JANUARY, 1944

OHIO
AGRICULTURAL
EXPERIMENT
STATION
Wooster, Ohio

BULLETIN 647

OHIO FOREST PLANTINGS

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The white pine plantation pictured on the cover is located in the Wooster (Ohio) Forest Arboretum and was 30 years old at the time the picture was taken. The tree being measured was 10.5 inches in diameter; a number of trees were approximately 12 inches in diameter. The average height of the planting was 48 feet.

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PREFACE

The authors wish to acknowledge the assistance, both financial and advisory, in the analysis and interpretation of the data rendered by the Central States Forest Experiment Station.

The organization, techniques, and forms used in the survey were largely developed to fit the problem found in Ohio. Considerable assistance was secured in the development of forms from the Lake States Forest Experiment Station and the Department of Forests and Waters, Pennsylvania. The method used in determining the average survival in the plots was developed by the Soil Conservation Service.

Valuable assistance in analyzing the data and determining their significance was given by Mr. G. H. Stringfield, Associate Agronomist, and Mr. J. T. McClure, Assistant Agronomist, Ohio Agricultural Experiment Station, and Mr. J. W. Osborne, United States Forest Service. For their assistance in reviewing the manuscript the authors are especially indebted to O. A. Alderman, State Forester of Ohio, A. G. Chapman, Silviculturist, and Paul O. Rudolf, Associate Silviculturist, both of the United States Forest Service, Oscar J. Dowd, Pathologist, United States Bureau of Entomology and Plant Quarantine, O. D. Diller, Associate Forester, J. S. Houser, Chief Entomologist, and Paul E. Tilford, Plant Pathologist, Ohio Agricultural Experiment Station.

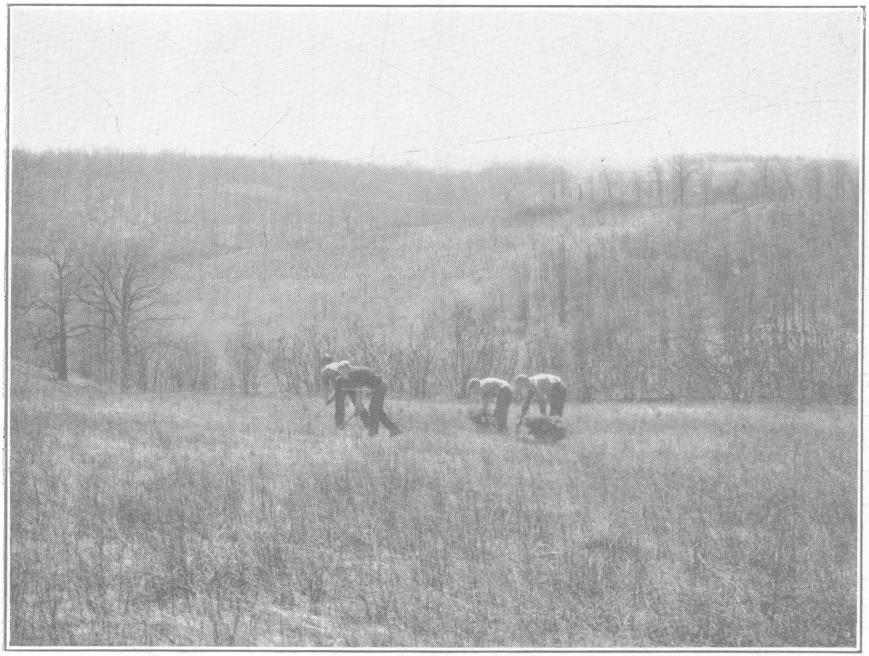

Fig. 1.—Reforesting typical old fields in Ohio

INTRODUCTION

There is in Ohio an estimated area of 1,500,000 to 2,000,000 acres of land which is of little value for agricultural purposes and yet is bearing little or no tree growth. Most of this area is in the eastern part of the State. This area of nonproductive land is found throughout the northeast and southeast regions (fig. 2) in separate, relatively small parcels adjoining and divided by farm land, forests, and communities and, because of its scattered nature, is frequently disregarded as a social or individual problem; tracts of land often have been abandoned or virtually so for many years and have not yet become restocked with native trees.

Such areas present a problem of land use. Occasionally, their best use may be of an agronomic nature and will justify some intensive improvement work, but more often their best use is of a forestry nature. Natural methods of restocking the area with trees may have failed or may be proceeding so slowly that artificial planting is indicated as the best solution.

The problems involved in artificially restocking an old field with trees include the questions of the proper species to use, the best methods of planting, and the later cultural treatments needed. The answers to these problems can be found to a large extent in the existing plantings that have been made in Ohio during the past 37 years. These plantings, set out for the most part by individuals on privately owned land, have been planted under nearly every conceivable condition, and their relative success or failure is a measure of the influence of these conditions.

