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**Northeastern Forest
Experiment Station**

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Estimating Yarding Costs For the Clearwater Cable Yarder

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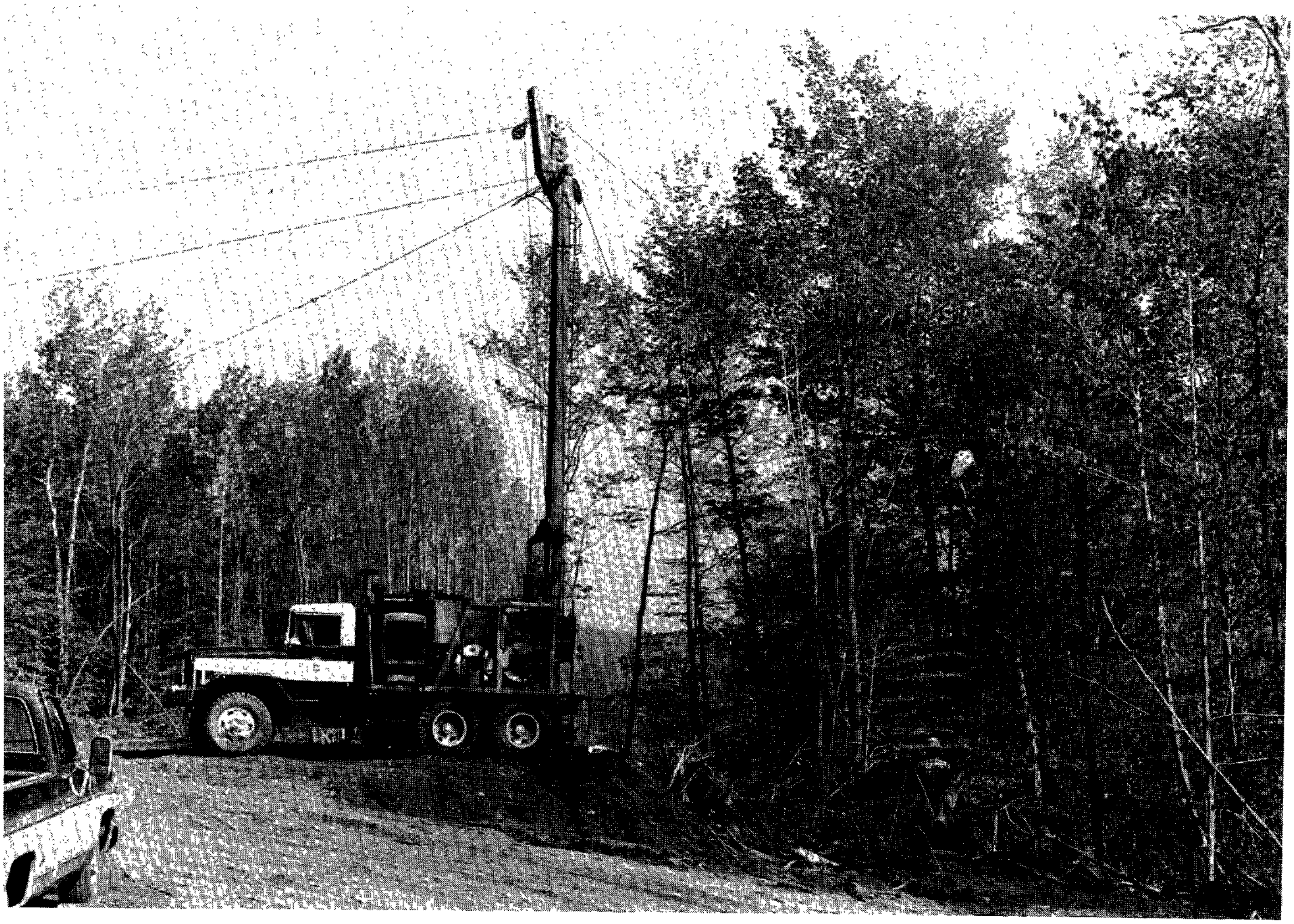

Abstract

Describes an equation that can be used to estimate yarding costs for the Clearwater cable yarder in clearcuts and light and heavy thinnings in eastern hardwoods. Yarding costs can be estimated with a hand-held calculator or the data can be incorporated into stump-to-mill desktop and mainframe computer programs.

