars). Volumes per 8-hour shift ranged from 378 m³ to 711 m³. Costs were derived by FERIC and are not actual costs of the cooperating company.

Yarding of the feller-director bunched wood significantly improved grapple-yarding productivity. The bunched-wood area produced 10% more trees per productive machine hour (PMH) and 36% more trees per turn than the adjacent unbunched area.

In addition to turn size, both terrain and operator visibility significantly affect yarding productivities and costs. This is highlighted when comparing an area of flat terrain in clear weather to an area with steep terrain with heavy morning fog. Yarding costs were $1.28/m³ and $2.36/tree better in the first location than in the second one. Correspondingly, there was a 71% difference in volume per PMH and an 86% difference in trees per PMH.

Decking time significantly increases with steeper terrain (12.1% in the steep area compared to 3.5% in the flat one). The steeper terrain caused more trees to slide away, thus requiring regrappling and replacing.

Introduction and Study Method

The majority of the Vail Operation's annual harvest is now in second-growth stands. These stands are smaller in diameter and of lower value than the previous old-growth timber. Weyerhaeuser is continually trying new methods and systems to reduce harvesting costs in these stands.

Keywords: Felling, Cable Logging, Grapple Yarders, Second Growth, Economic Analysis

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A Washington 108 swing yarder was used to grapple yard timber which had been mechanically felled. Felling was done by a 91-cm Weyerhaeuser W34 feller-director head mounted on a Timbco 2518 carrier. Two different falling patterns were tried to determine their effect on yarding costs and productivity. After felling, the trees were yarded to the roadside and windrowed along the road (Figure A). The windrowed trees were mechanically processed and then loaded and hauled to the dryland sortyard at Vail, Washington.

This report contains the results of the monitoring period of the yarder. FERIC instrumented the Washington 108 with a Model DSR Servis Recorder to identify machine activity (shift level study). The operator provided FERIC with daily recorder charts and shift reports which included details of non-productive time. In addition, data were collected in the Vail Camp Area B and Johnson Creek openings utilizing hand-held stop watches (detailed timing study).

Site and System Description

The three study areas are located in western Washington, approximately 35 km east of Olympia, Washington. Stand information is shown in Table 1.

TABLE 1. Stand Description.

	Vail Camp Areas A and B	Johnson Creek
Opening Area	6.5 ha each	1.3 ha
Slope Range	0-13%	0-56%
Slope Average	5%	28%
Slope Aspect	Northeast	Southeast
Terrain	Even	Even
Exposed Rock	None	None
Underbrush	Light	Medium
Obstacles	None	A few windfalls & old stumps
No. of stems per ha	458	733
Estimate gross volume/ tree yarded, m^3	1.50	1.64

In the Vail Camp area, two side-by-side openings were laid out so that a comparison could be made between yarding bunched and unbunched wood.

In Area A, trees were feller-directed and bunched (butts grouped together) with butts facing the haul road at approximately a 45-degree angle. In Area B, trees were just felled by the feller-director with butts facing the road at approximately a 45-degree angle. Trees in the Johnson Creek area were feller-directed and partially bunched (Figure B).

FIGURE A. Windrowed Trees in the Vail Camp Area.

FIGURE B. Johnson Creek Area.

Table 2 lists machine specifications of the yarder and Figures C and D show the yarder and backspar.

TABLE 2. 1969 Washington Model 108 Swing Yarder Operating Specifications.

Engine	GMC 8V-71 217 kW @ 2100 rpm
Undercarriage	Rubber Tired
Swing Capability	Yes
Tower Type	A-Frame
Height to Top of Fairlead	12.3 m
Number of Guylines	2
Weight	58 850 kg
Mid-Drum Performance	
Mainline	- 37 650-kg stall line pull - 400-m/min no load line speed
Haulback	- 9050-kg stall line pull - 550-m/min no load line speed
Grapple	Johnson Y86 (218-cm) Yarding Grapple

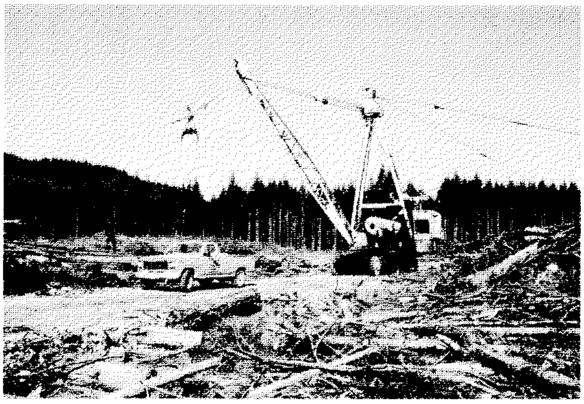

FIGURE C. 1969 Washington 108 Swing Yarder.

