Reprinted from the
JOURNAL OF FORESTRY
Vol. 83, No. 5, May 1985

When Is Hardwood Cable Logging Economical?

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ABSTRACT—Using cable logging to harvest eastern hardwood logs on steep terrain can result in low production rates and high costs per unit of wood produced. Logging managers can improve productivity and profitability by knowing how the interaction of site-specific variables and cable logging equipment affect costs and revenues. Data from selected field studies and forest model plots, as used in a simulation model, indicate that managers must consider cable logging technology, average slope distances required, volume and size of material cut, tree species and market price, and silvicultural treatment proposed.

There has been increasing interest in promoting cable logging technology in the eastern United States (Paul 1980, Virginia Polytechnic Institute 1982). The efficient use of cable logging in eastern hardwood stands depends on logging and processing costs, current market demand and prices for hardwood logs, cable logging technology, and landowners' objectives. A rigorous financial evaluation must be performed and the logging analyst must be familiar with the effects of site-specific variables on the total cost and revenue associated with a particular cable logging operation.

Decision-makers must know which variables affect cost and profitability and understand how those variables interact for a particular harvesting operation. They must be able to determine the total volume, species, and individual size of hardwood logs that can be removed without sustaining a loss.

Finally, decision-makers must be abreast of the applicability, costs, and potential productivity of various cable yarders at different average slope yarding distances. How far one must go on the slope to extract logs will significantly affect productivity and costs.

In this article, the effect on total production costs and revenues of alternate cable yarders, average slope yarding distances, size of material cut, tree species and market price, and silvicultural treatment proposed is evaluated with a simulation model called THIN (LeDoux and Butler 1981). The results can be used to help managers understand the feasibility of cable-logging eastern hardwoods.

Cable Logging Equipment

The type of cable yarder selected for yarding hardwood logs can undoubtedly affect the production rate and cost of that effort. Harvesting machines vary in efficiency according to terrain, average size of stem removed, and average slope yarding distance required. The THIN model (LeDoux and Butler 1981) and time-study data (Baumgras 1983, Fisher and Peters 1982, Rossie 1983) were used to estimate cost functions for various combinations of equipment, terrain, average slope yarding distance, and average tree size. *Figure 1* shows this variability in yarding cost for six cable yarders on mountainous terrain of moderate difficulty.

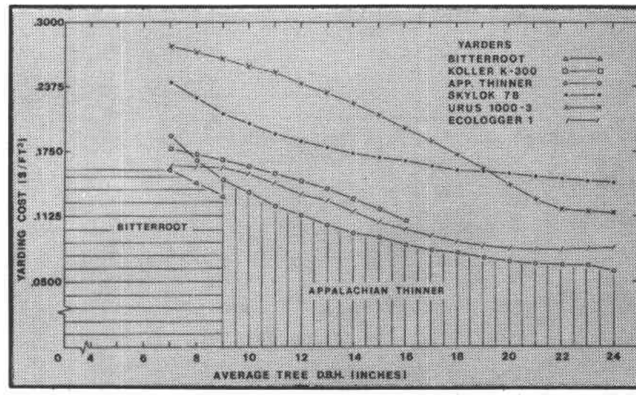

Figure 1. Simulated yarding costs for six cable logging systems used on mountainous terrain (200-foot average yarding distance, 2,000 ft³ removed per acre). Shaded region indicates diameter range best suited for individual machines.

The first system—the small, relatively inexpensive, low-capacity Bitterroot—can yard small logs. The second system—a slightly larger, relatively inexpensive, low-capacity Koller K-300—can harvest small as well as somewhat larger logs than the Bitterroot. The third system—a moderately expensive, medium-capacity Appalachian Thinner—handles small and large logs. The fourth system—an expensive, high-capacity Skylok 78—also harvests small and large logs. The fifth and sixth systems—the Urus 1000-3 and the Ecologger I—are moderately expensive, relatively high-capacity machines that yard small and large logs. The logs referred to here include both conventional and tree-length.

