

ANALYSIS OF HARVESTING OPPORTUNITIES
FOR THINNING EASTERN HARDWOODS
ON STEEP TERRAIN

by

Chris B. LeDoux and John E. Baumgras

ABSTRACT--Harvesting cost and revenue models were used to evaluate yarding costs by yarder type and to compare stump-to-mill harvesting costs to revenues available from multiproduct thinnings in eastern hardwoods. This analysis includes six types of cable yarders and thinnings in stands where the average diameter at breast height of trees harvested ranged from 7 to 12 inches. To include market factors, the analysis also includes four types of primary products, three product price levels, and three truck-haul distances. Results show that substantial cost savings can be realized by selecting the appropriate harvesting equipment; and that given favorable market conditions and efficient yarding, early entries for thinning can be economically feasible. Results also show the importance of factoring product mix, product prices, and market location into the economic analysis of thinning opportunities.

KEYWORDS--Harvest cost, revenue, product mix, product prices, market location, haul distance, multi-product, economic feasibility.

INTRODUCTION

Young-growth eastern hardwood stands will require thinnings to maximize product quality, volume, and value yields. Although the total supply of hardwood growing stock now exceeds demand, much of the supply is of poor quality or in low-value species (Bones 1978). Given the millions of acres of overstocked immature hardwood stands (USDA Forest Service 1982), thinning presents an excellent opportunity to improve the management and utilization of the eastern hardwood resource, and to satisfy the domestic and foreign demand for high-quality hardwoods. Thinning generally will favor increased growth of desirable crop trees. Species mix also can be manipulated to favor the more valuable species. Species composition is important because the differences in price between hardwood tree species for equivalent log sizes and grades can exceed \$300/Mbf (Ohio Agric. Stat. Serv. 1988). However, early thinnings yield low-quality products that have a low value. Consequently, early thinnings of young stands are the most difficult financially since stump-to-mill costs generally exceed product revenues.

This paper presents methods that can be used by managers and planners to select and/or match logging equipment to stand conditions or tree size, or to evaluate specific stands for thinning feasibility by explicitly considering logging costs, stand revenue, market demand, and utilization levels. This methodology also is demonstrated as a management tool to identify candidate stands for treatment given specific harvesting technology, inventory data, market demands and prices, and utilization objectives.

EQUIPMENT SELECTION

The cable yarder selected for harvesting hardwood timber will affect production rates and costs. Yarders vary in efficiency according to terrain, stem size, volume yarded per acre, and average slope yarding distance. The ECOST model (LeDoux 1985a) and sample forest-plot data were used to estimate costs for various combinations of equipment, volume removed per acre,

average tree diameter and average slope yarding distance. ECOST models stump-to-mill harvesting costs for cable yarding eastern hardwoods. The sample-plot data provided a range of tree-diameter and volume information that is indicative of thinning opportunities for Appalachian hardwoods (Baumgras 1984). To simplify the analysis, results shown in Figure 1 are based on removals of 1,900 ft³/acre and an average slope yarding distance of 300 feet.

The first system, the small relatively inexpensive, low-capacity Bitterroot¹ can yard small logs. The second, third, and fourth systems are slightly larger and relatively inexpensive. They include the low-capacity Koller K-300, Clearwater, and Ecologger I, which can harvest small and somewhat larger logs than the Bitterroot. The fifth and sixth are expensive, relatively high-capacity systems. They include the Urus 1000-3 and the Skylok 78 which can yard small and large logs. The logs referred to here include conventional stem-length sections to be later bucked into sawlogs, sawbolts, or pulpwood. The six cable systems differ in owning and operating costs and in the size of crew required. For example, the Bitterroot would require two people, the Koller K-300 and the Clearwater three people, and the others four to six people.

Significant cost savings can be realized by selecting the most efficient harvesting equipment. For the hardwood thinning applications tested, the Clearwater yarder seems the most cost effective system (Fig. 1). In the 7 to 9 inch d.b.h. range, the Bitterroot is closely competitive with the Clearwater. Cost estimates for the Koller K-300 and the Ecologger I are similar over the full range of average tree diameters. The Skylok 78 and the Urus 1000-3 also show similar yarding costs over the range of diameters evaluated; the Urus 1000-3 shows a small advantage between 7 and 9 inches d.b.h. At 9 inches d.b.h. yarding costs for the Clearwater are 17 percent less than those for the Ecologger I and Koller K-300, and 33 percent less than those for the Urus 1000-3 and Skylok 78. Other considerations for equipment selection include availability of service, repairs, and maintenance facilities.

