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THE FARM WOODLOT OF SOUTHEASTERN MINNESOTA
ITS COMPOSITION, VOLUME, GROWTH, VALUE, AND FUTURE POSSIBILITIES

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By E. G. CHEYNEY and R. M. BROWN[1]

INTRODUCTION

The growing shortage of hardwoods in the United States and the increasing price of lumber and wood products are now bringing the hardwood forests into the prominence they deserve. Originally, the hardwood forests generally grew on the better soils and have, therefore, been very largely cleared for agricultural crops. The only large tracts of hardwood forest which will not eventually be so converted are in the mountains or hills where the land is too steep for farming. Such areas are far too small to supply all the raw material needed by the hardwood industry. The only other source of hardwood timber in this country is the farm woodlots. In the future these woodlots will undoubtedly produce a large part of the hardwoods used in the United States and for this reason will play a very important rôle in the life of industries that are dependent upon hardwoods for their raw material.

These woodlots seem insignificant when considered individually, but in the aggregate they are of tremendous importance. Tillotson[2] states that of the 40,000,000 acres of hardwood forests in the central region of the United States three-fourths, or 30,000,000 acres, is in farm woodlots. The total area of woodlots in the United States exceeds that of the national forests.

No farm is being used to the best advantage if from 5 to 30 per cent of the area is neglected. Especially is this true when the time spent on this neglected area would be during the periods of slack work in winter. Often the land in woodlots is such that it can be neither farmed nor sold. Clearing of these lands is too costly except when the soils have a high agricultural value. Taxes must be paid on them and economy requires that they return a revenue, if possible. Intensive handling of the woodlot will aid materially in making the idle lands on the farm more productive without sacrificing time that should be spent on the more valuable agricultural lands. For this reason it would

[1] The writers wish to acknowledge the assistance of S. Gevorkiantz in compiling the data.

[2] Tillotson, C. R. Timber growing and logging practice in the central hardwood region. U. S. Dept. Agr. Bull. 1491. 1927.

be to the farmer's advantage if farm management plans of the future included provisions for the handling of farm woodlots on a sustained yield basis.

Increased returns mean an increase in the valuation of the farm property. New England banks have already recognized that a farm with a properly handled woodlot is a better security for loans than one without such an asset. For example, E. H. Thomson,[3] president, Federal Land Bank of Springfield, Mass., states:

"Our experience has shown that there are many farm loans that could not be made if it were not for the woodlot on the farm being an important part of the security." "While the bank encourages reforestation and the use of idle lands, we especially stress the care and improvement of stands of wood and lumber now found on the farm."

Farm woodlots are in a peculiarly favorable position for intensive management. They are usually located close to the owner's house and bounded by roads which make fire protection a fairly simple matter. They need attention at a time of year when the owner can best give it.

Very little has been done to determine the character and condition of the woodlots in southeastern Minnesota. This neglect has not been due to indifference in regard to their importance, but rather to the yet greater importance of the forests in the north. The Division of Forestry, recognizing the value of these woodlots to their owners and their place in the economic life of the industries dependent upon them, made a preliminary study to obtain definite information concerning their composition, volume, growth, value, and future possibilities. Woodlots were examined in fifteen counties: Carver, Dakota, Dodge, Fillmore, Goodhue, Houston, LeSueur, Mower, Olmsted, Rice, Scott, Steele, Wabasha, Washington, and Winona. In eight of these counties woodlots recommended by the county agents for their superior qualities were studied intensively.

Most of the forest in these counties is included in farm woodlots. The census of 1920 gives the total area of the farms in these counties as 3,408,530 acres, and the woodland as 724,835 acres, or 22 per cent of the farm area. Commercial logging has played very little part there. The timber was cut for the purpose of clearing the land; where the land was not needed or was too poor for farming, the timber was left. These remnants of the original forests make up the woodlots of today. Most of them have been rather severely culled over for the better species in the last fifteen years, but in very few cases have they been clear cut. In even fewer cases have they been handled with any idea of their welfare and improvement.

[3] Thomson, E. H. Importance of the farm woodlot in financing the farmer. Jour. of For. Vol. XXIV, No. 4, 1926.

A few of the woodlots studied were virgin timber which had never been culled or grazed, but most of them had been grazed continually and culled severely from time to time. The heavy culling probably accounts for the scarcity of the better species in the larger diameter classes. The dead and down trees had in most cases been quite thoroly picked up.

Two types of forest can conveniently be differentiated in the region covered by this study: one in which oaks predominate, and another in which oaks do not predominate. In the latter, basswood, maple, and elm are usually the principal species. The latter type might have been further subdivided into several subtypes in which some one of the above species predominates, but nothing would have been gained by such subdivision. Especially was this true because in many cases the original type has been changed by culling.

TOPOGRAPHY AND CLIMATE

The topography of this region varies greatly. In some counties, where the forests extend out on the prairies, the land is flat, but toward the southeastern corner of the state the hills rise higher and higher. In Houston, Fillmore, Winona, and Olmsted Counties they almost reach the proportions of small mountains. In general, this region resembles the hill country of central New York State.

The tributaries of the Mississippi—the Root, Whitewater, Zumbro, and Cannon rivers—have cut deep, steep-sided valleys. Many of these slopes are too steep for cultivation, therefore many woodlots are located on them. The steepness of the slope combined with the clayey character of the soil makes these hillsides very susceptible to erosion. Where the timber has been cut on the upper slopes they have already, in many cases, gullied so deeply that they are useless for cultivation or pasture.

The climate is severe and subject to great extremes. The winters are long, often extending from October to April and reaching a minimum temperature of 20 or more degrees below zero, and the maximum summer temperature may go 100 degrees above zero. Late spring and early fall frosts, especially the former, may do much damage to vegetation.

The precipitation averages about 32 inches, but is quite variable. The records show a range of 19.2 inches, from 25.6 in the driest year to 44.8 in the wettest year. April and October, with an average precipitation of 2.7 and 2.8 inches, respectively, show the least rainfall of the year with the exception of the winter months.

Soil

This whole region, with the exception of Houston County and a part of Fillmore County, lies within the glaciated portion of the state. The soils are, therefore, seldom uniform over very large areas. The soils over a county, for example, may be generally considered as clay, but there are scattered through it irregular patches of gravel and sand, distributed largely according to topography. Houston County and the eastern end of Fillmore County is the only portion of the whole state that has not been materially changed by glaciation and is rather uniformly a loess underlaid with heavy residual clay.

Procedure

The conditions under which this study was made placed many restrictions upon the methods which could be used.

It was desired to obtain an indication of the possibilities of the woodlots rather than the average conditions existing under the present neglect and mismanagement. Therefore only those tracts were studied that were highly recommended by the county agents because of their good care and exceptional quality. Plots were located in the best parts of these selected woodlots. The resulting figures are therefore considerably higher than might be expected.

Twenty plots were laid out, varying in size from one-fourth acre to one acre, and including an aggregate of 14 acres. All the trees on the plots were calipered at breast height and recorded by one-inch diameter classes and species. The total and merchantable heights were determined by ocular estimate.

Current growth was obtained by means of an increment borer. Borings were made in 576 trees and the width at breast height of the last 15 rings was measured and tallied by d.b.h. (diameter breast high) classes. An effort was made to bore at least one tree in each diameter class for each species on a plot. Only in a few instances was this impossible, because of defects and abnormalities.

A description was written of each plot, noting density, general condition of the stand, reproduction, ground cover, and general character of the soil. Wherever possible the owner was interviewed as to the value and usefulness of his woodlot, the condition of the local market for woodlot products, and the part which his own woodlot plays in his plan of farm management.

A stand table, showing the average number of trees per acre by species and d.b.h. classes, was computed by averaging all the plots in a given type. Stock tables showing the average volume per acre in cubic feet, including branch wood by species and d.b.h. classes, were

compiled by applying to these stand tables a volume table[4] based on d.b.h.[5] For each species in a type the width of the last 15 rings was averaged and curved on d.b.h. These diameter growth figures were applied to the diameters of the trees now standing to determine their size and distribution 15 years ago. The volume per acre of these trees 15 years ago was computed from the stand table by means of the volume table. From the past and present volumes the total and periodic annual growth for the 15-year period were obtained.