The six cable systems differ in hourly operating costs and in the size of crew required *(table 1)*. For example, the Bitterroot would require two people, the Koller K-300 three people, and the others four to six people.

The logging manager must match machine capability with tree size to ensure efficient operation. For example, although the cost curves *(fig. 1)* might appear to show that both the Bitterroot and the Koller K-300 are cost-efficient at large diameters, logs of trees larger than 9 inches may be too big for the Bitterroot, while logs from trees larger than 16 inches may be too large for safe handling by the Koller K-300. Conversely, using oversized machines when the average tree size is small may result in high costs and excessive stand damage.

Significant cost savings can be realized by properly matching logging machines with stand conditions on a tract-by-tract basis *(figs. 1-2)*. For example, the Bitterroot yarder, when cable yarding hardwoods with average slope yarding distances of 200 feet *(fig. 1)*, would be the best selection for stands with trees having an average d.b.h. of 7 to 9 inches. For the same conditions, the Appalachian Thinner would be the best selection for stands with trees 10 to 24 inches in

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Table 1. Hourly yarding costs[a] for six yarding systems.

Yarding system	Equipment[b]	Labor[c]	Chain saws[d]	Carriage	Radio signal[e]	Total cost
	Dollars/hr					
Bitterroot	6.26	13.00	2.65	0.61	1.09	23.61
Appalachian Thinner	14.35	26.00	2.65	.00	1.09	44.09
Koller K-300	10.95	32.50	2.65	.65	1.09	47.84
Ecologger I	18.81	32.50	2.65	.72	1.09	55.77
Urus 1000-3	34.63	32.50	2.65	.80	1.09	71.67
Skylok 78	78.13	39.00	2.65	.88	1.09	121.65

[a] *Includes all new equipment (costs obtained from equipment dealers).*
[b] *Includes depreciation, insurance, interest, operating costs (fuel, oil, lubricants, maintenance, repair, and taxes), and rigging.*
[c] *Rates obtained from cost guide for empirical appraisals, U.S. Forest Service, Region 9, Amendment 112.*
[d] *Three chain saws.*
[e] *Three transmitters.*

d.b.h. The other yarders are not competitive at this slope-yarding distance. For the same conditions but an average yarding distance of 400 feet *(fig. 2)*, the best choice is the Bitterroot for stands averaging 7 to 9 inches, the Ecologger I for stands averaging 10 to 19.5 inches, and the Urus 1000-3 yarder for stands averaging 20 to 24 inches. The large-capacity Skylok 78 yarder is not competitive at either the 200- or 400-foot yarding distance. These selections are based on yarding cost alone for 2,000 ft^3/acre removals; other volumes and factors such as facilities for service, repair, and maintenance must be weighed when selecting equipment. Managers also must consider the size and volume of the material harvested.

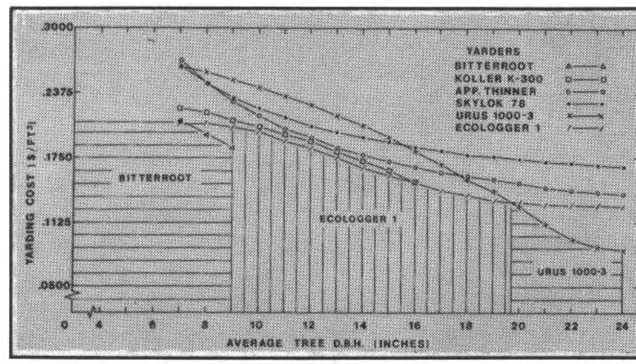

Figure 2. Simulated yarding costs for six cable logging systems used on mountainous terrain (400-foot average yarding distance, 2,000 ft³ removed per acre). Shaded region indicates diameter range best suited for individual machines.