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Introduction

Recent interest in promoting cable logging technology in the Eastern United States (Paul 1980; VPI&SU 1982) has led to production tests for and the development of a detailed, stump-to-mill cost-estimating package (LeDoux 1985) for six cable yarders of various sizes and capacities. These include the Appalachian Thinner, Bitterroot, Ecologger I, Koller K-300. Skylok 78, and Urus 1000-3. The cost equations for stump-to-mill timber production reflect conditions that would be encountered when logging hardwoods on steep, mountainous terrain in the Eastern United States.

A seventh system, the Clearwater yarder developed by the USDA Forest Service (USDA Forest Service 1981), was field tested in the Eastern Adirondack region of New York State (Bragg 1985; LeDoux and Peters 1985) and elsewhere (Till 1980; Sherar and Koger 1984), and subjected to comparative analysis (Sherar 1980; Walbridge et al. 1980; Gorsh 1983).

For this study, detailed time and motion data from the New York field studies, 1987 new equipment, labor, and fuel costs (Table 1), and the THIN yarding simulation model (LeDoux and Butler 1981) were used to develop a general equation for estimating yarding costs for the Clearwater yarder in eastern hardwoods for various stand conditions and silvicultural treatments. The cost equation was then used to compare the Clearwater yarder with the six previously mentioned systems.

Table 1.—Hourly yarding costs (1987) for the Clearwater yarder (includes all new equipment)

Item	Dollars/hr
Yarder and truck carrier	38.05[a]
Chain saws (3)	3.58
Labor	27.00[b]
Carriage	0.67
Radio signal (3 transmitters)	1.15
Total	70.45

[a]Includes depreciation, insurance, interest, and operating costs (fuel, oil, lubricants, maintenance, repair, taxes, and rigging) for the yarder and carrier.
[b]One yarder engineer, two chokersetters, one chaser; rates from "Cost Guide for Empirical Appraisals," USDA Forest Service, Region 9, Amendment 112.

Yarding Cost Equation

Simulated, delay-free data points for yarding cost were developed for the Clearwater yarder for a range of diameters (DBH), average slope yarding distances (SYD), and volumes cut per acre (VOAC). The stands chosen were from forest model plots of eastern hardwoods (Table 2). Each stand was thinned using a d/D ratio (arithmetic mean diameter of cut trees/arithmetic mean diameter of stand) of 1.0 to levels of 30 percent, 50 percent, and then clearcut. The trees cut from each treatment were bucked into logs[1] (LeDoux 1986). The THIN model (LeDoux and Butler 1981) and time-study data cited previously were used to develop the delay-free data points through numerous simulations. The simulated data points were pooled to develop a delay-free cost equation for the Clearwater yarder. Nonlinear

Table 2.—Stand data for eight forest model plots

Plot	Average d.b.a.[a]	Merchantable volume[b]	No. trees per acre[a]
	Inches	*Ft³*	
A2	7.2	2652	222
B10	8.1	2528	214
C8	9.1	3556	245
D14	11.6	3124	166
E13	12.7	4922	183
F4	16.8	6315	176
G4M	20.4	6466	162
H4M	24.0	6871	174

[a]Includes trees 5.0 inches or larger in d.b.h.
[b]Logs less than 4 feet long and less than 4 inches top diameter not included.

[1]LeDoux, C. B. 1984. Hardwood log bucking simulator. Unpublished computer program on file at the Northeastern Forest Experiment Station, 180 Canfield Street. P. O. Box 4360. Morgantown, West Virginia 26505.

multiple regression analysis was used to summarize the delay-free data points and the independent variables:

$$\text{Dollars/ft}^3 = 0.12577 - 0.00328\,(DBH) + 0.000048\,(SYD) + 623.08404\,(1/(VOAC * DBH))$$

$R^2 = 0.582$

where:

DBH = Arithmetic mean tree diameter at breast height, in inches; variable limits = 4 to 16 inches

SYD = Average slope yarding distance, in feet; variable limits = 50 to 900 feet

VOAC = Average volume removed per acre, in ft^3; variable limits = 780 to 6,871 ft^3

The equation is machine-specific and the variable limits should be observed carefully.

