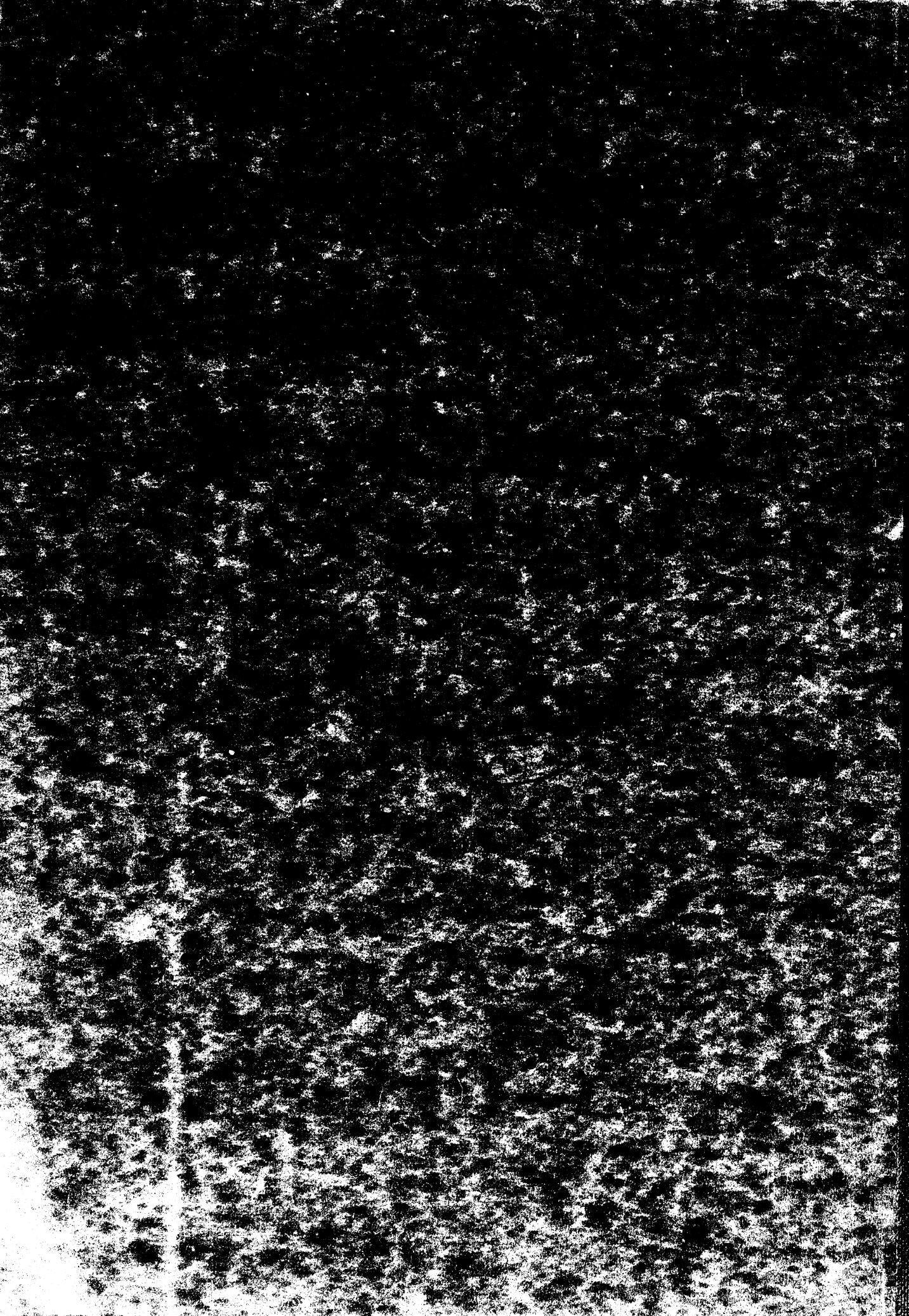
Zillgitt, Walter M
Northern Hardwood Cutting Methods. 1947.



NORTHERN HARDWOOD CUTTING METHODS

An Appraisal of the Financial Returns from a Northern Hardwood Forest Following Several Different Methods of Cutting

by

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A thesis submitted to the Faculty of the School of Forestry and Conservation of the University of Michigan in partial fulfillment of the requirements for the degree of Master of Forestry.

Ann Arbor, Michigan
May, 1947

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INTRODUCTION AND ACKNOWLEDGMENTS

Although old-growth northern hardwood forests are being depleted rapidly in the Lake States, there are still some over 2 1/2 million acres of saw timber remaining in the type.[1/] About one million acres of these merchantable stands are in the Upper Peninsula of Michigan, the locale of this study. Commercial forest land of all size classes in the northern hardwood type comprises almost 9 1/2 million acres in the region.[1/]

The northern hardwood forest is thus seen to be important to the Lake States region and to the Nation both in quantity of old-growth saw timber remaining and in potentialities for the future, as represented by the young stands.

Management research work to date in this important type has been largely silvicultural. Furthermore, recommendations have usually been expressed in terms of percentage or fraction of volume to be removed, applicable only to fully stocked stands, rather than defining the volume or basal area needed as growing stock to provide good growth and satisfactory return on the investment. There is no intention here to belittle silvicultural research; it is vital to improved forest practice and should be strengthened and extended. However, it is time for a business-like appraisal of the financial aspects of selection cutting in northern hardwoods. Private timberland owners, who control by far the greater portion of the merchantable hardwood volume, will, in the final analysis, stay in the timber growing business or liquidate solely on the basis of the soundness or unsoundness of the venture.

This paper is an attempt to evaluate the results of cutting experiments in the northern hardwood type at Dukes, Michigan from this point of view.

1/ Revised Forest Statistics for the Lake States, 1945. Lake States Forest Experiment Station Paper No. 1. September, 1946, Page 6.

The writer wishes to acknowledge the extensive field help given him in this study by W. A. Salminen, Timber Management Assistant at the Lake States Forest Experiment Station, Dukes, Michigan. Thanks also go to E. L. Demmon, Director of the Lake States Forest Experiment Station, for permission to incorporate Station file data in the paper, to L. G. Engle, Forester at the Lake States Forest Experiment Station, Dukes, Michigan, for supplying supplemental information needed in preparing the report, to S. R. Gevorkiantz, Silviculturist at the Lake States Forest Experiment Station, St. Paul, Minnesota, for helpful suggestions in field procedure and to F. H. Eyre, Silviculturist at the Lake States Forest Experiment Station, St. Paul, Minnesota, under whose direction the field work was carried out. The writer is especially grateful for the suggestions and constructive criticism of D. M. Matthews, Professor of Forest Management at the University of Michigan, under whose guidance the paper was prepared.

A BRIEF HISTORY OF THE CUTTINGS AT DUKES, MICHIGAN

Description of Experimental Area

The Upper Peninsula Experimental Forest is located at Dukes, Michigan, about 20 miles southeast of the City of Marquette. It was established in 1926 with the donation by the Cleveland-Cliffs Iron Company of 640 acres of land, half of which was in young second growth, the other half supporting old-growth saw timber. Although the area was enlarged to 11,200 acres[1/] and given National Forest status in 1935, the experimental cuttings described in this report are all located in the original half-section of old-growth timber.

The Experimental Forest is maintained by federal appropriations to the Forest Service, U. S. Department of Agriculture, and is administrated by the Lake States Forest Experiment Station in cooperation with the Upper Michigan National Forest.

The northern hardwood type predominates on the experimental area under discussion. In it sugar maple is most common, comprising 81 percent of the number of trees 5 inches d.b.h. and over and 87 percent of the merchantable volume. Yellow birch, red maple, American elm, basswood, beech, black ash, balsam fir and white spruce are also present in smaller numbers. Trees of all sizes are found in the forest, ranging from small seedlings to old veterans 100 feet high, 40 inches in diameter and 300 years old. The area was culled lightly for elm and basswood during the period 1906 to 1910.

Precipitation averages about 34 inches per year, one third falling as snow. The highest temperature recorded on the Forest to date is 102 ° F.; the lowest - 42 ° F. The mean temperature for the growing season, June 1 to September 30, is 60 ° F.

The tract is level and fairly well drained. The soil is a sandy

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1/ Some over 5,000 acres in government ownership.

loam, somewhat gravelly and stony.

The site can be considered medium to good for the northern hardwood type in the Lake States. The merchantable trees average between 2 1/2 and 3 16-foot logs, longer than is the case farther north and west in the Upper Peninsula, but shorter than in the vicinity of Goodman, Wisconsin and on the Menominee Indian Reservation.

The better grades of hardwood logs find ready sale in Marquette, Munising, Gladstone and Escanaba, Michigan. Small, low-grade logs are purchased for mine timbers by the iron mines in the Negaunee-Ishpeming area. Cull hardwood logs and limb wood down to 4 inches can be marketed at the chemical plant in Marquette, making close utilization practicable. Small, local portable sawmills are also in the market for tie cuts and saw logs. Veneer buyers from Wisconsin plants visit the area regularly. Obviously, the Experimental Forest is well favored in the matter of markets.

Review of Cuttings

Cutting was begun in 1926 on the experimental area, under cooperative agreement with the Cleveland-Cliffs Iron Company, and has continued intermittently until the present time. Marking of trees to be cut, supervision of the logging operation and establishment and maintenance of growth plots have been in each instance the responsibility of the Experiment Station. The Company has made the logging contract with the jobber, has marketed the timber products and has furnished the Station with complete records of the transaction.

A series of ten cuttings, all established by 1932, will be discussed briefly in the paragraphs which follow. Table 1 gives pertinent information as to number of trees per acre, basal area and volume (original, left and cut) for each unit. In Table 2 the average annual growth for 5, 10 and 15-year periods following cutting is presented.

All board-foot volumes in this and subsequent sections of the report

TABLE 1

Stand and Stock Table for One Acre
Sample Plots, Dukes, Michigan

Stand	Number of trees				Basal area - trees 10"d.b.h. and up	Gross volume
	10-15" d.b.h.	16-20" d.b.h.	21"-up d.b.h.	Total	Sq. ft.	Bd. ft.
22 Inch Diameter Limit Cutting						
Original	34.0	21.0	16.0	71.0	115.804	15,672
Left	33.0	19.0	8.0	60.0	83.944	11,074
Cut	1.0	2.0	8.0	11.0	31.860	4,598
Percent cut	3	10	50	15	28	29
Overmature and Defective Cutting No. 1						
Original	37.5	17.0	13.0	67.5	103.514	13,578
Left	27.0	10.0	1.0	38.0	42.945	5,208
Cut	10.5	7.0	12.0	29.5	60.569	8,370
Percent cut	28	41	92	44	58	62
12 Inch Diameter Limit Cutting						
Original	38.0	16.5	16.5	71.0	117.966	15,676
Left	20.0	0.0	0.0	20.0	15.558	1,573
Cut	18.0	16.5	16.5	51.0	102.408	14,103
Percent cut	47	100	100	72	87	90
Clear Cutting						
Original	36.5	19.0	20.5	76.0	123.313	17,513
Left	0.0	0.0	0.0	0.0	0.000	0
Cut	36.5	19.0	20.5	76.0	123.313	17,513
Percent cut	100	100	100	100	100	100
Heavy Improvement Cutting						
Original	33.0	23.5	12.5	69.0	105.357	13,985
Left	23.5	16.5	3.0	43.0	58.379	7,550
Cut	9.5	7.0	9.5	26.0	46.978	6,435
Percent cut	29	30	76	38	45	46

TABLE 1 (Cont.)