Volume and Size of Wood Harvested

Generally, increases in tree size and volume harvested improve yarding productivity and reduce yarding costs. Four forest model plots (U.S. Forest Service [no date]) were chosen for the simulated clearcut. The results were used to illustrate the effect of tree size and volume removed on the cost of cable logging *(fig. 3)*. Forest model plots 4, 7, 13, and 14 *(table 2)*, which span the range of diameters, volumes, and species mixes typical of Appalachian hardwood stands, were clearcut. *Figure 3* shows the economic feasibility of three cable logging systems on the basis of simulated total costs and revenues. Yarding with the Ecologger I would be profitable in stands where the average tree diameter exceeds 11.8 inches. For the Skylok 78 and Urus 1000-3 to be profitable, the average tree diameter should exceed 12.6 and 12.8 inches, respectively *(fig. 3)*.

Product yield is another variable that can significantly affect the cost of cable logging. For example, what if the volumes from forest model plots 4, 7, 13, and 14 were sold as pulpwood? The total revenue curve in *figure 3* shows that pulpwood cable logging is not economical for any yarder. The revenue sources in *figure 3* represent sawlog material converted to sawlogs, with pulpwood not harvested and sawlog and pulpwood material converted to pulpwood.

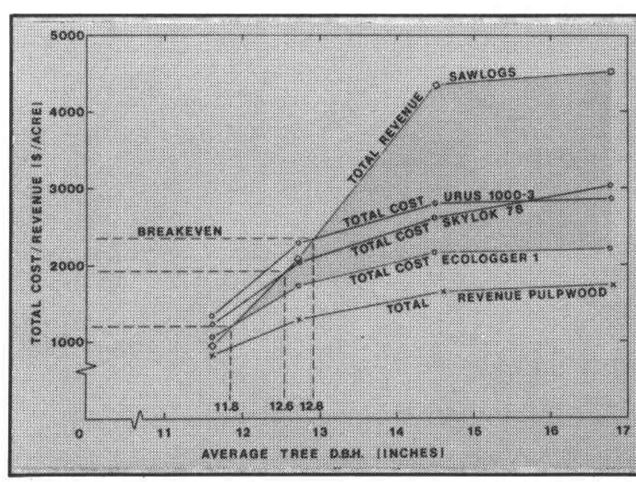

Figure 3. Simulated total costs and revenues for three yarders, by average tree d.b.h. Shaded region shows areas of economic feasibility.

Tree Species and Market Prices

The species mix within a proposed cable-logging venture also can significantly affect the cost of cable logging. I am using data from four forest model plots; other conditions will have different outcomes. Accordingly, the size and volumes shown by plot in *table 2* were held constant and assigned species mixes to reflect high-value, medium-value, low-value, and very low-value markets. The high-value species are walnut and black cherry; medium-value species are northern red oak and white oak; low-value species include hickory and black birch mix; species of very low value are beech and cucumber *(fig. 4)*. The species mixes have been assigned the values in *table 3* to develop revenue curves by species mix value and to demonstrate the effect on cable logging costs. Clearly, it would be economical to log the high- and medium-value species mix with the Ecologger I. Cable logging the

Table 2. Stand data and tree attributes for four forest model plots.

Forest model plot no.	Average tree d.b.h.	Average merchantable height to 4-inch top	No. of trees	Species mix	Cubic-foot volume[a]	Board-foot volume[b]
	Inches	*Feet*			*Ft³/acre*	*Board feet/acre*
4	16.8	79.9	84	Basswood Cucumber Hickory Red oak Soft maple Walnut White oak Yellow-poplar	5,622	21,360
7	14.5	60.2	130	Basswood Hickory Red oak Yellow-poplar	5,414	20,569
13	12.7	48.8	148	Basswood Beech Black cherry Cucumber Hard maple Red oak White oak Yellow-poplar	4,379	11,586
14	11.6	31.8	162	Beech Black birch Black gum Hard maple Red oak Soft maple White oak Yellow-poplar	2,778	4,720