FOREST TYPES

A. Mixed Hardwood Type

Composition

The average composition of well stocked woodlots of the mixed hardwood type, by both number of trees and volume, is shown in Tables I and II. Any woodlot, of course, may vary considerably from this average. Maple, basswood, and elm are the principal species in this type, comprising 25, 19, and 11 per cent respectively, of the number of trees, or slightly more than half of the entire stand. On a volume basis, however, the relative importance of these three species is somewhat different. Basswood occupies the leading position, making up about a third of the stand by volume. Elm and maple are present in about equal amounts and together make up another third. As stated previously, the oaks are not common in this type. Red oak, the most abundant, comprises only 6 per cent of the trees and 10 per cent of the volume. The only other oaks represented are white and bur oak. Together they constitute less than 2 per cent of the stand on either a numerical or a volume basis. The percentage of the total volume of the stand made up by each species is shown in Figure 1.

Hard maple is the most abundant species in the young growth, between 0.6 and 3.5 inches in diameter, where it makes up about 33 per cent of the trees. Ironwood, the worst weed tree of the region, comprises approximately 13 per cent, and basswood 11 per cent of these sizes. Elm, which held third place for the entire stand, drops back to seventh place in the small diameters and makes up only 5 per cent of these sizes. Shagbark hickory and green ash each comprise 9 per cent, and black ash 7 per cent of these saplings. The oaks are not so well represented in the young growth as in the main stand. All together they make up less than 2 per cent of the trees. There is scarcely any reproduction, even of hard maple.

[4] Chittenden, A. R. Improvement of the farm woodlot. Mich. Agr. Expt. Sta. Bull. 122. 1923.

[5] Owing to the numerous species involved and the objections of owners, no sample trees were cut. Comparable volume tables based on both d.b.h. and height are not available for all these species.

TABLE I

STAND TABLE

AVERAGE NUMBER OF TREES PER ACRE, MIXED HARDWOOD TYPE, SOUTHEASTERN MINNESOTA, 1925

Diameter breast high, in.	Maple		Basswood		Elm		Shagbark Hickory		Ironwood		Black Ash		Red Oak		Green Ash	
	No. of trees	Per cent	No. of trees	Per cent	No. of trees	Per cent	No. of trees	Per cent	No. of trees	Per cent	No. of trees	Per cent	No. of trees	Per cent	No. of trees	Per cent
1	14.9	21.08	1.9	3.5	.8	2.7	1.7	8.2	1.7	8.5	2.6	15.0	..	..	3.4	23.4
2	9.0	12.73	5.3	9.7	2.2	7.4	3.6	17.6	3.8	18.9	1.9	10.9	.1	.6	2.9	20.0
3	12.0	16.97	3.7	6.8	2.3	7.6	4.0	19.5	8.0	39.8	2.9	16.7	.6	3.6	2.8	19.3
4	7.9	11.17	4.3	7.9	2.7	8.9	4.3	21.0	3.3	16.4	1.9	10.9	1.3	7.9	1.1	7.6
5	4.9	6.93	4.1	7.5	2.0	6.6	2.3	11.2	2.7	13.4	1.4	8.1	2.2	13.3	1.6	11.0
6	4.9	6.93	3.3	6.1	2.0	6.6	1.4	6.8	.4	2.0	2.4	13.8	1.6	9.7	.3	2.1
7	3.3	4.67	3.8	7.0	1.6	5.3	1.9	9.3	.2	1.0	1.9	10.9	1.2	7.3	.2	1.4
8	3.2	4.53	3.4	6.2	2.3	7.6	.6	2.9	..	..	.6	3.5	.7	4.2	.4	2.8
9	1.8	2.55	3.7	6.8	2.4	8.3	.3	1.5	..	..	.3	1.7	1.0	6.1	.6	4.1
10	1.3	1.84	4.2	7.7	1.8	6.0	.2	1.0	..	..	.4	2.3	.9	5.5	.2	1.4
11	1.2	1.70	2.3	4.2	1.3	4.3	.1	.5	..	..	.3	1.7	1.6	9.7	.4	2.8
12	1.1	1.56	3.4	6.2	1.8	6.0	.1	.5	..	..	.3	1.7	.8	4.9	.2	1.4
13	1.2	1.70	1.6	2.9	1.2	4.0	..	..	..	..	.2	1.1	.9	5.5	.2	1.4
14	.8	1.13	1.7	3.1	1.1	3.6	..	..	..	..	..	..	1.0	6.1	..	..
15	.9	1.27	1.7	3.1	.9	2.9	..	..	..	..	.2	1.1	.6	3.6	..	..
16	.6	.85	1.1	2.0	.8	2.7	..	..	..	..	.1	.6	.7	4.2	.1	.7
17	.7	.99	1.5	2.6	1.0	3.3	..	..	..	..	..	..	.4	2.4	.1	.7
18	.1	.14	.9	1.6	.6	2.0	..	..	..	..	..	..	.3	1.8	..	..
19	.1	.14	.7	1.3	.3	1.0	..	..	..	..	..	..	.4	2.4	..	..
20	.2	.28	.7	1.3	.6	2.0	..	..	..	..	..	..	.1	.6	..	..
21	.1	.14	.2	.4	.1	.3	..	..	..	..	..	..	..	..	..	..
22	.1	.14	.2	.4	.2	.6	..	..	..	..	..	..	.1	.6	..	..
23	..	..	.6	1.0	..	..	..	..	..	..	..	..	..	..	..	..
24	.1	.14	.2	.4	.1	.3	..	..	..	..	..	..	..	..	..	..
25	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
26	.1	.14	..	..	..	..	..	..	..	..	..	..	..	..	..	..
27	..	..	.1	.2	..	..	..	..	..	..	..	..	..	..	..	..
28	.1	.14	..	..	..	..	..	..	..	..	..	..	..	..	..	..
29	.1	.14	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total	70.7	100	54.6	100	30.1	100	20.5	100	20.1	100	17.4	100	16.5	100	14.5	100
Percentage	24.8		19.2		10.6		7.2		7.1		6.1		5.8		5.1	

TABLE I—*Continued*

Diameter breast high, in.	Largetooth Aspen		Butternut		Boxelder		Hackberry		White Oak		Bur Oak		Bitternut Hickory		Miscellaneous		Total	
	No. of trees	Per cent	No. of trees	Per cent	No. of trees	Per cent	No. of trees	Per cent	No. of trees	Per cent	No. of trees	Per cent	No. of trees	Per cent	No. of trees	Per cent	No. of trees	Per cent
1	..	..	..	..	..	..	..	..	..	..	..	..	.1	7.7	.9	32.1	28.0	9.8
2	.1	.8	.2	1.9	.1	2.0	.1	3.6	..	..	.2	12.5	.1	7.7	.3	10.7	29.9	10.5
3	1.1	8.3	.4	3.8	.2	4.0	..	..	..	..	.3	18.8	.2	15.4	.4	14.3	38.9	13.7
4	1.9	14.4	.7	6.7	..	..	..	..	..	..	.3	18.7	.4	30.8	.2	7.1	30.3	10.7
5	1.2	9.1	.6	5.7	.2	4.0	.1	3.6	.2	6.9	.2	12.5	.3	23.1	.3	10.7	24.3	8.5
6	.2	1.5	.7	6.7	.8	16.0	.2	7.1	.6	20.7	.2	12.5	.2	15.4	.1	3.6	19.3	6.8
7	.1	.8	.8	7.6	.4	8.0	.1	3.6	.3	10.4	.1	6.3	..	..	..	..	15.9	5.6
8	.3	2.3	1.6	15.2	.3	6.0	.1	3.6	.4	13.8	..	..	..	..	..	..	13.9	4.9
9	1.2	9.1	1.9	18.1	1.3	26.0	.1	3.6	.6	20.7	.1	6.3	..	..	.2	1.1	15.5	5.4
10	2.1	15.9	.4	3.8	1.1	22.0	..	..	.7	24.1	..	..	..	..	..	..	13.3	4.7
11	2.1	15.9	.6	5.7	.4	8.0	.3	10.7	.1	3.4	.1	6.2	..	..	..	..	10.8	3.8
12	2.1	15.9	.7	6.7	.1	2.0	.1	3.6	..	..	..	..	..	..	.1	3.6	10.8	3.8
13	.7	5.3	.7	6.7	.1	2.0	.2	7.1	..	..	..	..	..	..	.2	7.1	.7	2.5
14	.1	.8	.7	6.7	..	..	.2	7.1	..	..	.1	6.2	..	..	.1	3.6	5.7	2.0
15	..	..	.2	1.9	..	..	.1	3.6	..	..	..	..	..	..	..	..	4.6	1.6
16	..	..	.3	2.8	..	..	.1	3.6	..	..	..	..	..	..	..	..	3.8	1.3
17	..	..	..	..	..	..	.1	3.6	..	..	..	..	..	..	..	..	3.8	1.3
18	..	..	..	..	..	..	.3	10.7	..	..	..	..	..	..	..	..	2.2	.8
19	..	..	..	..	..	..	.2	7.1	..	..	..	..	..	..	..	..	1.7	.6
20	..	..	..	..	..	..	.1	3.6	..	..	..	..	..	..	..	..	1.7	.6
21	..	..	..	..	..	..	.2	7.1	..	..	..	..	..	..	..	..	.6	.2
22	..	..	..	..	..	..	.1	3.6	..	..	..	..	..	..	..	..	.8	.3
23	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.6	.2
24	..	..	..	..	..	..	.1	3.6	..	..	..	..	..	..	..	..	.6	.2
25	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
26	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.1	.2
27	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.1	
28	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.1	
29	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.1	
Total	13.2	100	10.5	100	5.0	100	2.8	100	2.9	100	1.6	100	1.3	100	2.8	100	284.5	100
Percentage	4.6		3.7		1.8		1.0		1.0		.6		.4		1.0		100	

Based on 13 sample plots ranging from ¼ to 1 acre in size and totaling 9 acres.

