United States
Department of
Agriculture

Forest Service

**Northeastern Forest
Experiment Station**

Research Paper
NE-582

1986

Costs, Yields, and Revenues Associated with Thinning and Clearcutting 60-year-old Cherry-Maple Stands

Gary W. Miller
Raymond L. Sarles

Abstract

Logging costs, product yields, and harvest revenues were determined for three thinning treatments (75, 60, and 45 percent residual stocking) and clearcutting in 60-year-old cherry-maple stands. The study area was logged by a three-man crew using chain saws and a wheeled skidder. Time study and yield data indicated that production rates and costs were similar among the four treatments. Production rates ranged from 18.5 to 19.3 cunits per day, depending on the treatment. Total logging costs, including felling, bucking, skidding, loading, hauling, and roads, ranged from $44 to $35 per cunit, decreasing as the cut increased. Sawlog yields ranged from 1,621 to 13,281 board feet per acre (International ¼-inch rule), while pulpwood yields ranged from 630 to 1,897 cubic feet per acre. Harvest revenues were sufficient to pay for roads and timber sale costs in all treatments except the lightest thinning treatment.

The Authors

Gary W. Miller is an economist for the timber management project at the Timber and Watershed Laboratory, Northeastern Forest Experiment Station, Parsons, West Virginia.

Raymond L. Sarles is a research forest products technologist at the Forestry Sciences Laboratory, Northeastern Forest Experiment Station, Princeton, West Virginia.

Introduction

Stocking guides can be used to prescribe thinning treatments in immature hardwood stands. They provide general guidelines on residual stand density based on growing-space requirements of individual trees. Preliminary growth information indicates that field tests are needed to evaluate and refine current recommendations on stocking control (Leak 1981). Also, information on costs and revenues associated with thinning operations is needed to develop economic guidelines for managing even-aged hardwood stands. This information will help forest managers determine practical thinning schedules based on volume growth and value factors in individual stands.

Scientists at the Timber and Watershed Laboratory in Parsons, West Virginia, installed a thinning study in cherry-maple stands on the Monongahela National Forest to test the Allegheny hardwoods stocking guide (Roach 1977). Cost and yield data were collected during the harvesting operations. This paper reports logging costs, yield of merchantable products, and revenues associated with three thinning treatments and clearcutting.

Study Area and Methods

Treated stands were previously unmanaged, about 60 years old. The overstory was primarily black cherry and red maple with some patches of white ash. The understory was made up of American beech, red maple, and sugar maple. Rainfall in the area averages 55 to 60 inches per year, and site index for black cherry is 75 feet. Slopes are generally less than 10 percent. The area is representative of about 125,000 acres of commercial forests in central West Virginia and resembles the Allegheny hardwood forests of northwestern Pennsylvania.

According to the stocking chart (Roach 1977), the study area was 113 percent stocked before thinning. Based on a complete inventory of all trees 1.0 inch in d.b.h. and larger on nineteen ½-acre plots, the average basal area was 169 ft^2 per acre. Sixty-nine percent of the basal area was in the cherry, ash, and yellow-poplar species group. Basal area in saplings (1.0 to 5.5 inches d.b.h.) averaged 25 ft^2 per acre. The area averaged 852 trees per acre with an average stand diameter of 6.0 inches. In merchantable trees (7.0 inches d.b.h. and larger), the stand averaged 224 trees per acre with an average d.b.h. of 10.2 inches. Pretreatment sawtimber volume averaged 11,400 board feet per acre (International ¼-inch rule); total merchantable volume averaged 4,350 ft^3 per acre (Table 1).

Four cutting treatments were studied: 75, 60, 45, and 0 percent residual stand stocking. Fourteen 2-acre plots, four in each thinning treatment and two in the clearcut treatment, were included in the cost study. In each plot, trees were marked for removal to achieve the desired residual stocking (Fig. 1). Residual stand stocking in the thinning treatments was measured with the stocking guide for Allegheny hardwoods (Roach 1977). In the clearcut treatment, all stems 1.0 inch d.b.h. and larger were cut (Table 1).