The importance of the reforestation program in Ohio and the probability of its expansion made the solution of some of these problems imperative. For this reason, a survey project was drawn up, designed to study the existing plantings and determine their present condition and growth. The survey was limited to plantings made with trees secured from the nurseries of the Ohio Division of Forestry.

The plan was submitted to the Work Projects Administration as a relief project and received approval in 1938.

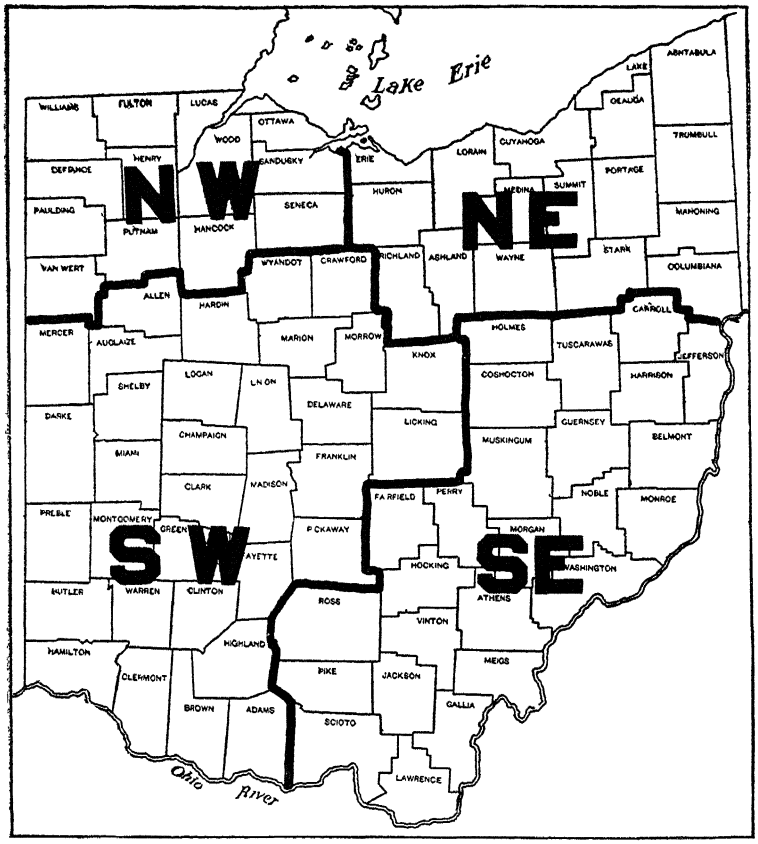

Fig. 2.—Counties of Ohio as grouped into regions

A SURVEY OF FOREST PLANTATIONS IN OHIO

ROBERT R. PATON,[1] EDMUND SECREST,[2] AND HAROLD A. EZRI[3]

SURVEY PROCEDURE

PERSONNEL

The field crews, under college-trained foresters acting as county supervisors, were composed of 7 or 8 men.

Each county supervisor had only one crew in his charge, with the result that a close degree of supervision was achieved at all times. Such supervision was necessary because of the technical nature of the data being secured, the necessity for identification of a great variety of species, the determination of site factors, and the maintenance of favorable public relations.

TECHNIQUES

The nursery shipping records of the Ohio Division of Forestry were used as the basis for the survey. These records provided the names and addresses of the cooperators, the species, age, and number of trees purchased, and the year of planting.

After the planting had been located, the crew visited the area, mapped the existing planting, and divided it into plots where necessary. The plot division was based on observable differences in site, changes in species or mixtures, differences in date or method of planting, and such other factors as competing vegetation, grazing by livestock, and erosion. Thus, each plot represented a uniform set of conditions, so far as possible, and became the working unit of the survey.

The following data were secured for each plot and entered on the field form:

Site factors:

Ground cover at time of planting
Exposure (N, NE, E, etc.)
Topography (bottom land, hillside, hilltop)
Degree of erosion
Degree of drainage
Competing vegetation at time of survey

Other factors:

Field preparation
Planting method
Planter (self, hired crew, or organization)
Necessity for cutting or cleaning
Evidence of injury, including grazing

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[1]Associate Forester, Ohio Agricultural Experiment Station, Division of Forestry.
[2]Director, Ohio Agricultural Experiment Station.
[3]Assistant, Ohio Agricultural Experiment Station, Division of Forestry. Now with our armed forces.

Growth and survival data were secured in the following manner:

Height.—Heights of 200 or more trees in each plot and selected from the entire plot were measured to the nearest foot. Where there were fewer than 200 trees in the plot, all trees were measured. If the plot contained a mixture, 200 or more trees of each species were measured.