Miscellaneous—Kentucky coffee tree 41%; red cedar 22%; willow 19%; black cherry 11%; and dogwood 7%.

TABLE II

Stock Table

Average Volume per Acre in Cubic Feet, Mixed Hardwood Type, Southeastern Minnesota, 1925*

Diameter breast high, in.	Basswood		Elm		Maple		Red Oak		Largetooth Aspen		Butternut		Hackberry		Black Ash	
	Volume cu. ft.	Per cent	Volume cu. ft.	Per cent	Volume cu. ft.	Per cent	Volume cu ft.	Per cent	Volume cu. ft.	Per cent	Volume cu. ft.	Per cent	Volume cu. ft.	Per cent	Volume cu. ft.	Per cent
4	6.5	.7	4.0	.7	11.8	2.4	2.0	.6	2.8	1.6	1.0	.7	..	..	2.8	3.3
5	12.3	1.3	6.0	1.1	14.6	3.0	6.7	2.1	3.7	2.0	1.6	1.1	.3	.3	4.3	5.1
6	15.3	1.6	9.2	1.7	22.4	4.6	7.1	2.2	1.0	.6	3.0	1.9	1.0	.8	11.2	13.3
7	26.4	2.8	10.8	2.0	23.3	4.8	8.5	2.7	.8	.4	5.4	3.5	.8	.6	13.2	15.7
8	32.7	3.4	22.1	4.1	30.6	6.2	6.3	2.0	3.1	1.7	14.7	9.6	1.0	.8	5.2	6.2
9	46.1	4.9	30.7	5.7	22.3	4.5	12.6	3.9	15.4	8.5	23.7	15.5	1.4	1.0	4.2	5.0
10	68.4	7.2	28.7	5.4	21.6	4.4	14.3	4.4	34.2	18.9	7.1	4.6	..	..	7.1	8.4
11	47.8	5.0	27.3	5.1	25.0	5.1	31.8	9.9	43.3	23.9	11.3	7.4	6.8	5.1	6.8	8.1
12	86.0	9.0	44.2	8.3	27.5	5.6	19.2	6.0	52.8	29.1	16.5	10.8	2.8	2.1	8.2	9.7
13	47.3	5.0	37.2	7.0	37.2	7.6	26.8	8.3	20.1	11.1	20.1	13.1	6.7	5.0	6.7	8.0
14	59.8	6.3	40.0	7.5	27.7	5.6	36.0	11.2	4.0	2.2	23.8	15.5	7.9	5.9	..	..
15	69.7	7.3	37.0	6.9	37.0	7.5	23.1	7.2	..	..	9.2	6.0	4.6	3.4	9.2	10.9
16	53.3	5.6	37.0	6.9	26.4	5.4	31.7	9.9	..	..	15.8	10.3	5.3	4.0	5.3	6.3
17	79.2	8.3	55.0	10.3	36.3	7.4	24.2	7.5	..	..	..	..	6.0	4.5	..	..
18	54.6	5.7	34.1	6.4	6.8	1.4	20.5	6.4	..	..	..	..	20.5	15.4	..	..
19	46.2	4.9	23.1	4.3	7.7	1.6	30.8	9.6	..	..	..	..	15.4	11.6	..	..
20	52.5	5.5	43.7	8.2	17.5	3.6	8.7	2.7	..	..	..	..	8.8	6.6	..	..
21	19.4	2.0	9.7	1.8	9.7	2.0	..	..	..	..	..	..	19.4	14.6	..	..
22	21.8	2.3	21.8	4.1	10.9	2.2	10.9	3.4	..	..	..	..	10.9	8.2	..	..
23	60.5	6.4	..	..	..	..	..	..	..	..	..	..	..	..	..	..
24	26.9	2.8	13.5	2.5	13.5	2.8	..	..	..	..	..	..	13.5	10.1	..	..
25	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
26	..	..	..	..	17.6	3.6	..	..	..	..	..	..	..	..	..	..
27	18.7	2.0	..	..	..	..	..	..	..	..	..	..	..	..	..	..
28	..	..	..	..	20.4	4.1	..	..	..	..	..	..	..	..	..	..
29	..	..	..	..	22.6	4.6	..	..	..	..	..	..	..	..	..	..
Total	951.4	100	535.1	100	490.4	100	321.2	100	181.2	100	153.2	100	133.1	100	84.2	100
Percentage ...	30.7		17.3		15.9		10.4		5.9		4.9		4.3		2.7	

TABLE II—*Continued*

Diameter breast high, in.	Boxelder		Green Ash		Shagbark Hickory		White Oak		Ironwood		Bur Oak		Bitternut Hickory		Miscellaneous		Total	
	Volume cu. ft.	Per cent	Volume cu. ft.	Per cent	Volume cu. ft.	Per cent	Volume cu. ft.	Per cent	Volume cu. ft.	Per cent	Volume cu. ft.	Per cent	Volume cu. ft.	Per cent	Volume cu. ft.	Per cent	Volume cu. ft.	Per cent
4	..	..	1.7	3.0	6.5	12.7	..	..	5.0	30.3	.5	4.7	.7	25.9	.3	1.6	45.6	1.5
5	.7	1.2	4.6	8.1	7.0	13.6	.7	2.4	8.0	48.5	.7	6.5	1.0	37.0	1.0	5.5	73.2	2.4
6	3.5	5.8	1.5	2.7	6.6	12.8	2.5	8.4	2.0	12.1	1.0	9.3	1.0	37.1	.5	2.8	88.8	2.9
7	3.1	5.1	1.5	2.7	13.2	25.7	2.3	7.8	1.5	9.1	.8	7.5	..	..	..	..	111.6	3.6
8	3.1	5.1	4.2	7.4	5.2	10.1	4.2	14.2	..	..	..	..	..	..	..	..	132.4	4.3
9	16.8	27.8	6.9	12.2	4.2	8.2	6.9	23.3	..	..	1.4	13.1	..	..	2.8	15.5	195.4	6.3
10	18.0	29.8	3.6	6.4	3.6	7.0	10.7	36.1	..	..	..	..	..	..	..	..	217.3	7.0
11	9.0	14.9	9.0	15.9	2.3	4.5	2.3	7.8	..	..	2.3	21.5	..	..	..	..	225.0	7.3
12	2.8	4.7	5.5	9.7	2.8	5.4	..	..	..	..	..	..	..	..	2.8	15.5	271.1	8.7
13	3.4	5.6	6.7	11.9	..	..	..	..	..	..	..	..	..	..	6.7	37.0	218.9	7.1
14	..	..	..	..	..	..	..	..	..	..	4.0	37.4	..	..	4.0	22.1	207.2	6.7
15	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	189.8	6.1
16	..	..	5.3	9.4	..	..	..	..	..	..	..	..	..	..	..	..	180.1	5.8
17	..	..	6.0	10.6	..	..	..	..	..	..	..	..	..	..	..	..	206.7	6.7
18	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	136.5	4.4
19	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	123.2	4.0
20	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	131.2	4.2
21	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	58.2	1.9
22	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	76.3	2.5
23	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	60.5	1.9
24	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	67.4	2.2
25	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
26	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	17.6	.6
27	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	18.7	.6
28	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	20.4	.6
29	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	22.6	.7
Total	60.4	100	56.5	100	51.4	100	29.6	100	16.5	100	10.7	100	2.7	100	18.1	100	3095.7	100
Percentage	2.0		1.8		1.6		1.0		.5		.3		.1		.6		100	

Based on 13 sample plots ranging from ¼ to 1 acre in size and totaling 9 acres. Miscellaneous—Kentucky coffee tree; red cedar; willow; black cherry; and dogwood. Volume includes cordwood in tops and branches.

