

Station Paper No. 73

Northeastern Forest Experiment Station

Upper Darby, Pennsylvania
Ralph W. Marquis, Director

1954

Cutting Mountain Hardwood Stands

Ralph W. Marquis

Sidney Weitzman

Carl J. Holcomb

CONTENTS

	Page
Introduction	1
Condition of the stand before cutting . .	2
Experimental treatments	2
Response to different treatments	4
Regeneration after 5 years	5
Growth after 5 years	9
Quality of the stand after cutting . .	9
Cutting cycles	10
The cost of conditioning cuts	12
Are conditioning cuts worthwhile?	17
Literature cited	19

Cutting Mountain Hardwood Stands

by Ralph W. Marquis¹
Sidney Weitzman
Carl J. Holcomb

*Northeastern Forest Experiment Station
Forest Service, U.S. Dept. Agriculture*

INTRODUCTION

ON THE FERNOW Experimental Forest in West Virginia, as on several other experimental forests in the Northeast, studies are being conducted to compare the biologic and economic results of different methods of forest management. The experiments are being carried out on compartments varying in size from 50 to 150 acres. Such areas are large enough to permit the simulation of commercial logging operations. The treatments applied to these compartments are designed to encompass different silvicultural systems, different product objectives, and different intensities of forest management. Essentially they are long-term studies.

To demonstrate the nature of the experimental treatments, four 5-acre plots were established in 1949. These plots are located side by side on one of the better sites on the Fernow Experimental Forest; they were similar in cover type and species composition when they were established.

¹DR. MARQUIS IS DIRECTOR OF THE NORTHEASTERN FOREST EXPERIMENT STATION. MR. WEITZMAN AND MR. HOLCOMB ARE RESEARCH FORESTERS STATIONED AT THE EXPERIMENT STATION'S RESEARCH CENTER AT ELKINS, WEST VIRGINIA.

The plots, each cut in 1949, were reexamined 5 years later to determine growth, tree quality, and reproduction. Records of costs and of returns from products sold were kept during the logging operations. The records from these demonstration plots are not intended to take the place of those that will come from the larger compartments. But since the plots were cut first, the 5-year records from them are available first; and these records show the nature of the results expected from the compartment studies.

CONDITION OF THE STAND BEFORE CUTTING

The original stand on the four plots was characteristic of much of the second-growth forests growing on the better sites in this part of the Appalachian Mountains. Fifty years ago this area was logged according to the prevailing practices of clear-cutting and high-grading. Forest fires had burned over the area repeatedly, and there was a large volume in cull trees. Trees of poor form and unmarketable species were left (fig. 1). Nevertheless, ingrowth and additional growth on the residual trees had made the stand volume large enough for another cut. An illustration of the defective condition of the original stand is provided by data from Plot A (table 1).

Table 1.—Stand condition on Plot A
before cutting

Item	Volume per acre ¹	
	Board feet	Percent
In cull trees	1,210	9
In defect	3,176	25
In sound wood	8,488	66
Total	12,874	100

¹In trees 10 inches d.b.h. and over.

EXPERIMENTAL TREATMENTS

Following is a brief description of the experimental treatments used on the demonstration plots in 1949. Similar treatments are being applied to the larger compartments. Volumes are in trees 10 inches d.b.h. and larger:

Plot A

Commercial clear-cut

All merchantable trees down to 6 inches d.b.h. removed. Cull, defective, and undesirable trees left. No cultural practices used. This is typical of liquidation cutting common in the area. Volume removed was 11,651 board feet of sawlog material per acre. Including trees below sawtimber size, this