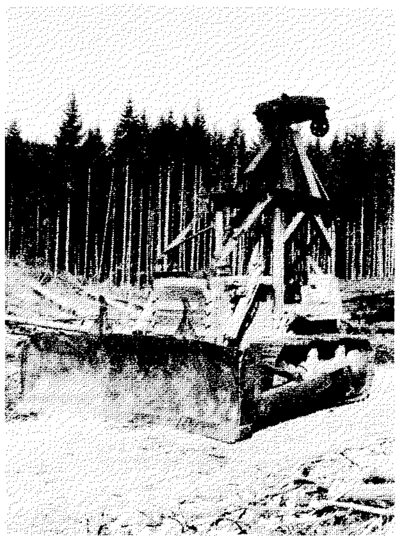

FIGURE D. 1970 Caterpillar D8 Backspar.

The yarding crew consisted of two men--a machine operator and a hooktender. FERIC considers both to have been skilled and efficient.

The maximum yarding distance in Vail Camp was 220 m. The flat terrain caused some deflection problems on longer yarding distances but only 45% of the hookups in Area A required spotting by the hooktender.

The maximum yarding distance in the Johnson Creek area was 200 m. In this area, heavy morning fog (maximum visibility of 50 m) and a knoll just before the road, obscured the operator's vision and required the hooktender to spot 88% of the hookups by radio.

Results and Discussion

Summary statistics for individual time elements are reported for each operating area. Table 3 contains the calendar time distribution which shows that 73% of the possible shifts were worked.

This report makes two comparisons:

1) Bunched (Vail Camp Area A) versus unbunched wood (Vail Camp Area B) in similar 5% slope terrain; and

2) Terrain effect, primarily unbunched wood on 5% slope (Vail Camp Area B) with partially bunched wood on 28% slope (Johnson Creek).

The shift level study results (Table 3) show that bunching had a positive effect on production. When comparing the two areas of similar terrain (Vail Camp Areas A and B) it was found that bunching resulted in 36% more trees per turn and was 10% more productive.

TABLE 3. Time and Production Summary for Shifts Worked.

Identification	Vail Camp Area A		Vail Camp Area B		Johnson Creek		Combined	
Report Period	Mar. 21-31/86		Aug. 4-12/86		Sept. 18-19/86			
Possible Shifts in Period	11		9		2		22	
	Total	%	Total	%	Total	%	Total	%
Shifts Worked (With Production)	7	63.6	7	77.8	2	100.0	16	72.7
Weekends (# Shifts) of No Activity	4	36.4	2	22.2	0	0	6	27.3
Total	11	100.0	9	100.0	2	100.0	22	100.0
Productive Machine Hours (PMH)	Total	Avg Shift	Total	Avg Shift	Total	Avg Shift	Total	Avg Shift
Yarding	39.8	5.7	36.3	5.2	9.4	4.7	85.5	5.4
Road Change	6.0	0.9	5.1	0.7	0.8	0.4	11.9	0.7
Subtotal	45.8	6.6	41.4	5.9	10.2	5.1	97.4	6.1
Non-Productive Time								
Repair			0.8	0.1	0.8	0.4	1.6	0.1
Service	0.4	0.1	0.8	0.1			1.2	0.1
Wait Parts								
Wait Mechanics								
Non-Mechanical Delays								
Number of Moves	1						1	
Move to New Area	1.3	0.2					1.3	0.1
Other	5.7	0.8	0.2	—	—	—	5.9	0.3
Subtotal	7.4	1.1	1.8	0.2	0.8	0.4	10.0	0.6
Total[1]	53.2	7.7	43.2	6.1	11.0	5.5	107.4	6.7
Productive Time Ratio (Productive Hours/Total Hours)	86.1%		95.8%		92.7%		90.7%	
Availability (for Shifts Worked Only)[2]	99.2%		96.3%		92.7%		97.4%	
Production								
Volume Produced, m^3	4471.5		3663.0		529.7		8664.2	
Tree Count	2981		2442		323		5746	
Number of Turns	1538		1735		248		3521	
Average Tree Size, m^3	1.50		1.50		1.64		1.51	
Volume per PMH, m^3	97.6		88.5		51.9		89.0	
Trees per PMH	65.1		59.0		31.7		59.0	
Turns per PMH	33.6		41.9		24.3		36.1	
Trees per Turn	1.9		1.4		1.3		1.6	
Volume per Turn, m^3	2.9		2.1		2.1		2.5	
Production per 8-Hour Shift[3]								
Volume, m^3	710.5		644.3		377.8		647.9	
Number Trees	473.9		429.5		230.8		429.5	
Total Equipment Cost per 8-Hour Shift	$1176.32		$1176.32		$1176.32		$1176.32	
Yarding Cost per m^3 [3]	$1.66		$1.83		$3.11		$1.82	
Yarding Cost per Tree [3]	$2.48		$2.74		$5.10		$2.74	