The distribution of the trees per acre by d.b.h. classes is shown in Figure 2. This curve shows that the small sizes are not well represented even in the better woodlots. This is mainly due to grazing.

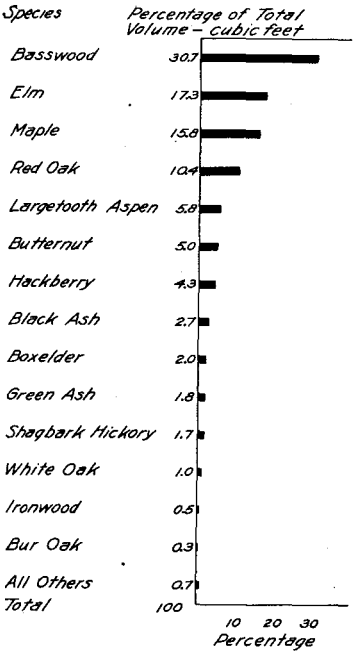

Fig. 1. Proportion of Species in the Stand by Volume
Mixed Hardwood Type

Above 3 inches the diameter classes are well represented. The trend of the curve from this point probably does not vary considerably from the trend of the stand graph of a normal stand of this character. Approximately 90 per cent of the trees are less than 12 inches in diameter.

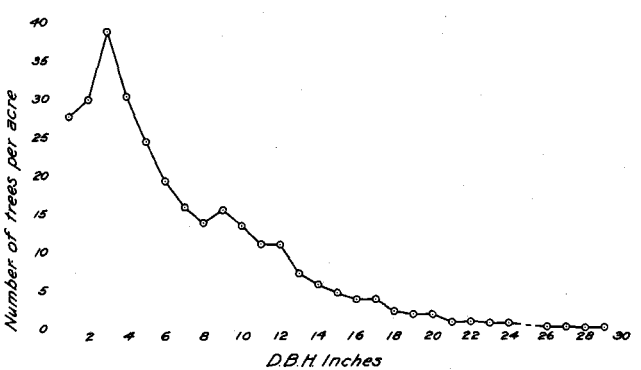

Fig. 2. Average Number of Trees per Acre
Mixed Hardwood Type

Volume

The volume per acre that might be expected in a small, well stocked, and conservatively handled woodlot of this type is shown in Table II. The volume above 4 inches, including the cordwood in tops and branches, is 3100 cubic feet or, using a converting factor of 85 cubic feet to the cord, 36 cords to the acre. If about one third of the volume of the stand above 10 inches is considered sawlog material and there are 6 board feet to the cubic foot, the better woodlots will average 5000 board feet to the acre. The stock graph, Figure 3, shows the distribution of volume per acre in cubic feet by diameter classes. Approximately two thirds of the volume is found in the trees with a diameter 12 inches or over.

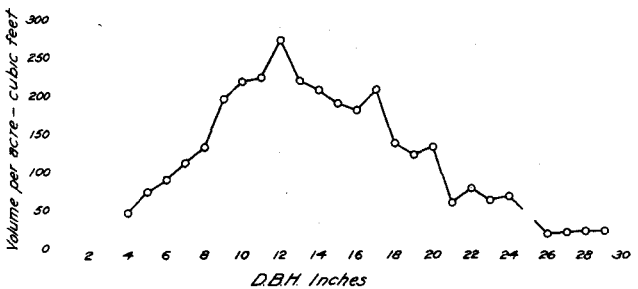

Fig. 3. Average Volume per Acre in Cubic Feet
Mixed Hardwood Type

Growth

The number of years required for each species in the mixed hardwood type to grow one inch in diameter at breast height is shown in Table III and Figure 4. From 4 to 16 inches in diameter, it takes basswood on the average 8 to 7 years to grow one inch in diameter, maple 10 to 9 years, hackberry 9 to 7 years, red oak 10 to 5 years, and bur oak 14 to 6 years. Taking all diameters into consideration, basswood is the most consistently rapid grower. The slowest growing species, according to these curves, are shagbark hickory and hard maple. Red oak and hackberry show the most rapid growth in the larger diameter classes.

TABLE III

NUMBER OF YEARS REQUIRED TO GROW 1 INCH IN DIAMETER BREAST HIGH
MIXED HARDWOOD TYPE, SOUTHEASTERN MINNESOTA

Diameter breast high, in.	Basswood		Maple		Elm		Red Oak		Butternut		Black Ash	
	Years	Basis No. of borings*	Years	Basis No. of borings	Years	Basis No. of borings	Years	Basis No. of borings	Years	Basis No. of borings	Years	Basis No. of borings
3	8.4	3	10.1	4	10.6	..	9.8	2	8.6	1	11.8	3
4	8.1	5	9.9	4	9.9	5	9.7	2	8.6	1	10.9	3
5	7.8	5	9.7	4	9.3	5	9.6	3	8.6	1	10.0	4
6	7.7	8	9.5	5	8.7	7	9.3	3	8.5	3	9.1	5
7	7.6	4	9.4	4	8.2	4	8.8	6	8.4	3	8.6	4
8	7.5	5	9.3	4	7.8	6	8.1	1	8.0	4	8.3	1
9	7.4	4	9.2	4	7.5	7	7.3	2	7.3	3	8.2	1
10	7.4	4	9.1	2	7.4	3	6.6	3	6.8	1	8.0	2
11	7.3	4	9.0	1	7.2	4	6.0	6	6.6	4	7.8	1
12	7.2	5	9.0	1	7.1	3	5.7	3	6.4	1	7.7	2
13	7.2	2	9.0	1	7.1	4	5.4	2	6.4	3	7.6	1
14	7.1	3	8.9	..	7.0	2	5.2	2	6.3	2	7.5	..
15	7.0	4	8.9	..	6.9	3	5.1	1	..	..	7.5	1
16	7.0	1	8.9	1	6.9	3	5.0	1	..	..	..	..
17	6.9	1	..	..	6.8	2	..	..	..	..	..	..
18	6.9	2	..	..	6.8	2	..	..	..	..	..	..
19	6.9	..	..	..	6.8	1	..	..	..	..	..	..
20	6.8	..	..	..	6.8	1	..	..	..	..	..	..
21	6.8	1	..	..	6.7	1	..	..	..	..	..	..
22	..	..	..	..	6.7	1	..	..	..	..	..	..
Total	..	61	..	35	..	64	..	37	..	27	..	..

TABLE III—*Continued*

Diameter breast high, in.	Hackberry		Shagbark Hickory		Green Ash		Bur Oak		Largetooth Aspen		Boxelder		White Oak	
	Years	Basis No. of borings	Years	Basis No. of borings	Years	Basis No. of borings	Years	Basis No. of borings	Years	Basis No. of borings	Years	Basis No. of borings	Years	Basis No. of borings
3 ..	..	..	12.0	1	9.4	1	..	..	8.1	1	..	..	..	..
4 ..	8.3	..	11.6	4	9.2	2	13.7	1	8.1	1	..	..	..	..
5 ..	8.3	1	11.1	4	9.0	1	12.9	..	8.0	1	6.7	1	..	..
6 ..	8.3	1	10.9	3	8.9	1	12.1	1	7.9	..	6.7	1	17.9	1
7 ..	8.3	..	10.5	3	8.7	1	11.4	..	7.8	1	6.6	1	14.1	1
8 ..	8.3	..	10.3	2	8.6	2	10.6	..	7.6	1	6.5	1	11.6	1
9 ..	8.3	1	10.3	3	8.4	1	9.9	1	7.2	1	6.4	1	10.0	1
10 ..	8.2	..	10.2	1	8.2	1	9.1	..	6.6	1	6.2	1	8.7	1
11 ..	8.2	2	10.2	1	8.1	1	8.4	1	6.2	1	6.0	1	..	..
12 ..	8.0	1	..	..	..	..	7.7	..	6.0	1	5.7	1	..	..
13 ..	7.8	1	..	..	..	..	7.0	..	5.8	1	5.4	1	..	..
14 ..	7.5	2	..	..	..	..	6.2	1	..	..	..	..	..	..
15 ..	7.2	1	..	..	..	..	..	..	..	..	..	..	..	..
16 ..	6.7	..	..	..	..	..	..	..	..	..	..	..	..	..
17 ..	6.3	1	..	..	..	..	..	..	..	..	..	..	..	..
18 ..	5.9	2	..	..	..	..	..	..	..	..	..	..	..	..
19 ..	5.5	1	..	..	..	..	..	..	..	..	..	..	..	..
20 ..	5.2	..	..	..	..	..	..	..	..	..	..	..	..	..
21 ..	4.8	1	..	..	..	..	..	..	..	..	..	..	..	..
22 ..	4.4	1	..	..	..	..	..	..	..	..	..	..	..	..
Total .	..	16	..	22	..	11	..	5	..	12	..	9	..	5

* Based on the width of the last 15 rings at breast height.