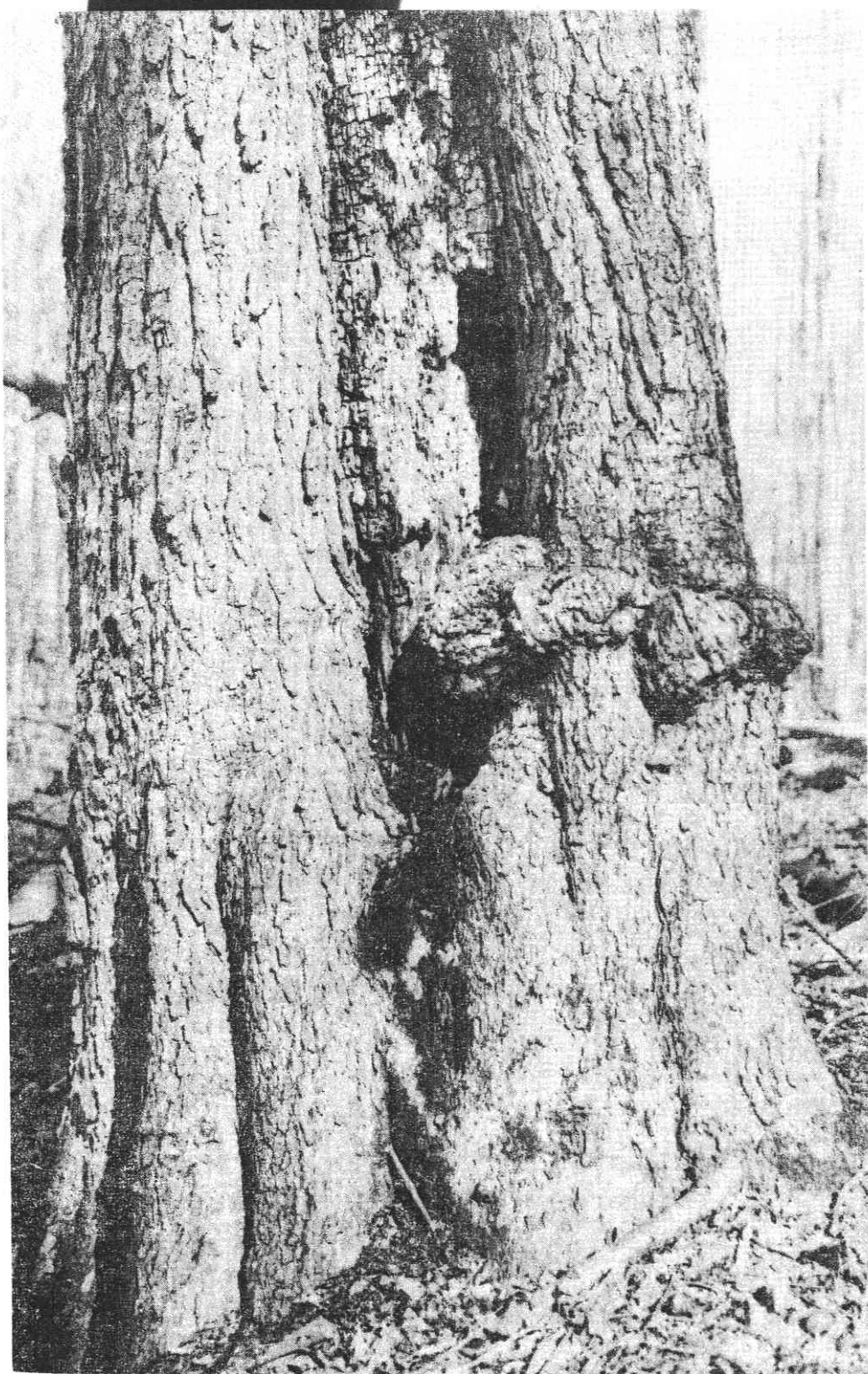


Figure 1.--An example of the large defective trees found in unmanaged stands. Trees like this make up a large portion of the volume. They are putting on no net growth, and many of them are unmerchantable.