ECONOMIC FEASIBILITY

The economic feasibility of thinning requires that revenues exceed costs. The feasibility analysis therefore requires estimates of total stump-to-mill cost and estimates of revenue based on delivered product prices. ECOST estimates of total stump-to-mill costs are shown in Figure 2. These cost curves include fell-limb-buck costs, yarding costs for the Clearwater yarder, loading cost, and trucking cost as a function of haul distance for 20-, 40-, and 60-mile one-way hauls. Differences between cost curves by haul distance demonstrate the impact of the location of the timber stand relative to product markets. Favorable hauling conditions assumed in the cost analysis include a tractor-trailer combination capable of averaging 25 miles per hour. Other cost estimates are delay-free such that the cost curves represent the minimum stump-to-mill costs for each scenario.

¹ The use of trade, firm, or corporation names in this paper is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture or the Forest Service of any product or service to the exclusion of others that may be suitable.

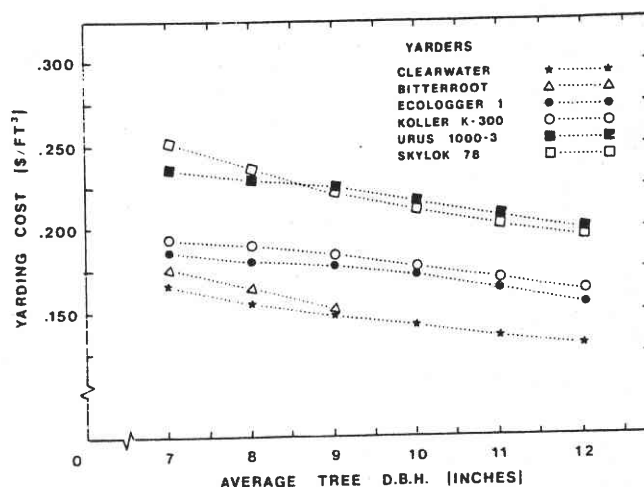


FIGURE 1. Simulated comparison of six cable yarders by average tree d.b.h. (slope yarding distance = 300 feet; volume cut/acre = 1,900 ft³).

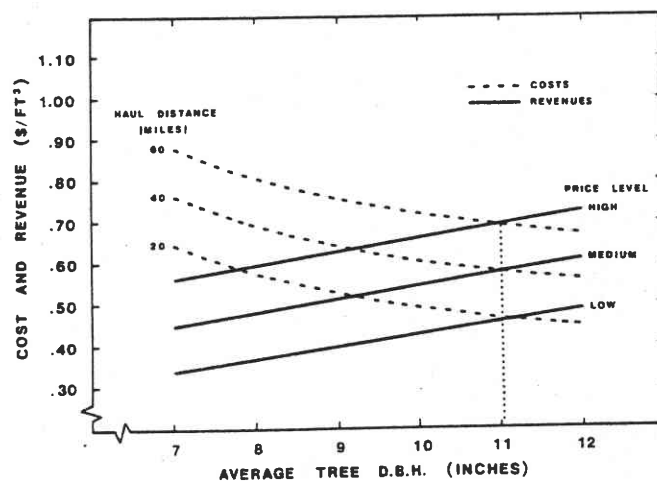


FIGURE 2. Simulated cost and revenue per acre by average tree d.b.h., haul distance, and price levels.

The revenue estimates in Figure 2 assume multiproduct harvests that maximize revenue from the available product mix. Curves for product mix and harvesting revenue were estimated with the APTIN computer program (Baumgras and Yandle 1986). This program estimates product yields for thinnings in Appalachian hardwoods and determines revenue/acre based on the available product mix and specified product. For this example, program inputs included basal-area removals by tree-diameter class summarized from 113 sample thinning plots grouped by the average d.b.h. of trees removed from each plot. The summary of sample plot-

data in Table 1 shows the wide range of conditions sampled (Baumgras 1984). Price inputs reflect the range of prices from forest-products price bulletins published in the Northeast. The differences between revenue curves in Figure 2 represent relative price differences. The slope of each curve reflects changes in product mix with increasing average tree d.b.h.

