Harvesting Costs & Returns Under 4 CUTTING METHODS in Mature Beech-Birch-Maple Stands in New England

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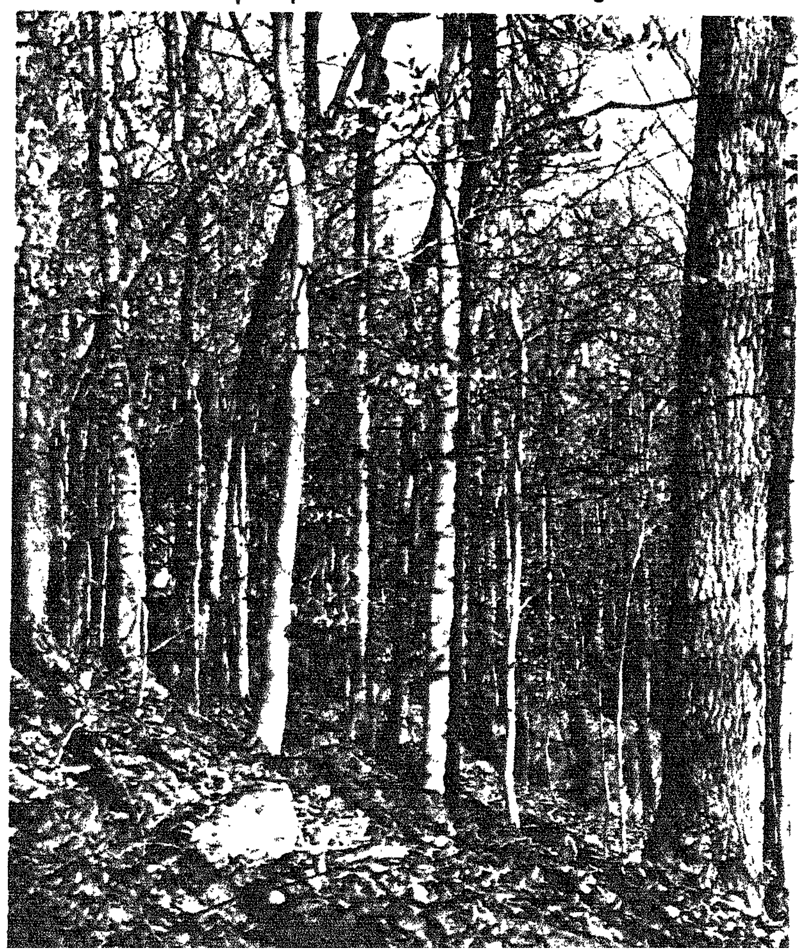
BEECH-birch-maple forests in New England are adaptable to a variety of cutting methods. The silvicultural implications of these different methods have been frequently studied and reported *(Blum and Filip 1963, Gilbert and Jensen 1958, Jensen 1943, Marquis 1965b)*. But, the costs and returns associated with logging under the various cutting methods have not been adequately studied.

Recognizing the need for combined silvicultural and economic information of this type, the Northeastern Forest Experiment Station began a timber-management study on the Bartlett Experimental Forest in New Hampshire in 1950. Many years will be required to fully evaluate this long-term study, but preliminary information is now available about logging costs and returns, production rates, and products obtained from initial harvests made by four different cutting methods.

STUDY METHODS

Four cutting methods—selection, patch, diameter-limit, and commercial clearcutting—are being compared on compartments large enough to simulate commercial-size logging operations. Five separate logging contractors were involved in these cuttings over a 14-year period (1950 to 1963). Unfortunately, not all of these contractors operated under all four cutting methods. However, all operated in fairly similar stands, followed the same merchantability standards, practiced tree-length skidding and multi-product utilization, and sold products to essentially the same industries. All used one-man chain saws and crawler tractors.

Figure 1.—A typical stand of mature beech-birch-maple timber in which the cuttings were made. Scattered boulders and steep slopes are common in this region.



All cuttings were made in previously unmanaged stands (fig. 1). These stands had been high-graded several times between 1870 and 1900—first for spruce and later for the better sugar maple and yellow birch. Some large hemlocks were also removed about 1918.