The delay-free cost must be adjusted to allow for nonproductive time. Delay percentage is the proportion of nonproductive time expressed as a percentage of total time. One minus the proportion of nonproductive time is the proportion of productive time. For example, if the delay is 10 percent, the proportion of nonproductive time is 0.1, and the proportion of productive time is 0.9. The delay-free cost is adjusted by dividing it by the proportion of productive time to obtain the cost with delay.

Yarding Delays

The observed productive time for the Clearwater yarder was only 40 percent of total time; however, this low time was due to the unexpected (and rare) breakdown of the skyline and mainline. Eliminating this delay would result in a productive rate of nearly 60 percent, which compares favorably with the other cable systems mentioned (LeDoux 1985). Productive delays accounted for 14.5 percent of total time and nonproductive delays 45.5 percent. The following is a breakdown of the nonproductive and productive delays with the Clearwater yarder:

Delay	Percent
Nonproductive	
Broken skyline	60.3
Broken mainline	35.1
Loose hydraulic hose	0.5
Fix stop	0.4
Miscellaneous	3.7
Total	100.0
Productive	
Hangups	47.3
Wait on skidder	20.3
Move stop	16.7
Tangled mainline	11.3
Hit stop	2.4
Slipped choker	2.0
Total	100.0

The delay percentages can be used to adjust the delay-free cost estimates. For example, a logger is estimating yarding costs for a hardwood stand with an average arithmetic tree d.b.h. of 8.0 inches, an average slope distance of 200 feet, and an average volume removal of 2,000 ft^3. The delay-free yarding cost is:

$$= 0.12577 - 0.00328\,(8) + 0.000048\,(200) + 623.08404\,(1/(2000 * 8)) = 0.148$$

Adjusting the delay-free cost with an average delay percentage of 0.23 (LeDoux 1985) = 0.148(1-0.23) = 0.148/0.77 or \$0.192/ft^3. Users may wish to substitute delay percentages based on their own observations.

Applying the Cost Equation

Yarding costs can be estimated with a hand-held calculator or the data can be incorporated into stump-to-mill desktop and mainframe computer programs. Information on the arithmetic mean d.b.h. to be harvested, average slope yarding distance, and average volume cut per acre can be obtained from the inventory and cruise data and the logging plan for the tract. Figure 1 shows the impact of silvicultural treatment on yarding cost. Heavy-volume removals reduce yarding costs; the reverse is true for low removals. Information such as that in Figure 1 also can be used to plan harvesting limits. For example, a logger is allowed \$0.12/ft^3 for the yarding operation. Projecting a line representing 0.12/ft^3 on Figure 1 shows that the break-even points require harvesting limits of 9.5, 12.0, and 14.5 inches d.b.h. for clearcuts, heavy, and light thinnings, respectively.

Clearwater Versus Other Yarders

The Clearwater Yarder is competitive with the Appalachian Thinner in the d.b.h. range of 7 to 10 inches, and with the Koller K-300 and the Ecologger I in the range of 7 to 16 inches (Fig. 2). It is important to note that the competitive ranking of these machines will be affected by differences in factors such as initial investment, salvage value, crew size required, payload capacity, and line speed. Also, the comparisons shown are based on specific sets of stand conditions and will change accordingly with changes in slope yarding distance and volume removal.

Because of its limited capacity (3,500 pounds), the Clearwater yarder cannot bring in heavy loads to increase production and reduce the cost per unit produced. In this study, the actual working payload was about 1,250 pounds, rather low for a system that costs about \$95,000. Also, the limited mainline pull (7,500 pounds) of this machine resulted in significant delays in breaking the turn of hooked logs from their lay. Sherar and Koger (1984) reported that increased mainline pull would result in fewer delays.

