

Productivity and Cost Evaluation for Non-guyline Yarders in Northern Idaho

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INTRODUCTION

Harvesting areas often include a riparian zone that requires protection from logging activities (Lawson 2002). Felling and wood extraction activities in these zones can be prohibitive due to strict environmental requirements and higher logging costs. Greater difficulties occur on small parcels of steep slopes (> 35%) along streams and lakes, where ground-based wood extraction may not be applied. In such environmentally sensitive areas, it is hard to justify use of large or expensive cable or helicopter logging equipment to harvest timber. Therefore, there are not only environmental requirements (Idaho's Forest Practices Act), but also economic objectives to be achieved in these sensitive areas from commercial thinning operations.

A new approach for skyline operations that is suited to harvesting timber on steep slopes and environmentally sensitive zones is the use of non-guyline yarders with a gravity skyline system. Non-guyline yarders have been developed by adding a winch and a tower to conventional logging equipment (feller-bunchers and excavators). Without guylines to rig, the machine can be moved more quickly between landing positions along the hauling roads, or within stands. The elimination of guylines on the rear of the main spar, also allows forest traffic to pass without disruption of the yarding operation.

The objectives of the study were to: 1) determine yarding production rates and costs for two non-guyline yarders, and 2) evaluate their operational capabilities and limitations in commercial thinning operations in Northern Idaho.

STUDY METHODS

Non-guyline yarding equipment

Two modified yarders without guylines were recently introduced in northern Idaho by independent logging contractors for use in commercial thinning: the TIMBCO T-425 yarder (a feller/buncher-based machine), and the CAT 315-L yarder (an excavator-based machine). Both were re-built as yarders with the addition of a two-drum winch (Allied Winch W400™ model) and a small tower for use as a gravity skyline system without guylines. (Table 1). A live skyline with a gravity carriage return (Christy™) and with lateral yarding capacity was used for both TIMBCO and CAT yarders to transport logs and tree-lengths uphill to the landings respectively (Fry 1983). Both yarders allowed for

minimization of the initial investment because they use re-built equipment. The non-guyline yarders can operate with crew size of two-persons, which also means a reduced labor cost, compared with conventional yarders such as the Christy and the Ecologger (Sturos et al. 1996; and Fisher et al. 1980).

Table 1. Technical specifications of non-guyline yarders

Technical Specifications	TIMBCO T-425 yarder	CAT 315-L yarder
Machine base	Feller-buncher	Excavator
Diesel engine	169 Hp Cummins B	102 Hp Caterpillar 3046T
Operating weight (lb)	58,422	38,360
Ground pressure (lb/inch ²)	6.46	5.65
Under-carriage type	CAT D6H	CAT D5H
Upper-carriage type	Self-leveling capability	Non self-leveling capability
Tower height (ft)	28	25
Tower-end	Lattice boom-end	Excavator bucket

Study sites

Two sites were selected near the town of Saint Maries in northern Idaho. Both sites had similar species composition of western white pine (*Pinus monticola*) and Douglas-fir (*Pseudotsuga menziesii*) (Benson et al. 1987). Characteristics of the stands and site conditions are listed in Table 2: Syringa South (TIMBCO site) and Heinaman Creek (CAT site). The prescription for both sites included a commercial thinning leaving a residual stand of 60 to 65 trees per acre. The site conditions and thinning treatments were similar in both working units, but the initial number of trees per hectare was lower on the Heinaman Creek site and average tree size was larger.

Table 2. Study sites and stand characteristics

Characteristics	Syringa South	Heinaman Creek
Area (acres)	16.80	25.45
Age (years)	60	80
Trees per acre	324	252
Stand DBH (inch)	11	13
Stand height (ft)	75	82
Avg. ground slope (%)	41	45

Yarding operations

In both working sites, the skyline corridors were arranged in a fan-shape pattern from landings. Tail trees were used to create required deflection in all skyline corridors. Yarding distances ranged from 15 to 540 ft. Single-span skyline configurations were used at both sites without intermediate supports.