When the compartment study was begun in 1950, beech—which had never been cut heavily—made up over 50 percent of the gross volume. The stands were of low overall quality and vigor, but they did contain some thrifty trees of the high-value species: sugar maple, yellow birch, paper birch, and white ash. Trees of all species ranged in size from saplings to occasional stems of more than 30 inches diameter at breast height. The merchantable sawtimber volume averaged about 9,000 board feet per acre, and total merchantable volume averaged about 2,300 cubic feet per acre.[1]

All compartments were situated on mountainous terrain at elevations between 900 and 2,200 feet above sea level. Slopes averaged between 10 and 25 percent, but steeper pitches up to 40 percent were common. Large and small granite boulders were prevalent.

Cutting Methods

Selection cutting.—The long-term aim under selection cutting is to develop and maintain an all-aged distribution of vigorous high-quality trees. Individual trees were marked for removal in all size classes larger than 5.0 inches d.b.h. As a rule, the marked volume represented about 20 to 30 percent of the initial cubic-foot volume. Because these stands contained many defective trees, the first cutting under this method was primarily for salvage and stand improvement. Eleven compartments, totaling 423 acres, were included in the selection cutting method.

Patch cutting.—Patch cuttings are clearcuttings of small areas intended to favor the regeneration of yellow and paper birch. Patches in this study ranged from 1/10 to 2/3 acre and were

[1] Board-foot volumes are based on International log rule, ¼-inch kerf, for hardwoods over 11.0 inches d.b.h. and for softwoods over 9.0 inches d.b.h. Sawtimber trees averaged 14 inches d.b.h. with two 16-foot logs. Total cubic-foot volumes are based on trees over 5.0 inches d.b.h.

generally laid out in portions of the stand that contained groups of mature, overmature, or defective timber. All merchantable trees over 5.0 inches d.b.h. within the patch were harvested. Four compartments, totaling 120 acres, were cut by this method. Within this area, 38 patches were cut, totaling 16 acres.

Diameter-limit cutting. — All merchantable trees over 13.0 inches d.b.h. were harvested.[2] In addition, practically all paper birch trees (including trees down to 7.0 inches d.b.h.) were harvested because they were mature or overmature and would not last until the next cutting cycle. Under this diameter-limit specification, 55 percent of the initial board-foot volume and 52 percent of the initial cubic-foot volume were harvested. Two compartments, totaling 80 acres, were cut by this method.

Commercial clearcutting.[3]—This method usually involves a harvest of all merchantable trees. The stand remaining after the harvesting operation will vary according to available markets and the product objective of the contractor. In our study, nearly all of the board-foot volume and 82 percent of the cubic-foot volume were removed. The volume remaining was in poletimber trees 5.0 to 9.0 inches d.b.h. and in trees of all sizes that were highly defective. One compartment of 41 acres was cut by this method.

Skid Roads

Except for the compartment handled as a commercial clearcutting, the main skid-road system was laid out by a research forester before logging. Long steep grades, abrupt curves, and wet spots were avoided wherever possible. Streams and stream beds were crossed at right angles in most places.

The compartment handled as a commercial clearcutting had no planned road system. Instead, the contractor was given a free hand to locate the skid roads as he wished. Generally, he devel-

[2] A 13-inch diameter limit was chosen to strike a fairly even balance between the volume of growing stock cut and the amount retained for further growth and development. In other hardwood stands this limit may be higher or lower to attain the same objective.

[3] This method differs from the clearcutting method recommended by Gilbert and Jensen (1958) primarily because the stand was not completely removed by harvesting and follow-up cultural work.