Figure 1.—A 60-year-old cherry-maple stand thinned to 45 percent residual stocking.

Table 1.—Characteristics for four cutting treatments in 60-year-old cherry-maple stands

Residual stocking treatment (percent)	Stand	No. stems per acre: 1.0-6.9 inches d.b.h.	No. stems per acre: 7.0 inches d.b.h. and larger	Basal area per acre: 1.0-6.9 inches d.b.h.	Basal area per acre: 7.0 inches d.b.h. and larger	Merchantable volume[a] per acre: Ft^3	Merchantable volume[a] per acre: Board feet
				Ft^2	Ft^2		
75	Initial	716	222	43.2	123.5	4,215	10,860
	Cut	47	65	10.2	29.4	942	1,621
	Residual	669	157	33.0	94.1	3,273	9,239
60	Initial	641	229	44.5	124.0	4,208	10,553
	Cut	62	104	13.1	47.2	1,524	2,701
	Residual	579	125	31.4	76.8	2,684	7,852
45	Initial	601	240	41.9	133.4	4,560	11,720
	Cut	71	149	15.1	70.9	2,315	4,433
	Residual	530	91	26.8	62.5	2,245	7,287
0	Initial	553	207	38.1	127.1	4,451	13,281
	Cut	553	207	38.1	127.1	4,451	13,281
	Residual	0	0	0	0	0	0

[a]Board-foot volume includes trees 10 inches d.b.h. and larger, cubic-foot volume includes trees 7.0 inches d.b.h. and larger.

An experienced three-man crew using chain saws and a midsize (96 hp) wheeled skidder, felled and removed all marked trees that were 7.0 inches d.b.h. and larger. Marked trees smaller than 7.0 inches d.b.h. were felled and left in the woods. One crew member was responsible for all felling, limbing, and topping. The other crew members were involved with pulling cable, setting chokers (Fig. 2), skidding tree-length logs to the landing, and bucking logs on the landing. Trees were topped at 4.0 inches diameter outside bark (d.o.b.) and skidded tree length. A maximum of 10 chokers per hitch were used for skidding.

Figure 2.—One crew member was responsible for pulling cable and setting chokers.

Time Study Data

Time study and yield data were collected during logging. Man hours were measured with stopwatches. Machine hours associated with log skidding were measured with a clock attached to the skidder. Machine hours associated with felling and bucking were estimated from the detailed time study data.

Two major work cycles were timed: tree felling and log skidding. Productive time in the tree-felling cycle included the time required to walk from tree to tree, actual cutting time, and the time required to limb and top an individual tree. Productive time in the log-skidding cycle included the travel time of the skidder between the landing and the plots and the time required to set chokers, winch logs, and buck logs on the landing. Delays within the individual work cycles were included in the time study data (Fig. 3). Nonproductive activities such as coffee breaks and cleanups not related to the work cycles were timed and recorded separately. The time study data indicated the amount of productive time, delay time, and nonproductive time in an 8-hour day.

Figure 3.—Tree-length logs entangled in slash and residual stems were a major cause of skidding delays.

Yield Data

Yield data were collected in conjunction with the time study data. Prior to logging in a given 2-acre plot, d.b.h. was measured and painted on the side of each marked tree. The species and d.b.h. of each tree included in a felling or skidding cycle (Fig. 3) were recorded.

The volume produced in each work cycle was determined from local volume tables developed for the immediate study area. Cubic-foot volume included wood and bark for all stem and branch sections that were at least 4.0 inches d.o.b. Board-foot volume, (International ¼-inch rule) included all sawlogs that met the requirements of USDA Forest Service log grades (Rast et al. 1973).

Analysis

A regression equation was developed for each treatment to predict productive felling time per tree as a function of cubic-foot volume per tree. Other variables, including d.b.h., slope, and board-foot volume per tree, were not significant at the 5 percent level. A regression equation also was developed for each treatment to predict productive skidding time per turn as a function of number of logs per turn, one-way skidding distance per turn, and cubic-foot volume per turn. Other variables, including slope and board-foot volume per turn, were not significant at the 5 percent level.