TABLE 1.

SUMMARY OF SAMPLE PLOT (N = 113)
CHARACTERISTICS

Item	Average	Minimum	Maximum
Stocking (ft ² /acre) ^{a/}			
Initial	136	80	221
Removed	49	18	118
Residual	87	52	108
Mean d.b.h. (inches) ^{b/}			
Initial	10.0	7.9	15.4
Removed	8.7	6.4	14.4
Residual	10.9	6.9	16.1
Average total height (feet) ^{c/}	78	58	103

^{a/} Trees - 5.0 inches d.b.h.

^{b/} Quadratic mean.

^{c/} Dominant and codominant cut trees.

Four types of primary products are included in the revenue analyses and include only bolewood ≥ 4.0 inches diameter outside bark (d.o.b.) from trees ≥ 5.0 inches d.b.h. Product definitions and specifications include:

Large Sawlogs: USDA Forest Service factory grade 3 or better, scaling diameter ≥ 10 inches.

Small Sawlogs: USDA Forest Service factory grade 3 or better, 10 inches $>$ scaling diameter ≥ 8 inches.

Sawbolts: Sawable roundwood ≥ 6.0 inches d.o.b. suitable for manufacturing wooden pallets or other low-quality sawn products. Because of size and/or quality, will not make a factory grade 3 sawlog.

Pulpwood-Fuelwood: Bolewood ≥ 4.0 inches d.o.b. that will not make sawlogs or sawbolts due to crook, sweep, defect, or diameter constraints.

Input prices by product classification (International 1/4-inch log scale) and relative price level are:

Item	High	Medium	Low
Large sawlogs (dollars/Mbf)	175	150	120
Small sawlogs (dollars/Mbf)	120	105	90
Sawbolts (dollar/Mbf)	110	95	80
Pulpwood-Fuelwood (dollars/100 ft ³)	55	44	33

Comparing these cost and revenue estimates identifies economically feasible thinning opportunities. With three cost levels and three revenue levels, there are nine

possible cost curve-revenue curve intersections. Each intersection defines the minimum average d.b.h. that is economically feasible for the specified cost and revenue assumptions. The best-case scenario, high prices and low costs, shows that thinning is feasible at 7.8 inches d.b.h. Under the worst case scenario, low prices and high costs, no thinning is economically feasible. Medium price and cost levels constrain thinning to removals averaging 11 inches d.b.h. or larger. It is interesting that at about 11 inches average tree d.b.h., thinning becomes feasible at all price levels and haul distances (Fig. 2). Similar results were reported by Ledoux (1985b). The variability of feasibility limits demonstrates the importance of considering market factors such as location and prices, as well as harvesting costs. The effect of average d.b.h. on both revenue and costs also demonstrates the importance of linking costs and revenue estimates to stand attributes.

SELECTING CANDIDATE STANDS

To periodically update the feasibility analysis of thinning opportunities, cost and revenue models such as ECOST and APTHIN can be linked with current price data and forest-inventory data bases. A simplified example is shown by the economic feasibility matrix presented in Figure 3. In this example, forest-inventory data are stratified by mean d.b.h. volume per acre available from alternative thinning levels or levels of initial stocking, and stand location relative to product markets. Each matrix cell can represent either one or more specific timber stands, or the total number of acres in each strata. In practice, the cost and revenue models could be applied to each candidate stand in the forest inventory file; and a listing made of feasible stands or acres for thinning opportunities. This analysis could be repeated as often as necessary to include changes in product markets, prices, harvesting technology, or silvicultural objectives.

