



NATURAL REGENERATION ON A FORTY-FIVE ACRE  
OAK-MIXED HARDWOOD AREA SEVEN YEARS  
AFTER "COMMERCIAL" CLEAR CUTTING

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Thesis for the Degree of M. S.  
MICHIGAN STATE UNIVERSITY

Alvin Donald Gammon

1958





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NATURAL REGENERATION ON A FORTY-FIVE ACRE  
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By

ALVIN DONALD GAMMON

AN ABSTRACT

Submitted to the College of Agriculture  
Michigan State University of Agriculture and  
Applied Science in partial fulfillment of  
the requirements for the degree of

MASTER OF SCIENCE

Department of Forestry

1958

APPROVED

U. J. Rudolph



Alvin D. Gammon

#### ABSTRACT

In spite of the importance of the oak type in Michigan, there is a dearth of information concerning the effects of various cutting practices on oak regeneration.

While clear cutting rarely has been recommended for managing oak in Michigan, there is a need for exploring the ecological changes that occur when oak stands are removed by clear cutting.

The purpose of this study is to ascertain the development of natural regeneration following clear cutting of an excellent forty-five acre mature oak-mixed hardwood stand in 1950, in Ionia County, Michigan.

Forty-six mil-acre plots were located throughout the cutover area in 1952. Tree reproduction was diagrammed and tallied by species and height in inches. The plots were re-examined in 1953, 1955, and 1957.

Substantial changes in the composition of the stand occurred as a result of the logging. The composition of the stand before logging was red and white oak, sugar maple, hickory, yellow-poplar, elm, white ash and red maple. By 1957, the reproduction in order of abundance was white ash, sugar maple, American elm, red maple, black cherry, red oak and yellow-poplar.

Seedling reproduction sufficient to restock the area originated within the first two years after logging. The number of seedlings increased in the third year after logging. By 1955, the number present had decreased below the number present in 1952. There was a further decrease in 1957. The majority of the seedlings present in the three

re-examinations were survivors from the first examination in 1952. Reproduction of sprout origin, principally of red oak, was only 8.6 percent of the total reproduction in 1952, and it decreased with each subsequent examination.

The reproduction of sprout origin made the best height growth, increasing from an average of 29 inches in 1952, to an average height of 144 inches in 1957. The average height of the seedlings increased from 9 inches to 41 inches during this period.

Fluctuations occurring within the number and distribution of seedlings present by species, between the examinations, indicate that the reproduction is not yet fully established; however, there were 2,390 seedlings per acre classed as small saplings in 1957, indicating that partial establishment has been achieved by all species in the seventh year after logging.

The percentage of stems browsed by rabbits increased regularly from three percent in 1952, to 36 percent in 1957. Red maple and red oak were the species browsed the most by 1957, with 67 percent and 66 percent of the stems browsed, respectively. This severe browsing is reflected by their slight increases in height. Between 1952 and 1957, the total average height growth was from eight to 19 inches for red maple and from six to 12 inches for red oak.

The percentage of red oak of the total seedlings was relatively stable for the four examinations, being 6 percent for the first three examinations and 8 percent in the fourth examination.



The significance of the developments observed in this study indicate that clear cutting oak-mixed hardwood stands is suitable for obtaining adequate natural regeneration to form the next stand; however, it will result in substantial species composition changes with the oaks, hickories, and yellow-poplars being reduced to minor components of the regenerated stand.

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## CHAPTER I

### INTRODUCTION

A knowledge of natural reproduction is the key to the successful development of forests and to methods of silvicultural management and protection. Fifty years ago Henry S. Graves (1908) said that the study of natural reproduction constituted one of the most important lines of research of the American forester. This statement is still as true today as it was then.

In 1954, the cut in the hardwood forests of Michigan was 390 million board feet. Approximately nine percent of this volume, thirty-three million board feet, was red oak (Quercus rubra L.). The volume of red oak was exceeded by sugar maple (Acer saccharum March.), yellow birch (Betula Alleghaniensis Britton), the aspens (Populus grandidentata Michx.) and (P. tremuloides Michx.), and two elms (Ulmus americana L.) and (U. rubra Muhl.), in that order, Horn (1957).

In spite of the importance of the oak type, there is a dearth of information concerning the effect of various cutting practices and supplementary cultural measures on oak regeneration.

For lack of accepted guides, trial-and-error silvicultural methods have been used in harvesting and attempting to regenerate oak woodlands in Michigan. On the assumption that selection cuttings are not applicable to mature stands which are typically even-aged, usually some modification of the shelterwood system has been employed. While clear cutting rarely has been recommended for managing oak in Michigan,

there is a definite need for exploring the ecological changes that occur when such stands are removed by clear cutting.

The purpose of this study is to ascertain the development of natural regeneration following clear cutting of an excellent 45-acre mature oak-mixed hardwood stand in 1950 in Ionia County, Michigan.

## CHAPTER II

### REVIEW OF LITERATURE

Although there have been many investigations made of the natural regeneration of hardwoods in the forest of the northeast and the south, only a few investigators have studied the reproduction of the oak and mixed hardwood forests of the Lake States. In this region, most of the reproduction studies have been in the northern hardwood type.

#### I. HARDWOOD REPRODUCTION STUDIES IN THE LAKE STATES

Oak-Mixed Hardwoods. Gysel and Arend (1953), studying oak sites in southern Michigan, found that in mature stands, on very good sites, oaks were represented by only four percent of the total number of trees of reproduction size. The remaining 96 percent of the tree reproduction included black cherry (Prunus serotina Ehrh.), sugar maple, flowering dogwood (Cornus florida L.), three hickories - shagbark (Carya ovata (Mill.) K. Koch), pignut (C. glabra (Mill.) Sweet), and bitternut (C. cordiformis (Wangenh.) K. Koch) - red maple (Acer rubrum L.), white ash (Fraxinus americana L.), sassafras (Sassafras albidum (Nutt.) Ness), and slippery elm.

Rudolph and Arnold (1956) found that in the first year after cutting in old-growth oak-mixed hardwoods in the Fred Russ Forest, sugar maple, red maple, and black cherry seedlings were abundant without apparent relation to the method of cutting, or absence of cutting on control (uncut) plots. Yellow-poplar (Liriodendron tulipifera L.) seedlings increased directly with the severity of cutting during the first



year after treatment. They observed a decrease in the number of yellow-poplar seedlings in the second year after cutting. The abundance of oak seedlings also increased directly with the severity of cutting after one growing season.

Scholz and DeVriend (1957) studied the changes in tree reproduction on the Dundee Timber Harvest Forest in eastern Wisconsin from 1951 to 1955. On a two-acre mixed-oak area five years after clear cutting, they found ample natural regeneration, averaging 7,080 trees per acre, with a satisfactory percentage and distribution of red oak present. However, the percentage of oak was substantially less in the reproduction than in the original stand; also, there was an increase of less desirable species in the reproduction as compared to the composition of the parent stand.

Northern Hardwoods. In 1920, Buttrick (1921) established a reproduction study in a cut over northern hardwood area in northern Michigan. Unfortunately the field work for this study was performed by students who were unable to distinguish the seedling classes as planned in the study. The data thus collected was unsatisfactory to use in formulating any conclusions.

Herbert (1924) investigated the reproduction on an unburned area that had been clear cut two years earlier. His study was near Johannesburg, Michigan, in an area typical of the hardwood region of the northern part of the lower peninsula of Michigan. He found adequate natural reproduction following clear cutting, to the extent of 32,912 seedlings per acre, mostly of maple.

In a nine-year report on reproduction following various cutting methods in northern hardwoods at the Upper Peninsula Experimental Forest, Lake States Forest Experiment Station, Eyre and Neetzel (1937) found good stocking present irrespective of the cutting method. They found an average of 24,700 seedlings per acre ranging from one year old to one and a half inches in diameter, with sugar maple comprising 99 percent of the total number. They noted that a dense growth of shrubs and woody herbs grew on the areas that were cut to a 12-inch diameter limit and on the clear cut area. This competition was detrimental to the growth of tree seedlings for a year or so but at the end of five years sugar maple was the dominant vegetation.

Zillgitt (1950) reporting on this same study also stated that regardless of the method of cutting, reproduction, mostly sugar maple, is always adequate in number and distribution in the northern hardwood type of Michigan. He noted that the proportion of trees of good origin, seedling or seedling sprout, increased regularly from clear cut to uncut reserves. Thus, in the proportion of good trees per acre, all degrees of partial cuttings are superior to clear cutting. Cope (1950) questioned the species composition of the reproduction. He stated that in the eastern northern hardwood region the only way to obtain a good representation of such intolerants as basswood (Tilia americana L.), white ash, and black cherry was by clear cutting.

In a 20-year report on the same study reported by Zillgitt in 1950, Eyre and Zillgitt (1953) recommended the selection method of cutting with certain modifications as the best system for managing mature northern hardwoods in the Lake States.

## II. HARDWOOD REPRODUCTION STUDIES IN THE NORTHEAST

Mixed Hardwoods. In a study to determine the influence of various factors affecting reproduction of hardwoods in Connecticut that had been under management for twenty years, Averell (1929) found that the method of cutting, whether partial or clear cut, had less influence on the reproduction than was generally attributed to it. Factors of greater importance were seed supply, germination, and survival of young plants. He also noted that the method of cutting should discourage reproduction of sprout origin. He found that on good sites woody shrubs get a good start the first year after logging and remain ten or more years as a severe hinderance to natural reproduction. He observed that rabbits favor hardwood reproduction over shrubs for browsing, with the maples and oaks at the top of the preferred list of plants. He concluded that on a rotation of 80 years or more, clear cutting permits plentiful reproduction of desirable seedling or seedling-sprout origin.

On three areas each of improvement cuttings, commercial cutting to a 10-inch, and a 12-inch diameter limit, and on uncut forest, Moore and Waldron (1938) found an abundance of reproduction on both the treated and untreated stands. They found that oak reproduction decreased on the cove sites and increased on the slope sites. The reproduction on all of the areas sampled was mostly of seedling origin. The cut over areas studied were logged from one to 11 years prior to this study. The study area was in the hardwood region of New Jersey.

Wood (1938) also studied seedling reproduction of oak in New Jersey. He found that the large number of acorns destroyed in unprotected

areas indicated that herbivorous animals alone may totally prevent seedling regeneration of chestnut oak (Quercus montana Willd.) in the southern New Jersey woods.

Tryon and Finn (1947) found adequate natural reproduction 19 years after logging on 20 experimental improvement cutting areas on the Black Rock Forest in New York. They analyzed their findings statistically and found that there was significantly more red oak reproduction in the cutting areas than in uncut control areas. A regression calculation indicated that the cutting practice used would result in adequate regeneration of the better merchantable species in approximately 16 years. They regarded this as a start towards something clear and definite in the nature of a cutting cycle. The better merchantable species were red oak and chestnut oak.

Northern Hardwoods. Dawson (1847) concluded from his observations on forest succession following fire and cutting in Nova Scotia that conifers do not reproduce themselves adequately naturally, but hardwoods tend to regenerate themselves on denuded forest areas by the sprouting of roots and stumps. He did not recognize a difference between sprout growth and the more desirable seedling reproduction.

Knechtel (1903), in an elaborately designed experiment studied the natural reproduction in the virgin forest of the Adirondack mountains of New York. His conclusions were the same as those which Dawson had made from general observations.

From observations on clear cut strips 200 feet wide in Delaware County, New York, Cope (1935) believes that adequate reproduction to

[illegible]

maintain good stands of northern hardwoods would be achieved by clear cutting on a 40-year rotation.