To compare production rates and logging costs among the four treatments, selected values were used in the equations to predict mean productive felling and skidding times (Table 2). For felling, we used the mean volume per tree computed from the marked cut in each treatment. These values differed slightly from the mean volumes observed in the time study. For skidding, we predicted mean productive time based on an average load of 10 logs per turn in the thinning treatments and 8 logs per turn in the clearcut treatment. These were the most frequently observed loads in each treatment, slightly more than the mean number of logs observed in the time study. Volume per turn was estimated using number of logs times the volume per tree in each treatment (Table 2). We also used a one-way skidding distance of 500 feet per turn in each treatment. While the mean observed skidding distance varied among plots and treatments, 500 feet was the mean skidding distance throughout the study area.

Using the regression equations and selected values (Table 2) for each independent variable, mean productive times (delays not included) for felling and skidding cycles were predicted for each cutting treatment. Volume figures used in the equations were then combined with the predicted cycle times to compute production rate estimates for felling and skidding in cubic feet per productive hour (Table 3).

An efficiency factor, which indicates the relationship between productive time and total time, was used to account for delays (Table 3). Production rate per scheduled hour is the product of efficiency factor and the production rate per productive hour.

Results

A total of 1,298 felling cycles was observed during the time study. Each felling cycle included the productive time and delay time required to fell, limb, and top a merchantable tree. For all observations combined, the average tree was 9.0 inches d.b.h., the average volume was 15.2 ft^3 per tree, and the average total production time was 3.7 minutes per tree. The average felling production rate was 244 ft^3 per hour.

Most felling delays were caused by the lower production rate in the skidding operation. In fact, felling delays were necessary to avoid delays in the skidding operation. Felling delays classified as "waiting for skidder, helping skidder, or resting" were periods when the feller had prepared enough tree-length logs to sustain skidding production. If the feller had continued to fell and prepare logs during these delays, the excess slash and tops would have caused winching and travel problems for the skidder. As a result, the feller was able to keep up with the skidding operation even though 44 percent of his total time was classified as delay or nonproductive time (Table 4).

Table 2.—Selected values used in regression equations to compute felling and skidding production rates in four cutting treatments

Residual stocking treatment (percent)	Number of tree-length[a] logs per turn	Skidding[b] distance	Volume per[a] turn	Volume per[c] tree
		Feet	*Ft³*	
75	10	500	145	14.5
60	10	500	147	14.7
45	10	500	155	15.5
0	8	500	172	21.5

[a]Loads based on most frequent number of logs observed in each treatment times volume per cut tree in each treatment.
[b]Mean one-way skidding distance throughout the study area.
[c]Mean volume per cut tree in each treatment.

Table 3.—Felling and skidding production rates for four cutting treatments

Residual stocking treatment (percent)	Subsystem	Production rates[a] per productive hour	Efficiency[b] factor	Production rates per scheduled hour	Production rates per 8-hour day
		Ft³	*Percent*	---------- *Ft³* ----------	
75	Felling	430	59	254	2032
	Skidding	261	89	232	1856
60	Felling	437	56	245	1960
	Skidding	277	87	241	1928
45	Felling	422	55	232	1856
	Skidding	269	86	231	1848
0	Felling	538	50	269	2152
	Skidding	292	80	234	1872

[a]Skidding production rates are based on a mean one-way skidding distance of 500 feet per turn.
[b]Efficiency factor is productive time divided by total time.