The curves for the oaks show the most pronounced effect of competition on the growth of the small trees, while basswood and hard maple show very little. This may be one of the contributing causes of the abundance of the latter species in this type and the absence of the oaks. Data for the oaks in this type are very scanty, however. This may explain in part the wide difference in the rate of growth between the small and large trees. The same tendency, altho not so pronounced, is shown in the growth curves for these species in the oak type. In this case it is not due to insufficient data.

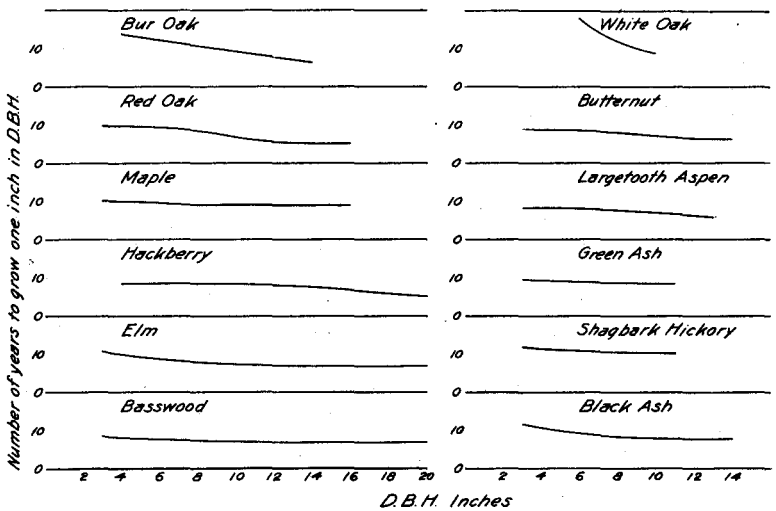

Fig. 4. Number of Years Required to Grow One Inch in Diameter Breast High Mixed Hardwood Type

The growth of the selected mixed hardwood woodlots may be taken as an indication of what might be expected in a managed woodlot of this type. The stands measured show a periodic annual growth of 76 cubic feet or nine-tenths of a cord per acre. Assuming the same conditions as before, the growth of the saw log material would be 120 board feet to the acre. Table IV and Figure 5 show the total periodic annual growth per acre of this type and the proportion of the growth made by each species.

TABLE IV

PERIODIC ANNUAL GROWTH PER ACRE IN CUBIC FEET
MIXED HARDWOOD TYPE
SOUTHEASTERN MINNESOTA

Species	Periodic annual growth†	Percentage of total growth
	cu. ft.	
Basswood	22.1	29.0
Elm	11.4	15.0
Maple	10.4	13.6
Red Oak	9.4	12.3
Largetooth Aspen	5.8	7.6
Butternut	4.5	5.9
Hackberry	2.9	3.8
Black Ash	2.5	3.3
Boxelder	2.2	2.9
Shagbark Hickory	1.7	2.3
Green Ash	1.6	2.1
White Oak	0.8	1.0
Bur Oak	0.3	0.4
All others‡	0.6	0.8
Total	76.2	100

Based on 13 sample plots ranging from ¼ to 1 acre in size and totaling 9 acres.
† Volume includes cordwood in tops and branches.
‡ Kentucky Coffee Tree, Red Cedar, Willow, Black Cherry, and Dogwood.

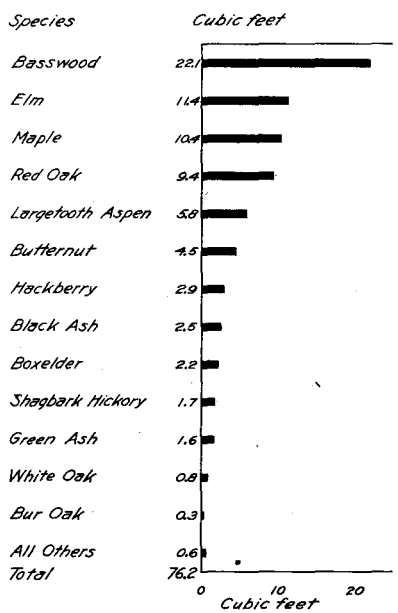

Fig. 5. Periodic Annual Growth per Acre in Cubic Feet
Mixed Hardwood Type

Choice of Species

The following species could be advantageously eliminated from the mixed hardwood type because of either slow growth or poor quality: Ironwood, dogwood, willow, red cedar, boxelder, bitternut hickory, and probably hackberry, butternut, and white oak.

The hackberry had made a remarkably good growth, but the wood is of doubtful value. Butternut also grows fairly rapidly but walnut is more valuable and should be favored when it occurs, rather than the butternut. Bur oak showed so much better growth than white oak on the plots studied that it seems to be the more profitable tree to grow. This is only an indication, and the data are too scanty to support a positive recommendation.

Strangely enough, no black walnut was found on the plots studied, and yet it occurs in considerable quantities throughout the region. It has undoubtedly been culled from many of the woodlots. Possibly the explanation lies in the density of the stands in the plots.

If the above policy were carried out, the following species would be favored in the mixed hardwood type: Basswood, red oak, burr oak, largetooth aspen, shagbark hickory, Kentucky coffee tree, black cherry, and black walnut. These are all desirable species and there is a sufficient variety fully to utilize the site.

B. Oak Type

Composition

Practically all the species found in the mixed hardwood type are found also in the oak type, where the oaks are the principal species on both a numerical and a volume basis. Tables V and VI show the average composition of the plots selected and probably represent fairly well the composition of the average woodlot of this type. Red oak is by far the most common tree. Of the total number of trees 0.6 inch and over in diameter, red oak makes up 45 per cent, while white oak comprises only 11 per cent. Altho represented only in diameter classes of less than 9 inches, ironwood makes up 11 per cent of the trees in the stand. Aspen, which was practically absent in the mixed hardwood type, makes up 9 per cent of the total number of trees above 0.6 inches. Maple, basswood, and elm, abundant in the hardwood type, are not common in the oak type and make up only 0.6, 4, and 3 per cent, respectively, of the number of trees. The three oaks, red, white, and bur, comprise 63, 19, and 6 per cent, or 88 per cent of the total cubic volume. The combined volumes of basswood, elm, and hard maple represent only 3 per cent of the stand. Figure 6 shows the proportion by volume of each species in the stand.

TABLE V

STAND TABLE

AVERAGE NUMBER OF TREES PER ACRE, OAK TYPE, SOUTHEASTERN MINNESOTA, 1925

Diameter breast high, in.	Red Oak		White Oak		Ironwood		Aspen		Bur Oak		Basswood		Elm		Butternut	
	No. of trees	Per cent	No. of trees	Per cent	No. of trees	Per cent	No. of trees	Per cent	No. of trees	Per cent	No. of trees	Per cent	No. of trees	Per cent	No. of trees	Per cent
1	.2	.2	.4	1.5	1.8	7.2	4.2	20.2	..	..	1.4	15.9	3.0	45.5	.4	7.1
2	.8	.8	.8	3.1	6.8	27.2	.4	1.9	.4	2.9	.2	2.3	1.4	21.2	.2	3.6
3	1.2	1.2	1.4	5.4	11.8	47.2	1.6	7.7	.4	2.9	1.2	13.6	.2	3.0	.2	3.6
4	1.0	1.0	.6	2.3	3.4	13.6	3.6	17.3	1.4	10.1	1.2	13.6	.8	12.1	1.4	25.0
5	5.0	4.8	1.0	3.9	1.0	4.0	3.4	16.3	2.4	17.4	1.2	13.6	.6	9.1	.6	10.7
6	7.2	6.9	.8	3.1	..	..	2.4	11.5	2.0	14.5	1.0	11.4	.2	3.0	.4	7.1
7	8.2	7.9	1.2	4.6	..	..	2.4	11.5	1.0	7.2	.6	6.8	..	..	.4	7.1
8	11.4	11.0	2.0	7.8	0.2	.8	1.4	6.7	.6	4.4	.2	2.3	..	..	.2	3.6
9	13.2	12.7	2.0	7.8	..	..	.2	1.0	1.6	11.4	.4	4.5	..	..	.2	3.6
10	11.4	11.0	3.0	11.6	..	..	.6	2.9	2.2	15.9	.2	2.3	.2	3.0	.2	3.6
11	9.6	9.2	3.0	11.6	..	..	.2	1.0	.2	1.5	..	..	..	..	.2	3.6
12	10.8	10.4	1.4	5.4	..	..	.2	1.0	.2	1.5	.4	4.5	..	..	.2	3.6
13	9.0	8.7	2.2	8.5	..	..	.2	1.0	.2	1.5	.2	2.3	.2	3.0	.6	10.7
14	5.0	4.8	1.2	4.6	..	..	..	..	.2	1.5	.4	4.6	..	..	.2	3.6
15	2.4	2.3	1.0	3.9	..	..	..	..	..	..	.2	2.3	..	..	..	..
16	3.2	3.1	1.0	3.9	..	..	..	..	..	..	..	..	..	..	..	..
17	1.0	1.0	0.8	3.1	..	..	..	..	.4	2.9	..	..	..	..	.2	3.5
18	1.6	1.5	0.4	1.6	..	..	..	..	..	..	..	..	..	..	..	..
19	.8	.8	1.0	3.9	..	..	..	..	..	..	..	..	..	..	..	..
20	.2	.2	.2	.8	..	..	..	..	.2	1.4	..	..	..	..	..	..
21	.4	.4	..	..	..	..	..	..	..	..	..	..	..	..	..	..
22	.2	.2	.4	1.6	..	..	..	..	.2	1.4	..	..	..	..	..	..
23	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
24	..	..	..	..	..	..	..	..	.2	1.4	..	..	..	..	..	..
Total	103.8	100	25.8	100	25.0	100	20.8	100	13.8	100	8.8	100	6.6	99.9	5.6	100
Percentage	44.9	.1	11.1		10.8		9.0		6.0		3.8		2.8		2.4	