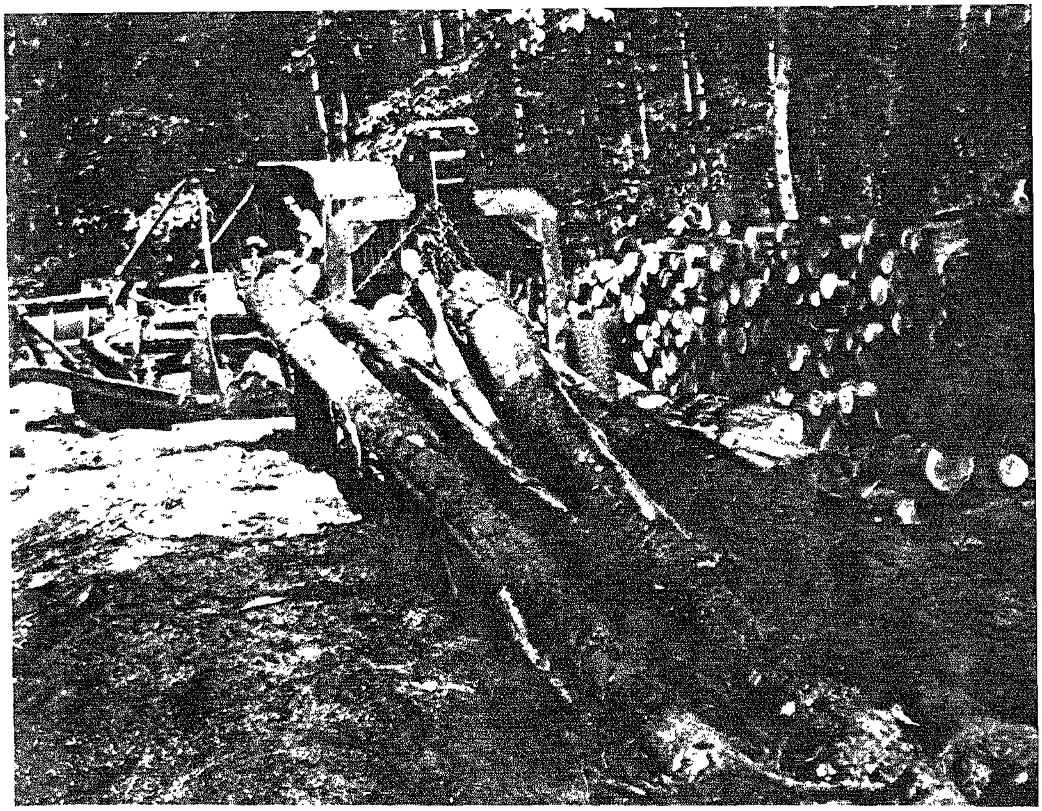


Figure 2.—Four to six tree-lengths made up a full tractor-arch skidding load. The tree-lengths ranged from 15 to 50 feet and averaged about 35 feet.

oped the necessary roads as the logging operation progressed. Perhaps because of this, much of the road system was poorly located for efficient skidding.

Skidding costs for the selection, patch, and diameter-limit cuttings—but not for the commercial clearcutting—include the construction of water-diversion ditches installed at the completion of the operation. Such after-logging care helps to prevent erosion and gullying and can be accomplished at moderate cost *(Trimble and Barr 1960, Weitzman 1952, Trimble et. al. 1957)*.

Logging and Markets

Each compartment in the study was considered a distinct logging chance, having its own skid-road system and landing sites. Only two of the 18 compartments covered in this report were not located along a truck road. However, adjustments in labor

Figure 3.—Multi-product utilization. The tree-lengths were bucked at roadside landings to yield the highest product returns: logs, millwood, and pulpwood in order of priority.

and equipment hours were made to compensate for the travel time beyond the compartment boundary.

The size of the logging crews varied from two to six men, depending on the job at hand. Most frequently, the contractors preferred to use a four-man crew: one faller, one skidding operator, and two buckers. Even though the men were assigned specific tasks, they frequently helped one another to avoid delays.

Felled timber was skidded in tree-lengths to the landings. Skidding distance seldom exceeded 1,500 feet and averaged less than 1,000 feet (fig. 2).

Cutters bucked trees to yield the highest possible returns (fig. 3). High-value products included paper birch and yellow birch millwood, mixed hardwood logs for veneer and core stock, white ash logs for handle stock, mixed hardwood dowel stock,[4] and

[4] A dowel-stock market has been available only in the most recent sales on the Experimental Forest. However, some of the 8- and 10-inch diameter beech and sugar maple trees converted into pulpwood in past sales covered by this report would have been satisfactory as dowel stock. Based on field checks, about 10 percent of the hardwood pulpwood would have met the dowel-stock specifications. Hence the standard cords of hardwood pulpwood actually sold were reduced by 10 percent, and this 10 percent was considered as a dowel-stock product in each method of cutting.

softwood sawlogs. Merchantable material that did not meet specifications for these products was bucked into pulpwood.