Although it could have operated with a two person crew, the TIMBCO yarder operation had two choker-setters, and one yarder operator and was observed only at roadside yarding. A log-length harvesting method was used, in which felling, delimbing and bucking were done with a mechanized Volvo TM harvester and logs were extracted to roadside. Logs averaged 29 ft in length with an average diameter of 10 inch. Average yarding distance was 261.34 ft with an average lateral distance of 15.17 ft.

The CAT yarder operation was organized with one choker-setter and one yarder operator. The Cat operation alternated work duties of the two workers each half-day to reduce job fatigue, as well as allow both of the crew to gain experience in operating the yarder. In this operation a tree-length method was implemented. Trees were felled, delimbed and topped with chainsaws before yarding. The tree-lengths were extracted in two different ways. First by extracting with the yarder to roadside landings, and secondly by yarding within the stand and forwarding with a grapple-skidder to a landing for processing.

Yarding Study

Detailed time studies were conducted to collect data on every machine work cycle: outhaul, lateral-out, hook, lateral-in, inhaul, unhook, and delays. For each cycle, number of logs (TIMBCO) or tree-lengths (CAT), yarding distance, lateral distance and slope were collected. Whenever road and landing changes occurred, the rigging and set-up times were also measured and recorded. Time elements of the road/landing changes were also recorded in centi-minutes with a stopwatch. The distances between road/landing changes, and lateral and yarding distances were measured in meters using a rangefinder. The average piece volume for each site was calculated by sampling piece size at landing and using log-scaling information provided by the mills.

A cost appraisal procedure was developed to evaluate the equipment investment, as used and re-built machines (Cothren 2002). Investment was estimated as 50% of the initial value (20% salvage and 30% major overhaul) plus the value of the yarder attachments: tower, winch and carriage. The owning, operating and labor cost per hour for yarding were computed using the Miyata machine rate calculation method including labor cost (\$20.00/hr) and fringe benefits (40%) (Miyata 1980).

- ❑ TIMBCO T-425 yarder: (\$ 315,000) (0.5) = \$ 157,500
CAT 315-L yarder: (\$ 280,000) (0.5) = \$ 140,000
- ❑ Tower, winch, and carriage = \$ 40,000. It was considered the same for both machines.
- ❑ Total investment
TIMBCO T-425 yarder: \$ 197,500
CAT 315-L yarder: \$ 180,000

RESULTS AND DISCUSSIONS

The equations for predicting delay-free cycle time for each operation were developed with the number of logs/tree-lengths, lateral distance, and the yarding distance as significant independent variables at a level of 95% ($p < 0.05$). Ground slope was found not to be significant at the same significance level in both operations. Multiple regression analyses are illustrated in Table 3 and 4.

Table 3. Yarding cycle elements, independent variables and statistics for the TIMBCO yarder.

(N=218 observations)

Yarding phase SE	Min/cycle	(% cycle)	Equation	R ²	
Travel empty (Outhaul)	0.33	6	Y (centi-min) = 20.0780 + 0.4883 (X) X = 261.34 ft (Yarding distance)	0.30	11.98
Lateral outhaul	0.39	6	Y (centi-min) = 39.26	-	-
Hook	1.92	32	Y (centi-min) = 192.22	-	-
Lateral inhaul	0.21	4	Y (centi-min) = 8.1016 + 0.8601 (X) X = 15.17 ft (lateral distance)	0.26	18.63
Travel loaded (Inhaul)	0.59	10	Y (centi-min) = 58.61	-	-
Unhook	1.44	25	Y (centi-min) = 144.31	-	-
Delay-free cycle	4.88	83	Y (centi-min) = 301.0938 + 27.4456 (X1) + 0.2961 (X2) + 0.2312 (X3) X1 = 3.81 (# logs) X2 = 261.34 ft (Yarding Distance) X3 = 15.17 ft (Lateral distance)	0.28	102.47
Yarding delays	0.46	8			
Road/land. changes	0.51	9			
Average cycle	5.85	100			

Table 4. Yarding cycle elements, independent variables and statistics for the CAT yarder.