Stand and Stock Table for One Acre
Sample Plots, Dukes, Michigan

Stand	Number of trees 10-15" d.b.h.	Number of trees 16-20" d.b.h.	Number of trees 21"-up d.b.h.	Number of trees Total	Basal area - trees 10"d.b.h. and up Sq. ft.	Gross volume Bd. ft.
Light Improvement Cutting						
Original	30.0	25.0	13.0	68.0	106.554	14,343
Left	20.0	21.0	9.0	50.0	80.675	10,893
Cut	10.0	4.0	4.0	18.0	25.879	3,450
Percent cut	33	16	31	26	24	24
Group Selection Cutting						
Original	39.0	26.5	20.5	86.0	142.142	19,736
Left	31.0	17.0	9.0	57.0	79.224	10,815
Cut	8.0	9.5	11.5	29.0	62.918	8,921
Percent cut	20	36	56	34	44	45
70 Percent Selection Cutting						
Original	39.0	22.0	16.0	77.0	126.547	16,047
Left	29.0	9.5	1.0	39.5	42.914	5,170
Cut	10.0	12.5	15.0	37.5	83.633	10,877
Percent cut	26	57	94	49	66	68
Overmature and Defective Cutting No. 2						
Original	41.0	22.0	17.0	80.0	135.595	16,793
Left	29.0	13.0	4.0	46.0	61.440	6,887
Cut	12.0	9.0	13.0	34.0	74.155	9,906
Percent cut	29	41	77	42	55	59
Virgin Forest Reserve Area						
Original	33.0	26.5	14.0	73.5	118.303	15,910
Left	33.0	26.5	14.0	73.5	118.303	15,910
Cut	0.0	0.0	0.0	0.0	0.000	0
Percent cut	0	0	0	0	0	0

TABLE 2

Average Annual Growth Per Acre
Sample Plots, Dukes, Michigan

Cutting unit	Gross annual growth[1] Bd. ft.		
	5-year average	10-year average	15-year average
22 Inch Diameter Limit	245	228	236
Overmature and Defective No. 1	165	188	236
12 Inch Diameter Limit	98	98	161
Clear Cutting	0	0	7
Heavy Improvement	163	171	218
Light Improvement	235	256	255
Group Selection	58	118	151
70 Percent Selection	112	183	222
Overmature and Defective No. 2	255	296	296[2]
Virgin Forest Reserve Area	191	79	89

1/ Mortality deducted. No deduction made for defect.

2/ 10-year average repeated. 15-year average not yet available.

are either by the Scribner or Scribner Decimal C log rules.

22 Inch Diameter Limit Cutting

This tract of 19.25 acres was logged during October, 1926. All trees over 22 inches d.b.h. were cut, together with a few of the more defective smaller trees. The volume removed totalled 2,350 bd. ft. per acre net, leaving a residual stand of 7,360 bd. ft. net per acre.

Two disadvantages of cutting to this rather rigid diameter limit were apparent at once: many of the trees cut were sound, vigorous and making good growth; some of the trees left were defective and unhealthy. However, gross annual growth has been satisfactory. (See Table 2)

Following cutting, 4 acres of permanent sample plots were established on the unit. Each tree 2 inches d.b.h. and larger was given a permanent number, and its total height, merchantable length (in the case of the larger trees) and diameter breast high were measured and recorded. Repeat measurements on the plots at 5-year intervals form the basis of the growth data presented in this paper.

In the summer of 1943 a second cut was made, eliminating most of the small defective trees left at the time of the first cutting. 11,600 bd. ft. of saw logs, 18,890 bd. ft. of mine timbers and 101 cords of chemical wood were removed in this operation.[1/]

Overmature and Defective Cutting No. 1

In the winter of 1927-28 another unit of 10 acres was logged. All overmature and defective trees were marked, regardless of size or position in the stand. The cut per acre was 4,900 bd. ft. net, with a residual volume of 3,540 bd. ft. net.

After cutting, 2 acres of permanent sample plots were laid out on the unit.

Growth has been good, especially when it is considered that it has

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1/ 1,580 bd. ft. net per acre.

accrued on sound, thrifty trees. Mortality has been negligible.

12 Inch Diameter Limit Cutting

A second unit of 5 acres was cut during the winter of 1927-28. All trees in the 12 inch d.b.h. class and larger were marked, together with some smaller trees injured in logging or especially defective. 7,300 bd. ft. net were removed per acre, leaving a residual stand of 410 bd. ft. net.

Two acres of sample plots were established following cutting.

Except for the close utilization practiced, this operation was very similar to commercial clear cutting. It was too drastic to be considered a selection cutting. Growth has been rapid, but means little for the present, since there is insufficient volume on the unit to justify a logging operation.

Clear Cutting

Still a third unit of 5 acres was logged in the winter of 1927-28. Everything merchantable, even for chemical wood down to 5 inches d.b.h., was cut under this plan. 10,740 bd. ft. net was the volume removed per acre, with no residual volume.

Again 2 acres of permanent sample plots were established after logging was over.

A fine stand of second-growth northern hardwoods is now growing on the area, but it will be 120 years or more before anything approaching a mature stand will be in evidence.

Heavy Improvement Cutting

During November and December, 1928, another unit of 7.77 acres was logged over in the same general area. All overmature and defective trees regardless of size were selected for cutting. The stand was less decadent than in the case of the overmature and defective cutting described previously, and so a lighter cut resulted. A volume of 3,470 bd. ft. net per acre was removed, leaving a residual volume of 5,490 bd. ft. net.

A 2-acre permanent sample plot was established following cutting.

Growth has been fairly good and mortality not too severe. As on all units opened up to any great extent, reproduction is developing rapidly.

Light Improvement Cutting

Another unit of 7.53 acres was cut in December, 1928, with 3.2 acres in the northern hardwood type and 4.33 acres in mixed hardwoods and conifers. A very light selection in the hardwood type removed only the most decadent trees, irrespective of size. The volume removed was 1,570 bd. ft. net per acre; the volume left was 7,890 bd. ft. net.

A sample plot of 1 acre was laid out in the hardwood type.

Growth per acre has been impressive on this unit because of the large growing stock base left. The effect of this heavy residual investment upon interest earned will be apparent later in the discussion.

Group Selection Cutting

During the late fall and early winter of 1929 a special experimental cutting of 32.15 acres was established. All merchantable trees in small groups up to one-third of an acre or so in size were cut. Areas between the clear cuttings were culled very lightly for the most defective trees. The purpose of such a selection was to facilitate the reproduction of yellow birch and other species, American elm and basswood in particular, which were not faring too well in the light selection cuts tried previously. 3,190 bd. ft. net were removed per acre, leaving a residual stand of 8,400 bd. ft. net.

Four acres of sample plots were established in the hardwood type on this unit.

Very good results in perpetuating yellow birch were obtained under the group selection method.[1/] However, growth has not been outstanding

1/ Perpetuation of yellow Birch in Lake States Forests. W. M. Zillgitt and F. H. Eyre. Journal of Forestry, Vol. 43, No. 9, September, 1945.

because the stimulation was restricted to trees along the edges of the openings. Furthermore, mortality has been severe among the defective trees left between the openings. Because of the special nature of this cutting, data from it are not combined with those from other cuttings in the valuation studies to be described later in this report.

In the fall of 1944 a second cut was made in this unit, removing the more defective trees from between the openings and enlarging some of the latter. In this operation 47,560 bd. ft. of saw logs, 15,970 bd. ft. of mine timbers and 207 cords of chemical wood were cut.[1/]

70 Percent Selection Cutting

Cutting was resumed in the fall of 1930, a unit of 29.79 acres being logged. All overmature and defective trees were marked together with any trees over 17 inches d.b.h., unless their removal would leave too large an opening in the stand. The emphasis was placed on spacing rather than on leaving good trees. The cut amounted to 3,500 bd. ft. net per acre - the residual volume 3,200 bd. ft. net.

A permanent sample plot of 4 acres was established on the unit following cutting.

During the first few years after logging some of the defective trees spared in marking blew down, broke off or died standing, destroying the fine spacing sought after in the original selection and reverting the unit to a virtual overmature and defective cutting. After the heavy mortality of the first few years, growth has been good on this area.

Overmature and Defective Cutting No. 2

In the fall and early winter of 1932-33 a second overmature and defective cutting of 12.6 acres was established. All overmature and defective trees regardless of size or spacing were marked for cutting. 4,200 bd. ft. net were cut per acre; a residual stand of 5,500 bd. ft.

1/ 1,980 bd. ft. net per acre.

net remained.

Following cutting, the customary sample plot was established, in this case 1 acre.

Growth from the first has been more rapid on this unit than on any other in the experimental area. There has been no mortality to date.

Virgin Forest Reserve Area

While not a cutting in the strict sense, this reserve area of 9 acres is included in the present series to serve as a control. It has been left in an undisturbed condition and is typical of the 9 units just described before cutting commenced. Its volume after 15 years was 10,130 bd. ft. net.

A 2-acre permanent sample plot was established on the area in 1927 and growth records have been kept thereafter in the same manner as on the cutting units.

The reserve area has made some growth during the 15 years of observation, but it has been spotty and sporadic. The writer feels that over a longer period of time mortality would largely offset growth.

A VALUATION STUDY OF DUKES CUTTINGS UNDER A TWO-CUT LIQUIDATION PLAN

Procedure

Before any attempt could be made to place a value upon the stands on the cutting units just described or to evaluate average annual growth, it was first necessary to determine the amount of defect present in each instance. This appraisal had to be made on standing trees, a highly complex undertaking. In the absence of any tried and true method, a special local study was carried out and a reasonably accurate procedure developed for estimating cull in northern hardwood stands.[1/] Using this method, a very careful cull analysis was made of each tree 10 inches d.b.h. and larger on each sample plot on each cutting unit.[2/] On the basis of this cruise, gross volume per acre, cull volume per acre, net volume per acre and the cull percent were determined for each unit as of 15 years following cutting. In calculating net volume per acre, the products removed in second cuttings in two instances were taken into account.

The cull percents derived above were applied to 15-year gross annual growth averages in order to reduce them to net merchantable volume. Table 3 gives for each cutting the resulting net average annual growth.

Net volume per acre 15 years after cutting for each unit was next reduced by 15 years' net growth to provide a fair estimate of residual net volume. (See Table 4)

The net average annual growth volumes from Table 3 were then plotted

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1/ Estimating Cull in Northern Hardwoods. W. M. Zillgitt and S. R. Gevorkiantz. Lake States Forest Experiment Station Paper No. 3. November, 1946.

2/ The Scribner board-foot volume table contained in Technical Note No. 203, Lake States Forest Experiment Station, August, 1943 - enlarged to give volumes by tenth-inch diameter classes - was used in this work.