The buckers stacked the short products—pulpwood and millwood—by hand, but the skidder helped to deck most of the logs with the tractor winch or blade.

Records

On each compartment, daily records were kept for each man and the particular phase of the operation in which he was engaged. The elapsed time for men and equipment was recorded in the following three categories:

Cutting.—This included man-hours of felling, limbing, topping, and bucking; decking or stacking products at roadside; preparing and bulldozing landings; refueling chain saws; sharpening the saw chain; travel within the compartment; and rest periods.

Skidding.—This included man-hours of hooking, skidding, and unhooking tree-lengths; swamping and bulldozing skid roads and trails; bulldozing water-diversion ditches; and rest periods.

Tractor.—This included elapsed hours for bulldozing skid roads, trails, and landings; skidding tree-lengths; decking products at roadside; daily lubrication; and minor repairs. The operator's time for bulldozing landings and decking products was most appropriately placed under cutting labor, because this type of work was considered most helpful to the fallers and buckers. Then too, the tractor operator, fallers, and buckers worked so closely together on these tasks that it was impractical to record the time in more than one category.

Final evaluations of cutting and skidding labor were made in man-hours, even though some men were paid on a piece-rate basis and others on an hourly-basis within the same compartment.

To use a basic measurement for the combination of products harvested and the various scaling rules used, a unit of 100 cubic feet was selected. Such a unit of measurement is generally referred to as a cunit. Approximate conversions to cunits were made as follows:

Product	Scale	Cunits
Logs	1,000 board feet*	1.47
Ash handle stock	1,000 board feet*	1.47
Birch millwood	Standard cord	.88
Dowel stock	Standard cord	.88
Pulpwood	Standard cord	.83

* Based on International log rule, ¼-inch kerf.

Current local wage and equipment rates were applied to determine harvesting costs.[5] Likewise, the best estimate of current local prices paid by the nearest markets for the various products was used to determine harvesting returns. Loading and truck hauling costs were deducted from delivered prices to appraise product values at compartment roadside. The scale of products was based on mill tally slips. Applied rates for labor and equipment were as follows:

Item	Rate
Labor (including fringe benefits)	$2.50 per man-hour
Chain saw (one-man type) and hand tools	1.20 per cunit
Tractor (40-60 H.P.), winch, and arch	4.50 per elapsed hour

The following roadside product prices were used to evaluate roadside returns:

Product	Price Per 1,000 board feet
Hardwood logs:	
Red oak	$100
Yellow birch	100
Paper birch	110
Sugar maple	100
Red maple and beech	50
Ash handle stock	65
Softwood logs:	
Red spruce	50
Eastern hemlock	40
	Per standard cord
Birch millwood	$ 33
Dowel stock	25
Hardwood pulpwood	13

[5] Costs of marking the individual trees or patches to be harvested have not been included in this report. However, since selection and patch cutting involve marking costs, and diameter-limit and clearcutting do not, this factor will also affect the overall cost-return relationships of the various methods.

RESULTS

Products

The volume of products harvested by each cutting method is given in table 1. Over half of the yield in the selection and patch cuttings was in pulpwood—55 and 57 percent, respectively (fig. 4). The trees marked for removal in the selection cutting generally were those of the poorest quality in the stands. Similar poor-quality trees were removed in the patch cutting as a result of the patch locations; the patches were deliberately laid out in portions of the stand that contained a high proportion of defective trees. In effect, both cuttings were stand-improvement operations. Future cyclic cuts should yield less pulpwood and a higher proportion of the high-value products. Nevertheless, if multi-product utilization is continually practiced, at least one-third of future yields will probably be in pulpwood or a similar low-value bulk product.

Because of the heavy cutting of sawtimber-size trees, the diameter limit and commercial clearcutting methods yielded a large proportion of high-value products. In the diameter-limit cutting, the yield in high-value products amounted to 70 percent; in commercial clearcutting the yield was 59 percent.