Table 4.—Breakdown of felling delays observed in all residual stocking cutting treatments combined

Delay category	Percent of felling delay time	Percent of total felling time
Waiting for skidder	43	19
Equipment maintenance and refueling	25	11
Resting	16	7
Crew breaks	8	4
Helping skidder	7	3
Consultation	1	≤1
Total	100	44

Table 5.—Breakdown of skidding delays observed in all residual stocking cutting treatments combined

Delay category	Percent of skidding delay time	Percent of total skidding time
Waiting for product	34	5
Crew breaks	27	4
Equipment maintenance and refueling	18	3
Product jam	14	2
Consultation	4	1
Travel impeded	3	≤1
Total	100	15

We observed 205 skidding turns during the time study. Each skidding turn included the productive time and delay time required to travel into the woods, hookup, winch, skid, and buck a load of tree-length logs. For all observations combined, the average load consisted of 8.7 tree-length logs, and the average volume was 136 ft³ per load. Logs were skidded an average distance of 500 feet and the average total time was 35.7 minutes per turn. The average skidding production rate was 229 ft³ per hour.

Delays accounted for only 15 percent of total skidding time, leaving few opportunities for increasing daily output (Table 5). The most common delay, "waiting for product," accounted for 5 percent of total skidding time. This delay usually resulted from hung trees or trees that could not be limbed and topped until they were winched free of slash.

Production Rates

Production rates were similar among the four cutting treatments (Table 3). Daily output ranged from 18.5 cunits per day in the 45 percent residual stocking treatment to 19.3 cunits per day in the 60 percent treatment. Skidding was the "weak link" in all treatments—that part of the logging system with the lowest output per day (Baumgras and Martin 1978). Thus, the skidding operation determined the production rate of the entire system.

Costs

Wages were assumed to be $7.00 per hour plus 31 percent mandatory fringe benefits for Social Security, Workmen's Compensation insurance, and unemployment insurance. The total labor cost for felling, bucking, and skidding was $220.08 per day (Table 6).

Machine costs were computed by a method proposed by Miyata (1980). Fixed costs associated with felling, bucking, and skidding were based on a new pickup truck and new chain saws (1982 models) and a used skidder (1978 model). Purchase prices and assumptions presented in Table 7 were used to compute depreciation, interest, insurance, and taxes, the major components of fixed costs. The total fixed cost for the equipment used in felling, bucking, and skidding was $48.96 per day (Table 6).

Variable machine costs were estimated using cost factors (Miyata 1980), actual operating hours, and the manufacturer's recommended maintenance schedule for each piece of equipment. Fuel, lubricants, filters, tires, chains and bars, maintenance, and repairs are the major components of variable costs. The skidder cost $9.93 per operating hour and operated 5.75 hours per day. Each chain saw cost $2.10 per operating hour. One saw used for felling operated 3.35 hours per day, while a spare saw used for bucking on the deck operated 1.60 hours per day. The pickup truck cost $5.00 per operating hour and operated 2 hours per day. The total variable cost for the equipment used in felling, bucking, and skidding was $77.60 per day (Table 6).

Wages and fixed machine costs were the same for all treatments. A comparison of machine operating time and variable machine costs indicated negligible differences among the treatments. Thus, the cost per unit of volume for logs bucked and decked at roadside landings was determined by dividing daily output into $346.64, the total daily cost in all treatments.

Felling, bucking, and skidding costs were lowest in the 60 percent residual stocking treatment and highest in the 45 percent treatment (Table 8), but the difference in costs was less than $1.00 per cunit. As a result, the cost of merchantable material decked at roadside landings was nearly the same in all treatments, ranging from $17.98 to $18.76 per cunit. Total logging costs, however, include the costs of loading and hauling and the cost of roads. While loading and hauling costs were the same for all treatments, road costs resulted in distinct differences among the four treatments.

Table 6.—Labor and equipment costs associated with felling, bucking, and skidding

Item	Cost per scheduled hour			Cost per 8-hour day
	Fixed[a]	Variable	Total	
Labor (3-man crew)		*Dollars*		*Dollars*
wages	—	21.00	21.00	168.00
fringe benefits	—	6.51	6.51	52.08
			Total	220.08
Equipment				
chain saw	0.19	0.88	1.07	8.56
chain saw (spare)	0.19	0.42	0.61	4.88
wheeled skidder	3.99	7.15	11.14	89.12
pickup truck	1.75	1.25	3.00	24.00
Total	6.12	37.21	43.33	346.64

[a]Fixed cost includes depreciation, 15-percent cost of capital, insurance, and taxes.