Hough (1937) recommended a light individual tree selection cut prior to clear cutting in the beech (Fagus)-birch-maple-hemlock (Tsuga) type of the Allegheny Plateau. The first cut would open the crown of the stand and favor germination, survival, and growth of the seedling reproduction. His recommendation was based on a reproduction study in 60-year-old second growth on three types of areas; one was uncut, another was cut to a 10-inch diameter limit, and the third was selectively logged. In 1928, prior to cutting, study plots were established on each of the three areas. Detailed maps showing all tree reproduction and lesser vegetation on each plot were made at that time. Re-examinations were made in the spring and in the fall after each growing season for six years. He found that in the spring many seeds germinated with nearly all of the species present in the stand being represented by seedlings, but few of the newly germinated seedlings of a particular year's crop survived to the next growing season. He reported an 82 percent reduction by 1933 of the sugar maple and white ash that had germinated in the spring of 1928. The 1928 crop of black cherry was reduced 88 percent by 1933. The 1929 crop of ash and black cherry was reduced slightly less by 1933, the reductions being 78 and 79 percent. All of the seedlings grew slowly in height but excellent growth was maintained by the seedling sprouts. Hough considered the limiting factors to a natural regeneration to be: (1) the amount of soil moisture in the upper soil layer during late summer dry periods, (2) competition from shrubs and herbs, (3) the condition of the

seedbed, (4) browsing by deer and rodents, (5) also frost and winter kill, and fungus disease and insect damage.

Ostrom (1938) considered that the nature of the present second growth attested the success of clear cutting in 1900 of old growth and virgin stands on the Allegheny Plateau in Pennsylvania. In one second growth 13-year-old reproduction stand he found 4,250 stems per acre of which 55 percent were seedlings.

### III. HARDWOOD REPRODUCTION STUDIES IN THE SOUTH

In a seven-year study of yellow-poplar reproduction, Sims (1932) found a regular turnover in seedlings. He concluded that root competition and shading are probably the primary causes of the failure of yellow-poplar seedlings to develop.

McCarthy (1933) stated that yellow-poplar seeds falling at the time of cutting can reach the soil and receive sufficient warmth from the sun to encourage germination. Once germination is accomplished the seedlings must face a critical period of one to three years. They must have protection from drying out in the summer and from frost heaving in the winter, but the grasses or weeds providing this protection must cast little or no overhead shade. They require good moist conditions with good drainage, also there must not be any nearby rivals of sprout growth.

Kuenzel and McGuire (1942) studied the response of chestnut oak reproduction to release by clear cutting and partial cutting in a second growth stand in southern Indiana compared with an uncut stand during the period from 1929 to 1939. They found that the oak reproduction

remained the dominant species on all three methods of treatment. The greatest height growth was on the clear cut area. By 1939, most of the oak reproduction was of seedling origin, but 97 percent of all the chestnut oaks over one inch diameter breast high were of sprout origin. The sprouts averaged 21 feet in height and only a small number of seedlings had successfully established themselves in the overstory.

Downs and McQuilkin (1944) indicated from their study of southern Appalachian oaks that a partial cut system was best for regeneration of oaks in that region. They compared a partial cut system with the seed tree method.

Wahlenberg (1956) in an analysis of variance of number of desirable stems per acre found that moisture was the only variable having a significant effect on reproduction. When the comparison was made of various cutting treatments on a uniform moist area, he found that the reproduction was significantly better on the clear cut area. Wahlenberg was concerned with the regeneration of mixed oak and hardwood old growth in North Carolina under various types of cuts.



## CHAPTER III

### THE STUDY AREA AND FIELD PROCEDURE

The area selected for this study was formerly a mature oak-mixed hardwood stand approximately 45 acres in size, located in Ionia County, Michigan. During the winter of 1950, a harvest cut was made to a 12-inch diameter limit resulting in practically a clear cut condition. The trees that were left were generally small, poorly formed unmerchantable trees of little value for seed production.

#### I. DESCRIPTION OF STUDY AREA

The study area is located in Ionia County, Michigan, approximately two and one half miles west and one-fourth mile south of the junction of Highway 16 and the Ionia County Clarksville Road. The area is approximately 47 miles west of East Lansing, in Section 29, Township 6 North, Range 8 West, Michigan Meridian.

The topography is generally level, and the site quality would be classed as very good, as described by Gysel and Arend (1953). The predominant soil type is Celina loam; however, there is a small strip of Conover loam across a portion of the northern half of the area.

The Celina series and the Conover series include Gray Brown Podzolic soils developed on Calcareous loam glacial till. The Celina soils are moderately well drained and the Conover soils are imperfectly drained. The native vegetation for both series is deciduous forests; consisting of sugar maple, elm, beech and some oak for the Celina

series, and elm, ash, soft maple, white oak, (Quercus alba L.), shag-bark hickory and basswood for the Conover series.

The area is bordered on the north and east by old fields, and on the south by an uncut stand similar to the stand on which this study is based. It is bordered on the north half of the west side by a young mixed hardwood stand which apparently developed after a clear cut operation approximately fifty years ago. On the south half of the west side it is bordered by a cultivated field.

The original stand consisted of red oak, white oak, sugar maple, and hickory, with lesser amounts of yellow-poplar, elm, white ash, and red maple. The quality and quantity of the trees removed in the harvest cut are illustrated in Figs. 1, 2, and 3.

Logging was done in the winter following a good acorn crop. The slash was heavy and was not scattered. The condition of the slash and the remaining trees are illustrated in Figs. 4 and 5.

## II. FIELD PROCEDURE

In June and October of 1952, 46 mil-acre plots were installed throughout the woodlot to study tree regeneration. They were circular plots located at 100-foot intervals along three north and south lines evenly spaced across the area. Fig. 6 shows the location of the area and its surroundings, and the plot locations.

Wooden stakes, painted yellow, were set at the plot centers, and witness trees and stumps were also painted to facilitate future location of the plots. In the fall of 1957, the wooden stakes were



**Fig. 1.** An illustration of the quality of the oak that was harvested. (Photograph courtesy U. S. F. S., Lower Peninsula Research Center.)



**Fig. 2.** The woodlot during the logging operation. Note the proximity of the stumps and logs. (Photograph courtesy U. S. F. S., Lower Peninsula Research Center.)



Fig. 3. A typical log landing scene during logging, showing both quality and quantity of trees that were harvested, and the complete removal of all vegetation within the log landing area. (Photograph courtesy U. S. F. S., Lower Peninsula Research Center.)



Fig. 4. The woodlot in 1950 after logging, illustrating in the foreground the practically clear cut condition with unscattered slash. The background shows the trees that were not logged. (Photograph courtesy U. S. F. S., Lower Peninsula Research Center.)





Fig. 5. A view of the woodlot after logging was completed in 1950 showing in the foreground the typical size and form of the trees left and in the background the density of the unscattered logging slash. (Photograph courtesy U. S. F. S., Lower Peninsula Research Center.)

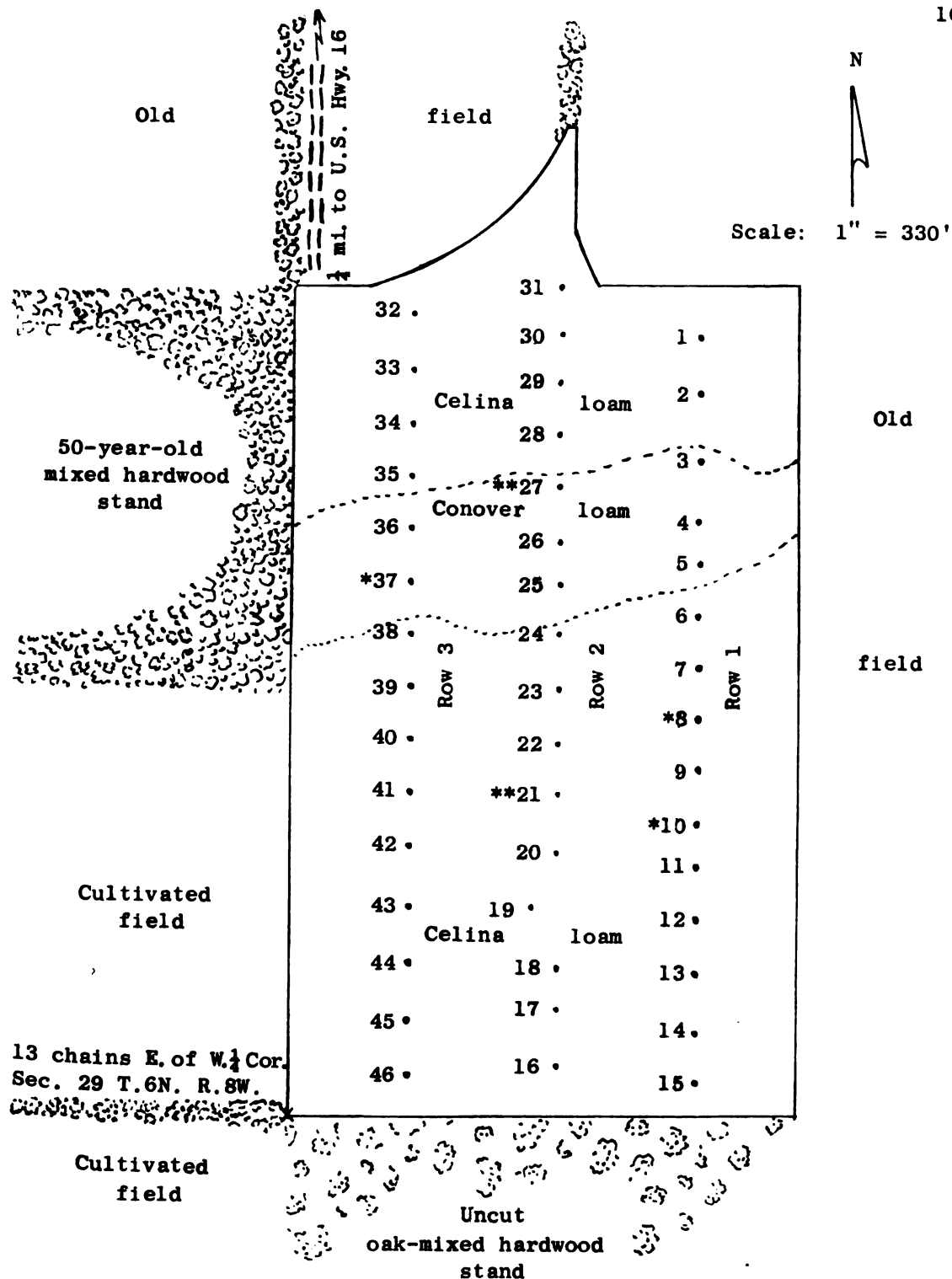


Fig. 6. The study area and its surroundings.

\*Plots 8, 10, and 37 could not be relocated in 1955 and 1957.

\*\*Plots 21 and 27 could not be relocated in 1957.



replaced with steel pipes and the witness trees were remarked with yellow paint.

Tree reproduction was diagrammed and tallied by species and height in inches for each plot at the time of installation. The plots were re-examined to determine height growth and composition changes in June 1953, in October 1955, and in the fall and winter of 1957.

The area has remained relatively undisturbed since cutting, except for normal hunting and wildlife use.



## CHAPTER IV

### RESULTS AND DISCUSSION

A wide variety of woody and herbaceous plants were present on the area at the time of the first examination in 1952. The principal woody plants were elderberry (Sambucus canadensis L.), raspberry (Rubus occidentalis L.), blackberry (R. canadensis L.), and dogwood. The predominant herbaceous plants were thistle (Cirsium sp.), golden-rod (Solidago sp.), and milkweed (Asclepias sp.).