TABLE V—*Continued*

Diameter breast high, in.	Largetooth Aspen		Shagbark Hickory		Black Ash		Black Cherry		Yellow Birch		Cottonwood		Hard Maple		Miscellaneous		Total	
	No. of trees	Per cent	No. of trees	Per cent	No. of trees	Per cent	No. of trees	Per cent	No. of trees	Per cent	No. of trees	Per cent	No. of trees	Per cent	No. of trees	Per cent	No. of trees	Per cent
1	.4	8.0	..	..	..	..	.2	6.7	..	..	..	..	.6	42.8	.2	14.3	12.8	5.5
2	.2	4.0	..	..	.4	12.5	.4	13.3	.4	22.2	.2	12.5	..	..	.8	57.1	13.4	5.8
3	.2	4.0	1.0	26.3	1.2	37.5	.4	13.3	.4	22.2	..	..	.2	14.3	.2	14.3	21.6	9.3
4	.4	8.0	.8	21.1	.6	18.8	.2	6.7	..	..	..	..	..	..	.2	14.3	15.6	6.7
5	.2	4.0	.4	10.5	..	..	..	..	.4	22.2	..	..	..	..	..	..	16.2	7.0
6	.4	8.0	.4	10.5	..	..	.4	13.3	..	..	..	..	.2	14.3	..	..	15.4	6.7
7	1.4	28.0	.4	10.5	.2	6.3	.4	13.3	.2	11.1	.2	12.5	..	..	..	..	16.6	7.2
8	.4	8.0	.4	10.5	..	..	.4	13.3	.2	11.1	.4	25.0	..	..	..	..	17.8	7.7
9	.4	8.0	..	..	..	..	..	..	.2	11.1	.2	12.5	..	..	..	..	18.4	8.0
10	.4	8.0	.4	10.5	.4	12.5	.4	13.3	..	..	.2	12.5	..	..	..	..	19.6	8.5
11	.2	4.0	..	..	.2	6.2	..	..	..	..	.2	12.5	..	..	..	..	13.8	6.0
12	.4	8.0	..	..	.2	6.2	.2	6.7	..	..	..	..	..	..	..	..	14.0	6.0
13	..	..	..	..	..	..	..	..	..	..	.2	12.5	..	..	..	..	12.8	5.5
14	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	7.0	3.0
15	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3.6	1.6
16	..	..	..	..	..	..	..	..	..	..	..	..	.2	14.3	..	..	4.4	1.9
17	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2.4	1.0
18	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2.0	.9
19	..	..	..	..	..	..	..	..	..	..	..	..	.2	14.3	..	..	2.2	.9
20	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.4	.2
21	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.4	.2
22	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.8	.3
23	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
24	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.2	.1
Total	5.0	100	3.8	99.9	3.2	100	3.0	99.9	1.8	99.9	1.6	100	1.4	100	1.4	100	231.4	100
Percentage	2.2		1.6		1.4		1.3		.8		.7		.6		.6		100	

Based on 7 sample plots ranging from ¼ to 1 acre in size and totaling 5 acres. Miscellaneous—dogwood, bitternut hickory, and boxelder.

TABLE VI

STOCK TABLE

AVERAGE VOLUME PER ACRE IN CUBIC FEET, OAK TYPE, SOUTHEASTERN MINNESOTA, 1925

Diameter breast high, in.	Red Oak		White Oak		Bur Oak		Aspen		Basswood		Butternut		Largetooth Aspen		Hard Maple	
	Volume cu. ft.	Per cent	Volume cu. ft.	Per cent	Volume cu. ft.	Per cent	Volume cu ft.	Per cent	Volume cu. ft.	Per cent	Volume cu. ft.	Per cent	Volume cu. ft.	Per cent	Volume cu. ft.	Per cent
4	1.5	.1	0.9	.1	2.1	1.1	5.4	6.4	1.8	2.8	2.1	3.4	.6	1.4	.9	3.5
5	15.0	.7	3.0	.5	7.2	3.8	10.2	12.1	3.6	5.7	1.8	2.9	.6	1.4	..	..
6	33.1	1.6	3.7	.6	9.2	4.8	11.0	13.1	4.6	7.3	1.8	2.9	1.8	4.3	.9	3.6
7	57.4	2.8	8.4	1.4	7.0	3.7	16.8	2.0	4.2	6.6	2.8	4.5	9.8	23.2	..	..
8	108.3	5.4	19.0	3.2	5.7	3.0	13.3	15.8	1.9	3.0	1.0	3.1	3.8	9.0	..	..
9	166.3	8.2	25.2	4.2	20.2	10.6	2.5	3.0	5.0	8.0	2.5	4.1	5.0	11.9	..	..
10	184.7	9.1	48.6	8.1	35.6	18.8	9.7	11.6	3.2	5.1	3.2	5.3	6.5	15.4	..	..
11	196.8	9.7	61.5	10.3	4.1	2.2	4.1	4.9	..	..	4.1	6.6	4.1	9.7	..	..
12	270.0	13.4	35.0	5.8	5.0	2.7	5.0	5.9	10.0	15.8	5.0	8.1	10.0	23.7	..	..
13	274.5	13.6	67.1	11.2	6.1	3.2	6.1	7.3	6.1	9.6	18.3	29.6	..	..	..	..
14	180.0	8.9	43.2	7.2	7.2	3.8	..	..	14.4	22.7	7.2	11.7	..	..	..	..
15	100.8	5.0	42.0	7.0	..	..	..	..	8.4	13.3	..	..	..	..	..	..
16	153.6	7.6	48.0	8.0	..	..	..	..	..	..	..	..	..	..	9.6	37.8
17	55.0	2.7	44.0	7.3	22.0	11.6	..	..	..	..	11.0	17.8	..	..	..	..
18	99.2	4.9	24.8	4.1	..	..	..	..	..	..	..	..	..	..	..	..
19	56.0	2.8	70.0	11.7	14.0	7.4	..	..	..	..	..	..	..	..	14.0	55.1
20	15.9	.8	15.9	2.7	..	..	..	..	..	..	..	..	..	..	..	..
21	35.2	1.7	..	..	..	..	..	..	..	..	..	..	..	..	..	..
22	19.8	1.0	39.6	6.6	19.8	10.4	..	..	..	..	..	..	..	..	..	..
23	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
24	..	..	..	..	24.5	12.9	..	..	..	..	..	..	..	..	..	..
Total	2023.1	100	599.9	100	189.7	100	84.1	100	63.2	100	60.8	100	42.2	100	25.4	100
Percentage ...	63.3		18.8		6.0		2.6		2.0		1.9		1.3		.8	