Table 7.—Data used to compute machine costs associated with felling, bucking, and skidding

Item	Price	Economic life	Salvage value	Scheduled hours per year
	Dollars	*Years*	*Percent*	*Number*
Chain saw	650	2	20	1,800
Chain saw (spare)	650	2	20	1,800
Wheeled skidder	30,000	5	20	1,800
Pickup truck	9,000	3	20	1,800

Table 8.—Logging costs per cunit for four cutting treatments

Residual stocking treatment	Daily labor and machine cost	Daily production rate[a]	Felling, bucking, and skidding cost	Loading and hauling cost[b]	Road cost	Total logging cost
Percent	*Dollars*	*Cunits*		*Dollars per cunit*		
75	346.64	18.56	18.68	14.50	10.62	43.80
60	346.64	19.28	17.98	14.50	6.56	39.04
45	346.64	18.48	18.76	14.50	4.32	37.58
0	346.64	18.72	18.52	14.50	2.25	35.27

[a]Based on daily skidding production as "weak link" in the harvesting system.
[b]Based on one-way haul distance of 14 miles.

Loading and hauling cost amounted to $14.50 per cunit (Table 8). This included the fixed and variable costs of two used tandem-axle trucks and a knuckleboom loader mounted on another tandem-axle truck. Labor costs included the wages and fringe benefits for two men. A local logging contractor provided data for estimating loading and hauling costs.

Road costs per unit of volume depend on the volume harvested per acre, the length of road needed, and the cost per mile of road. Wheeled-skidder logging systems in the central Appalachian region require 1 mile of bulldozed road for every 20 acres of timberland harvested—skid roads account for 89 percent of road length and truck roads account for 11 percent (Kochenderfer 1977). Skidroads cost about $1,200 per mile and minimum-standard truck roads with culverts cost about $8,100 per mile, excluding gravel (Kochenderfer and others 1984). Thus, the weighted cost of roads needed to employ a wheeled-skidder logging system is about $2,000 per mile. With access to 20 acres of forest land, the resulting road cost is $100 per acre. Using this estimated road cost per acre and the average yield per acre in each treatment (Table 9), we estimated that road costs ranged from $2.25 to $10.62 per cunit. Note that road costs per cunit decreased as more volume per acre was harvested (Table 8).

Total logging costs ranged from $43.80 per cunit in the 75 percent residual stocking treatment to $35.27 per cunit in the clearcut treatment (Table 8).

Treatment Yields

Product yields included sawlogs and pulpwood in each of the four cutting treatments. The average yield in the 75 percent treatment was 1,621 board feet of sawlogs and 630 ft^3 of pulpwood per acre. Ninety-five percent of the sawlog volume was in small, factory grade 3 logs, 4 percent was in grade 2 logs, and 1 percent was in logs below grade. The total yield from this treatment was 942 ft^3 per acre (Table 9).

The average volume yield from plots thinned to 60 percent residual stocking was 2,701 board feet of sawlogs and 1,004 ft^3 of pulpwood per acre. Ninety-three percent of the board-foot volume was in factory grade 3 logs, 6 percent was in grade 2 logs, and 1 percent was in grade 1 logs. The total yield from this treatment was 1,524 ft^3 per acre.

In the 45 percent treatment, the average yield included 4,433 board feet of sawlogs and 1,462 ft^3 of pulpwood per acre. Ninety-one percent of the board-foot volume was in factory grade 3 logs, 7 percent in grade 2 logs and 2 percent in grade 1 logs. The total yield was 2,315 ft^3 per acre.