Table 1.—*Total harvested volume, by product and method of cutting*

Product	Selection cutting	Patch cutting	Diameter limit	Clear-cutting
Hardwood logs (board feet)[1]	392,135	48,645	236,675	128,485
Softwood logs (board feet)[1]	74,580	11,405	77,460	57,450
Ash handle stock (board feet)[1]	8,620	1,800	2,630	20,155
Birch millwood (standard cords)	187.80	23.50	90.24	58.92
Dowel stock (standard cords	162.83	69.12	80.53	91.37
Pulpwood (standard cords)	1,465.48	276.47	322.10	365.50
Total in cunits	2,223.7	401.9	879.2	734.0
Average per acre (cunits)[2]	5.3	3.4	11.0	17.9
Percent in pulpwood	55	57	30	41

[1] Board-feet, International log rule, ¼-inch kerf.

[2] Based on compartment acreages.

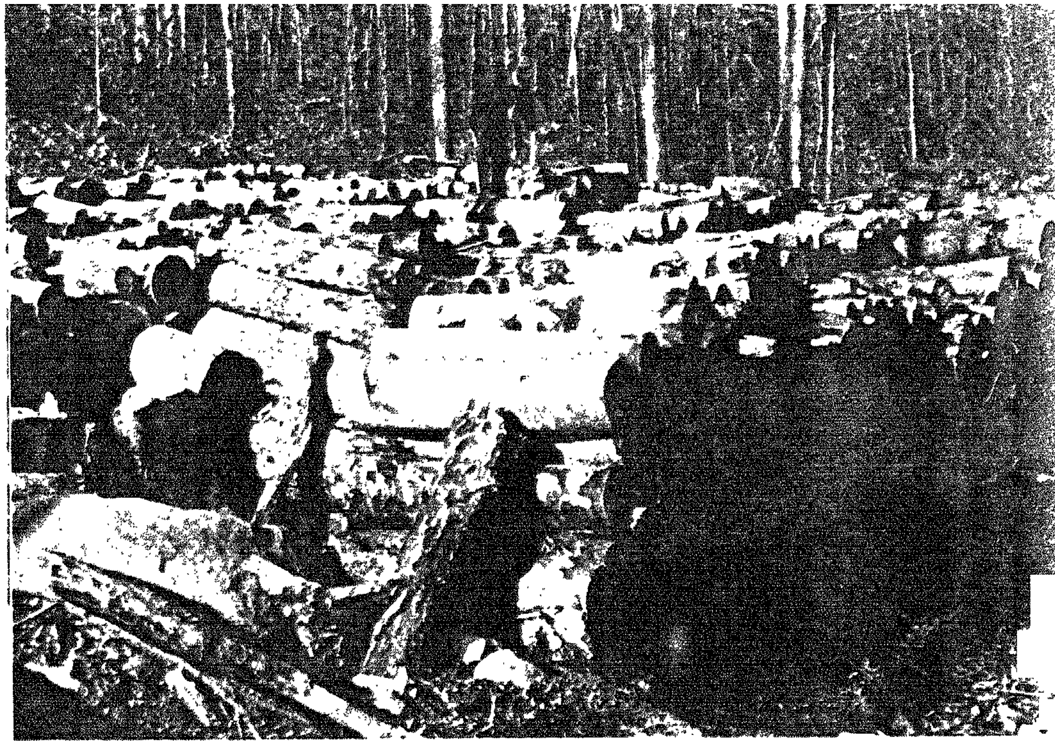


Figure 4.—The yield in pulpwood was high in the four cutting methods.

Production

The average labor input per cunit was fairly uniform among three of the cuttings: selection, patch, and commercial clearcutting (table 2). The diameter-limit cutting averaged about 1 man-hour per cunit lower than the others. In all cutting methods, about two-thirds of the labor input was for cutting; one-third was for skidding.

The tractor time per cunit did not vary much among cutting methods.

The output per man-day averaged about 1¾ cunits for the selection and patch cuttings and for the commercial clearcutting. In the diameter-limit cutting, production averaged about 2¼ cunits per man-day—nearly 29 percent higher. This higher production resulted mostly from a combination of higher average tree size and better quality trees harvested. Others have found that tree size had an important bearing on *cutting time in hardwood* stands *(Campbell 1953, Jiles and Lehman 1960).*