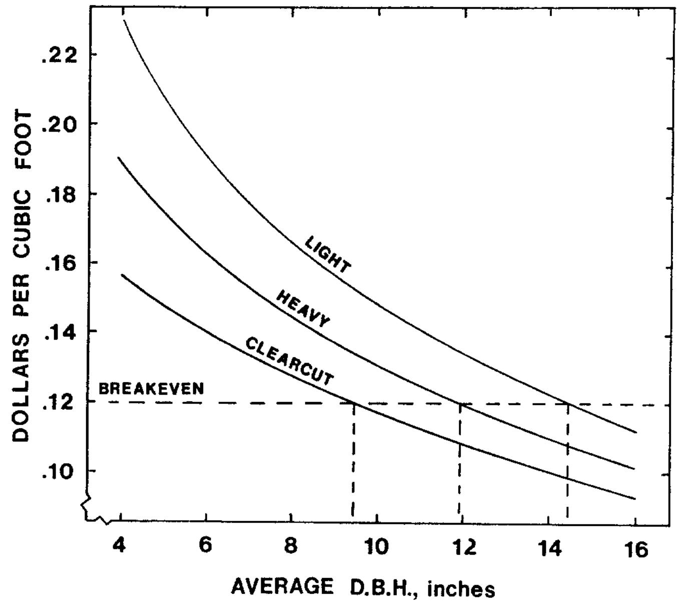

Figure 1.—Simulated yarding cost and break-even points by silvicultural treatment for the Clearwater yarder.