The average yield from the clearcut treatment was 13,281 board feet of sawlogs and 1,897 ft^3 of pulpwood per acre. Seventy-three percent of the board-foot volume was in factory grade 3 logs, 18 percent in grade 2 logs, and 9 percent in grade 1 logs. The total merchantable yield was 4,451 ft^3 per acre, including both sawlogs and pulpwood (Fig. 4).

Table 9.—Average volume yields per acre for cutting treatments

Residual stocking treatment (percent)	Sample area	Average yield[a] per acre	
	Acres	*Board feet*	*Ft^3*
75	8	1621	942
60	8	2701	1524
45	8	4433	2315
0	8	13281	4451

[a]Cubic-foot volume includes wood and bark 4.0 inches d.o.b. for all roundwood removed.

Figure 4.—Most of the board-foot volume yield was in small, sound logs.

Discussion

This study provided the basic information needed to estimate cash flows associated with initial thinning treatments and clearcutting in 60-year-old Allegheny hardwood stands. Average product yields and market prices were used to compute potential revenues associated with each treatment. Logging production rates and selected assumptions regarding roads, wages, and machine costs were used to determine how each treatment affected landowner and logger income.

Markets were available for the products harvested from the study area. A local sawmill paid stumpage prices of $63 per thousand board feet (M bf) for woods-run sawtimber and $3 per cunit for pulpwood. Roads were constructed prior to the timber sale, so these prices did not include an adjustment for road costs. Where roads are needed, stumpage prices would be reduced and the landowner would receive less revenue than these prices indicate. In the current recommended thinning treatment (60 percent residual stocking), actual stumpage revenues exceeded probable road costs by about $100 per acre (Table 10). With this excess revenue, the landowner could pay for other sale costs, such as cruising and marking the timber, maintaining boundary lines, and supervising the harvest. Thus, thinning to 60 percent residual stocking can result in positive cash flows, even where access roads are needed. Because yields and total revenues increased with heavier removals, the 45 percent treatment and the clearcut treatment also can result in positive cash flows where roads are needed. The 75 percent treatment did not provide sufficient revenues to be commercially viable in areas without access roads.

Roads constructed for initial commercial thinnings will benefit the landowner in future sales. Harvesting costs will be reduced and the landowner will receive higher stumpage revenues in later operations. Long-term profitability will depend on residual stand growth and future market conditions, but the results indicate that thinnings in stands similar to the study area would pay for access roads, provide immediate income for the landowner, and improve the potential for future profits.

Income for the logging contractor is the difference between revenues for products delivered to the mill and the total cost of felling, bucking, skidding, loading, and hauling merchantable material. Because road costs are accounted for in the stumpage price, the landowner actually pays for access to the timber. The timber buyer in this study paid local logging contractors $68 per M bf for sawlogs and $34 per cunit for pulpwood delivered to the mill. Payments for products exceeded logging costs in all four harvest treatments (Table 11).

Time studies disclosed moderate differences in logging costs. The production rates varied less than 100 ft^3 per day, and daily costs were equal. Income for the logging contractor increased as more volume per acre was removed, primarily because roundwood products were more valuable in the heavier cutting treatments. The profit margin was highest in the 60 percent treatment, about 6 percent.

Table 10.—Harvest revenues, costs, and income per acre for the landowner

Residual stocking treatment (percent)	Stumpage revenue: Sawtimber			Stumpage revenue: Pulpwood			Total revenue per acre	Road costs per acre	Landowner income per acre
	Price per M bf	Yield per acre	Revenue per acre	Price per cunit	Yield per acre	Revenue per acre			
	Dollars	*M bf*	*Dollars*	*Dollars*	*Cunits*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
75	63	1.62	102	3	6.3	19	121	100	21
60	63	2.70	170	3	10.0	30	200	100	100
45	63	4.43	279	3	14.6	44	320	100	220
0	63	13.28	837	3	19.0	57	894	100	794

Table 11.—Logging revenues, costs, and income per acre for the logging contractor