amounted to 13,181 equivalent board feet or 89 percent of the gross volume.²

Plot B

16-inch diameter limit cut

All trees above the 16-inch d.b.h. class removed. Only cultural practice was removal of large defective trees over 16 inches d.b.h. Sawtimber volume removed was 8,778 board feet per acre. Breakage of smaller trees plus cubic-foot material in upper logs brought total cut to 9,231 equivalent board feet. Total removed was 65 percent of total volume.²

Plot C

Extensive selection cut

This was a moderate improvement or selection cut. Overmature, defective, and undesirable trees, regardless of size, were cut. Cultural measures included girdling of cull trees and after-logging care on skid roads. Skid roads laid out not to exceed 20 percent grade. Sawlog volume removed was 6,618 board feet per acre, or 6,958 board feet equivalent, including small and damaged trees. Together with cull, this amounted to 51 percent of the total volume.²

Plot D

Intensive selection cut

A light selection cut removing only the defective trees, irrespective of size. Because of the large amount of defect, the conditioning cut removed 5,819 board feet of sawlog material per acre, or 6,263 board feet equivalent, including small and damaged trees. This amounted to 48 percent of the total.² Cultural measures included girdling of cull trees, extra care in felling, lopping of tops, and after-logging care on skid roads. Skid roads laid out on gentle 10-percent grade.

Table 2 shows the volumes per acre before and after cutting in each of the 5-acre plots.

RESPONSE TO DIFFERENT TREATMENTS

The forest landowner whose unmanaged stand is ready for cutting has a number of alternatives. For example, he may improve his stand with a conditioning cut and postpone

²TOTAL GROSS VOLUME INCLUDED TREES 6 INCHES D.B.H. AND OVER.

Table 2.--Volume per acre before and after cutting in 1949

(In board feet, International $\frac{1}{4}$ -inch rule)

Plot	Original volume ¹			Residual volume ¹		
	Merchant-able	Cull	Total	Merchant-able	Cull	Total
A	11,664	1,210	12,874	13	1,210	1,223
B	12,689	364	13,051	3,909	142	4,051
C	13,882	1,294	15,176	7,264	0	7,264
D	13,390	1,221	14,611	7,571	0	7,571

¹In trees 10 inches d.b.h. and over.

the receipt of some stumpage revenue. Or he may liquidate his growing stock.

To make a wise decision he should know how his stand will respond to different intensities of management, and he should know what each alternative will cost him in terms of additional investment or postponed income. The compartment studies are designed to supply this information. Early results from the demonstration plots, though inconclusive, may give some direction to his thinking.

Regeneration After 5 Years

The owner will be interested in the amount of reproduction established after cutting under different intensities of management, the type of reproduction established, and the probable future growth.

Adequate regeneration was established under all intensities of management (table 3), though border effects obscure this conclusion on small plots. How well these seedlings will continue to grow under each treatment is necessarily a matter of conjecture, but there is enough experience in this region to raise predictions above the level of mere guessing.

In the clear-cut area the established reproduction should be able to thrive. It should overtop weeds and briars in the next few years.

The diameter-limit cutting area is characterized by scattered and fairly large openings. These openings are 87 percent stocked, with seedlings established at the rate of



Figure 2.--Where selection cuts were made, seedling reproduction in small openings shows good height and form.

Table 3.--Reproduction before cutting and 5 years after cutting¹

Plot	Before cutting (1948)		After cutting (1953)			
	Stocked	Seedlings per acre	Total area		Openings only	
			Stocked	Seedlings per acre	Stocked	Seedlings per acre
	Percent	Number	Percent	Number	Percent	Number
A	84	1,540	100	8,733	100	8,928
B	78	4,280	81	8,500	87	9,000
C	88	2,540	87	7,333	100	11,600
D	80	1,760	88	6,875	90	10,500

¹Established seedlings 1.0 foot high to 0.5 inches in d.b.h.

9,000 per acre. Reproduction established in these openings should also grow well.