Table 2.—*Physical inputs and outputs*

Item	Selection cutting	Patch cutting	Diameter limit	Clear-cutting
Labor per cunit:				
Cutting (man-hours)	3.17	3.15	2.22	3.01
Skidding (man-hours)	1.40	1.52	1.29	1.41
Labor input (man-hours)	4.57	4.67	3.51	4.42
Tractor use per cunit:				
Cutting (elapsed hours)	0.04	0.05	0.11	0.02
Skidding (elapsed hours)	1.07	1.04	1.07	1.20
Tractor input (elapsed hours)	1.11	1.09	1.18	1.22
Production:				
Output per man-day (cunits)	1.75	1.71	2.28	1.81
Output per man-hour (cunits)	.22	.21	.29	.23

Cost and Return Analysis

The average dollar cost to harvest a cunit of product was nearly identical in the selection, patch, and commercial clearcutting (table 3). The lowest cost was in the diameter-limit cutting, where the cost averaged more than $2 per cunit less than the others.

The cutting phase accounted for slightly more than half the cost per cunit in the selection and patch methods, and slightly less

Table 3.—*Dollar costs per cunit of product harvested*

Work phase	Selection cutting	Patch cutting	Diameter limit	Clear-cutting
Cutting:				
Labor	$7.93	$7.81	$5.55	$7.53
Chain saw	1.20	1.20	1.20	1.20
Tractor[1]	.18	.23	.50	.09
Subtotal	9.31	9.30	7.25	8.82
Skidding:				
Labor	3.50	3.80	3.23	3.53
Tractor	4.82	4.68	4.82	5.40
Subtotal	8.32	8.48	8.05	8.93
Total costs	17.63	17.78	15.30	17.75

[1] Bulldozing landing sites and decking products.

Table 4.—*Summary of dollar costs, returns, and conversion surplus per cunit of product harvested*

Cutting method	Costs	Returns	Conversion surplus[1]
Selection cutting	$17.63	$26.77	$ 9.14
Patch cutting	17.78	26.28	8.50
Diameter limit	15.30	38.19	22.89
Clearcutting	17.75	31.12	13.37

[1] Balance for stumpage, supervision, and profit.

than half in the diameter-limit cutting. In the commercial clearcutting, the average cost was about evenly divided between cutting and skidding.

Dollar returns per cunit were about the same in the selection and patch cuttings, both of which averaged much lower than the other methods (table 4). The lower returns resulted from differences in the quality and value of the harvested products. Under the selection and patch methods, the initial cuttings were essentially stand-improvement operations, which removed many poor-quality trees. On the other hand, the bulk of the cut in the diameter-limit and commercial clearcutting methods was in better quality trees that yielded products of higher value. However, in all cuttings returns exceeded costs. The balance per cunit for stumpage, supervision, and profit—conversion surplus—ranged from $8.50 per cunit in patch cutting to $22.89 per cunit in the diameter-limit cutting.

DISCUSSION

Harvesting costs and returns—and hence profit margins—tend to vary from one operating unit to another. The efficiency of the logging crew, especially the judgment and experience of the logging foreman, is a major factor. Timber size, species, and quality are also important determinants of costs and returns. Likewise, the type of equipment used will affect costs; costs will probably be reduced in the future because of the steady improvements in cutting and skidding equipment now taking place. Labor-payment methods—hourly, piece, or bonus—also have an effect on costs.

A forest managed on an uneven-aged basis with periodic selection cuttings might never differ radically from the unmanaged stands in this study. Minor differences that might be expected would include a gradual improvement in quality during the next few harvest cuttings and a trend toward higher proportions of the tolerant species such as sugar maple and beech *(Filip and Leak 1962, Leak and Wilson 1958)*.

On the other hand, a forest managed under an even-aged system with clearcutting would differ considerably from these unmanaged stands. The proportion of intolerant and intermediate species such as paper birch, yellow birch, and white ash would be higher *(Blum and Filip 1962, Leak and Wilson 1958, Marquis 1965a)*. Quality would vary with the intensity of management. With moderately intensive management, utilizing control of undesirable stems, and a program of periodic thinnings, the size distribution, species composition, quality, and volume of material removed throughout a rotation would bear little semblance to the harvest reported here.

Thus these logging cost and return data must not be extended beyond their intended application. These data apply to initial harvests in previously unmanaged old-growth northern hardwood stands; they are only indicative of the range of values that might be expected on similar logging operations in similar stands, and they do not reflect long-term cost-return ratios under various systems of forest management.

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