[1] Does not include hours spent away from the study site.

[2] NOTE: Availability for Shifts Worked

$$= \frac{\text{Total Hours} - \text{Sum of (Repair + Service + Wait Parts + Wait Mechanics)}}{\text{Total Hours}} \times 100\%$$

[3] Machine Productive Time Ratio = 91%

FERIC observed that the feller-director bunches in Vail Camp Area A were loosely built. When the grapple was hooking-up, it was seldom able to get all the pieces in the bunch. It is felt that better made bunches would result in greater productivity. An earlier FERIC study (Peterson 1986) showed bunching resulted in a 65% increase in pieces yarded per shift and a 40% reduction in cost per piece.

The detailed timing data (Table 4) showed the outhaul, hookup, and inhaul phases together were 0.58 min/cycle higher at the Johnson Creek operation. FERIC believes much of this difference resulted from the poor operator visibility and steeper terrain at Johnson Creek. In the Vail Camp Area B location, the unhooking time was longer by 0.18 min/cycle caused by the extra time it took for the slack in the opening line to spool on the winch. It is felt that the uphill yarding at Johnson Creek resulted in marginally slower inhaul speeds, thus not creating as much slack in the opening line. FERIC was unable to collect sufficient data at Johnson Creek to calculate line speeds to confirm this. Decking time was greater by 0.26 min/cycle in the Johnson Creek area because of steeper terrain that allowed trees to slide down the windrow pile after unhooking. These trees had to be regrappled and then replaced in the windrow pile. The detailed timing data showed that 4% of the yarding cycle time was spent decking in Vail Camp Area B versus 12% in Johnson Creek. Detailed timing data were not gathered for Vail Camp Area A, so yarding phase comparisons could not be made between the Vail Camp areas. FERIC was not able to quantify the effect of the partial bunching in Johnson Creek.

TABLE 4. Yarding Phase Value Comparisons.

Yarding Area	Yarding Phase	Number Observations	Total Time (min)	Minimum (min)	Maximum (min)	Mean Value (min)	Standard Deviation (min)
Vail Camp Area B	Outhaul	583	146.0	0.04	0.68	0.25	0.12
	Hookup	583	228.0	0.05	2.99	0.39	0.30
	Inhaul	583	183.4	0.06	1.00	0.31	0.18
	Unhook	583	161.8	0.09	0.70	0.28	0.11
	Deck	55	25.9	0.07	2.38	0.47	0.16
Johnson Creek	Outhaul	174	83.2	0.09	1.04	0.48	0.15
	Hookup	174	85.2	0.10	2.89	0.49	0.42
	Inhaul	174	96.6	0.20	2.19	0.56	0.25
	Unhook	174	18.1	0.02	0.70	0.10	0.08
	Deck	53	38.9	0.12	3.23	0.73	0.59

For yarding observations in Vail Camp Area B and Johnson Creek, the minimum, maximum, and mean values were calculated for each phase. In addition, the standard deviation was computed. This information is shown in Table 4.

There was little delay time caused by mechanical reasons in either area. There were three repair occurrences--a haulback line was repaired for 0.8 hours, a tire was repaired for 0.4 hours, and a broken guyline was replaced for 0.4 hours. Service time (warmup and fuel up) accounted for 1.2 hours.

Non-mechanical delays totaled 7.2 hours. The majority of this time (3.8 hours) was for a company crew meeting. It is worth noting that the operation did not stop for coffee or lunch breaks. Both employees took breaks and ate while the other was performing some operating task.