Survival.—An estimate was made of the average survival of each plot or of each species in the plot by a method developed and used by the Soil Conservation Service in Ohio. This method was as follows: The number of living trees in a row of 10 consecutive planted spaces was counted and expressed in per cent. This figure represented one sample. An effort was made to secure at least 10, preferably 25, such samples in each plot. The survival for each sample was tallied in a dispersion form. The mean and the standard error of the mean were determined, and if the error was found to be less than 5 per cent, the estimate of survival was entered on the field form for that plot. If the error was more than 5 per cent, additional samples were taken, or the data were discarded and another more intensive group of samples taken.

Survivals were taken for each species separately if the plot was a mixture and if it was possible to determine the pattern followed in planting the mixture; otherwise, no survival estimate was made.

The density of the planted trees and the species and number of volunteers found in each plot were determined by tallying all trees found in two 1/20-acre sample quadrats laid out in each plot. The planted trees were recorded separately from the volunteers.

ANALYSIS OF RESULTS

The data were sorted by counties, by species, and by plots, and the average survival and average annual height growth for each species for each region were calculated.

The amount of influence of the various factors of site on the different species was then studied by determining the average survival and average annual height growth for each species under each site condition.

PLANTING HISTORY

DEVELOPMENT OF FOREST PLANTING

Forest planting stock was first distributed to landowners by the State in 1904, when the Wooster Nursery at the Ohio Agricultural Experiment Station was established.

Early efforts at tree planting were concerned largely with the production of species suitable for fence posts, rather than for reforestation as it is thought of today. There was a great demand for catalpa seedlings and for small quantities of black locust, Osageorange, and mulberry. Many of these early plantings are still to be seen scattered about the State. There was a perceptible decline in this type of planting after 1912. One of the factors responsible for this trend was that catalpa fell into disrepute, partly because of a lack of understanding of the site requirements of the species, with the result that many plantings were made in unsuitable locations and the growth rates were unsatisfactory.

The concept of reforestation was undergoing a fundamental change around 1920 which was reflected in the type of reforestation practiced. Hardwoods were found to be unsuitable for reforesting open areas, and pines began to be used in increasing numbers.

Passage of the Clarke-McNary Law in 1924 made Federal assistance available to State nurseries in the production of planting stock for reforestation and made possible the establishment of a new and larger nursery at Marietta, Ohio, in 1925. This increase in productive capacity resulted in more extensive planting operations.

The Soil Conservation Service and the Civilian Conservation Corps, which were organized in 1935 and 1933, respectively, provided another stimulus to reforestation.

Progress in reforestation has thus been speeded up through increased public interest in the problem. Vocational agriculture classes and 4-H Clubs have taken up the work under the guidance of teachers, leaders, and county agricultural agents, who have placed increasing emphasis upon the necessity for reforestation.

The State planting program has made some progress toward reducing the total area in need of reforestation and in creating public interest in conservation, but by comparison with the amount of idle land in Ohio, it is still inadequate. Being on a purely voluntary basis, it has encountered difficulties due to lack of competent supervision and to the disorganized state of the work. Because of these obstacles, only 9,000 acres of forest plantations had been established up to and including 1938 by private cooperators, and only 200 windbreaks had been planted in western Ohio.

The organization, during recent years, of county land-use planning committees, composed of progressive farmers, should prove to be a constructive step toward eliminating some of the difficulties in planning and carrying out recommended procedures. These committees, working toward a coordinated program of land use, are influencing landowners to retire unproductive land to forests.

SHIPMENT OF SPECIES

For this survey the State was divided into four sections or regions based on very broad forest types, which are, in turn, expressions of the topographic, geologic, and climatic differences described more fully later in this report. The species which have been most prominent in reforestation work in the State as a whole are presented in table 1, showing the numbers which have been distributed through 1938, and in tables 30, 31, 32, and 33, they are listed by regions.

Four species, red, Scotch, and white pines and black locust, together comprise nearly 60 per cent of the total. The conifers as a group comprise 71.6 per cent of the total. Small quantities of a number of species have been used in an experimental way, but the total quantity of these has been small, and their contribution in area to the reforestation problem, negligible. Shortleaf pine is becoming more important, and in a few years will hold a higher rank than indicated in table 1.