TABLE 3

Reduction of Gross Average Annual Growth Per Acre for 15 Years to Net Volume Sample Plots, Dukes, Michigan

Cutting unit	Gross average annual growth: 15 years Bd. ft.	Cull percent	Net average annual growth: 15 years Bd. ft.
22 Inch Diameter Limit	236	19.8	189
Overmature and Defective No. 1	236	22.1	184
12 Inch Diameter Limit	161	21.2	127
Clear Cutting	7	17.6	6
Heavy Improvement	218	24.4	165
Light Improvement	255	24.0	194
Group Selection	151	23.3	116
70 Percent Selection	222	20.7	176
Overmature and Defective No. 2	296 1/	14.6	252 1/
Virgin Forest Reserve Area	89	36.7	56

1/ 10-year average. 15-year average not yet available.

TABLE 4

Residual Volume Per Acre After Cutting

Cutting unit	Net volume per acre after 15 years	15-year net growth per acre	Residual net volume per acre after cutting
	Bd. ft.		
22 Inch Diameter Limit	10,200	2,840	7,360
Overmature and Defective No. 1	6,300	2,760	3,540
12 Inch Diameter Limit	2,310	1,900	410
Clear Cutting	90	90	0
Heavy Improvement	7,970	2,480	5,490
Light Improvement	10,800	2,910	7,890
Group Selection	10,140	1,740	8,400
70 Percent Selection	5,840	2,640	3,200
Overmature and Defective No. 2	9,280 1/	3,780	5,500
Virgin Forest Reserve Area	10,130	840	9,290

1/ Extended 5 years.

over net residual volumes from Table 4 and a curve fitted. (Figure 1) From this curve, net average annual growth volumes for a series of residual volumes ranging from 0 to 9.5 M ft. b. m. were read and inserted in Table 5. As stated earlier, volumes from the Group Selection Cutting were not included in this and succeeding steps of the analysis. All volumes referred to from this point on in the study will be net, unless specifically stated otherwise.

The second phase of the valuation study consisted of grading each log in each tree 10 inches d.b.h. and over on each sample plot on each cutting unit. The O.P.A. log grading specifications contained in MPR 348, Amendment No. 8, were adhered to strictly in this operation. When field work had been completed, the gross volume in each grade and the percentage of gross volume in each grade were computed for each unit.[1/] The log grade and other product proportions resulting from this procedure are presented in Table 6.

After the lengthy and rather tedious routine just described, the matter of values could finally be considered. The O.P.A. log ceiling prices contained in MPR 533-2, Amendment No. 4, effective November 29, 1945, form the basis for all value comparisons in this paper. An allowance of $5.00 per M ft. b. m. for hauling was added to the O.P.A. log ceilings to establish F.O.B. Mill prices. Other products were priced at the current rate, F.O.B. Mine or Plant. By deducting direct logging costs - costs built up for the Dukes area by time studies over a period of years and adjusted to currect economic conditions - a surplus value was derived for each product. These surplus values are shown in Table 7.

It was necessary to use different direct logging costs for the

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1/ In distributing the board-foot volume among logs in trees of different sizes, Technical Note No. 198 D, Taper Table IV - Sugar Maple, Lake States Forest Experiment Station, February, 1943 and Table 46, Scribner Scale of 16-Foot Logs, on page 155 of Timber Cruising by James W. Girard and Suren R. Gevorkiantz, Forest Service, U. S. Department of Agriculture, October, 1939, were employed to advantage.

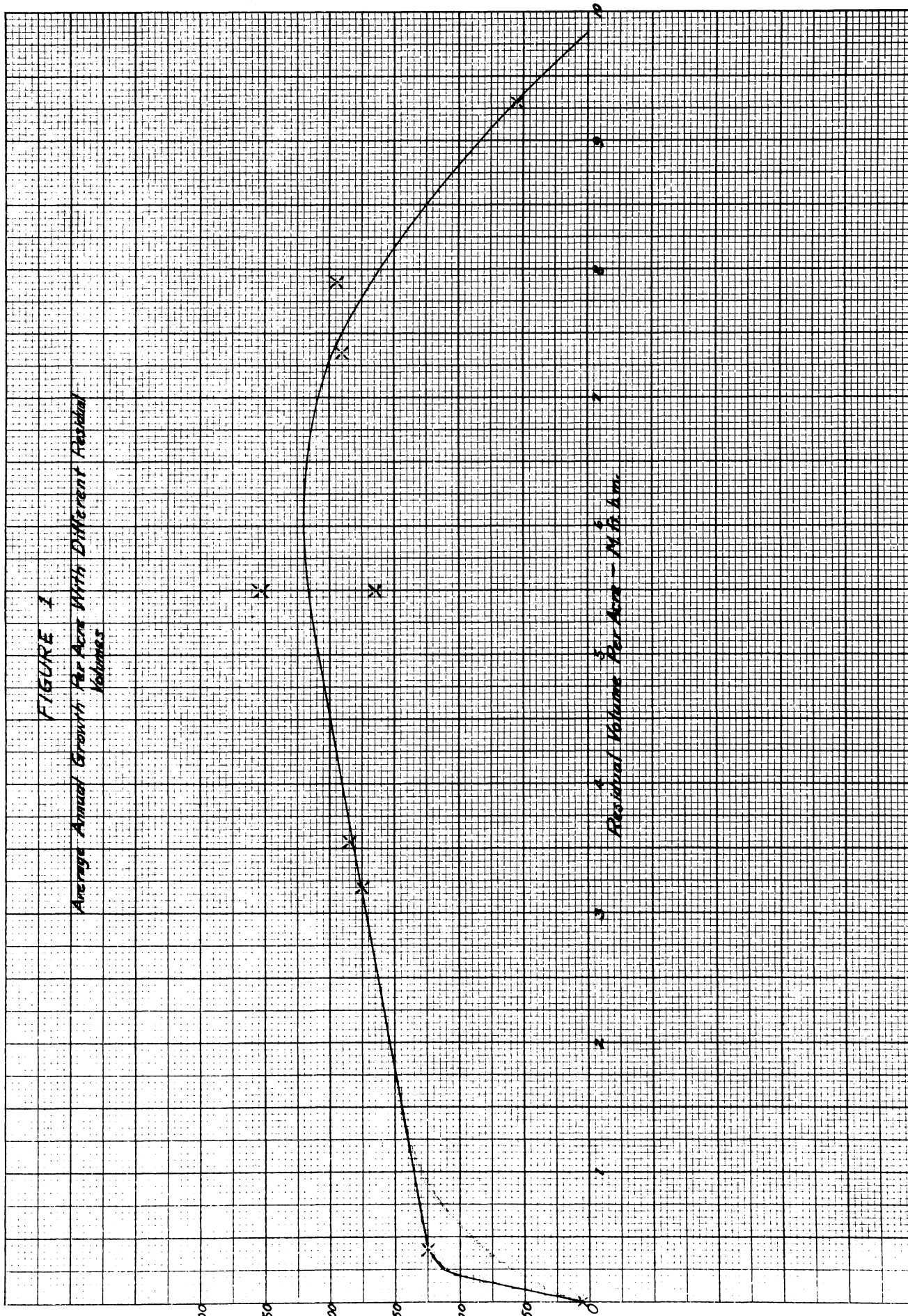

FIGURE 1

Average Annual Growth Per Acre With Different Residual Volumes

TABLE 5

Average Annual Growth Per Acre
With Different Residual Volumes

Residual volume per acre M ft.b.m.	Average annual growth per acre Bd. ft.
0.0	6
0.5	129
1.0	137
1.5	146
2.0	155
2.5	164
3.0	173
3.5	182
4.0	192
4.5	200
5.0	209
5.5	217
6.0	221
6.5	218
7.0	208
7.5	192
8.0	163
8.5	126
9.0	84
9.5	35

TABLE 6

Log Grade Proportions on Each Unit After 15 Years

Cutting unit	Log grade proportion after 15 years Percent					
	No. 1	No. 2	No. 3	Mine timber	Chemical wood	Total
22 Inch Diameter Limit	24	52	18	3	3	100
Overmature and Defective No. 1	20	39	32	5	4	100
12 Inch Diameter Limit	4	39	32	17	8	100
Clear Cutting	0	15	0	85	0	100
Heavy Improvement	27	38	20	6	9	100
Light Improvement	19	55	19	1	6	100
Group Selection	23	52	16	6	3	100
70 Percent Selection	17	48	22	7	6	100
Overmature and Defective No. 2 1/	23	53	18	2	4	100
Virgin Forest Reserve Area	20	40	27	2	11	100

1/ 10 years in this case.

TABLE 7

Surplus Value of Forest Products
Dukes, Michigan

Value class	Value of product - dollars					
	No. 1 logs	No. 2 logs	No. 3 logs 1/	Mine timbers	Chemical bolts	Chemical wood
	Per M ft.b.m.			Per lin.ft.	Per M ft.b.m.	Per cord
F. O. B. Mill	89.00	38.00	31.00	.0855	25.34	10.00
Direct logging cost	24.45	24.45	24.45	.0855	21.94	9.14
Surplus	64.55	13.55	6.55	.0000	3.40	0.86

1/ Special surplus values used for 12 Inch Diameter Limit and Clear Cuttings.

12 Inch Diameter Limit and Clear Cutting Units because of the small size logs involved. On the 12 Inch Diameter Limit cutting merchantable trees averaged less than 13 inches d.b.h. after 15 years, so a direct logging cost of $38.00 was employed. On the Clear Cutting the few logs present were of small mine timber size (2 bd. ft. per lin. ft.), so a direct logging cost of $42.75 was used. The surplus values of log grades shown in Table 7 were reduced accordingly for these units.

The gross volume of each cutting unit after 15 years was next distributed among the several forest products by applying the grade proportions from Table 6. Then, each gross volume by grade was reduced by the appropriate cull percent from Table 3. In the case of mine timbers and chemical wood, no reduction was necessary, since, if accepted at all, little or no deduction would be made for defect in these products. The merchantable volume of each product was next multiplied by its surplus value and the resulting sums totalled. To these figures were added the value of chemical wood in tops[1/] and trees under 10 inches d.b.h.[2/] to give a surplus value per acre for the stand on each unit 15 years after cutting. Finally, fixed per acre costs of $7.50 were deducted from each surplus value in order to convert to recovery value. Recovery value rather than stumpage value was employed in this report to avoid the necessity of assigning an arbitrary percentage of margin. Since recovery value was used consistently in growth and residual stand valuations alike, this disregard of margin should not influence earned interest rates significantly.

The same process outlined in the preceding paragraph was employed to derive a recovery value per acre for the original gross volume on each unit. Since knowledge of the original grades was lacking, the proportions shown in Table 6 for the Virgin Forest Reserve Area were

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1/ Computed from the table given in Technical Note No. 184, Volume of Fuel Wood in Tree Tops. Lake States Forest Experiment Station. March, 1942.

2/ Computed from permanent sample plot records for the units in question.

applied to original gross volumes for all units.

The grade proportions from Table 6 were next applied to the 15-year gross average annual growth volumes from Table 3. Reduced by the appropriate cull percent from Table 3, the resulting net volumes by grades for each unit were multiplied first by 15 years and then by the surplus value for each product from Table 7. These surplus values were then totalled. The writer considers this a conservative approach. Growth accrued on the perimeter of the trees where the lumber grade is highest, yet the grade proportion for growth was calculated on the basis of the proportion of grades in the total stands. Considerable thought and effort was devoted to devising a more satisfactory method of evaluating growth for this study, but without success.