TABLE VI--*Continued*

Diameter breast high, in.	Cottonwood		Black Cherry		Black Ash		Shagbark Hickory		Elm		Ironwood		Yellow Birch		Bitternut Hickory		Total	
	Volume cu. ft.	Per cent	Volume cu. ft.	Per cent	Volume cu. ft.	Per cent	Volume cu. ft.	Per cent	Volume cu. ft.	Per cent	Volume cu. ft.	Per cent	Volume cu. ft.	Per cent	Volume cu. ft.	Per cent	Volume cu. ft.	Per cent
4	..	..	0.3	1.5	0.9	5.1	1.2	6.9	1.2	9.1	5.1	51.0	..	..	0.3	100.0	24.3	.8
5	..	..	..	..	..	..	1.2	6.9	1.8	13.6	3.0	30.0	1.2	17.1	..	..	48.6	1.5
6	..	..	1.8	9.1	..	..	1.8	10.6	.9	6.8	..	..	..	..	..	..	70.6	2.2
7	1.4	6.6	2.8	13.9	1.4	7.8	2.8	16.2	..	..	..	..	1.4	20.0	..	..	116.2	3.6
8	3.8	17.9	3.8	18.8	..	..	3.8	21.9	..	..	1.9	19.0	1.9	27.2	..	..	168.2	5.3
9	2.5	11.9	..	..	..	..	..	..	..	..	..	..	2.5	35.7	..	..	231.7	7.3
10	3.2	15.3	6.5	32.0	6.5	36.3	6.5	37.5	3.2	24.3	..	..	..	..	..	..	317.4	9.9
11	4.1	19.4	..	..	4.1	22.9	..	..	..	..	..	..	..	..	..	..	282.9	8.8
12	..	..	5.0	24.7	5.0	27.9	..	..	..	..	..	..	..	..	..	..	350.0	11.0
13	6.1	28.9	..	..	..	..	..	..	6.1	46.2	..	..	..	..	..	..	390.4	12.2
14	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	252.0	7.9
15	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	151.2	4.7
16	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	211.2	6.6
17	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	132.0	4.1
18	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	124.0	3.9
19	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	154.0	4.8
20	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	31.8	1.0
21	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	35.2	1.1
22	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	79.2	2.5
23	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
24	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	24.5	.8
Total	21.1	100	20.2	100	17.9	100	17.3	100	13.2	100	10.0	100	7.0	100	0.3	100	3195.4	100
Percentage	.7		.6		.6		.5		.4		.3		.2		.0		100.0	

Based on 7 sample plots ranging from ¼ to 1 acre in size and totaling 5 acres.

The oaks, altho they predominate in the main stand, are not abundant in the young growth. Red and white oak each make up about 5 per cent and bur oak 2 per cent of the trees between 0.6 and 3 inches in diameter. Ironwood is the most common species, making up 42 per cent of the trees in these diameter classes. Six per cent of these saplings are basswood; while maple, which made up 33 per cent of the young growth in the mixed hardwood type, is practically absent.

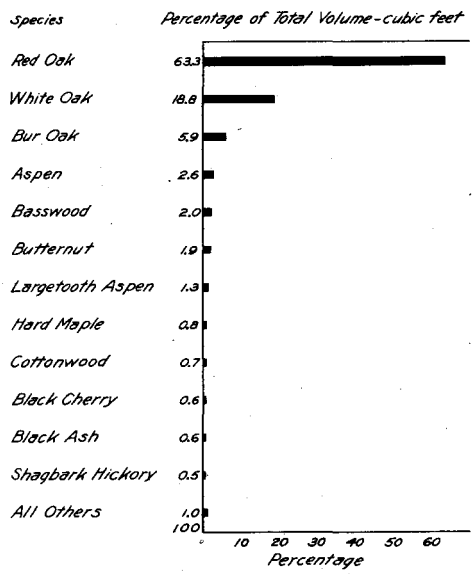

Fig. 6. Proportion of Species in the Stand by Volume Oak Type

Figure 7 shows the distribution of trees by classes. This curve shows that there is a lack of trees not only in the small, but in the medium sizes. In the oak type, this deficiency is even greater than in the mixed hardwood type. Over 80 per cent of the number of trees in the oak type are less than 12.5 inches d.b.h.

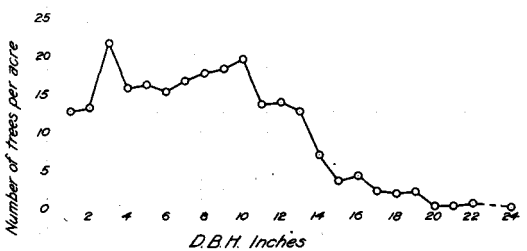

Fig. 7. Average Number of Trees per Acre Oak Type

Volume

Well stocked woodlots of the oak type have about the same volume per acre as those of the mixed hardwood type. Table VI shows a volume, including tops and branches, of 3200 cubic feet, or 38 cords per acre. Assuming the same proportion of saw-log material as in the mixed hardwoods, the oak woodlots have about the same volume

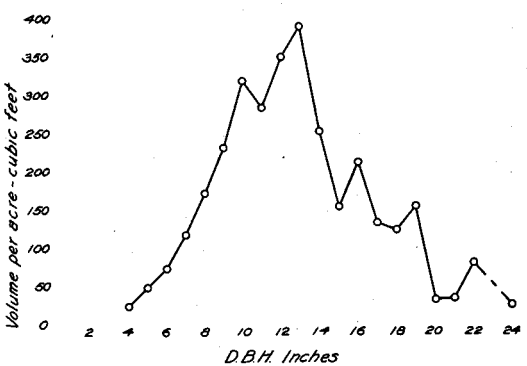

Fig. 8. Average Volume per Acre in Cubic Feet Oak Type

per acre—about 5000 board feet. Figure 8 shows the distribution of the cubic volume for all species by diameter classes. These volumes are probably a fair indication of the growing stock which might be expected in oak woodlots that are conservatively handled.

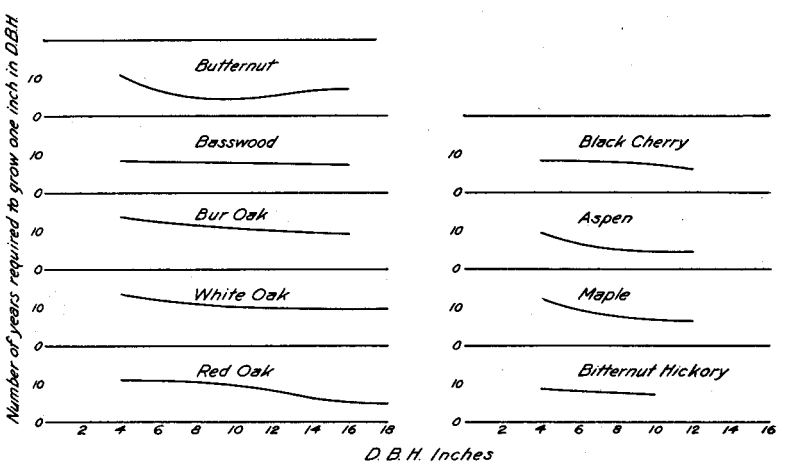

Fig. 9. Number of Years Required to Grow One Inch in Diameter Breast High Oak Type

TABLE VII

NUMBER OF YEARS REQUIRED TO GROW ONE INCH IN DIAMETER BREAST HIGH

OAK TYPE

SOUTHEASTERN MINNESOTA

Diameter breast high, in.	Red Oak		White Oak		Bur Oak		Basswood		Bitternut Hickory		Maple		Aspen		Butternut		Black Cherry	
	Years	Basis No. of borings*	Years	Basis No. of borings*	Years	Basis No. of borings*	Years	Basis No. of borings*	Years	Basis No. of borings*	Years	Basis No. of borings*	Years	Basis No. of borings*	Years	Basis No. of borings*	Years	Basis No. of borings*
4	11.1	2	13.6	1	13.8	3	8.5	1	8.6	2	12.5	1	9.4	..	11.0	1	8.3	1
5	11.1	3	12.9	3	13.1	3	8.4	..	8.3	1	10.8	..	8.3	1	8.2	1	8.2	..
6	11.0	6	12.3	1	12.6	5	8.2	1	8.1	2	9.1	2	7.0	1	6.6	1	8.1	1
7	10.9	5	11.8	3	12.0	2	8.1	1	7.9	2	8.2	1	5.7	2	5.6	2	7.9	2
8	10.5	6	11.0	3	11.5	2	8.1	1	7.8	1	7.4	1	5.0	2	4.9	..	7.7	2
9	10.1	8	10.6	3	11.0	2	8.0	2	7.4	..	7.0	1	4.7	1	4.6	1	7.4	..
10	9.5	7	10.2	3	10.7	1	8.0	1	7.2	1	6.8	1	4.6	1	4.6	..	7.2	2
11	8.9	7	10.0	2	10.2	1	7.9	1	..	..	6.7	1	4.5	..	4.8	1	6.8	..
12	8.1	7	9.9	2	10.0	1	7.8	1	..	..	6.5	..	4.5	1	5.4	2	6.2	1
13	7.4	7	9.8	1	9.8	1	7.6	2	..	..	..	..	..	..	6.1	2	..	..
14	6.3	8	9.8	1	9.6	1	7.4	1	..	..	..	..	..	..	6.6	1	..	..
15	5.5	4	9.8	1	9.5	..	7.3	2	..	..	..	..	..	..	7.0	1	..	..
16	5.0	7	9.8	1	9.4	..	7.2	1	..	..	..	..	..	..	7.3	1	..	..
17	4.9	2	9.7	2	..	1	..	1	..	..	..	..	..	..	..	..	..	..
18	4.9	3	9.6	1	..	..	..	1	..	..	..	..	..	..	..	..	..	..
19	4.9	1	9.5	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..
20	4.9	2	9.4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
21	..	1	9.3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
22	..	1	9.2	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total		87		31		23		17		9		8		9		14		10

* One boring per tree.