VOLUME HARVESTED ft ³ /Acre	HAUL DISTANCE Miles	AVERAGE TREE D.B.H. (INCHES)					
		7	8	9	10	11	12
1000	20	N	N	H	H-M		
	40	N	N	N	H	NA	NA
	60	N	N	N	N		
1500	20	N	N	H	H-M	H-M	H-M-L
	40	N	N	N	H	H	H-M
	60	N	N	N	N	N	H
2000	20		H	H	H-M	H-M	H-M-L
	40	NA	N	N	H	H	H-M
	60		N	N	N	N	H
2500	20			H	H-M	H-M	H-M-L
	40	NA	NA	N	H	H	H-M
	60			N	N	N	H
3000	20					H-M	H-M-L
	40	NA	NA	NA	NA	H	H-M
	60					N	H

FIGURE 3. Price levels providing economical thinning operations. Candidate stands stratified by volume available for removal, average d.b.h. of trees removed, and stand location defined by haul distance (H = high prices; M = medium prices; L = low prices; N = not feasible at high price levels; NA = nonexistent d.b.h.-volume combination).

Managers, planners, and loggers could use data such as that in Figure 3 in deciding on schedules for thinning treatments. For example, our data show that stands averaging 7 inches d.b.h., removals of 1,000 to 1,500 ft³/acre are not economical at any price level or haul distance. For stands averaging 9 inches, thinning is feasible for all removal levels given high market prices and 20-mile hauls. The same thinnings are not feasible given medium or low prices. The transition from small d.b.h. stands (7 inches) to larger d.b.h. stands (12 inches) clearly shows that in the latter, thinning is feasible for most combinations of value, d.b.h., haul distance, and price level. This matches practical experience in that larger d.b.h. trees are cheaper to harvest and also fetch higher prices at the mill.

CONSIDERATIONS FOR MANAGERS

Carefully selecting cable logging equipment to match stand conditions can result in substantial savings in logging costs. Using equipment that is too large and expensive will result not only in high costs but also in increased damage to the residual stand. By contrast, selecting small equipment to handle large logs could result in much downtime, equipment failures, high costs, and low wood flows.

Individual stands can be examined for thinning feasibility by considering stump-to-mill costs and product mixes available from a stand at any point in time. Careful consideration of product market-price levels and market locations can help in determining thinning feasibility in individual stands. Alternative transportation technology and transportation networks also should be considered.

Methods such as those summarized here can be linked to existing inventory data bases to evaluate candidate stands for thinning feasibility. The process can be automated by computerizing the methods for quick and inexpensive analysis of thinning feasibility as markets, locations, costs, and owner objectives change.

Economic feasibility is an essential though not the sole criterion. Where independent loggers are relied on to purchase stumpage and thus allow the manager or owner to manage his or her stands, it is important that stumpage bids for thinning be as profitable as other harvesting chances. Although our analysis includes only cable-logging technology, data from 113 sample plots, three levels of market price, and transport mileage, one could easily evaluate other scenarios with the methodology presented simply by making additional simulation runs.

REFERENCES CITED

- Baumgras, J.E. 1984. Predicting product yields from thinnings in Appalachian hardwoods. *Journal of Forestry*. 82(1):43-45.
- Baumgras, J.E. and D.O. Yandle. 1986. APTHIN: A microcomputer program to evaluate multiproduct utilization alternatives for thinnings in Appalachian hardwood stands. Pages 402-421 in *Proceedings forestry microcomputer software symposium* (H.V. Wiant, D.O. Yandle and W.E. Kidd, eds.). 1986 June 29-July 2; Morgantown, WV: West Virginia University.
- Bones, J.T. 1978. The forest resources of West Virginia. Res. Bull. NE-56. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 105 p.
- LeDoux, C.B. 1985a. Stump-to-mill timber production cost equations for cable logging eastern hardwoods. NE-566. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 6 p.
- LeDoux, C.B. 1985b. When is hardwood cable logging economical? *Journal of Forestry*. 83(5):295-298.
- Ohio Agricultural Statistics Service. 1988. Ohio timber prices, January 15, 1988. Columbus, OH: Ohio Agricultural Statistics Service. 2 p.
- U.S. Department of Agriculture, Forest Service. 1982. An analysis of the timber situation in the United States 1952-2030. Forest Resource Rep. 23 Washington, D.C.: U.S. Department of Agriculture, Forest Service. 499 p.

THE AUTHORS

Chris B. LeDoux is an Industrial Engineer and Project Leader; John E. Baumgras is a Research Forest Products Technologist, both with the Forest Service, Northeastern Forest Experiment Station, Morgantown, WV 26505.

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