The recovery value per acre of the residual stand on each unit following cutting was computed in this manner: The surplus value of 15 years' growth was subtracted from the surplus value of the stand after 15 years. From the resulting residual surplus value, $7.50 fixed per acre cost was deducted, leaving the residual recovery value per acre desired. The residual recovery value was subtracted from the recovery value after 15 years, the difference being divided by 15 years to provide the recovery value of the average annual growth under this plan.

Finally, the recovery value per acre of the volume removed in the first cutting on each unit was calculated by subtracting the recovery value of the residual stand from the recovery value of the original stand.

The recovery value per acre of the original stand, of the volume removed in the first cutting, of the residual stand, of average annual growth for 15 years and of the stand after 15 years are presented for each unit in Table 8.

TABLE 8

Recovery Values
Cutting Units, Dukes, Michigan

Cutting unit	Recovery value per acre - dollars				
	First cutting			Average annual growth - for 15-year period	Stand-after 15 years
	Total	Removed	Residual		
22 Inch Diameter Limit	212.32	39.19	173.13	4.88	246.39
Overmature and Defective No. 1	178.42	107.73	70.69	4.37	136.18
12 Inch Diameter Limit	168.72	168.72	0.00	0.00	0.07
Clear Cutting	234.59	234.59	0.00	0.00	0.00
Heavy Improvement	193.98	60.99	132.99	4.41	199.07
Light Improvement	204.21	30.30	173.91	4.62	243.24
Group Selection	254.62	65.03	189.59	2.92	233.44
70 Percent Selection	159.78	98.03	61.75	3.82	119.07
Overmature and Defective No. 2	212.69	84.94	127.75	6.49	225.08
Virgin Forest Reserve Area	204.70	0.00	204.70	1.33	224.58

Comparison of Return from Each Cutting After 15 Years

It seems proper at this time to indicate the possible returns from the units under discussion if a program of clear cutting followed by immediate land sale had been adopted in each instance. Cut-over hardwood land in the vicinity of Dukes, Michigan will bring, on the average, about $2.50 per acre. The maximum return per acre that could have been realized under clear cutting, then, is for each unit the total recovery value at the time of the first cutting from Table 8 plus $2.50. It is unlikely that the money recovered from clear cutting could have been invested safely for a long period at more than 3 per-cent, compound interest.

For purposes of comparison, this report will now show the interest earned under the methods of cutting actually adopted, assuming liquid-ation of the stands after 15 years of growth and immediate sale of the land at $2.50 per acre.

Annual tax payments used in this comparison are listed in Table 11. They are realistic for forest properties of this type and condition in Marquette and Alger Counties, Michigan. The future value of the terminable series of annual tax payments for each cutting unit was cal-culated by the use of the formula:[1/]

$$Cn = \frac{a\,(1.0p^{n}-1)}{0.0p}$$

Where, Cn = Future value

a = Appropriate annual tax payment per acre (Table 11)

n = 15 years

p = 3 percent

The compound interest earned for the period of 15 years by each unit was computed by the formula listed below:[2/]

$$1.0p^{n} = \frac{Cn}{Co}$$

1/ Management of American Forests. Donald Maxwell Matthews. Formula No. 5, page 222.

2/ Ibid. Formula No. 3, page 222.

Where, Cn = Recovery value of stand per acre after 15 years (Table 8) plus cut-over land value ($2.50) less annual taxes paid per acre for 15 years with interest calculated at 3 percent (First formula above)

Co = Residual recovery value of stand per acre at time of first cutting (Table 8) plus cut-over land value ($2.50)

n = 15 years

p = Interest rate

Simple interest earned during the 15-year period was determined by using the following formula:[1/]

$$1 + (n \times .0p) = \frac{Cn}{Co}$$

Where, $\frac{Cn}{Co}$ = Same values used in compound interest formula above

n = 15 years

p = Interest rate

The compound and simple interest rates earned by each cutting unit in 15 years under the two-cut liquidation plan as calculated by the above formulas are presented in Table 9.

The compound interest rates earned (from Table 9) were plotted over net residual volumes (also shown in Table 9) and a curve fitted. (Figure 2) A similar curve (Figure 3) was prepared for the simple interest rates in Table 9. Compound and simple interest rates earned on a series of residual volumes ranging from 0 to 9.5 M ft. b. m. were read from these curves and inserted in Table 10.

Summary

Examination of Table 9 discloses that under this two-cut liquidation plan, the Overmature and Defective Cutting No. 1 was most successful from the point of view of compound interest earned, with a rate of 4.1 percent. The 70 percent Selection and Overmature and Defective No. 2

1/ Presented to class in Forest Valuation at the University of Michigan by Prof. D. M. Matthews.

TABLE 9

Interest Earned by Each
Cutting in Fifteen-Year Period

Cutting unit	First cutting		Interest earned	
	Value removed per acre Dollars	Residual volume per acre M ft.b.m.	Percent Compound	Simple
22 Inch Diameter Limit	39.19	7.36	2.1	2.5
Overmature and Defective No. 1	107.73	3.54	4.1	5.5
12 Inch Diameter Limit	168.72	0.41	0.0	0.0
Clear Cutting	234.59	0.00	0.0	0.0
Heavy Improvement	60.99	5.49	2.4	2.9
Light Improvement	30.30	7.89	2.0	2.3
Group Selection	65.03	8.40	1.2	1.3
70 Percent Selection	98.03	3.20	4.0	5.4
Overmature and Defective No. 2	84.94	5.50	3.6	4.6
Virgin Forest Reserve Area	0.00	9.29	0.3	0.3

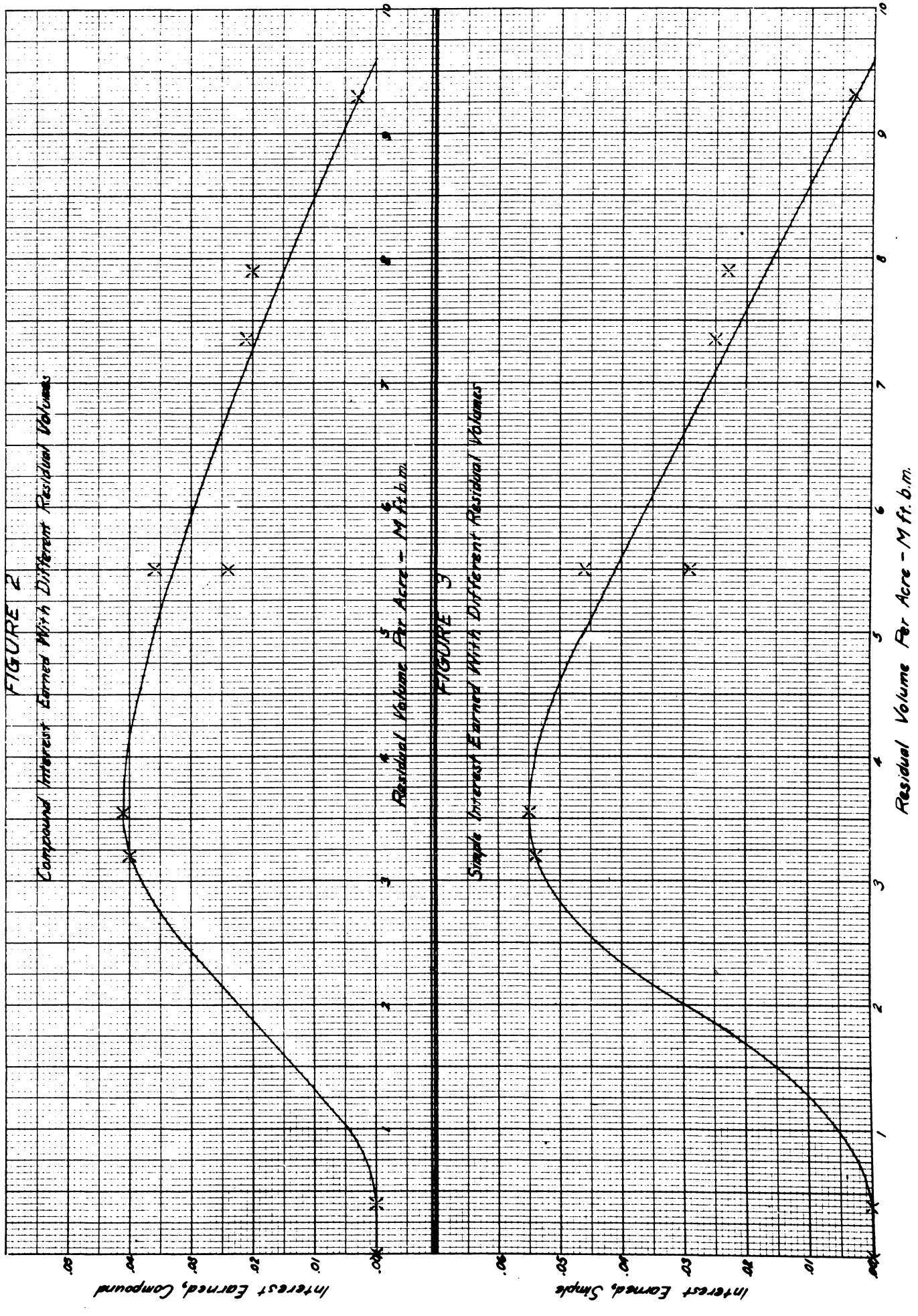
FIGURE 2
Compound Interest Earned With Different Residual Volumes
Interest Earned, Compound
Residual Volume Per Acre - M Ft. b.m.
FIGURE 3
Simple Interest Earned With Different Residual Volumes
Interest Earned, Simple
Residual Volume Per Acre - M Ft. b.m.

TABLE 10

Interest Earned in Fifteen Years on Different Residual Volumes

Residual volume per acre M ft.b.m.	Interest earned - percent	
	Compound	Simple
0.0	0.0	0.0
0.5	0.0	0.0
1.0	0.4	0.5
1.5	1.3	1.6
2.0	2.2	3.0
2.5	3.1	4.3
3.0	3.8	5.2
3.5	4.1	5.5
4.0	4.1	5.4
4.5	3.9	5.1
5.0	3.6	4.6
5.5	3.3	4.1
6.0	3.0	3.6
6.5	2.6	3.1
7.0	2.2	2.6
7.5	1.8	2.1
8.0	1.4	1.6
8.5	1.0	1.1
9.0	0.6	0.6
9.5	0.1	0.1

Cuttings also earned in excess of 3 percent, with marks of 4.0 and 3.6 percent respectively.

Residual volumes of 3.5 and 4.0 M ft. b. m. per acre (Table 10) should prove to be the best investment in growing stock under similar conditions, each earning 4.1 percent compound interest. Residual volumes of 4.5, 3.0 and 5.0 M ft. b. m. per acre would earn in excess of 3.5 percent compound interest, with rates of 3.9, 3.8 and 3.6 respectively. Residual volumes of 5.5, 2.5 and 6.0 M ft. b. m. per acre would earn 3.0 percent or better, with rates of 3.3, 3.1 and 3.0 respectively. In other words, a residual volume of from 2.5 to 6.0 M ft. b. m. per acre, inclusive, should earn at least 3 percent compound interest - as good or better than could be earned by clear cutting and investing soundly in some other enterprise.