Residual stocking treatment (percent)	Logging revenues: Sawlogs			Logging revenues: Pulpwood			Total revenue per acre	Logging costs			Income per acre
	payment per M bf	Yield per acre	Revenue per acre	Payment per cunit	Yield per acre	Revenue per acre		Cost per cunit	Yield per acre	Cost per acre	
	Dollars	*M bf*	*Dollars*	*Dollars*	*Cunits*	*Dollars*	*Dollars*	*Dollars*	*Cunits*	*Dollars*	*Dollars*
75	68	1.62	110	34	6.3	214	324	33.18	9.4	312	12
60	68	2.70	184	34	10.0	340	524	32.48	15.2	494	30
45	68	4.43	301	34	14.6	496	797	33.26	23.2	772	25
0	68	13.28	903	34	19.0	646	1,549	33.02	44.5	1,469	80

Literature Cited

Baumgras, John E.; Martin, A. Jeff. **The weak link logging system analyzer.** Gen. Tech. Rep. NE-40. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1978. 63 p.

Kochenderfer, J. N. **Area in skidroads, truck roads, and landings in the central Appalachians.** Journal of Forestry. 75(8):507-508; 1977.

Kochenderfer, J. N.; Wendel, G. W.; Smith, H. Clay. **Cost of and soil loss on "minimum-standard" forest truck roads constructed in the central Appalachians.** Res. Pap. NE-544. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1984. 8 p.

Leak, William B. **Do stocking guides in the eastern United States relate to stand growth?** Journal of Forestry. 79(10):661-664; 1981.

Miyata, Edwin S. **Determining fixed and operating costs of logging equipment.** Gen. Tech. Rep. NC-55. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1980. 16 p.

Rast, Everette D.; Sonderman, David L.; Gammon, Glenn L. **A guide to hardwood log grading.** Gen. Tech. Rep. NE-1. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1973. 32 p.

Roach, B. A. **A stocking guide for Allegheny hardwoods and its use in controlling intermediate cuttings.** Res. Pap. NE-373. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1977. 30 p.

Miller, Gary W.; Sarles, Raymond L. **Costs, yields, and revenues associated with thinning and clearcutting 60-year-old cherry-maple stands.** Res. Pap. NE-582. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1986. 18 p.

Logging costs, product yields, and harvest revenues were determined for three thinning treatments (75, 60, and 45 percent residual stocking) and clearcutting in 60-year-old cherry-maple stands. The study area was logged by a three-man crew using chain saws and a wheeled skidder. Time study and yield data indicated that production rates and costs were similar among the four treatments. Production rates ranged from 18.5 to 19.3 cunits per day, depending on the treatment. Total logging costs, including felling, bucking, skidding, loading, hauling, and roads, ranged from $44 to $35 per cunit, decreasing as the cut increased. Sawlog yields ranged from 1,621 to 13,281 board feet per acre (International ¼-inch rule), while pulpwood yields ranged from 630 to 1,897 cubic feet per acre. Harvest revenues were sufficient to pay for roads and timber sale costs in all treatments except the lightest thinning treatment.

ODC 242:221.01:651

Keywords: thinning; clearcutting; yields; costs; revenues

Headquarters of the Northeastern Forest Experiment Station are in Broomall, Pa. Field laboratories are maintained at:

- Amherst, Massachusetts, in cooperation with the University of Massachusetts.
- Berea, Kentucky, in cooperation with Berea College.
- Burlington, Vermont, in cooperation with the University of Vermont.
- Delaware, Ohio.
- Durham, New Hampshire, in cooperation with the University of New Hampshire.
- Hamden, Connecticut, in cooperation with Yale University.
- Morgantown, West Virginia, in cooperation with West Virginia University, Morgantown.
- Orono, Maine, in cooperation with the University of Maine, Orono.
- Parsons, West Virginia.
- Princeton, West Virginia.
- Syracuse, New York, in cooperation with the State University of New York College of Environmental Sciences and Forestry at Syracuse University, Syracuse.
- University Park, Pennsylvania, in cooperation with the Pennsylvania State University.
- Warren, Pennsylvania.