Growth

The number of years required for each species of the oak type to grow one inch in diameter at breast height is shown in Table VII and Figure 9. Of the three oaks, red oak grows fastest, especially in the larger diameter classes. Above 15 inches it often shows a growth of over two inches in radius in 15 years. For comparable d.b.h. classes, i.e., 4 to 16 inches, the range in the number of years required to grow one inch in diameter for red oak is 11 to 5 years, and for white and bur oak 14 to 9 years. In the large sizes, red oak is the most rapid growing species in this type, and popple and butternut show a fairly rapid rate of growth. White and bur oak are the slowest growers; and basswood is the most consistent grower for all diameter classes. These curves show that the growth in diameter of the oak saplings is retarded by the competition of other species. The apparent wide variation in diameter growth of the small and large sizes of hard maple may be due to insufficient data.

The periodic annual growth per acre in cubic feet of the oak type for the last 15 years is shown in Table VIII and Figure 10. These figures indicate an annual growth of 74 cubic feet, or 0.9 cord from well stocked, properly handled oak woodlots. The growth of saw-log material is practically the same as in the mixed hardwood type—120 board feet per acre. Red and white oak, because of the large proportion of the volume they make up, comprise 59 and 17 per cent of the growth per acre in cubic feet of the stand above 4 inches.

TABLE VIII

PERIODIC ANNUAL GROWTH PER ACRE IN CUBIC FEET
OAK TYPE
SOUTHEASTERN MINNESOTA

Species	Periodic annual growth	Percentage of total growth
	cu. ft.	
Red Oak	43.1	58.6
White Oak	12.2	16.6
Aspen	4.2	5.7
Bur Oak	4.1	5.6
Butternut	2.0	2.7
Basswood	1.7	2.3
Black Cherry	0.7	0.9
All others*	5.6	7.6
Total	73.6	100

Based on 7 sample plots ranging from ¼ to 1 acre in size and totaling 5 acres. Volume includes cordwood in tops and branches.
* Elm, ironwood, yellow birch, bitternut hickory.

Choice of Species

The following species probably could be advantageously eliminated from the oak type on account of slow growth or poor quality: Aspen, elm, boxelder, cottonwood, ironwood, black ash, hard maple, dog-

wood, bitternut hickory, white and bur oak. This would leave a stand of red oak, shagbark hickory, black cherry, basswood, yellow birch, butternut, and largetooth aspen.

Hard maple is a valuable tree, but its growth is usually so slow that it seems inadvisable to encourage it except where its tolerance is needed, or where it is to be used for the production of maple syrup and sugar. Red oak, black cherry, shagbark hickory, and yellow birch are all valuable trees and with the exception of shagbark hickory their growth is fairly rapid. They should consequently be encouraged in every way possible.

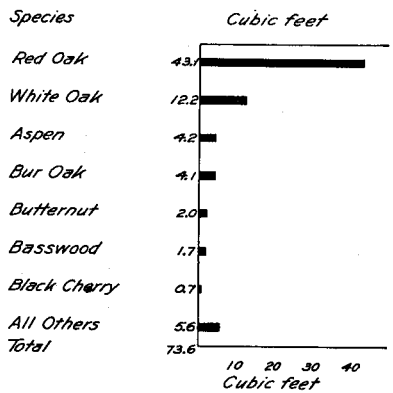

Fig. 10. Periodic Annual Growth per Acre in Cubic Feet Oak Type

In general, red oak in the larger diameters makes the most rapid growth. Butternut, elm, and largetooth aspen are also vigorous growers. The splendid development of the last species in one place in the vicinity of Rochester was very striking; it dominated the stand and had attained a height of 90 feet and a maximum diameter of 14 inches. It was apparently sound, straight, and clear for about three-fourths of its total height.

Fire Hazard

As previously stated, the fire hazard is slight. Very few of the woodlots studied showed any evidence of severe fires. There seems to be only one serious source of fire now and that will probably become more serious as time goes on unless some measures are taken to prevent it. The automobile has tremendously increased the number of picnickers and in many sections the farm woodlots offer the most inviting opportunities. Camp fires may be a serious menace.

Effect of Grazing

In both types the effect of grazing on reproduction was very marked. Where stock had been kept out, even for the last three or four years, considerable young growth was coming in. Reproduction was entirely lacking where the woodlots were grazed. In some stands which had been grazed for several years there were no trees less than 3 inches in diameter. On one plot there were no trees under 6 inches and on another none under 9 inches. The data collected in this survey show that the prohibition of grazing is essential to successful reproduction in the woodlots of southeastern Minnesota.

In some places where the crown density was below 6, the sod had formed to such a depth as to be a serious obstacle to reproduction.

Value and Future Possibilities

Owners expressed a great diversity of opinion in regard to the value of their woodlots. Some considered the woodlot to be a valuable adjunct to the farm; others laughed at the idea of its having a value and said they would be better off if someone would log it for them and take it away. Some thought the taxes on it amounted to more than it was worth.

This difference of opinion is due more to difference in point of view than to any actual difference in economic conditions. For example, one man classed his woodlot as absolutely worthless. His neighbor, who had a poorer woodlot, valued his very highly. He said he made a neat little sum every winter from the sale of cordwood, and in addition had obtained from his woodlot all the hardwood finish for his home and all the framing for his barn. In fact, one man who declared his woodlot worthless because there was no market for the products admitted in the next breath that it had supplied him with nearly all the lumber for his new home.

It was generally conceded that there was a cordwood market of from $7.00 to $11 per cord, according to the species and locality but, strangely enough, such a market was considered of no value. Yet this probably represented an opportunity more attractive than some others which they considered good. This attitude may be due to their failure to realize that this cut could be repeated every year; that it means the opportunity for him and his team to earn a labor income of $6.00 a day, and that at a time of year when both would otherwise be idle.

If the present average stand of timber in the 724,800 acres of woodland in these fifteen counties is taken as half of the stand shown in these stand tables for selected areas, and if 85 cubic feet are taken as a cord, it would mean an aggregate stand of 13,430,000 cords, a

very respectable figure. At half of the growth shown by these plots, this region would produce 320,000 cords of wood annually and continually; slightly less than a half cord per acre each year.

If we value this merchantable product at $8.00 per cord, the annual value of this crop is $2,500,000. Probably three fourths of this would represent wages of man and team and one fourth, or about $640,000, would be net profit and stumpage. This means that each acre of woodlot would pay annually for labor $2.65, in addition to 88 cents net for stumpage and profit.

These woodlots, as a whole, in addition to being of potential productive value to the owner, play an important rôle in controlling erosion; especially where they occur on hillsides. A properly managed woodlot has a continuous soil cover, less rapid run-off, less erosion, and consequently less silting in the streams. Individually, the effect may not be great but in the aggregate they are not without some influence (difficult to evaluate), on flood conditions in the Mississippi drainage basin. Well managed woodlots on all the watersheds of streams in the Upper Mississippi Valley would contribute materially to a rational system of flood control.

By proper management of the woodlots, as indicated by these well stocked plots, these returns could be easily more than doubled. The better stands are producing that much now. The intelligent farmer can increase this still more by proper care in weeding out slow growing species and replacing them with fast growing species; by cutting out overmature trees and giving young growth a chance; by filling in the blank spaces and thus increasing the density of the stand; by prohibiting grazing and permitting young growth to come in; by using good judgment in the cutting and marketing of this crop. Much more study will be needed before our woodlots can be intelligently handled, but this preliminary work is enough to show that the wood crop in Southeastern Minnesota is not to be despised, as it has been in the past. Here is an opportunity to make over 22 per cent of the land on the farms in Southeastern Minnesota—lands which are now in many cases considered worthless—produce a net annual revenue of from $1.50 to $2.00 per acre, with very little labor other than the harvesting of the crop.