Forty-five per cent of the planting stock thus far distributed has been sent to cooperators in the northeast region of Ohio, 32 per cent to cooperators in the southeast, 20 per cent to those in the southwest, and 3 per cent to those in

TABLE 1.—Shipments of planting stock by species

Species	Total	Per cent
Scotch pine	4,848,974	16.8
Red pine	6,323,643	21.9
White pine	2,694,931	9.3
Austrian pine	2,320,420	8.0
Corsican pine	1,444,982	5.0
Shortleaf pine	227,325	.8
Norway spruce	2,442,315	8.5
Japanese larch	71,866	.2
European larch	127,730	.4
Douglasfir	11,430	.1
Arborvitae	2,870	.....
Miscellaneous conifers	158,692	.6
Total conifers	20,675,178	71.6
Black locust	3,239,814	11.2
Black walnut	1,052,547	3.6
Tuliptree	884,827	3.1
White ash	823,850	2.9
Red oak	648,575	2.2
White oak	267,825	.9
Catalpa	967,453	3.3
Sugar maple	209,393	.7
Cottonwood	103,613	.4
Osageorange	43,202	.1
Total hardwoods	8,241,199	28.4
Grand total	28,916,577	100.0

TABLE 2.—Shipments of planting stock by 5-year intervals

Combined regional totals

	1904-08	1909-13	1914-18	1919-23
Conifer total	5,545	123,893	215,173	153,588
Hardwood total	629,100	633,414	111,952	335,720
Grand total	634,645	757,307	327,125	489,308

	1924-28	1929-33	1934-38	Total
Conifer total	4,788,612	9,008,272	6,380,095	20,675,178
Hardwood total	1,880,517	1,793,858	2,856,638	8,241,199
Grand total	6,669,129	10,802,130	9,236,733	28,916,377

the northwest (fig. 3). Although western Ohio has received comparatively small quantities, there are concentration of tree shipments in the vicinities of Cincinnati and Toledo.

The number of cooperators by counties indicated graphically in figure 4 shows essentially the same pattern as the distribution of trees in the total

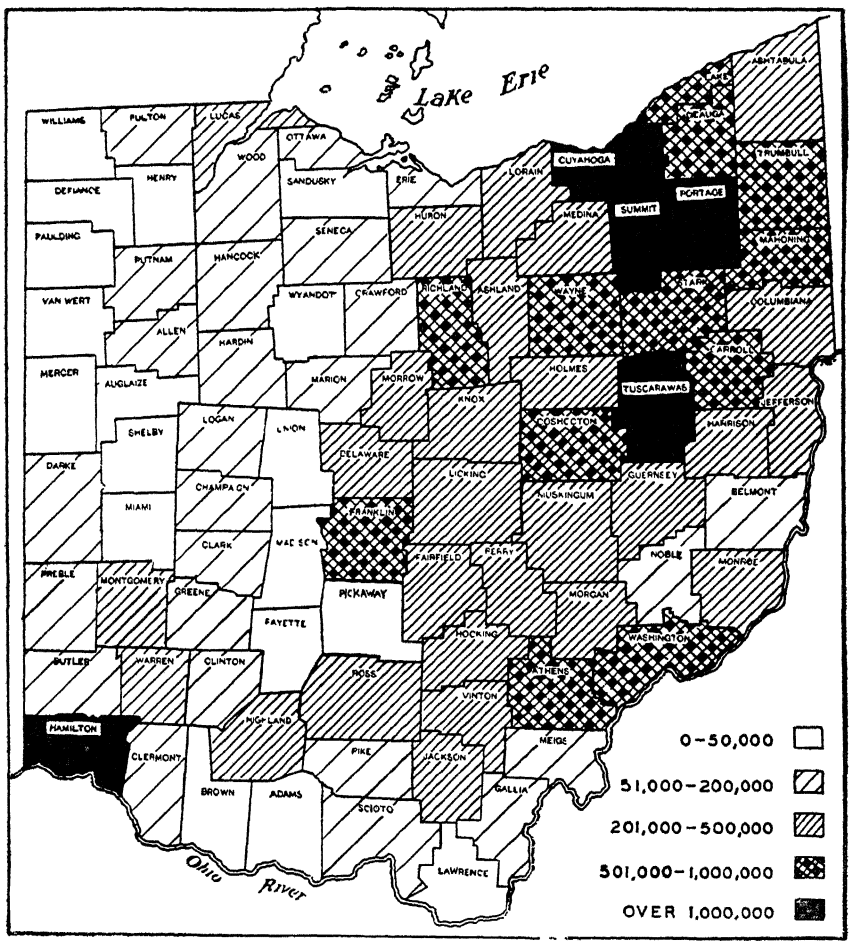

Fig. 3.—Distribution of trees shipped by counties

number (fig. 3). Although most of the cooperators are farmers, a number of other classes of cooperators have established plantings. Ranking second in number in all regions have been the 4-H Clubs and vocational agriculture classes, who have planted trees both in small individual plots and in group projects. Other types of cooperators are Scouts, conservation clubs, and similar organizations, chambers of commerce, public institutions, municipalities, and owners of large country estates. A large number of municipal plantings have been made, and some of the finest and most extensive plantings in the State are to be found around some of Ohio's public water supply reservoirs.