The selection cuts leave smaller holes in the canopy, but reproduction becomes established in these openings. Openings on Plot C are 100 percent stocked, with seedlings at the rate of 11,600 per acre. Plot D is 90 percent stocked in the openings, with seedlings at the rate of 10,500 per acre. There is good reason to believe that much of this regeneration will maintain itself. Furthermore, under the more intensive management the cutting cycle is shortened and the stand is repeatedly opened up.

Reproduction following the selection cuts is almost entirely of seedling origin (fig. 2). Sprout growth will probably be a component of the stand (fig. 3) following the diameter-limit cut, and will undoubtedly become a part of the stand following clear-cutting (table 4). This difference may become more important as the stands develop.

Table 4.--Sprout growth on the treated plots¹

Plot	Sprout clumps per acre
	Number
A	360
B	137
C	20
D	20

¹Only 1 sprout per clump was counted.

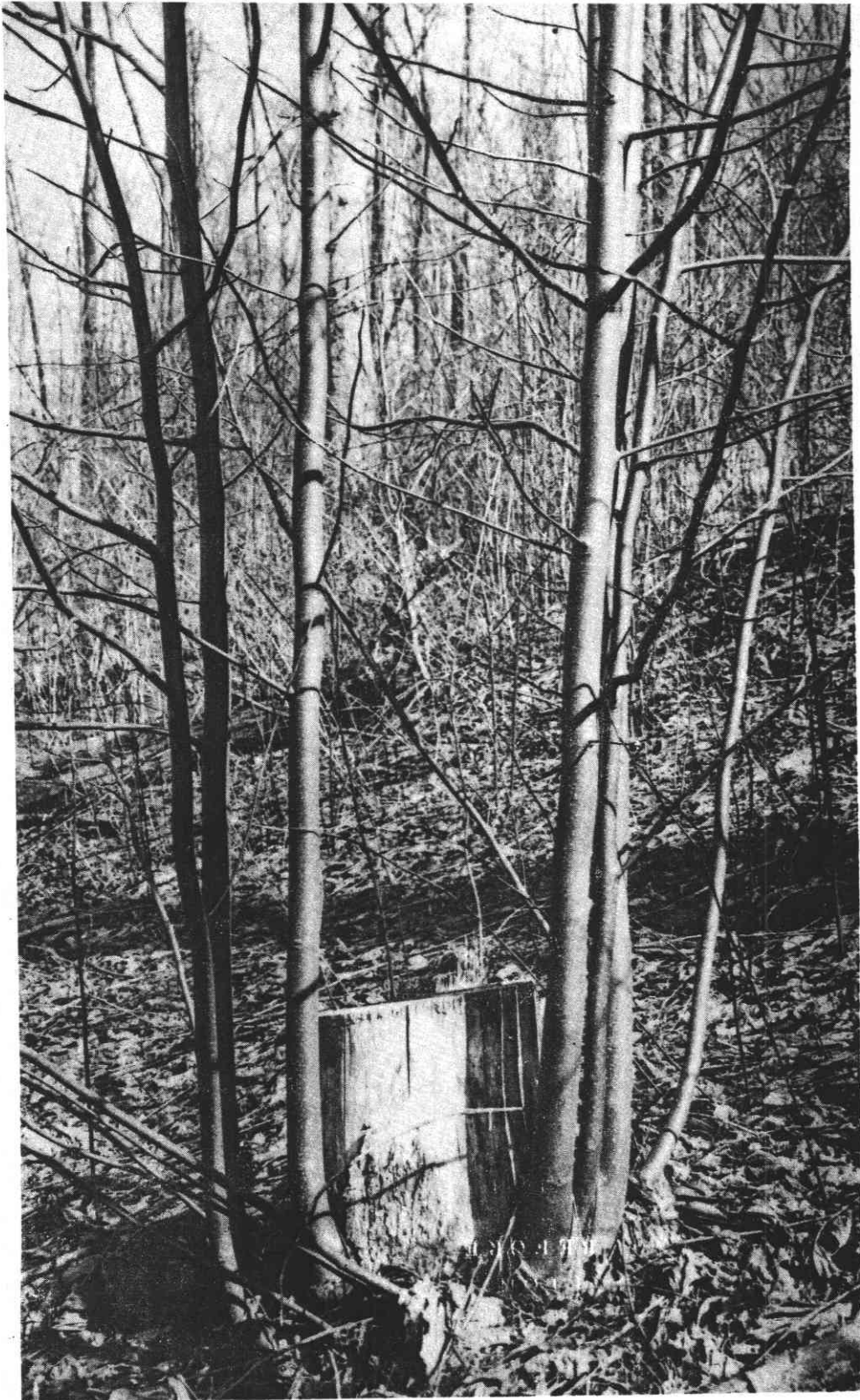


Figure 3.--Clump sprouts are characteristic of the clear-cut area. This 11-inch yellow-poplar stump put up 15 sprouts.

Although adequate quantities of reproduction were established following each treatment on this excellent site, the quality of reproduction is poorer on the plots clear-cut and cut to a 16-inch diameter. Results from the larger compartments, established on somewhat poorer sites, will show whether these relative differences in quality of reproduction will be greater on poorer sites.

Growth After 5 Years

If an area is clear-cut there obviously will be little or no growth on merchantable trees until the small stems grow into the merchantable size class (ingrowth). The other treatments will result in more growth on merchantable trees. What this growth amounted to in terms of volume during the 5 years following cutting is shown in table 5.

Table 5.--Residual volume and average annual growth per acre¹

Plot	Residual volume				Annual growth			
	Board foot		Basal area		Board foot		Basal area	