(N=237 observations)

Yarding phase	Min/cycle	% cycle	Equation	R ²	SE
Travel empty (Outhaul)	0.21	4	Y (centi-min) = 9.4824 + 0.05668 (X) X = 199.40 ft (Yarding distance)	0.52	8.57
Lateral outhaul	0.20	4	Y (centi-min) = 12.2712 + 0.4041 (X) X = 19.82 ft (Lateral distance)	0.19	22.00
Hook	1.45	29	Y (centi-min) = 145.36	-	-
Lateral inhaul	0.16	3	Y (centi-min) = 9.7074 + 0.3469 (X) X = 19.82 ft (Lateral distance)	0.23	16.75
Travel loaded (Inhaul)	0.54	11	Y (centi-min) = 36.96843 + 0.0830 (X) X = 199.40 ft (Yarding distance)	0.26	22.37
Unhook	1.23	24	Y (centi-min) = 122.50	-	-
Delay-free cycle	3.79	75	Y (centi-min) = 267.3049 + 0.26540 (X1) + 15.4750 (X2) + 0.61018 (X3) X1 = 199.40 ft (Yarding distance) X2 = 3.01 (# logs) X3 = 19.82 ft (Lateral distance)	0.21	78.78
Yarding delays	0.61	12			
Road/land. changes	0.67	13			
Average cycle	5.07	100			

The variability of some of the cycle time elements was not totally captured by the independent variables that were measured especially in elements, such as in the hook and unhook times. In the case of the hook time, there were other factors such the terrain

roughness and worker fatigue associated with longer yarding/lateral distances that might explain the high variability in cycle times. In the situation of the unhook time, the machine alignment with the yarding corridors to obtain the required deflection in most of the yarding turns was another factor that might also explain the degree of variability of this activity.

The resulting delay-free cycle time was 28% longer at the TIMBCO site (4.88 min) than at the CAT site (3.79 min). Hook time was the longest time element of the yarding cycle (30% cycle) for both operations. Unhooking was the second most time consuming element (25% cycle).

Landing and road changes on average, took slightly longer (0.67 min / turn) at Heinaman Creek (CAT yarder) than at Syringa South (0.51 min / turn). This was because the CAT yarder was used both on the roads and within stands, with a longer lateral distance: 18.92 ft vs. 15.17 ft, as well as with a larger average piece size: tree-length 50.00 ft³ vs. logs 19.42 ft³ for the TIMBCO.

The average set-up and rigging time for road/landing changes was 9% (TIMBCO) and 13% (CAT) of the average yarding cycle time, which may be explained by differences between time spent rigging skyline corridors and time spent on moves between settings. In the case of the CAT settings, most of the set-up time was spent to move between settings within stands. Average road/landing changing times ranged from 26.8 minutes up to 27.2 minutes respectively. Yarding productivity and costs are illustrated in Table 5.

Table 5. Yarding production rates and costs

	TIMBCO Yarder	CAT Yarder
Average logs per turn	3.81	3.01
Avg. volume per log, ft ³	19.42	50.00
Utilization rate (%)	78	70
Machine rate, \$/PMH	163.37	133.11
Production rate, ft ³ /PMH	532	1,052
Yarding costs, \$/ft ³	0.31	0.13

CONCLUSIONS

Non-guyline yarders are innovative technologies and demonstrated a good potential to efficiently remove trees in environmentally sensitive areas. Both non-guyline yarders are highly productive operations in the proper settings when compared with conventional skyline systems primarily due to faster road changes (less than 30 minutes) and short yarding distances (average <328 ft). The average piece size removed (cut-to-length vs. tree-length) and crew size (2 or 3-persons) greatly affected production rates and costs.

Both modified yarders were shown to be highly mobile and flexible equipment in commercial thinning because of the lack of guylines resulting in faster moving times for operating and set-up/rigging. The operational capability of yarding within stands without fastening guylines of the tower may allow efficient log extraction in the areas where the logs can not be skidded by ground-based equipment to the landings or on highly environmentally sensitive areas. They can work effectively off established roads and access areas that would otherwise require additional road construction. In these situations this type of yarders have unique applications compared with conventional yarders.

One of the major drawbacks of the non-guyline yarders observed was a decreased stability during lateral-in and inhaul operations when some hang-ups and wire crosses occurred. The short yarding/lateral distances that were used mean that these yarders require more frequent skyline road changes than the conventional yarding equipment.

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