TABLE 3.—Number of cooperators

Year	Southeast region	Southwest region	Northeast region	Northwest region	Total
1904-08	143	383	134	102	762
1909-13	141	289	97	63	590
1914-18	55	68	89	23	235
1919-23	107	103	148	36	394
1924-28	480	376	711	118	1,685
1929-33	1,678	688	1,736	149	4,251
1934-38	2,369	729	1,317	304	4,719
Total	4,973	2,636	4,232	795	12,636

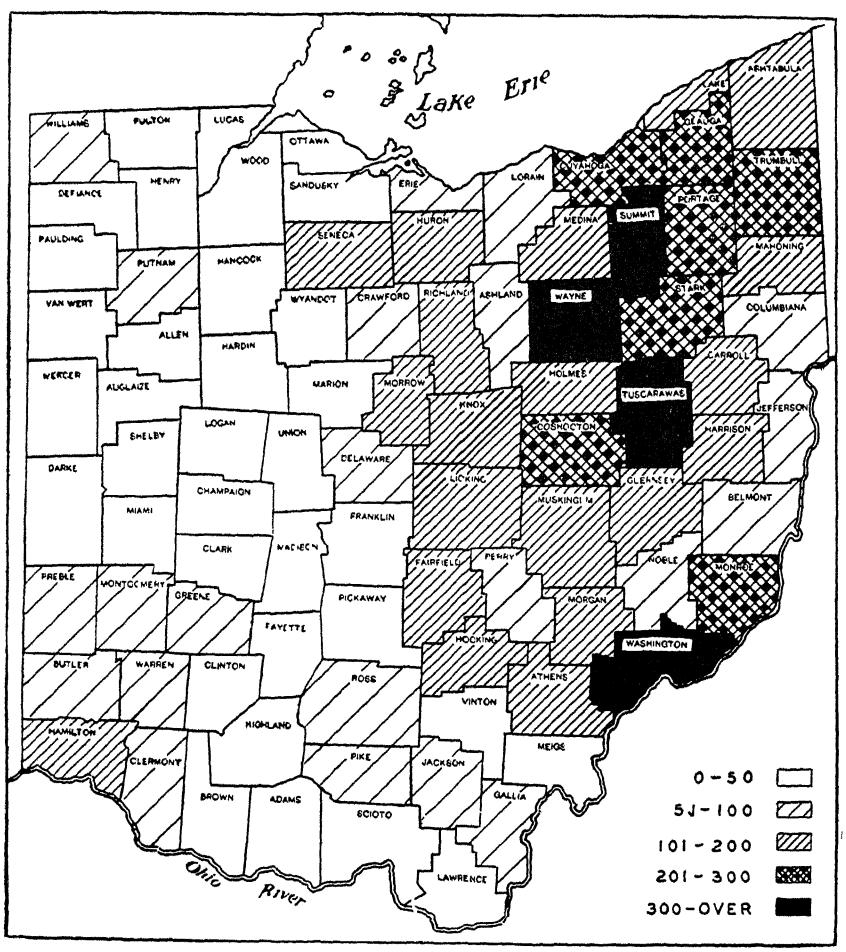

Fig. 4.—Number of cooperators, by counties

DESCRIPTION OF REGIONS

Certain distinctive differences occur between various sections of the State, and for the purposes of the survey, the counties were grouped into four regions, based upon these differences. These regions differ in topography, climate, and soil—important influences in determining forestry practices.

TOPOGRAPHY

All the State except the southeastern portion outlined in figure 2 has been glaciated and is characterized by rolling land with limited areas of hilly, broken terrain along stream banks and in the vicinity of the terminal moraines.

The lake plain section of northwestern Ohio is a nearly level area sloping slightly toward the north and varying in width from a narrow strip 2 to 10 miles wide in the northeast to a broad plain at its western extreme which embraces the greater part of northwestern Ohio. This plain is the former bed of a glacial lake, the waters of which have receded to the present shore line of Lake Erie. The plain is bounded by a ridge at its southern edge which forms the divide between the two great drainage systems of the State.

Southeastern Ohio is a part of the Allegheny foothills and was once a plateau of somewhat higher elevation than the adjoining country to the north and west. This region, affected only by erosion and weathering, has been transformed from a comparatively level plateau into a section of deeply dissected, steep hills; level areas occur only on ridges and in the valleys. The soil losses in this region are tremendous. Erosion is stimulated by clearing steep slopes and inefficient methods of farming.

CLIMATE

Average annual temperatures range from 48 degrees in northern Ohio to 55 degrees near the southern tip. Temperatures in the lake plain area are somewhat higher than the average for northern Ohio because of the influence of Lake Erie.