By 1955, at the time of the third examination, the ground cover was still extremely heavy but the character was changing. More woody plants, including vines, were appearing and the number of sun-demanding herbaceous plants was reduced. Blackberry and black raspberry had become the dominant woody plants, but more tolerant shrubs such as dogwood, ribes (Ribes spp.), and viburnum (Viburnum spp.), were increasing. Others present were staghorn sumac (Rhus typhina L.), prickly ash (Aralia spinosa L.), witch-hazel (Hamamelis virginiana L.), green-brier (Smilax sp.), and hawthorn (Crataegus beata Sarg.). Shade tolerant plants, including trillium (Trillium spp.), violets (Viola spp.), Solomon's seal (Polygonatum sp.), and woodland fern (Dryopteris sp.) were appearing.

Little change was observed in the ground cover between the third examination in 1955 and the fourth examination in 1957. Blackberry and black raspberry were still the most numerous woody plants, but the tree reproduction was beginning to overtop them on part of the area. This is shown in Fig. 7.





Fig. 7. The ground cover of blackberry and black raspberry in 1957. Aspens have overtopped the berries in the right foreground where a skid road was located during logging. The trees in the background were left in logging in 1950.

The information obtained from each examination was converted to a per acre basis, and summarized by years of examination. Tables are presented and discussed for each examination in relation to the origin, species composition, height, and distribution of the reproduction.

# I. THE REPRODUCTION IN 1952

Sprout Origin. The stocking and average height of sprouts by species in 1952 are shown in Table 1.

TABLE 1.  
STOCKING AND AVERAGE HEIGHT OF SPROUTS  
IN THE SECOND YEAR AFTER  
LOGGING -- 1952

| Species     | Number<br>of<br>sprouts<br>per<br>acre | Average<br>height |
|-------------|----------------------------------------|-------------------|
|             |                                        | inches            |
| Sugar Maple | 40                                     | 3                 |
| Red Oak     | 700                                    | 47                |
| White Ash   | 90                                     | 7                 |
| Beech       | 150                                    | 1                 |
| Dogwood     | 310                                    | 9                 |
| All Species | 1,290                                  | 29                |

Of the reproduction on the area in 1952 only 1,290 stems or 8.6 percent was of sprout origin; the remainder was of seed origin. The species of sprouts present on the sample plots in order of their abundance were red oak, dogwood, beech, white ash, and sugar maple. Red oak was

represented by 700 sprouts, or 54 percent of the total number per acre. It was also the tallest of all the reproduction, averaging 47 inches in height.

Seedling Origin. Seventy-eight percent of the seedling reproduction was composed of seven species; yellow-poplar, sugar maple, white ash, red maple, red oak, American elm, and black cherry, in that order. The remaining 22 percent consisted of 17 species: black oak (Quercus velutina Lam.), sassafras, American beech (Fagus grandifolia Ehrh.), ironwood (Ostrya virginiana (Mill.) K. Koch), three hickories -- pignut, bitternut, and shagbark --, basswood, white oak, dogwood, prickly ash, trembling aspen, bigtooth aspen, black walnut (Juglans nigra L.), hawthorn, witch-hazel, and black willow (Salix nigra Marsh.). In this study, these 17 species have been grouped as miscellaneous.

The stocking and average heights of the seedling reproduction in 1952 is shown in Table 2. There was a total of 13,900 seedlings per acre in 1952, of which 4,280 were yellow-poplar. Though yellow-poplar had the most stems, its average height of three inches was the lowest. The tallest seedlings were in the miscellaneous group which averaged 16 inches in height. Red oak was represented by 830 stems per acre with an average height of six inches.

The number of seedlings per acre by four height classes is shown in Table 3. Toumey and Korstian (1947) define three height classes for seedling reproduction: seedling, less than three feet; small sapling, three to ten feet; and large sapling, over ten feet and less than four inches in diameter. The seedling class was divided in this

TABLE 2.  
STOCKING AND AVERAGE HEIGHT OF SEEDLINGS  
IN THE SECOND YEAR AFTER  
LOGGING -- 1952

| Species        | Number<br>of<br>seedlings<br>per<br>acre | Average<br>height |
|----------------|------------------------------------------|-------------------|
|                |                                          | <u>inches</u>     |
| Yellow-Poplar  | 4,280                                    | 3                 |
| Sugar Maple    | 1,670                                    | 8                 |
| Red Oak        | 830                                      | 6                 |
| White Ash      | 1,590                                    | 9                 |
| Red Maple      | 1,220                                    | 8                 |
| American Elm   | 830                                      | 14                |
| Black Cherry   | 410                                      | 12                |
| Miscellaneous* | 3,070                                    | 16                |
| <hr/>          |                                          |                   |
| All Species    | 13,900                                   | 9                 |

\*The miscellaneous group includes black oak, sassafras, American beech, iron-wood, hickory, basswood, white oak, dog-wood, prickly ash, aspen, black walnut, hawthorn, witch-hazel, and black willow.



TABLE 3.  
NUMBER AND DISTRIBUTION OF SEEDLINGS PER ACRE  
BY HEIGHT CLASS IN THE SECOND  
YEAR AFTER LOGGING --  
1952

| Species                     | Height class* -- feet |                    |                   |                   | Total  |
|-----------------------------|-----------------------|--------------------|-------------------|-------------------|--------|
|                             | Under 0.5             | 0.5 to 3           | 3 to 10           | Over 10           |        |
|                             | Small<br>seedlings    | Large<br>seedlings | Small<br>saplings | Large<br>saplings |        |
| <hr/> Number per acre <hr/> |                       |                    |                   |                   |        |
| Yellow-Poplar               | 3,930                 | 350                | 0                 | 0                 | 4,280  |
| Sugar Maple                 | 1,020                 | 560                | 90                | 0                 | 1,670  |
| Red Oak                     | 500                   | 330                | 0                 | 0                 | 830    |
| White Ash                   | 630                   | 960                | 0                 | 0                 | 1,590  |
| Red Maple                   | 520                   | 700                | 0                 | 0                 | 1,220  |
| American Elm                | 90                    | 700                | 40                | 0                 | 830    |
| Black Cherry                | 220                   | 150                | 40                | 0                 | 410    |
| Miscellaneous               | 1,150                 | 1,570              | 350               | 0                 | 3,070  |
| All species                 | 8,060                 | 5,320              | 520               | 0                 | 13,900 |

\*Heights are separated into classes as defined by Toumey and Korstian (1947) as: seedling, less than three feet; small sapling, three to ten feet; and large sapling, over ten feet and less than four inches in diameter. The seedling class was separated in this study into two classes: small seedlings, less than one-half foot; and large seedlings, one-half to three feet.





study into two classes: under one-half foot; and one-half to three feet, to separate small and large seedlings.

No large saplings were present when the plots were established and only sugar maple, American elm, black cherry, and the miscellaneous group were represented in the small sapling class. The majority of the stems were in the small seedling class.

The distribution of seedlings by species for the percent of plots which were stocked is shown in Table 4. Distribution of the stocking by species on the plots was irregular. The percent of plots with one or more seedlings per plot ranged by species from 46 percent with the miscellaneous group to 19 percent with American elm. Red oak was represented on 38 percent of the plots. By individual species, the largest percent of stocked plots was in the one seedling per plot class, which ranged from 20 percent for red oak to 7 percent for sugar maple. In stocking by any species, only 7 percent of the plots were bare; no plots had only one seedling per plot; and 29 percent had 11 to 20 seedlings per plot.

Rabbit Browsing. Rabbit browsing was relatively unimportant at the time of the first examination. In 1952, only 3 percent of the total number of stems of reproduction had been browsed. By species, this ranged from 0 for yellow-poplar to 9 percent of the sugar maple. One percent of the red oak and 4 percent of the red maple had been browsed. This is shown as part of the data in Table 17 on page 49.

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TABLE 4.

PERCENT OF PLOTS STOCKED WITH VARIOUS NUMBERS OF SEEDLINGS, BY SPECIES -- 1952

| Species       | Number of seedlings per plot                    |    |   |    |   |   |      |       |       |    | Total Percent<br>of plots<br>stocked |
|---------------|-------------------------------------------------|----|---|----|---|---|------|-------|-------|----|--------------------------------------|
|               | 0                                               | 1  | 2 | 3  | 4 | 5 | 6-10 | 11-20 | 21 up |    |                                      |
|               | Percent of plots with above number of seedlings |    |   |    |   |   |      |       |       |    |                                      |
| Yellow-Poplar | 55                                              | 13 | 2 | 2  | 4 | 4 | 2    | 9     | 9     | 45 |                                      |
| Sugar Maple   | 56                                              | 7  | 9 | 9  | 2 | 4 | 13   | 0     | 0     | 44 |                                      |
| Red Oak       | 62                                              | 20 | 7 | 4  | 7 | 0 | 0    | 0     | 0     | 38 |                                      |
| White Ash     | 60                                              | 15 | 2 | 4  | 4 | 4 | 11   | 0     | 0     | 40 |                                      |
| Red Maple     | 79                                              | 11 | 4 | 0  | 0 | 0 | 2    | 2     | 2     | 21 |                                      |
| American Elm  | 81                                              | 11 | 4 | 0  | 0 | 0 | 2    | 2     | 0     | 19 |                                      |
| Black Cherry  | 68                                              | 26 | 4 | 2  | 0 | 0 | 0    | 0     | 0     | 32 |                                      |
| Miscellaneous | 54                                              | 9  | 7 | 7  | 0 | 4 | 11   | 4     | 4     | 46 |                                      |
| All Species   | 7                                               | 0  | 4 | 17 | 0 | 2 | 15   | 29    | 26    | 93 |                                      |

## II. THE REPRODUCTION IN 1953

Sprout Origin. The stocking and average height of sprouts in 1953 are shown in Table 5.

TABLE 5.  
STOCKING AND AVERAGE HEIGHT OF SPROUTS IN THE THIRD YEAR AFTER LOGGING --  
1953

| Species     | Number of sprouts<br>per acre in 1953 |                      |       | Change<br>in<br>species<br>total<br>1952<br>to<br>1953<br><br>percent | Average height of<br>sprouts in 1953 |                      |                |
|-------------|---------------------------------------|----------------------|-------|-----------------------------------------------------------------------|--------------------------------------|----------------------|----------------|
|             | Of<br>1952<br>origin                  | Of<br>1953<br>origin | Total |                                                                       | Of<br>1953<br>origin                 | Of<br>1953<br>origin | All<br>sprouts |
| Sugar Maple | 40                                    | 30                   | 70    | +75                                                                   | 50                                   | 24                   | 39             |
| Red Oak     | 220                                   | 0                    | 220   | -69                                                                   | 62                                   | 0                    | 62             |
| White Ash   | 90                                    | 0                    | 90    | 0                                                                     | 10                                   | 0                    | 10             |
| Beech       | 40                                    | 0                    | 40    | -79                                                                   | 22                                   | 0                    | 22             |
| Dogwood     | 50                                    | 0                    | 50    | -84                                                                   | 34                                   | 0                    | 34             |
| All Species | 440                                   | 30                   | 470   | -64                                                                   | 43                                   | 24                   | 42             |

In 1953, there were 470 sprouts per acre representing 3.1 percent of the reproduction. The only species with new sprouts was sugar maple. All of the original stems of sugar maple and white ash had survived, but dogwood, beech, and red oak had suffered heavy mortality. Red oak was still the species with the largest number of sprouts per acre, with 220 stems or 47 percent of the total. It had maintained good height growth and was still the tallest of all the reproduction, averaging 62

inches in height. Sugar maple sprouts of 1952 origin showed the greatest gain in average height, with an increase of 47 inches, bringing them to an average of 50 inches. The average height of all sugar maple sprouts was 39 inches. White ash had the least growth, having increased only three inches to an average of ten inches in height.