	Merchant- able	Cull	Merchant- able	Cull	Merchant- able	Cull	Merchant- able	Cull
	<u>Bd.ft.</u>	<u>Bd.ft.</u>	<u>Sq.ft.</u>	<u>Sq.ft.</u>	<u>Bd.ft.</u>	<u>Bd.ft.</u>	<u>Sq.ft.</u>	<u>Sq.ft.</u>
A	13	1,210	0.1	4.0	83	*26	0.7	0.1
B	3,909	142	27.7	1.2	360	43	2.1	.3
C	7,264	0	46.8	0	495	0	3.0	0
D	7,571	0	48.0	0	543	0	3.2	0

¹In trees 10 inches d.b.h. and over.

*The residual volume of 1,210 board feet per acre in cull trees was reduced by death and windthrow during the first 5 years. Otherwise a larger percentage of the growth would have been in unmerchantable trees.

Since the large cull trees were removed in the 16-inch diameter cut, growth on unmerchantable trees was less than 11 percent of total growth. The selection cuts removed all culls, and all growth was placed on merchantable trees. Since more growing stock was left following these cuts, annual growth of sawtimber trees was correspondingly greater.

Quality Of The Stand After Cutting

It is not sufficient to distinguish between the growth on cull and on merchantable trees. There are distinct differences in quality within the merchantable class--

differences that show up in the quality and price of the lumber that can be manufactured from different trees.

Table 6.--Butt log grades 5 years after cutting

Plot	Present volume ¹ per acre	Percentage of butt logs ² in log grade--			
		1	2	3	4
	<u>Bd.ft.</u>	<u>Per-</u> <u>cent</u>	<u>Per-</u> <u>cent</u>	<u>Per-</u> <u>cent</u>	<u>Per-</u> <u>cent</u>
A	118	0	7	45	48
B	4,824	6	13	40	41
C	8,931	19	15	33	33
D	9,505	16	16	34	34

¹In trees 12 inches d.b.h. and over.

²Based on grade of butt log, using specifications in U. S. Forest Products Laboratory hardwood log grades for standard lumber (8). Grade 4 includes sound merchantable butt logs other than standard lumber logs. Because a few larger trees were left in the extensive selection treatment (Plot C), it shows a slightly higher proportion in grade 1 logs than the intensive selection cut. The relationship will probably be reversed by the next cut.