[a] *Smalian's method.*
[b] *Doyle rule.*

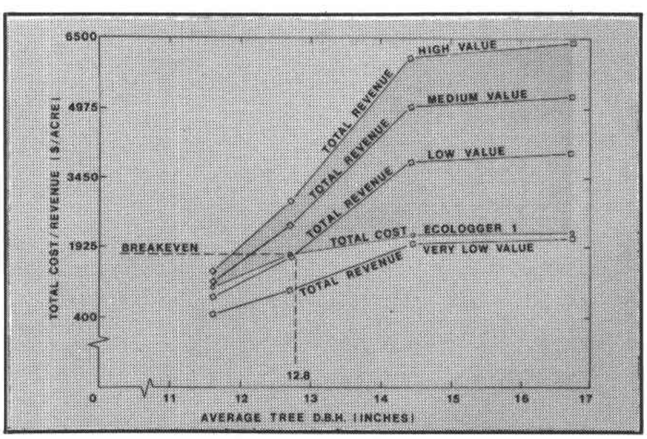

Figure 4. Simulated total costs and revenues for one yarder and four wood values, by average tree d.b.h. Shaded region shows areas of economic feasibility.

Table 3. Price list for logs delivered to Plum Creek, Inc., in Richwood, West Virginia (November 1983 prices).

Species	Log grade		
	Prime	Select	Common
	Dollar/Mbf		
Walnut	650	450	350
Black cherry	350	250	100
Northern red oak	275	225	100
Basswood	250	200	100
Hard maple	250	200	100
White oak	220	170	100
Birch	210	160	100
Hickory	210	160	100
Poplar	210	160	100
Soft maple	210	160	100
Beech	110	90	70
Cucumber	110	90	70
Gum	110	90	70
Sycamore	110	90	70

low-value species mix would be economical only if the diameter exceeded 12.8 inches. Cable logging the very low value species mix would not be economical at all.

Silvicultural Treatment

The objectives of the landowner as reflected in the silviculture treatment significantly affect cable-logging costs. Forest model plot No. 14 was used to illustrate the effect of silvicultural treatment on cable logging costs *(table 4)*. The plot was clearcut (trees down to 4 inches in d.b.h.). Then a diameter-limit cut to 10 inches d.b.h. was simulated. The results in *table 4* show that diameter-limit cutting significantly reduces all component costs. An increase in the average d.b.h. of cut trees of 36.2 percent results in a 33.8-percent reduction in felling, bucking, and limbing costs, and a 32.9-percent reduction in yarding costs. These reductions confirm what is known from experience: larger trees and logs are cheaper to harvest.

Table 4. Simulated clearcut and diameter-limit harvests of forest model plot No. 14 and changes in component harvesting costs.

Item	Clearcut[a]	Diameter limit[b]	Percentage change in component cost
Forest model plot no.	14	14	0
Average tree d.b.h. (inches)	11.6	15.8	+36.2
Total trees cut (no.)	162	80	−50.6
Cubic-foot volume (Smalian) (ft^3/acre)	2,778	2,356	−15.2
Fell, buck, limb (dollars/acre)	109.9	72.7	−33.8
Yarding with Ecologger I (dollars/acre)	468.9	314.6	−32.9
Loading (dollars/acre)	53.1	25.5	−51.9
Move in and out, rig up and down (dollars/acre)	55.6	47.1	−15.3
Delays (dollars/acre)	111.2	94.3	−15.2
Hauling (dollars/acre)	263.11	259.45	− 1.4

[a] *All trees cut to 4-inch d.b.h.*
[b] *Only trees greater than or equal to 10-inch d.b.h. cut.*

Considerations for Managers

Simulations such as those presented here suggest that cable logging of hardwoods can be economically feasible. Before deciding whether to cable log, the manager must consider the interaction of equipment and site-specific and market variables, and how these variables directly affect production rates and costs. The logging manager also should consider other equipment, species mixes, markets, and silvicultural treatments. If a manager is looking to operate in stands of a given size with a range of species mixes, selection of a specific yarder may be appropriate. For diverse stands, an industrial firm may wish to invest in two or three pieces of equipment to best meet harvesting needs.

Simulation does not provide all of the answers on whether to cable log. However, this method can pinpont the variables involved and their interaction so that logging managers can choose the best system for their needs. ■

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