The labour rates used in the cost analysis are current B.C. IWA rates plus a 35% burden (Table 5). Machinery costs are estimated by FERIC and are based on information from equipment and supplies distributors and use the standard owning, repairing, and operating formula format. Costs such as supervision, overhead, and crew and equipment transportation are not included. Also, interest or opportunity costs are excluded from the machinery costs reported in the text, but are listed in Table 5. Tree volumes were based on FERIC measurements in each stand.

For comparative purposes, a machine productive time ratio of 91% was used (Table 3). The yarding cost per tree in the Johnson Creek area was almost double that of the Vail Camp location. Comparing the yarding cost per cubic metre between areas, Johnson Creek was 87% more expensive than Vail Camp Area A, and 70% more than Vail Camp Area B. It must be kept in mind that the above compares only yarding costs. From the point of operating economics, the comparison must be on the cost differential from all logging phases.

Table 5. Machine Cost Analysis.

	Washington 108 Swing Yarder	Caterpillar D8 Backspar[1]
Ownership Costs		
Purchase Price (P)	$750 000	$ 60 000
Salvage Value(s), (30% of P)	$225 000	$ 18 000
Expected Life (yr)	10	5
Expected Life (h)	16 000	8 000
Interest Rate (I) %	12.5	12.5
Insurance Rate (Ins) %	1.5	1.5
Average Investment (AVI) = (P+S)/2	$487 500	$ 39 000
Loss in Resale Value ($/h) = (P-S)/h	$32.81/h	$ 5.25/h
Interest ($/h) = (I*AVI)/(h/yr)	$38.09/h	$ 3.05/h
Insurance ($/h) = (Ins*AVI)/(h/yr)	$ 4.57/h	$ 0.37/h
Operating and Repair Costs		
Wire Rope Costs (W):		
Mainline (335 m of 22 mm) @ $220/30 m	$ 2 457	0
Opening Line (335 m of 22 mm) @ $220/30 m	$ 2 457	0
Haulback (670 m of 19 mm) @ $165/30 m	$ 3 685	0
Strawline (700 m of 10 mm) @ $90/30 m	$ 2 100	0
Line Life (L), (h)	1 600	0
Rigging Cost (Rg)	$ 10 000	0
Rigging Life (RL), (h)	1 600	0
Fuel Consumption (L/h)	25	10
Fuel Cost ($/L)	$0.36	$0.36
Track and Undercarriage Life (L), (h)		5 000
Track and Undercarriage Replacement Cost (T)		$ 12 000
Annual Tire Consumption (T)	2	0
Tire Replacement Cost ($/T)	$550	0
Annual Repair & Maintenance Cost (R)	$ 40 000	$ 6 000
Wages ($/h) : (Current B.C. IWA Rates)		
1 Hooktender	$17.73	0
1 Machine Operator	$17.73	0
Wage Benefit Loading (%)	35	0
Line Cost = (Total W)/L	$ 6.69/h	0
Rigging Cost = Rg/RL	$ 6.25/h	0
Fuel Cost = (L/h) *($/L)	$ 9.00/h	$ 1.35/h[2]
Lube & Oil Cost = 10% *Fuel Cost	$ 0.90/h	$ 0.14/h
Tire Cost = T *($/T)/(h/yr)	$ 0.69/h	0
Track and Undercarriage Cost = (T/L)		$ 2.40/h
Repair & Maintenance Cost = R/(h/yr)	$25.00/h	$ 3.75/h
Labour Cost = (Total $/h) *[1+(%100)]	$47.87/h	0[3]
Operating & Repair Costs ($/h)	$96.40	$ 7.64
Total Cost		
Operating & Repair Costs ($/h)	$ 96.40/h	$ 7.64/h
Loss in Resale Value ($/h)	$ 32.81/h	$ 5.25/h
Insurance ($/h)	$ 4.57/h	$ 0.37/h
Total Cost ($/h)	$133.78/h	$ 13.26/h
Interest ($/h)	$ 38.09/h	$ 3.05/h
	$171.87/h	$ 16.31/h

[1] Used Machine
[2] Engine only runs 3 h/day = 600 h/yr
[3] Operator Included with Swing Yarder

REFERENCES

Peterson, J.T. 1986. Comparison of three harvesting systems in a coastal British Columbia second-growth stand. Forest Engineering Research Institute of Canada, Technical Report No. TR-73, 50 p.