Precipitation increases from northwestern Ohio toward the southeastern part of the State, from 33 to 36 inches average annual precipitation in the northwest to 39 to 42 inches in a wide belt along the Ohio River. A restricted area in Adams and portions of adjoining counties averages more than 42 inches of precipitation annually. Another area of high annual precipitation occurs in northeastern Ohio, in portions of Geauga, Ashtabula, and Lake Counties. In general, the eastern part of the State receives more precipitation than the western part, and the southeastern part more than the northeastern. Northwestern Ohio usually receives the smallest amount of precipitation of any part of the State.

The length of growing season, or frost-free period, increases generally from scattered areas with less than 150 days in the north to a belt along the Ohio River which has 178 to 192 growing season days. The lake plain strip along Lake Erie also has a long growing season, frequently exceeding 200 days. Over most of northern Ohio, disregarding the lake plains, the growing season averages 150 to 164 days in length, whereas in the southern part of the State the growing season averages 164 to 192 days.

SOILS

There are two great soil groups in the State, based upon the composition of the parent rock. Soils derived from limestone rock occupy the western part of the State, west of a line from Sandusky south along the Scioto River to Portsmouth; the soils east of this line are derived from sandstone and shale.

Glaciation has created further differences between these soil groups. Thus, northeastern Ohio is occupied by glacial sandstone and shale soils, whereas southeastern Ohio, being unglaciated, is a region of residual sandstone and shale soils. The soils of western Ohio are principally glacial limestone, whereas those of the lake plain area, having been further modified in character, are classified as Lacustrine soils. In northwestern Ohio, therefore, the soils are largely Lacustrine limestone, whereas the narrow lake plain belt of the northeast is characterized by Lacustrine sandstone and shale soils.

These basic descriptions of the major soil groups indicate some of the differences between regions. The survey did not attempt to correlate plantation results with soil types because of the difficulties involved in securing accurate soil information.

Observations were made concerning local drainage conditions, and an attempt was made to show its effect upon the survival and growth rates of forest plantings. (See "Drainage".) Drainage conditions vary widely, but in general, the soils of the eastern part of the State are adequately drained, whereas those in the level areas of western Ohio are less well drained. The Lacustrine soils of the northwest, particularly, are characterized by tight, impervious subsurface layers which frequently require tile drainage.

FOREST TYPES

The physiographic and climatic differences between the regions of the State are reflected to some extent in characteristic associations of species. Northeastern Ohio is occupied primarily by the beech-maple and mixed mesophytic types; limited areas of elm-ash-soft maple occur on poorly drained sites.

The oak-hickory type occurs principally in the southeast region, associated with beech, maple, and tuliptree in the northern part of the region, with pine and black walnut near the southern end. Chestnut was formerly an important species in this forest type.

In the southwest, bur oak, hickory, beech, and maple comprise the principal species; pin oak becomes important toward the south. Associated with these major species are elm, white ash, walnut, and cottonwood.

The flat, poorly drained area of the northwest is occupied partly by swamp forest types, including elm, ash, and soft maple, principally, with admixtures of cottonwood, swamp white oak, and sycamore, and partly, on better drained areas, by mixed oaks. In Williams, Fulton, and Defiance Counties, outside the Lacustrine lake plain area, the beech-maple type again makes its appearance.

Each of the four regions, therefore, is essentially an individual unit as to forest type. The northeast region can be designated broadly as beech-sugar maple type; the southeast, as mixed oak-hickory; the southwest, as bur oak-hickory-beech-maple; and the northwest, as mixed oaks and elm-ash-soft maple type.

SURVEY RESULTS

LOCATION OF PLANTINGS

The successful plantings examined in Ohio were distributed by regions as follows: In the southeast region 1,003 plantings were examined; the northeast, 799; the southwest, 529; and the northwest, 171, a total of 2,502 plantings.

The distribution of these plantings over the State is shown in figure 5. There is a notably heavier distribution of plantings in the eastern half of the State, with the greatest density in the northeastern part.