For the Company chiefly concerned with growing the greatest merchantable volume of timber on similar sites during a 15-year period, Table 5 indicates that a residual volume of 6.0 M ft. b. m. per acre would increase at the rate of 221 bd. ft. per acre per year. Other residual volumes which would grow 200 bd. ft. per acre annually or more would be 6.5 M ft. b. m. (218 bd. ft.), 5.5 M ft. b. m. (217 bd. ft.), 5.0 M ft. b. m. (209 bd. ft.), 7.0 M ft. b. m. (208 bd. ft.) and 4.5 M ft. b. m. (200 bd. ft. per acre). Stated briefly, a residual stand of from 4.5 to 7.0 M ft. b. m. per acre, inclusive, should grow at least 200 bd. ft. of merchantable timber per acre per year.

A VALUATION STUDY OF DUKES CUTTINGS UNDER SUSTAINED-YIELD MANAGEMENT

In the preceding section of this report the financial returns from different methods of cutting mature northern hardwood stands under a two-cut liquidation plan were discussed. The balance of the paper will be devoted to the returns possible under a program of sustained yield management. Cutting cycles of 5, 10, 15 and 20 years will be considered.

Procedure

The periodic recovery value of 5, 10, 15 and 20 years' growth for each cutting unit was a necessary prerequisite to any further computations. It was calculated by a procedure very similar to that used in evaluating growth under the first plan discussed. However, in this case the surplus value of the periodic growth had to bear the fixed per acre costs alone, since only growth, and not residual growing stock as well, was being removed.

The grade proportions from Table 6 were applied to the 5, 10 and 15-year gross average annual growth volumes from Table 2. In the absence of 20-year growth averages, those for the 15-year period were used for this cycle as well. Reduced by the appropriate cull percent from Table 3, the resulting net volumes by grades for each unit were multiplied first by 5, 10, 15 or 20 years and then by the surplus value for each product from Table 7. These surplus values were next totalled. Finally, fixed per acre costs of $7.50 were deducted to provide a recovery value of 5, 10, 15 and 20 years' growth for each cutting.

The periodic recovery values derived by this process are listed in Table 11, along with a repeat of residual recovery volumes and a list of the annual tax payments used in this study.

The compound interest earned for 5, 10, 15 and 20-year periods

TABLE 11

Values Per Acre Under Sustained Yield
Dukes Cuttings

Cutting unit	Value per acre - dollars					
	Periodic growth recovery				Recovery-residual volume	Annual tax
	5 years	10 years	15 years	20 years 1/		
22 Inch Diameter Limit	17.53	39.22	65.76	90.19	173.13	0.40
Overmature and Defective No. 1	8.48	28.30	57.99	79.82	70.69	0.30
12 Inch Diameter Limit	0.00	0.00	0.00	0.00	0.00	0.05
Clear Cutting	0.00	0.00	0.00	0.00	0.00	0.0375
Heavy Improvement	8.94	27.21	58.58	80.62	132.99	0.40
Light Improvement	13.78	39.36	61.83	84.94	173.91	0.40
Group Selection	0.00	15.53	36.35	50.96	189.59	0.40
70 Percent Selection	2.35	24.33	49.82	68.92	61.75	0.30
Overmature and Defective No. 2	20.70	57.39	89.83 2/	122.28 2/	127.75	0.40
Virgin Forest Reserve Area	6.23	3.95	12.38	19.00	204.70	0.50

1/ Based on 15-year growth averages.

2/ Based on 10-year growth average.

was computed by the use of the following formula:[1/]

$$1.0p^{t} - 1 = \frac{a}{Co}$$

Where, a = Recovery value of periodic growth (Table 11)

Co = Residual recovery value of stand (Table 11) plus cut-over land value ($2.50) plus annual tax payment (Table 11) capitalized at (divided by) an interest rate giving the same value to p in the formula above

t = Interval between payments

p = Interest rate

Simple interest earned during identical periods was derived by this formula:[2/]

$$t \times .0p = \frac{a}{Co}$$

Where, $\frac{a}{Co}$ = Same values used in compound interest formula above

t = Interval between payments

p = Interest rate

The compound and simple interest which would be earned by each cutting unit under a sustained yield plan with cutting cycles of 5, 10, 15 and 20 years are presented in Table 12.

Comparison of Return on Different Residual Volumes With 5, 10, 15 and 20-Year Cutting Cycles

In order to relate interest earned under sustained yield with different cutting cycles to residual volume, a series of eight curves was next prepared. In the first, the compound interest earned by each

1/ Adapted from Formula No. 9, page 224, in Management of American Forests. Donald Maxwell Matthews.

2/ Adapted from a formula presented to class in Forest Valuation at the University of Michigan by Prof. D. M. Matthews.

TABLE 12

Interest Earned Under Sustained Yield
Dukes Cuttings

Cutting unit	Interest earned - percent							
	5-year cycle		10-year cycle		15-year cycle		20-year cycle	
	Com-pound	Simple	Com-pound	Simple	Com-pound	Simple	Com-pound	Simple
22 Inch Diameter Limit	1.7	1.8	1.8	2.0	2.0	2.2	1.9	2.3
Overmature and Defective No. 1	1.8	1.9	3.0	3.4	3.6	4.7	3.5	4.9
12 Inch Diameter Limit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Clear Cutting	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heavy Improvement	1.0	1.0	1.6	1.7	2.2	2.5	2.1	2.6
Light Improvement	1.3	1.3	1.8	2.0	1.8	2.1	1.8	2.1
Group Selection	0.0	0.0	0.6	0.6	1.0	1.0	1.0	1.1
70 Percent Selection	0.3	0.3	2.9	3.3	3.5	4.6	3.4	4.7
Overmature and Defective No. 2	2.7	2.9	3.5	4.0	3.3	4.2	3.1	4.3
Virgin Forest Reserve Area	0.4	0.4	0.1	0.1	0.2	0.2	0.2	0.2

unit with a 5-year cutting cycle (Table 12) was plotted over residual volume. (Table 9) In the second, simple interest earned by each unit with a 5-year cutting cycle (Table 12) was plotted over residual volume. (Table 9) The process was repeated for 10, 15 and 20-year cutting cycles, compound interest and simple interest curves being fitted in each case. These eight curves, Figures 4 - 11, inclusive, are included with this report.

Table 13, compound interest rates earned on a series of residual volumes ranging from 0 to 9.5 M ft. b. m., and Table 14, simple interest rates earned on the same residual volumes, were prepared from these curves.

It seemed worthwhile at this point to correlate residual volumes used in the preceding pages with basal area, in order to make possible wider application of the results of the study. Consequently, residual basal areas from Table 1 were plotted over net residual volumes for the same cuttings, and a curve was fitted. (Figure 12) Basal areas for the same series of residual volumes referred to repeatedly in this paper were read from the curve and inserted in Table 15. By substituting the equivalent basal areas from Table 15 for residual volumes referred to at different points in the discussion, the effect of greater or lesser merchantable length should be minimized when considering northern hardwood stands growing at some distance from the Experimental Forest.

Summary

Under sustained yield management as under the two-cut liquidation plan, the Overmature and Defective Cutting No. 1 proved to be most promising when judged by compound interest earned. With a 15-year cutting cycle, an interest earned rate of 3.6 percent is shown for this cutting in Table 12. With a 20-year cutting cycle, and assuming the 15-year growth average will hold for an additional 5 years, the