Seedling Origin. The stocking and average height of the seedlings in the third year after logging is shown in Table 6. Neither the relative abundance nor the percent of the total seedlings of the seven major species changed between 1952 and 1953. Yellow-poplar, sugar maple, white ash, red maple, red oak, American elm, and black cherry, in that order, still composed 78 percent of the 14,590 seedlings per acre.

Losses through mortality were greatest in yellow-poplar and the miscellaneous group, but these also had the largest number of new seedlings which resulted in a net increase of 9 and 7 percent, respectively. Even though there were decreases of 5 and 42 percent in the number of sugar maple and American elm seedlings, the total number of seedlings of all species increased 5 percent.

The tallest seedlings were black cherry of 1952 origin with an average height of 28 inches. A weighted average for both seedlings of 1952 and 1953 origin shows that black cherry seedlings were the tallest in 1953, averaging 21 inches in height. Yellow-poplar was the species with the least height, having increased only two inches to an average height of five inches. Of the 850 red oak seedlings present, 740 were of 1952 origin, with an average height of ten inches, and 110 were new stems averaging nine inches. The average height of all the red oak seedlings was ten inches.



TABLE 6.

STOCKING AND AVERAGE HEIGHT OF SEEDLINGS IN THE THIRD YEAR AFTER LOGGING --  
1953

| Species       | Number of seedlings<br>per acre in 1953 |                      |        | Change<br>in<br>species<br>total<br>1952<br>to<br>1953<br>percent | Average height of<br>seedlings in 1953 |                      |                  |
|---------------|-----------------------------------------|----------------------|--------|-------------------------------------------------------------------|----------------------------------------|----------------------|------------------|
|               | Of<br>1952<br>origin                    | Of<br>1953<br>origin | Total  |                                                                   | Of<br>1952<br>origin                   | Of<br>1953<br>origin | All<br>seedlings |
|               |                                         |                      |        |                                                                   |                                        |                      |                  |
| Yellow-Poplar | 2,820                                   | 1,830                | 4,650  | +9                                                                | 5                                      | 4                    | 5                |
| Sugar Maple   | 1,370                                   | 220                  | 1,590  | -5                                                                | 16                                     | 16                   | 16               |
| Red Oak       | 740                                     | 110                  | 850    | +2                                                                | 10                                     | 9                    | 10               |
| White Ash     | 1,480                                   | 260                  | 1,740  | +9                                                                | 19                                     | 4                    | 17               |
| Red Maple     | 1,060                                   | 460                  | 1,520  | +25                                                               | 14                                     | 3                    | 11               |
| American Elm  | 370                                     | 110                  | 480    | -42                                                               | 15                                     | 4                    | 12               |
| Black Cherry  | 330                                     | 150                  | 480    | +17                                                               | 28                                     | 4                    | 21               |
| Miscellaneous | 2,170                                   | 1,110                | 3,280  | +7                                                                | 19                                     | 8                    | 15               |
| All Species   | 10,340                                  | 4,250                | 14,590 | +5                                                                | 14                                     | 6                    | 12               |





The number of seedlings per acre in 1953 by the four height classes is shown in Table 7. In 1953, the large sapling class was not represented. Red oak was the only species not represented in the small sapling class of reproduction. There were more stems of each of the species in the large seedling class than in the small seedling class, with the exception of yellow-poplar and the miscellaneous group.

The distribution of seedlings by species for the percent of plots which were stocked in 1953 is shown in Table 8. Distribution by species on the sample plots was still irregular. The percent of plots with one or more seedlings per plot ranged by species from 60 percent with yellow-poplar to 19 percent with American elm. Plots with red oak present had decreased to 31 percent of the total. By individual species, the largest percent of stocked plots was still in the one seedling per plot class, which ranged from 24 percent for red maple to 4 percent for sugar maple. Seventeen percent of the plots had one red oak present. Considering all species, there were only 11 percent of the plots without seedling reproduction. There were no plots with only one seedling. The largest number of the plots, 31 percent, were stocked with six to ten seedlings.

Rabbit Browsing. Yellow-poplar was still the species browsed the least, with only 3 percent of the stems having been browsed. American elm with 31 percent of stems nipped, was the species most browsed. Red oak and red maple were browsed to the extent of 9 and 15 percent of the stems present, respectively. Nine percent of all the reproduction in 1953 had been browsed. This is shown as part of the data in Table 17 on page 49.

TABLE 7.  
 NUMBER AND DISTRIBUTION OF SEEDLINGS PER ACRE  
 BY HEIGHT CLASS IN THE THIRD  
 YEAR AFTER LOGGING --  
 1953

| Species         | Height class -- feet |           |          |          | Total  |
|-----------------|----------------------|-----------|----------|----------|--------|
|                 | Under 0.5            | 0.5 to 3  | 3 to 10  | Over 10  |        |
|                 | Small                | Large     | Small    | Large    |        |
|                 | seedlings            | seedlings | saplings | saplings |        |
| Number per acre |                      |           |          |          |        |
| Yellow-Poplar   | 3,410                | 1,190     | 50       | 0        | 4,650  |
| Sugar Maple     | 300                  | 1,090     | 200      | 0        | 1,590  |
| Red Oak         | 200                  | 650       | 0        | 0        | 850    |
| White Ash       | 330                  | 1,190     | 220      | 0        | 1,740  |
| Red Maple       | 520                  | 960       | 40       | 0        | 1,520  |
| American Elm    | 130                  | 330       | 20       | 0        | 480    |
| Black Cherry    | 170                  | 180       | 130      | 0        | 480    |
| Miscellaneous   | 1,450                | 1,330     | 500      | 0        | 3,280  |
| All Species     | 6,510                | 6,920     | 1,160    | 0        | 14,590 |

TABLE 8.

PERCENT OF PLOTS STOCKED WITH VARIOUS NUMBERS OF SEEDLINGS, BY SPECIES -- 1953

| Species       | Number of seedlings per plot                    |    |    |   |   |   |      |       |       |    | Total Percent<br>of plots<br>stocked |
|---------------|-------------------------------------------------|----|----|---|---|---|------|-------|-------|----|--------------------------------------|
|               | 0                                               | 1  | 2  | 3 | 4 | 5 | 6-10 | 11-20 | 21 up |    |                                      |
|               | Percent of plots with above number of seedlings |    |    |   |   |   |      |       |       |    |                                      |
| Yellow-Poplar | 40                                              | 11 | 6  | 4 | 4 | 9 | 9    | 13    | 4     | 60 |                                      |
| Sugar Maple   | 54                                              | 4  | 20 | 9 | 0 | 0 | 13   | 0     | 0     | 46 |                                      |
| Red Oak       | 69                                              | 17 | 2  | 2 | 4 | 4 | 2    | 0     | 0     | 31 |                                      |
| White Ash     | 54                                              | 20 | 4  | 2 | 2 | 9 | 4    | 4     | 0     | 46 |                                      |
| Red Maple     | 61                                              | 24 | 7  | 0 | 0 | 0 | 4    | 2     | 2     | 39 |                                      |
| American Elm  | 81                                              | 11 | 4  | 2 | 0 | 0 | 2    | 0     | 0     | 19 |                                      |
| Black Cherry  | 67                                              | 22 | 7  | 4 | 0 | 0 | 0    | 0     | 0     | 33 |                                      |
| Miscellaneous | 49                                              | 9  | 7  | 2 | 7 | 4 | 13   | 9     | 0     | 51 |                                      |
| All Species   | 11                                              | 0  | 4  | 2 | 0 | 0 | 28   | 31    | 24    | 89 |                                      |

## III. THE REPRODUCTION IN 1955

Sprout Origin. The stocking and average height of the sprouts in the fifth year after logging is shown in Table 9. In 1955, 370 stems per acre remained of the 1,290 sprouts that were present in 1952. All of the sugar maple sprouts that appeared in 1953 were dead, but 70 new stems were present. Only 190 of the original 700 red oak sprouts per acre remained, and these averaged 106 inches in height. There were 66 percent less sprouts in 1955 than there were in 1952, with an average height of 83 inches, as compared to the first examination average of 29 inches. Dogwood sprouts were the tallest of all the reproduction, with an average height of 137 inches. White ash sprouts averaged only 36 inches.

Seedling Origin. The stocking and average height of the seedlings in 1955 are shown in Table 10. By 1955, the ranking of the major species had changed to white ash, red maple, sugar maple, yellow-poplar, American elm, black cherry, and red oak in that order. They represented 82 percent of the 12,220 seedlings per acre. The majority of the stems present were of 1952 origin with the exception of red maple seedlings. In 1955 there were 1,140 new red maple stems, compared with 670 that had survived from 1952 and 330 that had survived from 1953. This gave a total of 2,140 red maple seedlings, or a 75 percent increase since 1952. The largest decrease was in the number of yellow-poplar, with 69 percent less than in 1952. By 1955, there were only 770 of the 4,280 yellow-poplar seedlings found in 1952, and 440 of the 1,830 stems found in 1953. Yellow-poplar, with 120 per acre, had the

TABLE 9.

## STOCKING AND AVERAGE HEIGHT OF SPROUTS IN THE FIFTH YEAR AFTER LOGGING -- 1955

| Species     | Number of sprouts per acre<br>in 1955 |                      |                      |       | Change<br>in<br>species<br>total<br>1952<br>to<br>1955<br><br>percent | Average height of sprouts<br>in 1955 |                      |                      |                |
|-------------|---------------------------------------|----------------------|----------------------|-------|-----------------------------------------------------------------------|--------------------------------------|----------------------|----------------------|----------------|
|             | Of<br>1952<br>origin                  | Of<br>1953<br>origin | Of<br>1955<br>origin | Total |                                                                       | Of<br>1952<br>origin                 | Of<br>1953<br>origin | Of<br>1955<br>origin | All<br>sprouts |
|             |                                       |                      |                      |       |                                                                       |                                      |                      |                      |                |
|             |                                       |                      |                      |       |                                                                       |                                      |                      |                      |                |
| Sugar Maple | 20                                    | 0                    | 70                   | 90    | +125                                                                  | 90                                   | 0                    | 55                   | 63             |
| Red Oak     | 190                                   | 0                    | 0                    | 190   | -73                                                                   | 106                                  | 0                    | 0                    | 106            |
| White Ash   | 70                                    | 0                    | 0                    | 70    | -22                                                                   | 36                                   | 0                    | 0                    | 36             |
| Beech       | 30                                    | 0                    | 0                    | 30    | -80                                                                   | 100                                  | 0                    | 0                    | 100            |
| Dogwood     | 60                                    | 0                    | 0                    | 60    | -81                                                                   | 137                                  | 0                    | 0                    | 137            |
| All Species | 370                                   | 0                    | 70                   | 440   | -66                                                                   | 88                                   | 0                    | 55                   | 83             |

TABLE 10.