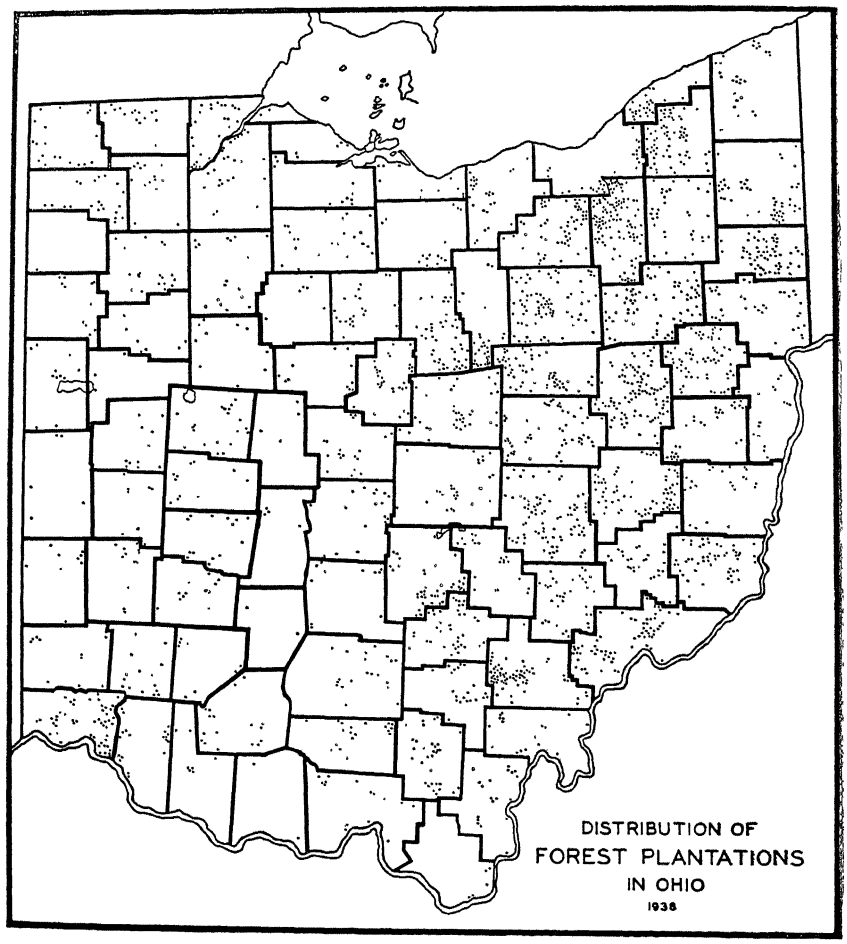

Fig. 5.—Distribution of forest plantations in Ohio

(Each dot represents one planting)

There are several reasons for the concentration of plantings in that part of the State and also for certain secondary groupings within the different counties. From the beginning of the reforestation program to the date of the survey, practically all forest planting was done by landowners on a voluntary basis, with little assistance from governmental agencies, except in the granting of below-cost stock. There was no other financial aid granted and, until 1934, there was no planting of trees on private land by the CCC. For this reason, those who planted trees did so because they were interested and could afford to do so. An effort was made to determine what the factors were that led people to practice reforestation work on their own land at their own expense. The map showing the number of cooperators by counties shows four counties with more than 300 cooperators in each, Summit, Wayne, Tuscarawas,