FIGURE 4

Compound Interest Earned With Different Residual Volumes
5 Year Cutting Cycle

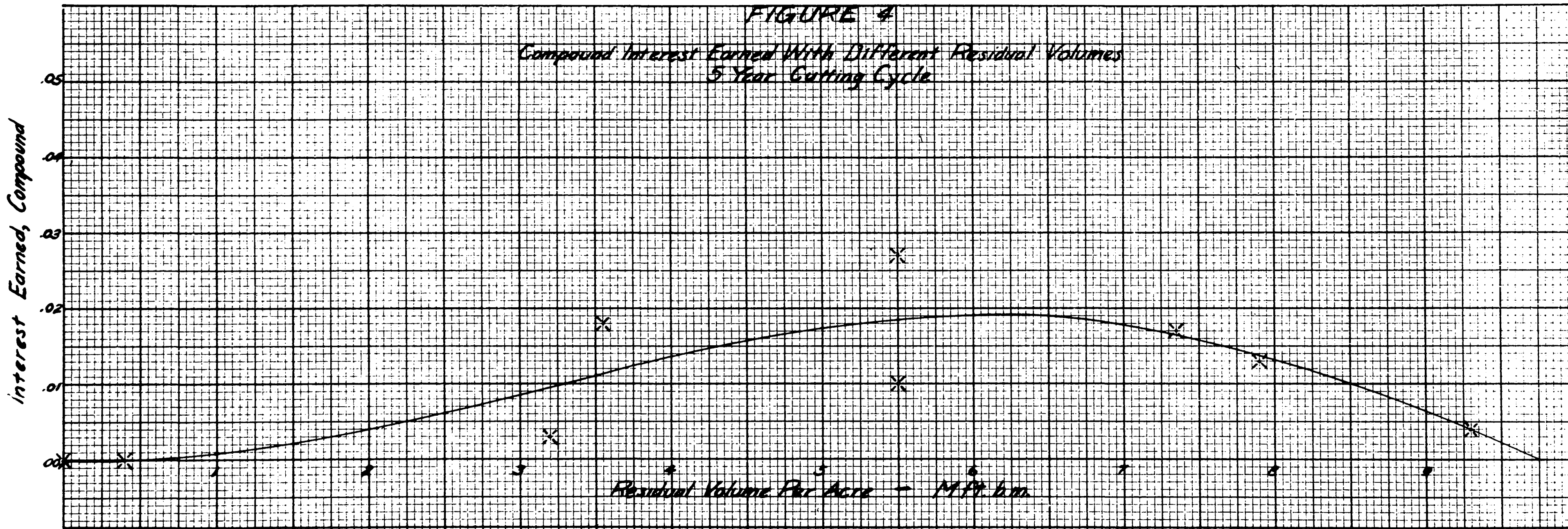

FIGURE 5

Simple Interest Earned With Different Residual Volumes
5 Year Cutting Cycle

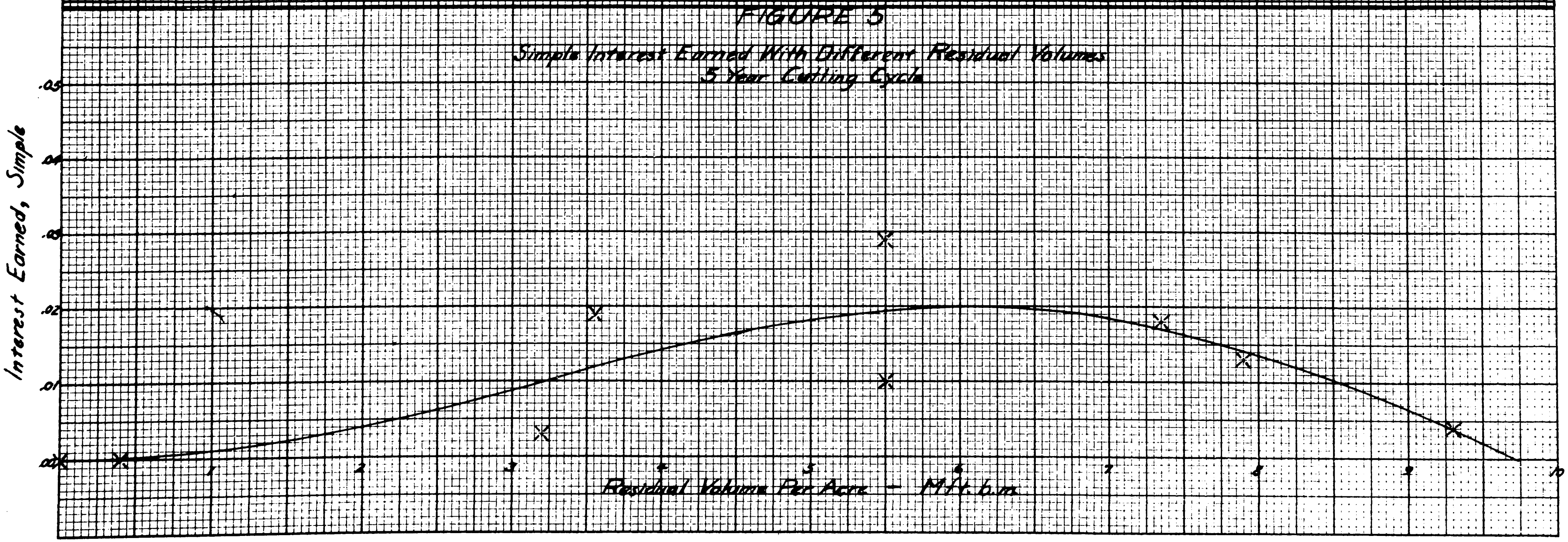

FIGURE 6

Compound Interest Earned With Different Residual Volumes
10 Year Cutting Cycle

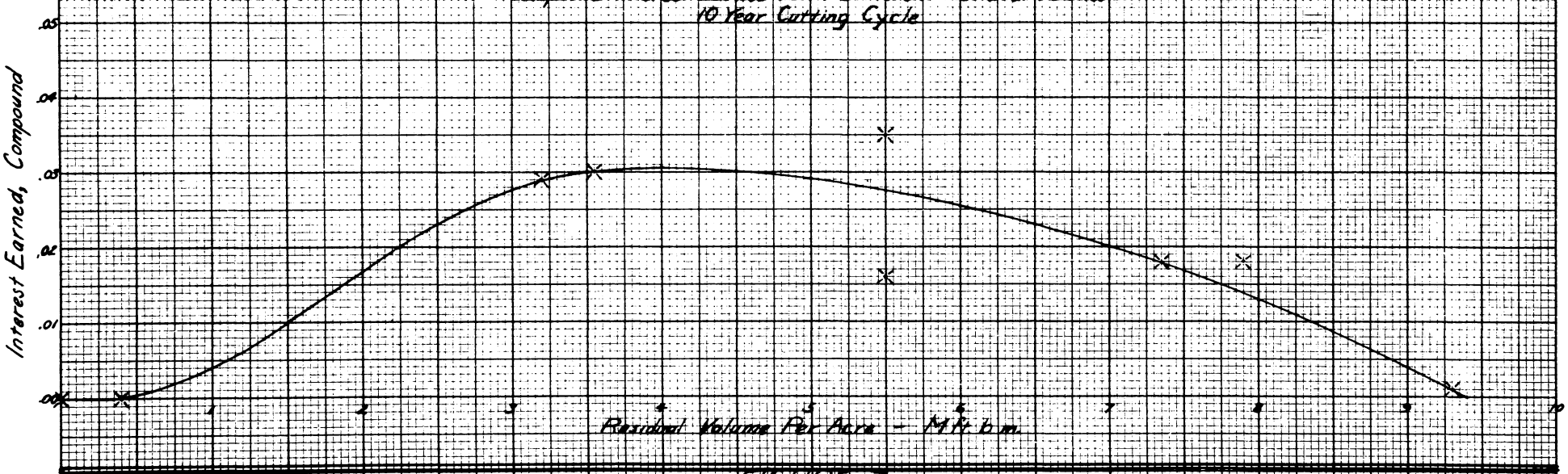

FIGURE 7

Simple Interest Earned With Different Residual Volumes
10 Year Cutting Cycle

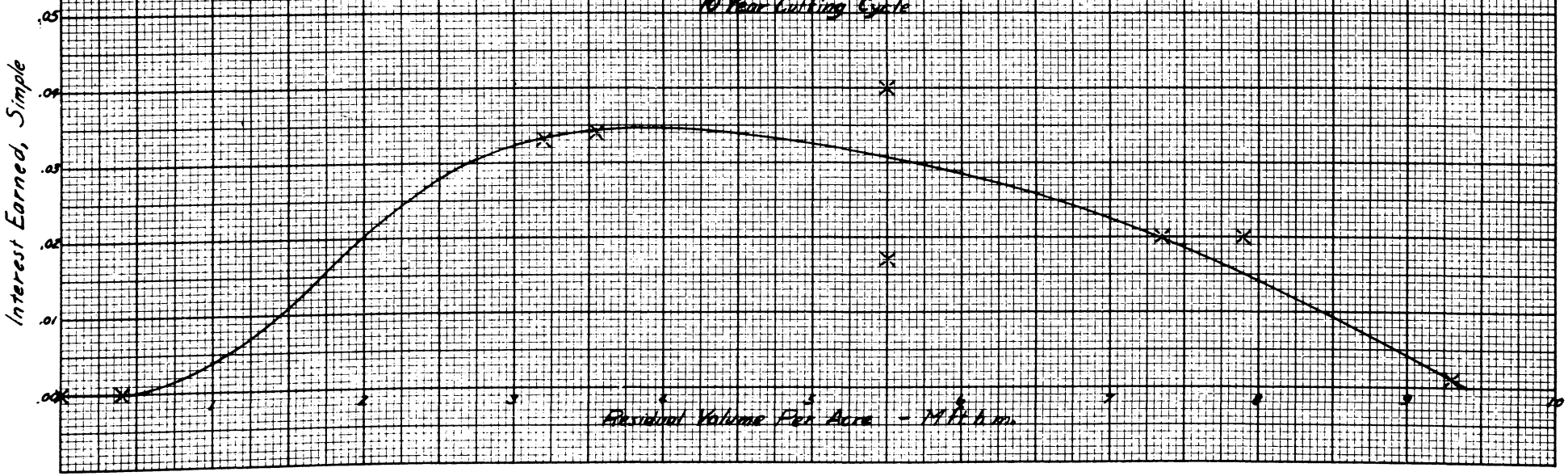

FIGURE 8

Compound Interest Earned With Different Residual Volumes
15 Year Cutting Cycle

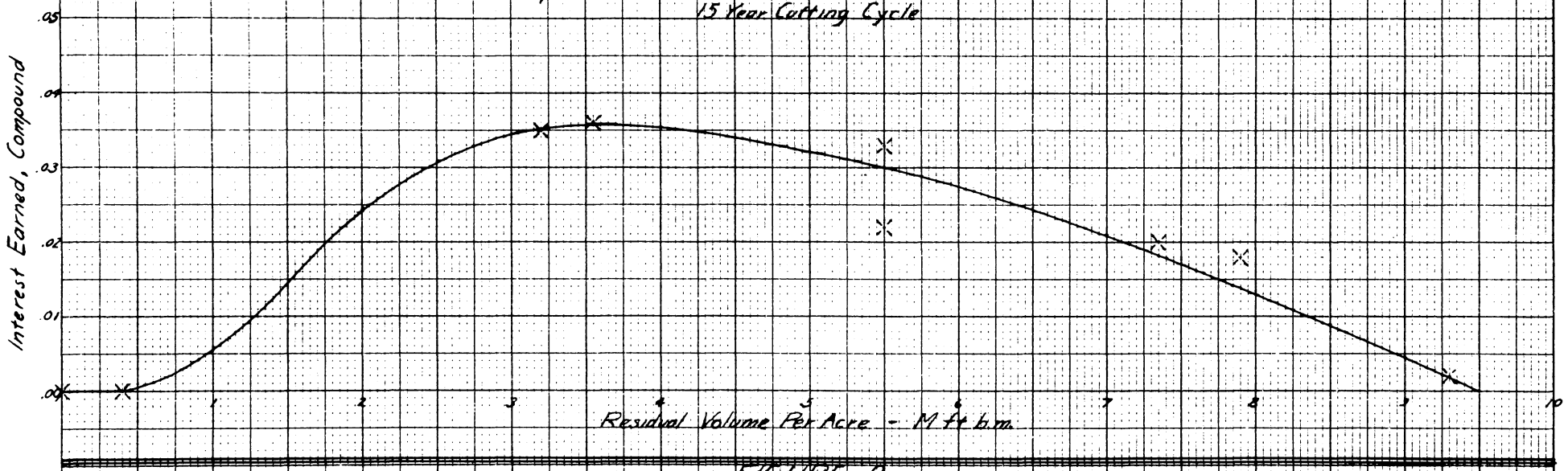

FIGURE 9

Simple Interest Earned With Different Residual Volumes
15 Year Cutting Cycle

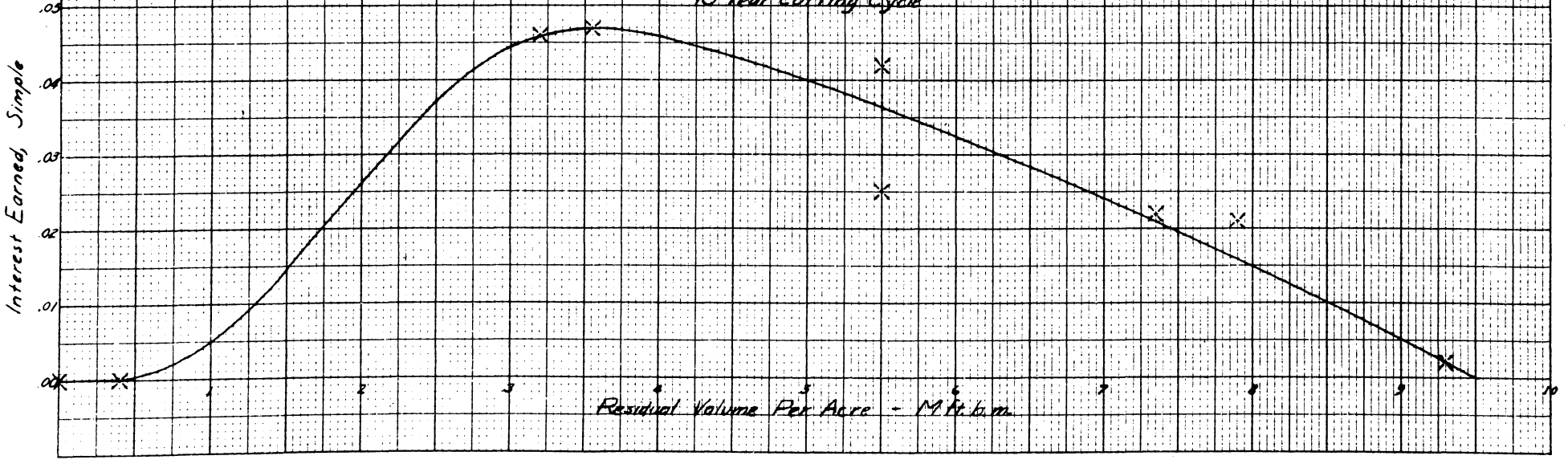

FIGURE 10

Compound Interest Earned With Different Residual Volumes
20 Year Cutting Cycle

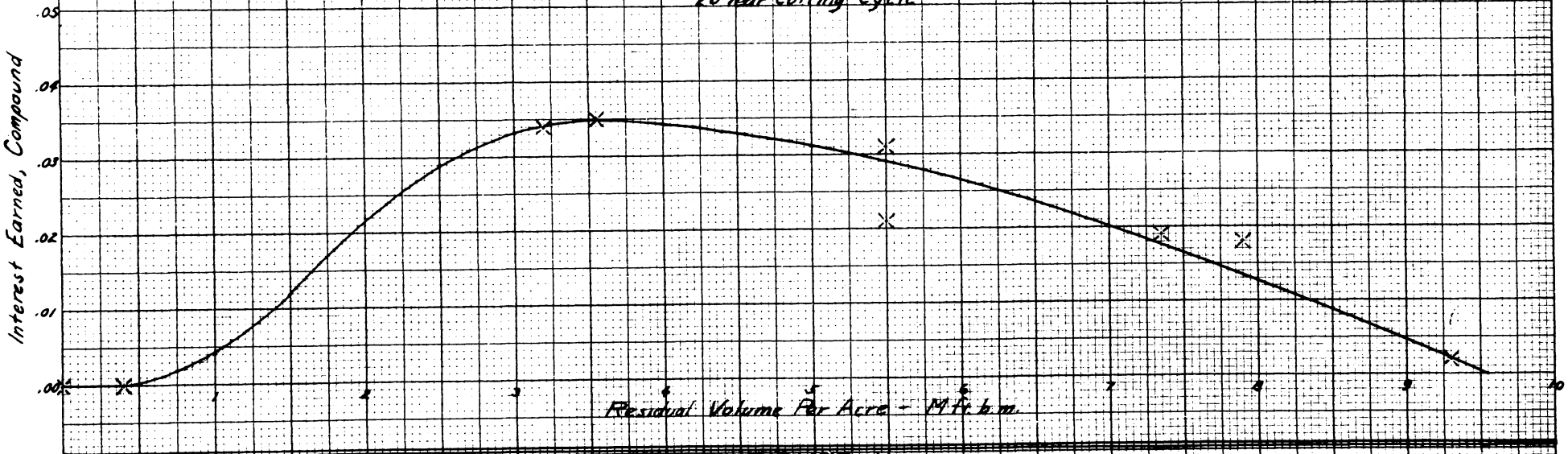

FIGURE 11

Simple Interest Earned With Different Residual Volumes
20 Year Cutting Cycle

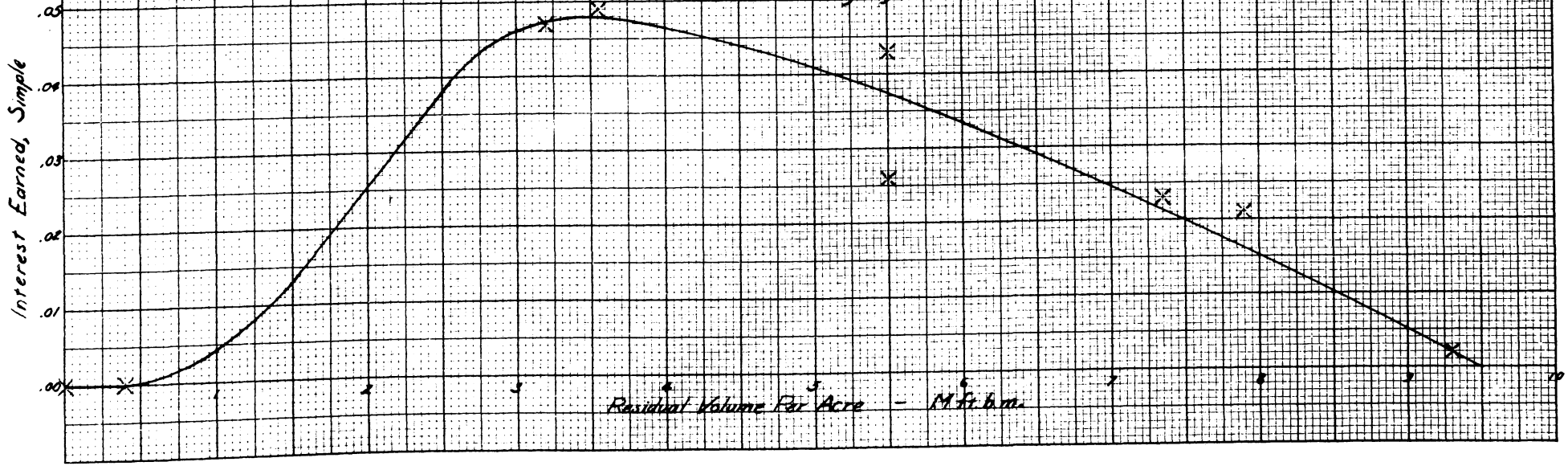

TABLE 13

Possible Return on Investment from Sustained Yield With Different Residual Volumes and Cutting Cycles Compound Interest

Residual volume per acre M ft.b.m.	Compound interest earned - percent Cutting cycle - years			
	5	10	15	20
0.0	0.0	0.0	0.0	0.0
0.5	0.0	0.0	0.0	0.0
1.0	0.1	0.4	0.5	0.4
1.5	0.2	1.0	1.4	1.2
2.0	0.4	1.7	2.4	2.2
2.5	0.6	2.3	3.1	2.9
3.0	0.8	2.8	3.5	3.3
3.5	1.1	3.0	3.6	3.5
4.0	1.4	3.1	3.5	3.4
4.5	1.6	3.0	3.4	3.3
5.0	1.7	2.9	3.2	3.1
5.5	1.9	2.8	3.0	2.9
6.0	1.9	2.5	2.8	2.6