## STOCKING AND AVERAGE HEIGHT OF SEEDLINGS IN THE FIFTH YEAR AFTER LOGGING -- 1955

| Species       | Number of seedlings per acre |                      |                      | Change<br>in<br>species<br>total<br>1952<br>to<br>1955<br>percent | Average height of seedlings<br>in 1955 |                      |                      |                  |
|---------------|------------------------------|----------------------|----------------------|-------------------------------------------------------------------|----------------------------------------|----------------------|----------------------|------------------|
|               | in 1955                      |                      |                      |                                                                   | in 1955                                |                      |                      |                  |
|               | Of<br>1952<br>origin         | Of<br>1953<br>origin | Of<br>1955<br>origin |                                                                   | Of<br>1952<br>origin                   | Of<br>1953<br>origin | Of<br>1955<br>origin | All<br>seedlings |
| Yellow-Poplar | 770                          | 440                  | 1,330                | -69                                                               | 25                                     | 23                   | 6                    | 23               |
| Sugar Maple   | 1,140                        | 90                   | 1,580                | -5                                                                | 33                                     | 43                   | 7                    | 28               |
| Red Oak       | 580                          | 50                   | 770                  | -7                                                                | 14                                     | 10                   | 10                   | 13               |
| White Ash     | 1,440                        | 180                  | 2,020                | +27                                                               | 37                                     | 14                   | 9                    | 29               |
| Red Maple     | 670                          | 330                  | 2,140                | +75                                                               | 23                                     | 4                    | 4                    | 10               |
| American Elm  | 700                          | 50                   | 1,050                | +27                                                               | 31                                     | 26                   | 7                    | 24               |
| Black Cherry  | 330                          | 140                  | 1,120                | +173                                                              | 60                                     | 9                    | 4                    | 21               |
| Miscellaneous | 1,300                        | 420                  | 2,210                | -28                                                               | 54                                     | 19                   | 15                   | 39               |
| All Species   | 6,930                        | 1,700                | 3,590                | -12                                                               | 35                                     | 17                   | 7                    | 24               |

least number of new seedlings. The largest net change was in the number of black cherry with an increase to 173 percent of the number present in 1952. There were 770 seedlings per acre of red oak present, averaging 13 inches in height. This represented a loss of 7 percent of the original number, and a growth of seven inches in height in three years. The tallest seedlings were black cherry of 1952 origin, averaging 60 inches. The average height of all the black cherry was 21 inches. The average height for red maple was the least, being only ten inches.

The number of seedlings per acre in 1955 by the four height classes is shown in Table 11. In 1955, the majority of the stems for all species except red maple and black cherry were still in the large seedling class. Red maple and black cherry were mainly in the small seedling class. Sugar maple, black cherry, white ash, and the miscellaneous group were represented in the large sapling class by 230 stems per acre.

The distribution of seedlings by species for the percent of plots which were stocked in 1953 is shown in Table 12. The percent of stocked plots ranged by species from 65 percent for red maple and the miscellaneous group, to 32 percent for American elm. Plots with red oak had increased to 42 percent. The largest percent by species of the stocked plots was still in the one seedling per plot class, which ranged from 25 percent for red maple to 19 percent each for yellow-poplar, sugar maple, red oak, and American elm. All of the plots were stocked with some species. The percent of plots stocked ranged from 2 percent with one seedling to 35 percent with six to ten seedlings per plot.





TABLE 11.  
 NUMBER AND DISTRIBUTION OF SEEDLINGS PER ACRE  
 BY HEIGHT CLASS IN THE FIFTH  
 YEAR AFTER LOGGING --  
 1955

| Species         | Height class -- feet |                    |                   |                   | Total  |
|-----------------|----------------------|--------------------|-------------------|-------------------|--------|
|                 | <u>Under 0.5</u>     | <u>0.5 to 3</u>    | <u>3 to 10</u>    | <u>Over 10</u>    |        |
|                 | Small<br>seedlings   | Large<br>seedlings | Small<br>saplings | Large<br>saplings |        |
| Number per acre |                      |                    |                   |                   |        |
| Yellow-Poplar   | 130                  | 900                | 300               | 0                 | 1,330  |
| Sugar Maple     | 410                  | 810                | 310               | 50                | 1,580  |
| Red Oak         | 130                  | 610                | 30                | 0                 | 770    |
| White Ash       | 380                  | 990                | 630               | 20                | 2,020  |
| Red Maple       | 1,150                | 850                | 140               | 0                 | 2,140  |
| American Elm    | 190                  | 600                | 260               | 0                 | 1,050  |
| Black Cherry    | 600                  | 350                | 120               | 50                | 1,120  |
| Miscellaneous   | 530                  | 890                | 680               | 110               | 2,210  |
| All Species     | 3,520                | 6,000              | 2,470             | 230               | 12,220 |

TABLE 12.

PERCENT OF PLOTS STOCKED WITH VARIOUS NUMBERS OF SEEDLINGS, BY SPECIES -- 1955

| Species       | Number of seedlings per plot                    |    |    |    |   |   |      |       |       |     | Total Percent<br>of plots<br>stocked |
|---------------|-------------------------------------------------|----|----|----|---|---|------|-------|-------|-----|--------------------------------------|
|               | 0                                               | 1  | 2  | 3  | 4 | 5 | 6-10 | 11-20 | 21 up |     |                                      |
|               | Percent of plots with above number of seedlings |    |    |    |   |   |      |       |       |     |                                      |
| Yellow-Poplar | 59                                              | 19 | 5  | 5  | 5 | 0 | 5    | 2     | 0     | 41  |                                      |
| Sugar Maple   | 43                                              | 19 | 19 | 5  | 2 | 0 | 12   | 0     | 0     | 57  |                                      |
| Red Oak       | 58                                              | 19 | 9  | 0  | 9 | 0 | 5    | 0     | 0     | 42  |                                      |
| White Ash     | 42                                              | 23 | 9  | 9  | 5 | 5 | 5    | 2     | 0     | 58  |                                      |
| Red Maple     | 35                                              | 25 | 12 | 12 | 5 | 0 | 9    | 2     | 0     | 65  |                                      |
| American Elm  | 68                                              | 19 | 7  | 0  | 0 | 2 | 2    | 2     | 0     | 32  |                                      |
| Black Cherry  | 52                                              | 23 | 14 | 2  | 7 | 0 | 2    | 0     | 0     | 48  |                                      |
| Miscellaneous | 35                                              | 21 | 12 | 12 | 5 | 5 | 5    | 5     | 0     | 65  |                                      |
| All Species   | 0                                               | 2  | 5  | 5  | 7 | 7 | 35   | 16    | 23    | 100 |                                      |

Rabbit Browsing. Yellow-poplar was browsed the least with only 5 percent showing signs of being browsed. Red oak was the most severely nipped with 60 percent of the stems browsed. An average of 21 percent of all the reproduction present in 1955 showed evidence of damage by rabbit browsing. This is shown as part of the data in Table 17 on page 49.

#### IV. THE REPRODUCTION IN 1957

Sprout Origin. The stocking and average height of the sprouts in 1957 is shown in Table 13. Although there were no sprouts of yellow-poplar present on the sample plots, yellow-poplar sprouts were evident on the area. Fig. 8 illustrates the sprouts from one yellow-poplar stump seven years after logging.

There were no new sprouts tallied in 1957. Of the original 1,290 sprouts per acre in 1952, only 220 had survived. All 70 sprouts of sugar maple that originated in 1955 survived, and this made the total number 290 per acre, or 22 percent of the original number in 1952. Red oak was still the most abundant with 110 sprouts. It was also the tallest of all the reproduction averaging 174 inches in height. Fig. 9 shows a typical clump of red oak sprouts in 1957. The average height of sprouts of all species had increased to 144 inches, a growth of 115 inches in five years. White ash sprouts were no longer present in 1957.

Seedling Origin. The stocking and average height of the seedlings in 1957 are shown in Table 14. The principal species in order of their abundance were white ash, sugar maple, American elm, red maple, black cherry, red oak and yellow-poplar. They represented 81 percent of the

1000

1000

TABLE 13.  
STOCKING AND AVERAGE HEIGHT OF SPROUTS IN THE SEVENTH YEAR AFTER LOGGING -- 1957

| Species     | Number of sprouts per acre |                      |                      |                      | Change<br>in<br>species<br>total<br>1952<br>to<br>1957 | Average height of sprouts<br>in 1957 |                      |                      |                              |   |     |
|-------------|----------------------------|----------------------|----------------------|----------------------|--------------------------------------------------------|--------------------------------------|----------------------|----------------------|------------------------------|---|-----|
|             | in 1957                    |                      |                      |                      |                                                        | inches                               |                      |                      |                              |   |     |
|             | Of<br>1952<br>origin       | Of<br>1953<br>origin | Of<br>1955<br>origin | Of<br>1957<br>origin |                                                        | Of<br>1952<br>origin                 | Of<br>1953<br>origin | Of<br>1955<br>origin | Of<br>1957<br>origin sprouts |   |     |
|             | Total                      |                      |                      |                      |                                                        |                                      |                      |                      |                              |   |     |
| Sugar Maple | 20                         | 0                    | 70                   | 0                    | 90                                                     | +125                                 | 128                  | 0                    | 114                          | 0 | 117 |
| Red Oak     | 110                        | 0                    | 0                    | 0                    | 110                                                    | -86                                  | 174                  | 0                    | 0                            | 0 | 174 |
| Beech       | 30                         | 0                    | 0                    | 0                    | 30                                                     | -80                                  | 123                  | 0                    | 0                            | 0 | 123 |
| Dogwood     | 60                         | 0                    | 0                    | 0                    | 60                                                     | -81                                  | 151                  | 0                    | 0                            | 0 | 151 |
| All Species | 220                        | 0                    | 70                   | 0                    | 290                                                    | -78                                  | 152                  | 0                    | 114                          | 0 | 144 |

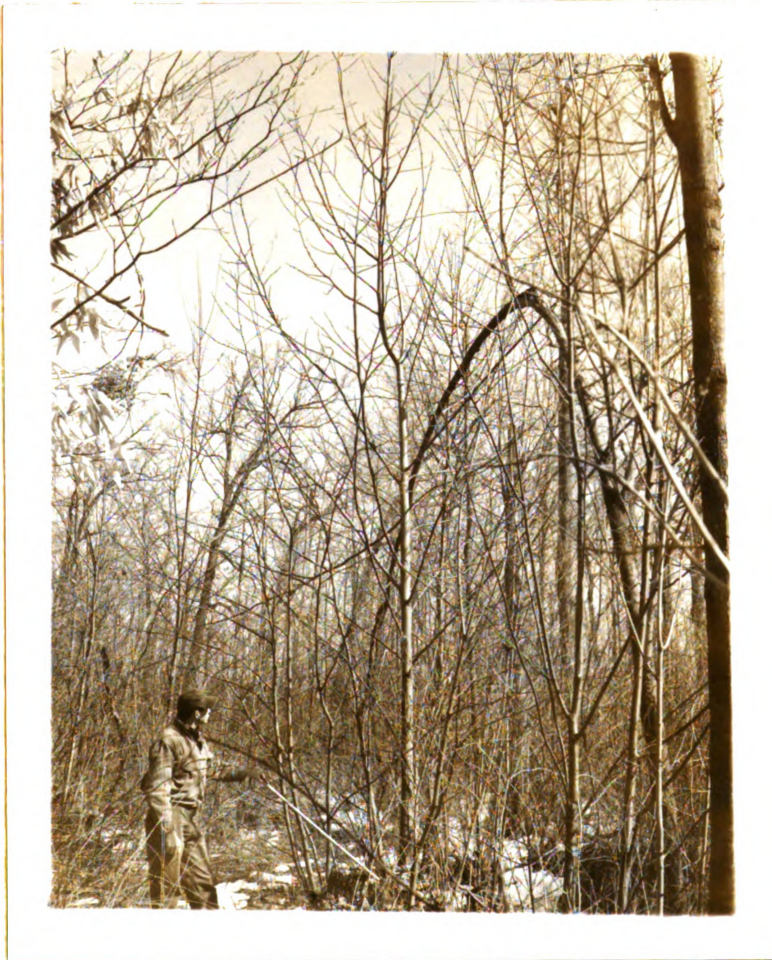


Fig. 8. An excellent yellow-poplar sprout with several smaller sprouts from a 24-inch stump seven years after logging.