Table 6 shows the relationship between the type of cut and the quality of the growing stock left. The percentage of grade 1 butt logs was about three times as great following the selection cuts as it was after the diameter-limit cut. This relationship exists because the selection cuts remove cull and defective trees and leave larger trees in the residual stand. Size is an important factor in grading logs; the average big log yields a higher proportion of the upper grades of standard lumber than the average small log (1, 7, 8).

Cutting Cycles

The owner who makes a conditioning cut will want to know how long he must wait before he will start receiving substantial income. In other words, he wants to know how long the conditioning process must continue, and what cutting cycle can be established for the future harvest cuts.

Cutting cycles are a basic control in management. They must be dovetailed with growing-stock levels. They affect growth, grade, reproduction, and the economics of logging. And, conversely, they are affected by each of these.

The compartment experiments under way on the Fernow Forest will in time provide more factual information to guide the owner. They will better establish relationships between growing stock and volume of growth; the effect of site quality on growth and thus on the frequency of cut; the effect of the frequency of cutting on grade and reproduction.

However, based on what we know now, a few generalizations may be made. Other things being equal, the period of waiting until another cut can be made will vary inversely with the amount of merchantable timber left in the stand. But operability is not the only consideration. If it were, a second cut could follow immediately after the conditioning cuts. Further improvement of the stand, optimum stocking, and stand structure must also be considered if good management is the objective.

The area clear-cut will not support another harvest until the reproduction established reaches merchantable size. Even on better sites this may take 50 or 60 years.

The area cut to a 16-inch diameter had almost 4,000 board feet per acre of merchantable timber left. If growth continues at the present rate another similar cut, yielding about 9,000 board feet, might be made 20 or 30 years after the first cut on better sites.

The cutting cycle on the area given an extensive selection cut may range from 10 to 20 years. At the present rate of growth the residual stand, with more than 7,000 board feet of merchantable timber and 47 square feet of basal area, will increase to more than 70 square feet of basal area in 10 years, and will support another cut. However, a longer cutting cycle may be desirable if optimum stocking has not been reached in 10 years.

On the area given the intensive selection cut, with an established road system and rapid growth on trees of relatively high quality, the cutting cycle may eventually be as low as 5 years on better sites. But during the 5 years following the first conditioning cut the stand may not reach the desired stocking and structure. It may be desirable to postpone the second cut until 10 or 15 years after the original conditioning. Leaving in the neighborhood of 65 square feet of basal area, with a cutting cycle of 15 years, has been recommended for northern hardwoods in the Lake States (4, 10).

When the biological relationship between growing stock and volume growth is firmly established, it will help

guide the owner to select a practical cutting cycle. However, his decision will also be based on the cost of logging and his objective of management. Thus, the decision will ultimately be the owner's and will be based on how he applies the available research facts to his own situation.

THE COST OF CONDITIONING CUTS

The management treatments identified with selection cuts cost more than diameter-limit cuts or liquidation cuts. It is only reasonable that they should. A conditioning cut takes all the cull trees and leaves many of the best merchantable trees for further growth. A smaller volume per acre is removed. And the cost of permanent skid roads and cultural practices, part of the more intensive management, is greater.

Table 7.--Value of products cut under different treatments

Plot	Sawlogs		Mine bars		Mine props		Total value, all products
	Total value	Value per M bd. ft.	Total value	Value per linear ft.	Total value	Value per linear ft.	
A	\$1,409.54	\$33.21	\$306.88	\$0.046	\$22.40	\$0.025	\$1,738.82
B	1,070.60	33.19	167.28	.049	39.02	.025	1,276.90
C	626.05	29.74	143.26	.044	39.76	.023	809.07
D	617.01	27.11	95.52	.040	27.70	.021	740.23

The cost of conditioning cuts includes several elements that do not enter into costs of diameter-limit and liquidation cuts. One of these elements is the higher costs per thousand board feet as smaller, poorer, and fewer trees are removed. Another is the investment in the stand represented by cultural work done as part of the conditioning cut. Another is the delay in the receipt of income because some merchantable timber is kept as growing stock and is not cut and sold.