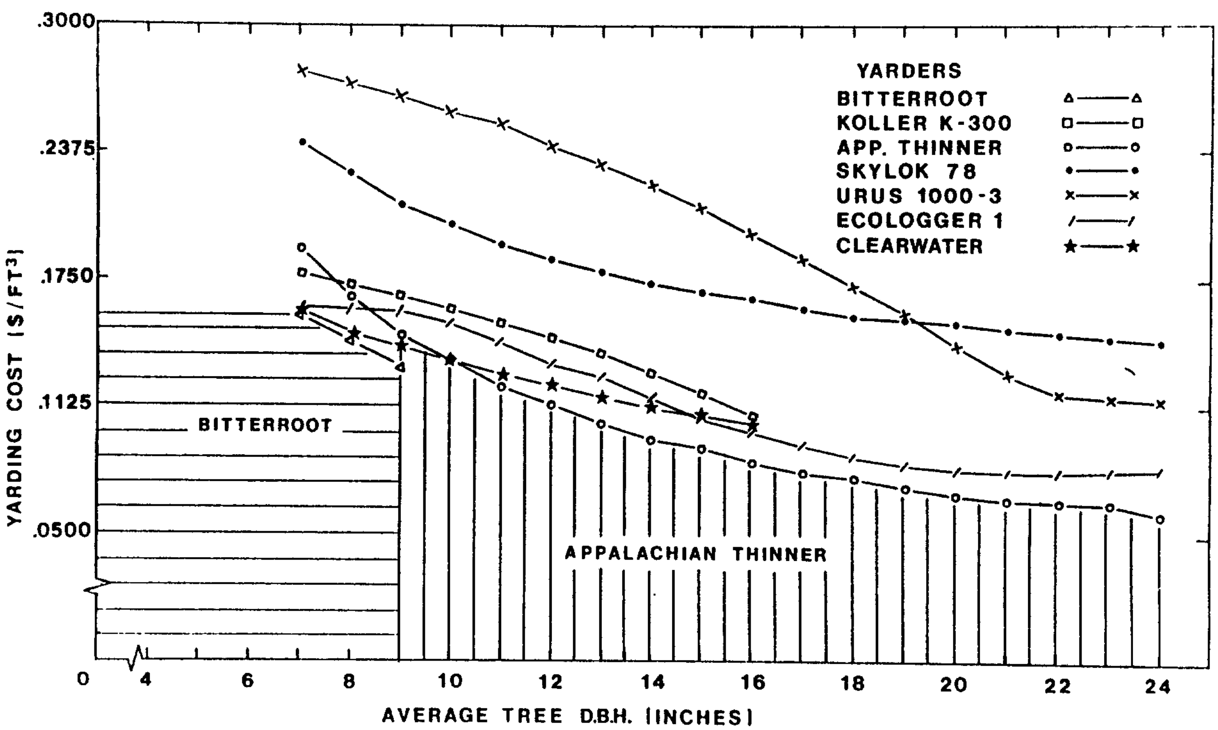

Figure 2.—Simulated comparison of seven cable yarders by average tree d.b.h. (SYD = 200 feet; VOAC = 2,000 ft³). Shaded areas indicate diameter range best suited for individual machines.

Literature Cited

Bragg, W. C. 1985. **Productivity and cost of the Clearwater yarder in the Eastern Adirondack region of New York State.** Syracuse, NY: State University of New York, College of Environmental Science and Forestry. 111 p. M.S. thesis.

Gorsh, J. W. 1983. **Efficient use of small timber systems.** In: Proceedings, timber harvesting in the Central Rockies: problems and opportunities; 1983 January 4-6; Fort Collins, CO. Publ. XCM-87. Fort Collins, CO: Colorado State University, Cooperative Extension Service. p. 133-141.

LeDoux, C. B. 1985. **Stump-to-mill timber production cost equations for cable logging eastern hardwoods.** Res. Pap. NE-566. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 6 p.

LeDoux, C. B. 1986. **Bucking logs to cable yarder capacity can decrease yarding costs and minimize wood wastage.** Southern Journal of Applied Forestry. 10: 180-183.

LeDoux C. B.; Butler, D. A. 1981. **Simulating cable thinning in young-growth stands.** Forest Science. 27(4): 745-757.

LeDoux, C. B.; Peters, P. A. 1985. **Computer planning tools applied to a cable logging research study.** In: Proceedings, improving mountain logging planning, techniques and hardware: a joint symposium of the IUFRO mountain logging section and the 6th Pacific Northwest skyline logging symposium; 1985 May 8-11; Vancouver, BC. Vancouver, BC: Forest Engineering Research Institute of Canada. p. 51-54.

Paul, J. G., ed. 1980. **Proceedings, 1980 cable yarding conference;** 1980 September 9-10; Asheville, NC. Asheville, NC: Hardwood Research Council; Norris, TN: Tennessee Valley Authority, Division of Land and Forest Resources. 151 p.

Sherar, J. R. 1980. **Comparison of skyline and ground-based harvesting systems.** In: Proceedings, 1980 cable yarding conference; 1980 September 9-10; Asheville, NC. Asheville, NC: Hardwood Research Council: Norris, TN: Tennessee Valley Authority, Division of Land and Forest Resources, p. 128-145.

Sherar, J. R.: Koger, J. 1984. **The Clearwater yarder: A Mississippi case study.** In: Peters, Penn A.; Luchok, John, eds. Mountain logging symposium proceedings; 1984 June 5-7; Morgantown, WV. Morgantown, WV: West Virginia University. p. 337-349.

Till, K. 1980. **Lightweight cable systems yard slash for firewood.** Spec. Rep. Missoula, MT: US Department of Agriculture, Forest Service, Equipment Development Center. 11 p.

U.S. Department of Agriculture, Forest Service. 1981. **Clearwater yarder operations manual.** Man. 81-2602. Missoula, MT: U.S. Department of Agriculture, Forest Service, Equipment Development Center. 18 p.

Virginia Polytechnic Institute and State University. 1982. **Proceedings, Appalachian cable logging symposium;** 1982 January 12; Blacksburg, VA. Blacksburg, VA: Virginia Polytechnic Institute and State University. 72 p.

Walbridge, T. A.; Griffeths, R. C.; Stuart, W.V. 1980. **Big yarders, big roads—small yarders, small roads.** In: Proceedings, 1980 cable yarding conference; 1980 September 9-10; Asheville, NC. Asheville, NC: Hardwood Research Council; Norris, TN: Tennessee Valley Authority, Division of Land and Forest Resources. p. 93-102.

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