**Fig. 9.** Typical red oak sprouts seven years after logging.



**STOCKING AND AVERAGE HEIGHT OF SEEDLINGS IN THE SEVENTH YEAR AFTER LOGGING -- 1957**

42

8,720 seedlings per acre. Of this total, 6,210 or 71 percent were from the original 13,900 seedlings present at the time of the first examination in 1952. Red oak was represented by 710 seedlings per acre, of which 560 were survivors from the first examination, 20 from the second, 100 from the third, and 30 were new seedlings in 1957.

The tallest seedlings, black cherry of 1952 origin, averaged 100 inches in height. Sugar maple of 1953 origin was the second tallest with an average of 95 inches. On the base of a weighted average of all the seedlings by species, the miscellaneous group was the tallest averaging 56 inches, and red oak was the smallest averaging 12 inches in height. Red maple with an average of 19 inches was only slightly taller than red oak. Yellow-poplar growth is illustrated in Fig. 10. Fig. 11 illustrates the stocking and height of some of the ash, sugar maple and black cherry on the area in 1957.

The reproduction per acre in 1955 by the four height classes is shown in Table 15. The majority of the reproduction was still in the large seedling class, but all species except red oak were represented in the large sapling class. The small sapling class was the second largest, with 2,390 stems as compared with 1,430 stems in the small seedling class.

The distribution of seedlings by species for the percent of plots which were stocked in 1957 is shown in Table 16. In 1957, all of the plots were still stocked but the percentage by species was reduced from the 1955 range. The range by species was from 51 percent with white ash, to 20 percent with yellow-poplar. Red oak was represented on 29 percent of the plots. The one seedling per plot class still had the



**Fig. 10. Yellow-poplar seedling growth seven years after clear cutting on a sample plot in an area that was completely denuded by the logging operation. The steel pipe indicated by the arrow is located at the plot center.**





Fig. 11. Dense seedling reproduction of ash, sugar maple, and black cherry in 1957. The seedling height in this area is well above the average for the reproduction over the area.



TABLE 15.  
NUMBER AND DISTRIBUTION OF SEEDLINGS PER ACRE  
BY HEIGHT CLASS IN THE SEVENTH  
YEAR AFTER LOGGING —  
1957

| Species         | Height class -- feet |                    |                   |                   | Total |
|-----------------|----------------------|--------------------|-------------------|-------------------|-------|
|                 | Under 0.5            | 0.5 to 3           | 3 to 10           | Over 10           |       |
|                 | Small<br>seedlings   | Large<br>seedlings | Small<br>saplings | Large<br>saplings |       |
| Number per acre |                      |                    |                   |                   |       |
| Yellow-Poplar   | 100                  | 170                | 370               | 20                | 660   |
| Sugar Maple     | 180                  | 510                | 530               | 120               | 1,340 |
| Red Oak         | 170                  | 520                | 20                | 0                 | 710   |
| White Ash       | 150                  | 970                | 680               | 80                | 1,880 |
| Red Maple       | 100                  | 570                | 70                | 20                | 760   |
| American Elm    | 240                  | 430                | 210               | 50                | 930   |
| Black Cherry    | 220                  | 350                | 120               | 70                | 760   |
| Miscellaneous   | 270                  | 690                | 390               | 330               | 1,680 |
| All Species     | 1,430                | 4,210              | 2,390             | 690               | 8,720 |

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2

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TABLE 16.

PERCENT OF PLOTS STOCKED WITH VARIOUS NUMBERS OF SEEDLINGS, BY SPECIES --- 1957

| Species       | Number of seedlings per plot                    |    |    |    |    |   |      | Total Percent    |       |
|---------------|-------------------------------------------------|----|----|----|----|---|------|------------------|-------|
|               | 0                                               | 1  | 2  | 3  | 4  | 5 | 6-10 | 10-20            | 21 up |
|               | Percent of plots with above number of seedlings |    |    |    |    |   |      | of plots stocked |       |
| Yellow-Poplar | 80                                              | 7  | 5  | 2  | 2  | 2 | 2    | 0                | 0     |
| Sugar Maple   | 55                                              | 17 | 10 | 7  | 2  | 2 | 7    | 0                | 0     |
| Red Oak       | 71                                              | 15 | 5  | 2  | 5  | 0 | 2    | 0                | 0     |
| White Ash     | 49                                              | 22 | 5  | 5  | 2  | 7 | 10   | 0                | 0     |
| Red Maple     | 66                                              | 22 | 5  | 2  | 0  | 0 | 5    | 0                | 0     |
| American Elm  | 77                                              | 12 | 5  | 0  | 2  | 0 | 2    | 2                | 0     |
| Black Cherry  | 54                                              | 34 | 2  | 5  | 5  | 0 | 0    | 0                | 0     |
| Miscellaneous | 52                                              | 20 | 17 | 2  | 2  | 0 | 2    | 5                | 0     |
| All Species   | 0                                               | 7  | 2  | 20 | 10 | 5 | 27   | 22               | 7     |
|               |                                                 |    |    |    |    |   |      |                  | 100   |

largest percent of stocking by species. It ranged from 34 percent with one black cherry seedling, to 7 percent with one yellow-poplar seedling. Twenty-seven percent of all plots had six to ten seedlings of some species and 2 percent had only two seedlings. Twenty percent of all plots had three seedlings on them.

Rabbit Browsing. By 1957, 36 percent of all the reproduction showed some browsing by rabbits. By species this ranged from 67 percent of the red maple and 66 percent of the red oak, down to 21 percent of the yellow-poplar. Table 17 shows the percent browsed by species for each examination. Fig. 12. illustrates browsed red maple, sugar maple, and American elm seedlings in 1957.

#### V. COMPARISON OF THE REPRODUCTION BY EXAMINATIONS

Trends in composition, height, and distribution of the reproduction are shown by comparing the four examinations.

Table 18 shows a comparison of the seedling and sprout reproduction for the four examinations. This table shows that sprouts comprised only a minor portion of the number of stems for each examination. The largest number of sprouts was present in the second year after logging, with a decrease in the three subsequent examinations. The number of seedlings had increased between 1952 and 1953, but the two subsequent examinations showed a substantial reduction in the total number per acre. The number of seedlings represented adequate reproduction present for each examination.

Fig. 13 indicates that the seedling reproduction that originated during the first two years after logging is the most important

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7  
8  
9

TABLE 17.

PERCENT OF REPRODUCTION BROWSED BY RABBITS  
BY SPECIES AND YEAR OF EXAMINATION

| Species             | Year of examination |      |      |      | Average |
|---------------------|---------------------|------|------|------|---------|
|                     | 1952                | 1953 | 1955 | 1957 |         |
|                     | Percent             |      |      |      |         |
| Yellow-Poplar       | 0                   | 3    | 5    | 21   | 7       |
| Sugar Maple         | 9                   | 8    | 30   | 26   | 18      |
| Red Oak             | 1                   | 9    | 60   | 66   | 34      |
| White Ash           | 8                   | 14   | 34   | 25   | 20      |
| Red Maple           | 4                   | 15   | 18   | 67   | 26      |
| American Elm        | 3                   | 31   | 38   | 56   | 32      |
| Black Cherry        | 6                   | 4    | 11   | 28   | 12      |
| Miscellaneous       | 3                   | 7    | 21   | 25   | 14      |
| Average all species | 3                   | 9    | 21   | 36   | 24      |





Fig. 12. Reproduction browsed by rabbits; red maple (1), sugar maple (2 and 4), and American elm (3). Photographed in 1957.

### COMPARISON OF THE NUMBER OF SEEDLINGS AND SPROUTS IN 1952, 1953, 1955, AND 1957

51

1952  
origin

1953  
origin

1955  
origin

1957  
origin

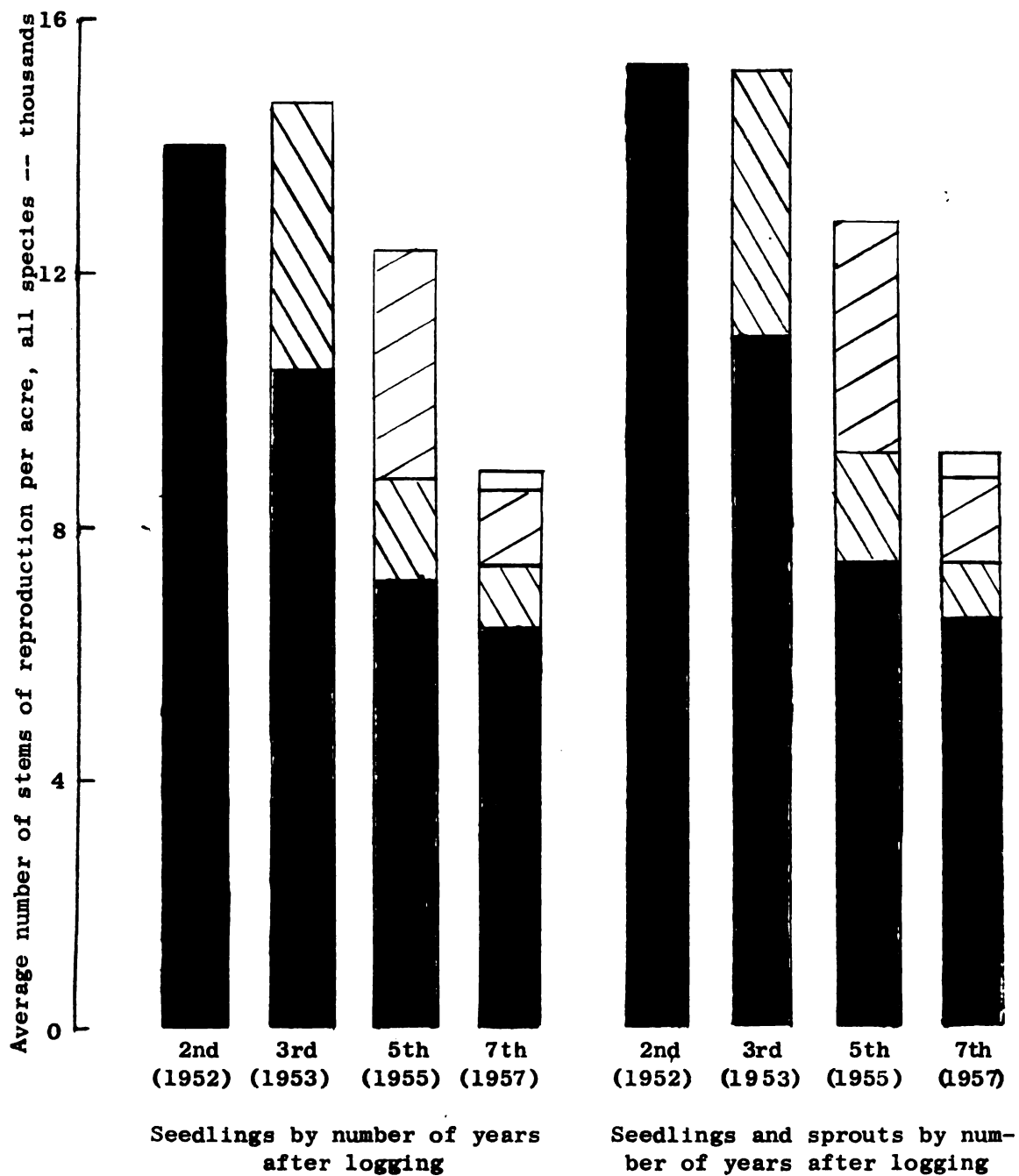


Fig. 13. Comparison of the average number of stems of reproduction per acre, all species, by seedling origin, and seedling and sprout origin for the second, third, fifth, and seventh years after logging.



reproduction on the area. Because of the relatively small number of sprouts, there is very little difference between the number of seedlings and the total reproduction for the four examinations. The major difference is a slight decrease in the total reproduction in the third year after logging as a result of sprout mortality even though the number of seedlings increased.