How much these investments will pay off in increased quantity and quality of timber can better be determined after the data from the larger compartments are analyzed, and only after the effects of different treatments are better established. Data from 5 years of record indicate that



Figure 4.--The commercial clear-cut area. All salable timber has been cut. Large cull trees are left. There is not much left for future growth.

these costs have already resulted in added volume and quality of growth for the future stand.

Table 7 shows the roadside value of products cut from the different plots under the described treatments (1951 prices). The values shown are weighted averages of different rates for better and poorer species. They show that the quality of products removed decreases as the intensity of management in the conditioning cut increases. Conversely they reflect the quality of material left under the different treatments.

Table 8 shows the net cash income from each treatment (rounded to the closest quarter dollar). Net cash income is based on the sale value of logs at landing after deducting all cash costs of logging, cultural operations, skid road construction, and after-logging care. Costs include labor and machine operation at current (1951) rates, and supplies. Taxes are not included in costs.

Table 8.—Net cash income from different treatments

Plot	Net return per 1,000 board feet	Net return per acre
A	\$13.75	\$179.25
B	16.25	150.25
C	10.25	72.25
D	6.25	39.25

As would be expected, the diameter-limit and clear-cut operations brought the greatest net cash income to the owner. Under the clear-cut that liquidated the entire merchantable volume the total net cash return to the owner was the greatest. But the efficiency of this operation was not the greatest; it is expensive to remove small trees (2, 6, 9, 3, 5). The 16-inch diameter-limit cut, which left almost 4,000 board feet of timber that was merchantable but less economical to harvest, probably brings the highest immediate net cash income per thousand board feet.

The two selection cuts yielded a cash return that is sufficient to cover costs of logging, road-building, and cultural work and still give the owner a small net cash income.

The results from these experimental treatments do not mean that every forest-land owner can make a selection cut with no cash outlay; a great deal depends on what he has in the stand to start with. They do indicate, however, that the fear of a heavy cash investment to bring an unmanaged



Figure 5.--An example of the diameter-limit cut. Notice the large opening left. The remaining trees are small. Some are badly formed, since the only cultural practice was to remove large defective trees. Since only the large trees were cut, the logging costs were lower than for clear-cutting.



Figure 6.--The intensive selection cut leaves a good distribution of desirable trees. All defective trees, regardless of size, were removed. Although returns from the initial cut were small, the stand has been put in good condition for producing valuable future crops.

stand to a managed condition may be more boggy than reality. They show that, at least under the conditions studied, the owner can improve his stand and meet all cash costs. And the owner who does not do his own logging can probably attract an operator who will follow his cutting rules. On very defective stands this might not be possible. The conditioning cut would call for cutting a disproportionate amount of small and low-grade material. Such a cut might not bring the owner the immediate revenue he needs and it might not permit the operator to pay out on his logging.

ARE CONDITIONING CUTS WORTHWHILE?

The records from 5 years' experience on the demonstration plots are obviously not conclusive. The full effects of the conditioning cut will not be reflected in the residual stand for many years. Nevertheless these 5-year records are worth considering as a preview of what may result over a period of years and as an indication of the net current cost or gain to be expected from the conditioning cut.

Even if the results of many years' study on larger compartments were now available, there would be no pat answer to this question. The owner will still have to adapt the silvicultural findings from these compartments to the forest conditions in the area he is planning to cut. And each owner will select a level of management based on his financial needs and his objective of management. However, these studies do furnish a set of comparative figures on regeneration, growth, and quality following treatment. When combined with the relative costs of treatment, these preliminary data may serve as a tentative guide to an owner comparing the worth of different treatments. As more information becomes available, these guides may be modified. In the meantime, a few generalizations may be made to guide forest owners and operators in the area.