6.5	1.9	2.3	2.5	2.3
7.0	1.8	2.0	2.1	2.0
7.5	1.6	1.7	1.8	1.6
8.0	1.3	1.3	1.4	1.3
8.5	1.0	0.9	0.9	0.9
9.0	0.6	0.4	0.5	0.5
9.5	0.2	0.0	0.0	0.0

TABLE 14

Possible Return on Investment from Sustained Yield With Different Residual Volumes and Cutting Cycles Simple Interest

Residual volume per acre M ft.b.m.	Simple interest earned - percent Cutting cycle - years			
	5	10	15	20
0.0	0.0	0.0	0.0	0.0
0.5	0.0	0.0	0.0	0.0
1.0	0.1	0.4	0.5	0.4
1.5	0.2	1.1	1.5	1.3
2.0	0.4	2.0	2.6	2.5
2.5	0.6	2.8	3.7	3.8
3.0	0.9	3.2	4.5	4.6
3.5	1.2	3.4	4.7	4.8
4.0	1.4	3.4	4.6	4.7
4.5	1.6	3.4	4.3	4.4
5.0	1.8	3.2	4.0	4.1
5.5	2.0	3.1	3.7	3.8
6.0	2.0	2.9	3.3	3.4
6.5	2.0	2.6	2.9	2.9
7.0	1.8	2.2	2.4	2.5
7.5	1.6	1.9	2.0	2.0
8.0	1.3	1.4	1.5	1.5
8.5	1.0	1.0	1.0	1.0
9.0	0.6	0.4	0.5	0.5
9.5	0.2	0.0	0.0	0.0

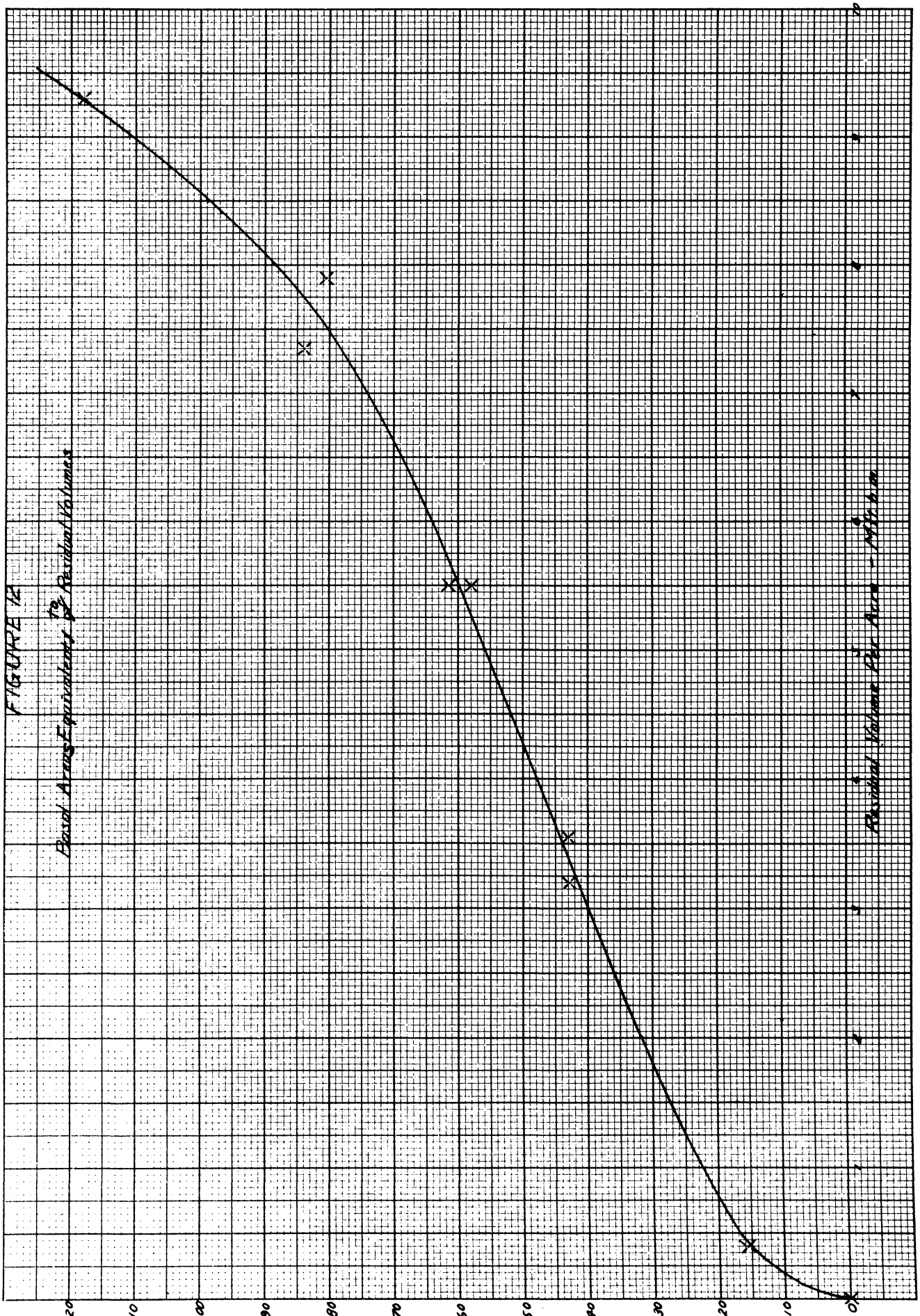
Basal Area Equivalent to Residual Volumes
Residual Volume Per Acre - Cubic Feet
Basal Area Per Acre - Sq Ft
0
10
20
30
40
50
60
70
80
90
100
110
120

FIGURE 12

TABLE 15

Basal Areas Equivalent to Residual Volumes
Dukes Cuttings

Residual volume per acre M ft.b.m.	Equivalent basal area per acre Trees 10" d.b.h. and up Sq. ft.
0.0	0.0
0.5	17.0
1.0	22.5
1.5	27.5
2.0	31.5
2.5	35.5
3.0	40.0
3.5	44.0
4.0	48.0
4.5	52.5
5.0	56.0
5.5	60.0
6.0	63.5
6.5	68.5
7.0	73.5
7.5	80.0
8.0	88.5
8.5	99.0
9.0	110.5
9.5	123.5

compound interest rate is 3.5 percent. The 70 Percent Selection Cutting with a 15-year cutting cycle and the Overmature and Defective Cutting No. 2 with 10-year cutting cycle would also earn 3.5 percent.