A comparison of the percentages by species of the seedling reproduction present for each examination is shown in Fig. 14. White ash is the only species that shows a regular pattern of increase for the four examinations. Red maple increased in the third and fifth years after logging, but by 1957, it had decreased to the same level as in 1952. Sugar maple and American elm showed a decrease in the third year after logging, but the two subsequent examinations show increases in their numbers. With the exception of the third year after logging, yellow-poplar shows a pattern of decreasing numbers. Red oak was relatively stable, increasing only slightly in the seventh year after logging. The percentage of black cherry was unchanged in the third year after logging. In the fifth year after logging it increased but the pattern was not continued in 1957. The percentage for the miscellaneous group was relatively stable for the four examinations, decreasing only 4 percent in the fifth year after logging with an increase of one percent between 1955 and 1957.

Fig. 15. shows that the average height of the yellow-poplar, sugar maple and white ash followed a regularly increasing trend. There was a broken pattern of increase in height for American elm, black cherry, and the miscellaneous group. The irregularity in height growth of

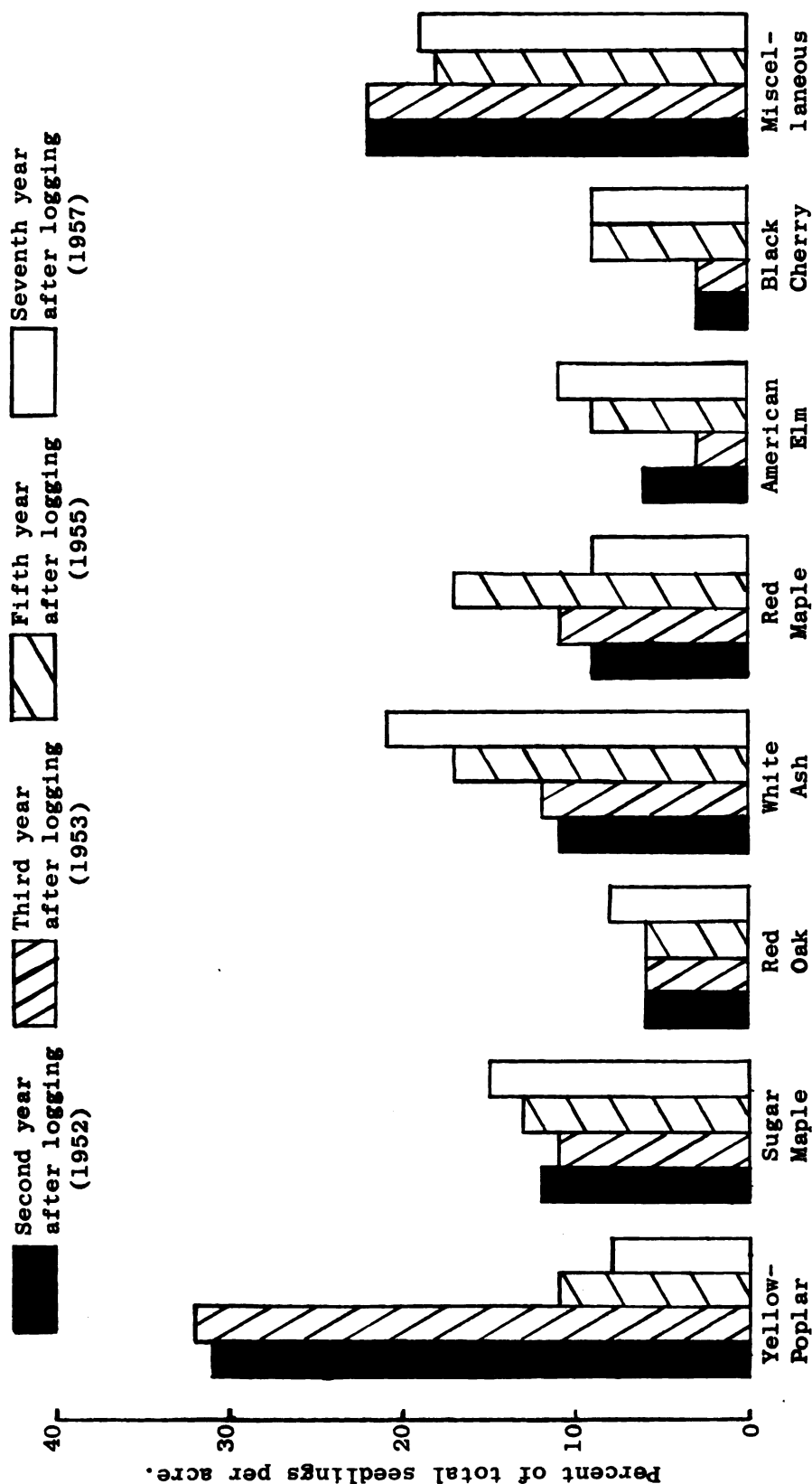


Fig. 14. Percentages by species of the total seedlings per acre present for the second, third, fifth, and seventh years after logging. The miscellaneous species group includes black oak, sassafras, basswood, white oak, dogwood, prickly ash, aspen, hickory, black walnut, hawthorn, witch-hazel, and black willow.

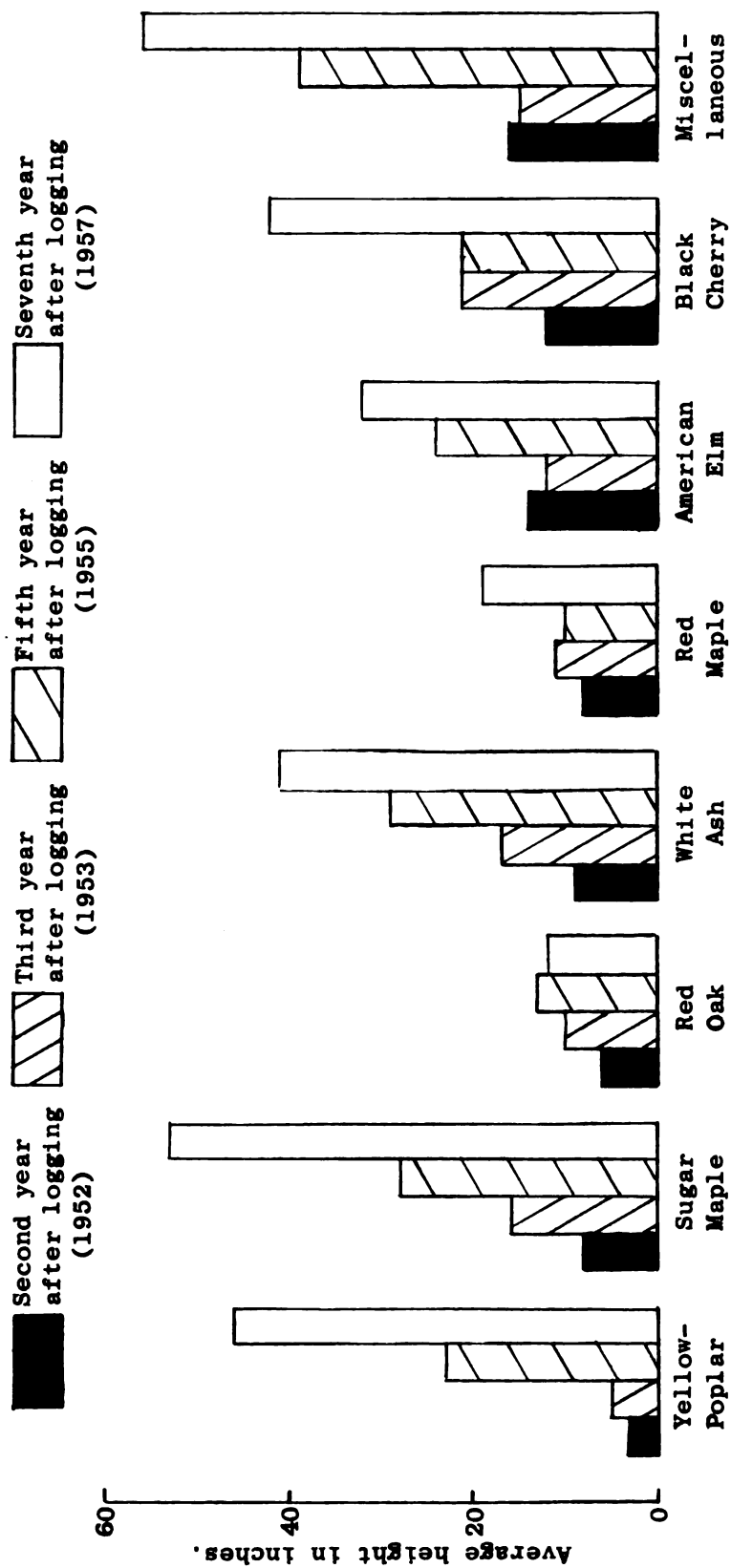


Fig. 15. Average seedling height by species for the second, third, fifth, and seventh years after logging.

these species is a result of averaging the low height of large numbers of new seedlings with decreased numbers of older, taller seedlings. The slowness and irregularity of the pattern of height growth for red oak and red maple is attributed to the severity of browsing of these species by rabbits.

Fig. 16 shows that there was an irregular pattern of increased distribution by species of the percent of plots stocked from 1952 through 1955. By 1957, there was a generally decreasing trend in the percent of plots stocked for all species.

Fig. 17 shows an irregular distribution of plots by number of seedlings per plot. There has been a general decrease in the percent of plots having more than ten seedlings per plot. In the seventh year after logging, this decreasing trend included the plots with six to ten seedlings per plot. In general the percentage of plots with one to five seedlings per plot has increased.