1. Growth is directly related to growing stock. The treatment that left a basal area of 48 square feet per acre gave the greatest increment. As the residual growing stock was decreased, the board-foot increment decreased. The optimum growing stock has not yet been established. Field observations and research elsewhere indicate that the residual growing-stock level can easily be increased to 65 square feet without loss in growth.

2. Log grades, and therefore the quality and value of the residual stand, are directly related to the intensity of the conditioning cut. In the more intensive selection cuts, removal of cull and defective trees in the first operation is more complete. Larger trees are left to grow. The higher the intensity of management, the greater the degree of stocking (in openings). Better grades are obtained in more fully stocked stands.

3. Reproduction was readily established under all intensities of management. Since the clear-cut area was only 5 acres in extent, it was probably seeded in from the side by light-seeded species. More control over the type of reproduction and the species composition is exercised in the more intensively managed stands.

4. Although the net cash return to the owner from the first harvest is undoubtedly greatest where the cut is heavy, there is reason to believe that heavy cutting is not the best alternative throughout a rotation, especially when figured on an annual basis. This reasoning is backed by the increased grade and growth rate in the more intensive conditioning cut, the established road system already constructed and paid for, and the shorter cutting cycle, which will permit more frequent cuts.

5. Although an owner's financial needs and product objective will determine his frequency of cut, he must be guided by the biological relationship between residual volume and growth in making his decision. With a residual growing stock of 60 square feet, a cutting cycle of 5 to 10 years appears silviculturally feasible; with 50 square feet, one of 10 to 15 years; with 40 square feet, one of 15 to 20 years; with 30 square feet, one of 20 to 30 years. On poorer sites, with lower growth rates, the cutting cycles will be longer for given growing-stock levels.

LITERATURE CITED

- (1) Bratton, Allen W.
1946. HARDWOODS--THE BIGGER, THE BETTER: HEMLOCKS--JUST GET BIGGER. Northeast. Forest Expt. Sta., Forest Econ. Note 2. 3 pp., illus.
- (2) Campbell, Robert A.
1953. LOGGING METHODS AND COSTS IN THE SOUTHERN APPALACHIANS. Southeast. Forest Expt. Sta., Sta. Paper 30. 29 pp., illus.
- (3) Cunningham, F. E., and Ferguson, R. H.
1946. COST OF PRODUCING HARDWOOD TIES IN CONNECTICUT. Jour. Forestry 44: 668-672.
- (4) Eyre, F. H., and Zillgitt, W. M.
1953. PARTIAL CUTTINGS IN NORTHERN HARDWOODS OF THE LAKE STATES. U. S. Dept. Agr. Tech. Bul. 1076. 124 pp., illus.
- (5) Ferree, Miles J.
1946. RATE OF MINE PROP PRODUCTION INCREASES WITH SIZE OF TREES. Northeast. Forest Expt. Sta., Forest Econ. Note 1. 2 pp., illus.
- (6) Jensen, Victor S., Behre, C. Edward, and Benson, A. O.
1940. COST OF PRODUCING WHITE PINE LUMBER IN NEW ENGLAND. U. S. Dept. Agr. Cir. 557. 40 pp., illus.
- (7) Stott, C. B.
1943. INCREASING PRODUCTION OF CRITICAL LUMBER GRADES BY SELECTION CUTTING. Jour. Forestry 41: 734-739.
- (8) United States Forest Products Laboratory.
1949. HARDWOOD LOG GRADES FOR STANDARD LUMBER. PROPOSALS AND RESULTS. Forest. Prod. Lab. Rpt. D1737. 15 pp., illus. Madison, Wis.
- (9) Worthington, Robert E.
1939. COST OF TRACTOR LOGGING IN SOUTHERN PINE. U. S. Dept. Agr. Tech. Bul. 700. 64 pp., illus.
- (10) Zillgitt, W. M.
1948. OPTIMUM ECONOMIC STOCKING FOR NORTHERN HARDWOODS. Lake States Forest Expt. Sta., Sta. Paper 10. 13 pp.