Other cutting combinations earning 3.0 percent compound interest or better are the Overmature and Defective Cutting No. 1 with a 10-year cycle (3.0 percent), 70 Percent Selection Cutting with a 20-year cycle (3.4 percent), and Overmature and Defective Cutting No. 2 with 15-year cycle (3.3 percent) and 20-year cycle. (3.1 percent)

Examination of Table 13 discloses these main points of interest: A residual volume of 3.5 M ft. b. m. (44.0 sq. ft. of basal area - Table 15) per acre with a 15-year cutting cycle should be the best investment with similar growing conditions, earning at the rate of 3.6 percent, compound interest. A residual volume of 3.0 M ft. b. m. with a 15-year cycle, a residual volume of 3.5 M ft. b. m. with a 20-year cycle, and a residual volume of 4.0 M ft. b. m. with a 15-year cycle would all earn 3.5 percent compound interest. A residual volume of 4.0 M ft. b. m. with a 20-year cycle and a residual volume of 4.5 M ft. b. m. with a 15-year cycle would both earn 3.4 percent compound interest. Residual volumes of 3.0 and 4.5 M ft. b. m. with 20-year cycles would both earn 3.3 percent compound interest. A residual volume of 5.0 M ft. b. m. with 15-year cycle would earn 3.2 percent compound interest. A residual volume of 2.5 M ft. b. m. with 15-year cycle, a residual volume of 4.0 M ft. b. m. with 10-year cycle, and a residual volume of 5.0 M ft. b. m. with 20-year cycle would all earn 3.1 percent compound interest. Residual volumes of 3.5 and 4.5 M ft. b. m. with 10-year cycles and a residual volume of 5.5 M ft. b. m. with 15-year cycle would all earn 3.0 percent compound interest.

Summed up briefly, residual volumes of from 3.5 to 4.5 M ft. b. m. (44.0 to 52.5 sq. ft. of basal area) per acre, inclusive, with a 10-year cutting cycle, residual volumes of from 2.5 to 5.5 M ft. b. m. (35.5 to 60.0 sq. ft. of basal area), inclusive, with a 15-year cycle,

and residual volumes of from 3.0 to 5.0 M ft. b. m. (40.0 to 56.0 sq. ft. of basal area), inclusive, with a 20-year cycle should all earn at least 3.0 percent compound interest for the Company interested in staying in business in this type.

CONCLUSIONS AND RECOMMENDATIONS

The methods of cutting at Dukes, Michigan which resulted in the highest interest earned on the investment in residual growing stock and land after 15 years have been reviewed in the summary at the end of the section dealing with the two-cut liquidation plan. The Overmature and Defective Cutting No. 1, which removed 62 percent of the gross volume and 58 percent of the basal area, leaving a net residual volume of 3,540 bd. ft. and 42.945 sq. ft. of basal area per acre showed up best, earning 4.1 percent compound interest. It was concluded that residual volumes of from 2,500 to 6,000 bd. ft. (35.5 to 63.5 sq. ft. of basal area) per acre should earn at least 3.0 percent compound interest under similar conditions.

It was also demonstrated that for the Company chiefly concerned with growing the greatest volume of merchantable timber on a corresponding site (perhaps to keep costly plants in operation), a residual stand of from 4,500 to 7,000 bd. ft. net (52.5 to 73.5 sq. ft. of basal area) per acre should grow 200 bd. ft. or more per acre per year.

The summary at the end of the preceding section of this report reviewed the methods of cutting at Dukes which should earn the highest interest return under sustained-yield management. Again it was the Overmature and Defective Cutting No. 1 under a 15-year cutting cycle which appeared the most promising, with an indicated earning of 3.6 percent compound interest. Under this plan it was concluded that residual volumes of from 3,500 to 4,500 bd. ft. (44.0 to 52.5 sq. ft. of basal area) per acre with a 10-year cutting cycle, from 2,500 to 5,500 bd. ft. (35.5 to 60.0 sq. ft. of basal area) with a 15-year cycle, and from 3,000 to 5,000 bd. ft. (40.0 to 56.0 sq. ft. of basal area) with a 20-year cycle should earn at least 3.0 percent compound interest under similar conditions.

Recommendations of cutting methods must, perforce, be conditioned

to a great degree by individual objectives of management. However, the writer is of the opinion that the general recommendation following will prove sound in most cases. It assumes that the 15-year growth average will remain approximately constant or decrease during the next 5 years, so that the slight superiority of the 15-year cutting cycle demonstrated in this study will be maintained.

On the basis, then, of studies carried on since 1926 at Dukes, Michigan and in the light of their interpretation in this report, the writer recommends the following as the most practical cutting method for comparable mature northern hardwood forests being managed under sustained yield:

1. Leave a well distributed stand of sound trees of from 2,500 to 5,500 bd. ft. or 35.5 to 60.0 sq. ft. of basal area per acre.

2. Cut the equivalent of accumulated growth every 15 years.

It might be interesting in closing to compare the above economic recommendation with silvicultural recommendations made for the type in the past. In a report prepared in 1938[1/] after a study of the same cuttings at Dukes, this conclusion was expressed: "On the basis of cutting experiments observed for ten years it has been shown that a selection type of cutting in which from one third to two thirds of the stand is removed in the first operation is well adapted to the northern hardwood forest." The same report, in referring to the cutting which showed up best in the present study (Overmature and Defective No. 1), listed the following among the advantages of this moderate degree of cutting: "Good silviculture may be practiced under this method since the cutting is heavy enough to insure removal of the unthrifty and diseased portion of the stand."

The writer feels that the cutting method demonstrated in this

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1/ Practical Cutting Methods for Northern Hardwoods. Francis H. Eyre and John R. Neetzel. Papers of the Michigan Academy of Science, Arts and Letters, Vol. XXIV, Part 1, 1938. Published, 1939.

report to be the most desirable as a business proposition, and still within the bounds of sound silvicultural practice, is well worthy of consideration by any Company which holds northern hardwood timberlands, and which desires to remain in the business permanently.

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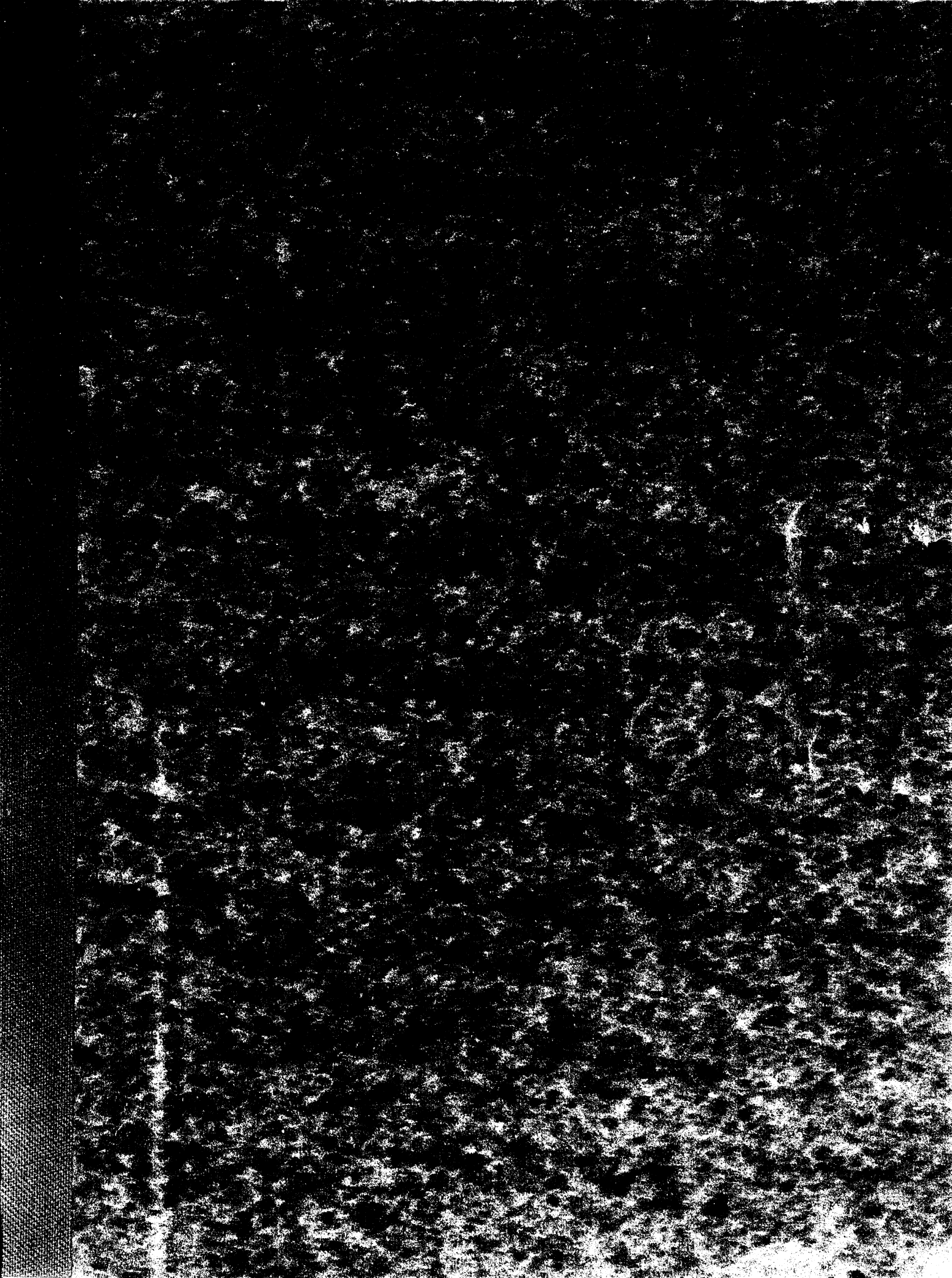

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