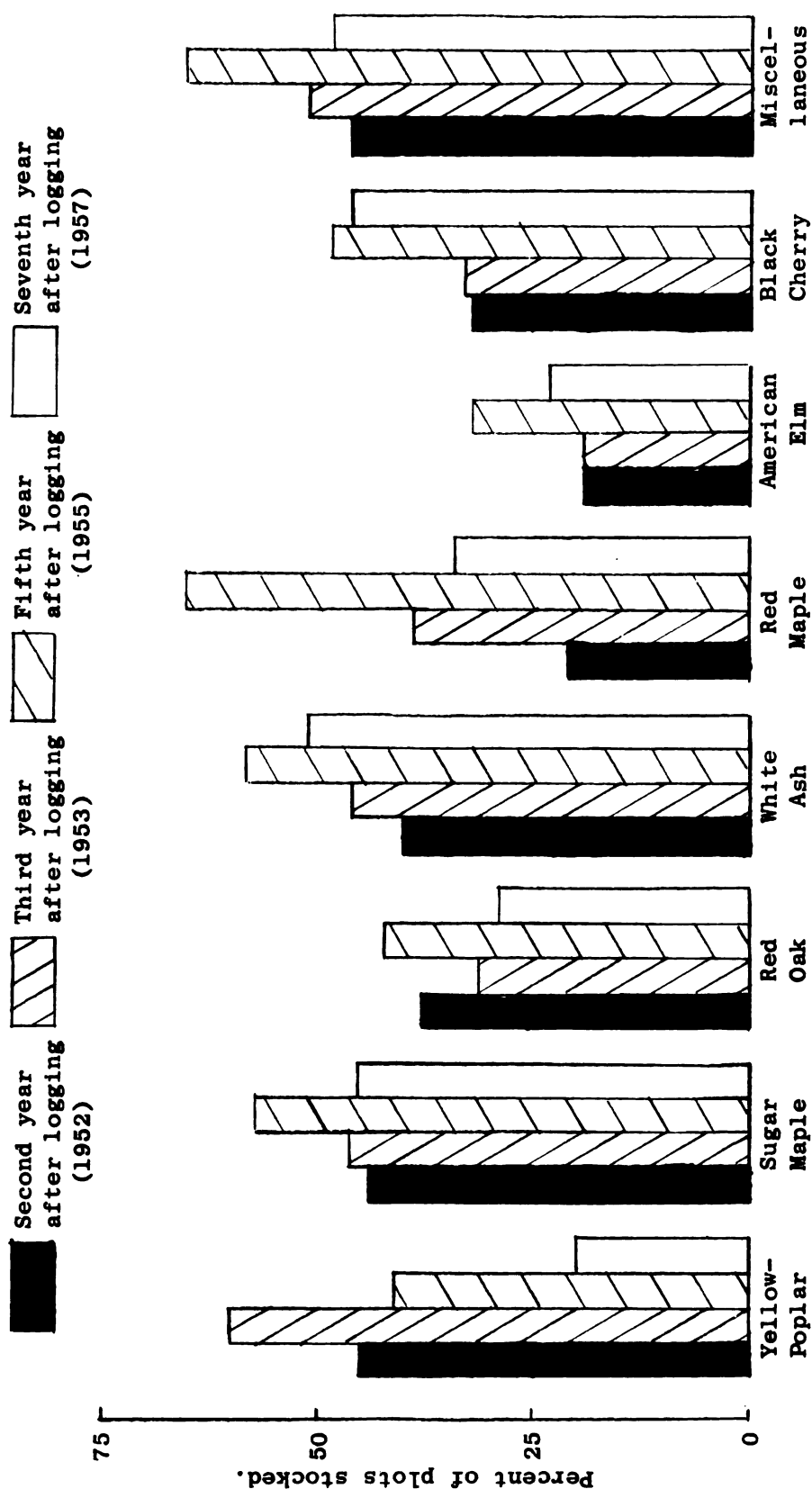


Fig. 16. The percent of the plots stocked with seedlings by species for each examination.

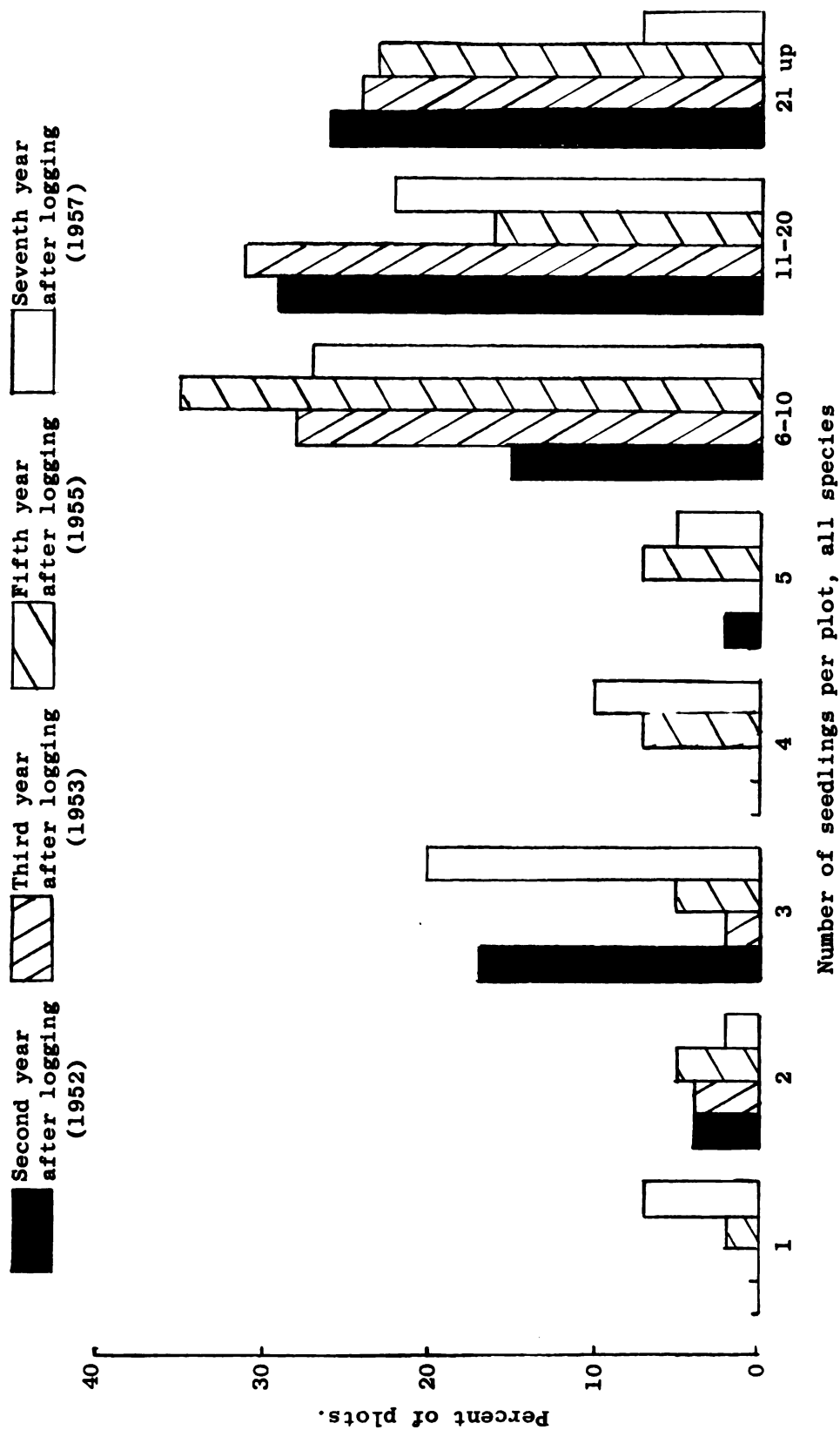


Fig. 17. The percent of plots stocked by number of seedlings per plot for each examination.

## CHAPTER V

### SUMMARY AND CONCLUSIONS

Four examinations of the natural regeneration following commercial clear cutting of an excellent oak-mixed hardwood stand in 1950 were made two, three, five, and seven years after logging. The examinations were made on 46 mil-acre plots established in 1952. The established reproduction was ample and mainly of seedlings originating after logging and before the first examination in 1952.

Reproduction of sprout origin, principally of red oak, was only 8.6 percent of the total reproduction in 1952, and decreased with each subsequent examination. The best height growth of all the reproduction was made by the red oak sprouts which grew from an average of 47 inches in 1952 to an average of 174 inches in 1957. Sprouts, in general, made the best height growth, increasing from an average of 29 inches in the first examination to an average height of 144 inches in 1957.

The composition of the stand before logging was red and white oak, sugar maple, hickory, yellow-poplar, elm, white ash, and red maple. The principal seedlings present in 1952, in order of their abundance were yellow-poplar, sugar maple, white ash, red maple, red oak, American elm, and black cherry. These species composed 78 percent of the seedling reproduction, with the remaining 22 percent composed of 17 miscellaneous species. Fluctuations in the ranking of these species occurred in the subsequent examinations, and in 1957 their ranking had changed to white ash, sugar maple, American elm, red maple, black

cherry, red oak, and yellow-poplar. These species composed 81 percent of the seedling reproduction at that time.

In 1952, seedling reproduction averaged 13,900 stems per acre with an average height of nine inches. The reproduction was classed principally as small seedlings, less than one-half of a foot in height. The distribution of stocking was irregular. Seven percent of the sample plots were without reproduction, 29 percent had in excess of eleven seedlings, and there were no plots with only one seedling. Red oak was represented on 38 percent of the plots. Rabbit browsing was relatively light with only 3 percent of the total reproduction browsed. Yellow-poplar was the most abundant species with 4,280 seedlings per acre, however, it averaged only three inches in height. Red oak was represented by 830 seedlings per acre with an average height of six inches.

By 1953, seedling reproduction had increased to 14,590 stems per acre with an average height of 12 inches. The number of yellow-poplar had increased to 4,650 per acre as a result of 1,830 new seedlings which more than replaced mortality losses. The majority of the seedling reproduction except for yellow-poplar and the miscellaneous group was large seedlings, between one-half and three feet in height. However, there was still considerable representation, particularly of yellow-poplar and the miscellaneous group, in the small seedling class. Distribution of stocking was still irregular with 11 percent of the sample plots unstocked and 31 percent of the plots with six to ten seedlings. Rabbit browsing had increased to 9 percent of the reproduction.



The number of seedlings had decreased by 1955 to 12,220 per acre. The average height had increased to 24 inches. The greatest mortality was in yellow-poplar which had only 31 percent of the stocking present in 1952. The reproduction was primarily classed as large seedlings, with a large number of small seedlings, but the small sapling class - over three feet but less than ten feet in height - was beginning to be well represented by all species. There was a small representation of sugar maple, white ash, black cherry, and the miscellaneous group in the large sapling class - over ten feet in height. Distributions of the stocking had improved with all of the sample plots being stocked. The percent of stocked plots ranged from 2 percent with one seedling to 35 percent with six to ten seedlings per plot. Rabbit browsing on red oak was serious with 60 percent of these seedlings browsed. An average of 21 percent of all the reproduction present had been browsed.

By 1957, the seedling stocking had decreased to 8,720 stems per acre. Of this total, 6,210, or 71 percent, were survivors from the original 13,900 seedlings present in 1952. Red oak was represented by 710 seedlings per acre averaging 12 inches in height. The average height of the seedling reproduction was 41 inches. The reproduction was still primarily in the large seedling class, but there were 2,390 stems per acre established in the small sapling class. Red oak was the only species not represented in the large sapling class. All of the plots were stocked. Twenty-seven percent of the sample plots were stocked with six to ten seedlings. Red oak was present on 29 percent of the plots. By 1957, an average of 37 percent of all the reproduction

had been browsed by rabbits. Red maple and red oak were the species browsed the most, with 67 percent and 66 percent browsed, respectively.

Significance of the developments observed in this study may be summarized as follows:

(1) Reproduction sufficient to restock the area was primarily of seedlings originating within the first two years after clear cutting.

(2) Species representation in the reproduction indicate that the composition of the regenerated stand will be greatly different from the stand which was clear cut. Red oak and yellow-poplar are minor components of the new stand, with hickory and white oak reduced to only occasional representation within the new stand. Former oaks, hickories, and yellow-poplars have been replaced by white ash, American elm, red maple and black cherry.

(3) Fluctuations occurring within the number and distribution of seedlings present by species indicate that the reproduction is not yet fully established; however, the representation in the small sapling or larger class in 1957 indicates that partial establishment by all species has been achieved by the seventh year after logging.

(4) Rabbit browsing is severely detrimental to the height growth of red oak and red maple seedlings. In the case of oak, rabbit browsing damage may be the most important factor in limiting the representation of oak in the established reproduction.

(5) Developments observed in this study indicate that clear cutting oak-mixed hardwood stands is suitable for obtaining adequate natural regeneration to form the next stand; however, it will result in substantial species composition changes with the oaks, hickories, and yellow-poplars being reduced to minor components of the regenerated stand.

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