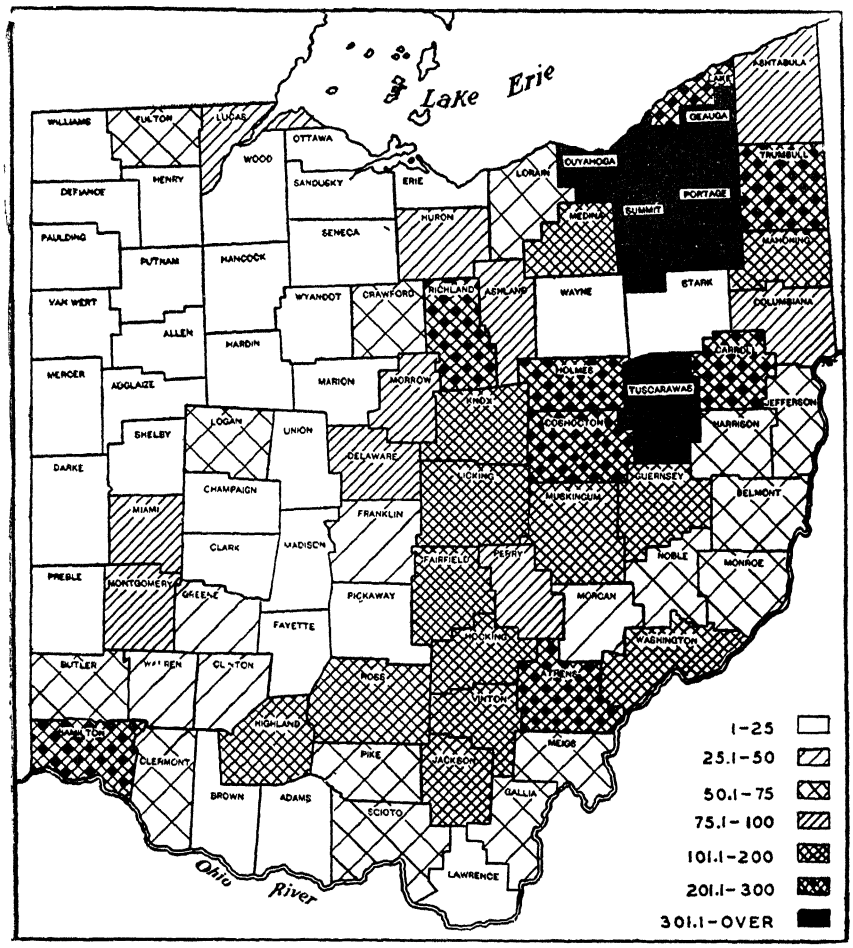

Fig. 6.—Acreage of forest plantations, by counties

and Washington. The reason for the large number of cooperators in Summit County is the presence there of many landowners from Akron and Cleveland, men who do not, for the most part, depend on the farms for their livelihood and who have reforested portions of their farms for aesthetic reasons.

Wayne County cooperators fall partly into the same class, but it is likely that many of them planted trees because of the influence of the Agricultural Experiment Station, since most of the plantings are near Wooster.

Tuscarawas County, which leads all others in number of cooperators, is an example of the influence of one man, the late George Boltz, who was county agricultural agent until his death, and who was very active in forestry work.

Washington County, which ranks second, is also an example of the industry and enthusiasm of one man, H. B. VanderPoel, instructor in vocational agriculture at Marietta.

The local groupings of plantings in different counties are caused by a number of factors, some of which are:

Proximity of a successful planting, such as on a State forest or on private land

Influence of enthusiastic individuals or leaders

Presence of recreation or vacation areas

Availability of CCC labor

Nondependence on the soil for income. This has been one of the chief factors leading to reforestation of private land, rather than the need for reforestation. The portions of counties where the need may be the greatest usually have the fewest plantings. On the other hand, good farming land is rarely reforested, as shown by the relatively few plantings in the western part of the State.

SIZE OF PLANTINGS

The total area of the plantings surveyed in the State is 9,257 acres, which does not include any of the plantings on State land or any of the areas planted with trees from other sources than the State forest nurseries. Neither does it include the large planting of 3,007 acres on the Mahoning Valley Sanitary District, which consists largely of trees from State nurseries.

The average size of forest plantings in Ohio is 3.69 acres and varies in the different regions from 4.84 acres in the northeast region to 1.81 acres in the northwest.

Table 4 shows the distribution of plantings by size classes. There are relatively few plantings more than 10 acres in size in the northwest region and few more than 25 acres in the southwest. In eastern Ohio, there are a number of successful plantings that are more than 100 acres in area.

CLASSES OF COOPERATORS

The cooperators who have achieved some degree of success in reforestation can be classified into certain groups, as shown in table 5. Farmers as a class have led all others in number of plantings established; 4-H Clubs and vocational agriculture students rank second. This latter group is more important in the southeast region than in the other regions.

In northeastern Ohio and, to a lesser extent, in the southwest, there is a large class of planters who reside in cities but own tracts of land in rural areas. These cooperators have reforested extensive areas, usually with a high degree of success, owing to close supervision of the planting operation.

TABLE 4.—Classification of forest plantations by area

Area Acres	Northeast		Southeast		Southwest		Northwest		State	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
0.1- 1.0	414	51.5	487	48.6	273	51.6	119	69.6	1,293	51.6
1.1- 5.0	267	33.3	383	38.2	191	36.2	40	23.3	881	35.1
5.1- 10.0	56	6.9	63	6.2	31	5.8	7	4.2	157	6.3
10.1- 25.0	35	4.4	47	4.8	24	4.6	2	1.1	108	4.3
25.1-100.0	28	3.5	21	2.0	10	1.8	3	1.8	62	2.5
Over 100.0	4	.4	2	.2	.....	.....	.....	.....	6	.2
Total plantings	804	100.0	1,003	100.0	529	100.0	171	100.0	2,507	100.0
Total acreage	3,891	.....	3,408	.....	1,649	.....	309	.....	9,257	.....
Average size of plantings	4.84	.....	3.40	.....	3.12	.....	1.81	.....	3.69	.....

TABLE 5.—Cooperators by classes

Class	Northeast	Southeast	Southwest	Northwest	State total
Farmers	477	595	364	179	1,615
Agricultural clubs	90	395	24	8	517
Scout organizations	9	.....	4	2	15
Municipalities	17	6	2	3	28
Institutions	24	28	31	11	94
Corporations	18	31	3	.....	52
Organizations and clubs	17	10	7	1	35
Townspeople	223	106	122	44	495
Estates	24	.....	7	.....	31
Total	899	1,171	564	248	2,882

Municipalities and institutions have also been successful in reforesting large tracts of idle land.

Corporations, largely clay mining, and coal mining companies have not been as numerous as some of the other cooperators but have planted many thousands of trees successfully.

TYPES OF PLANTINGS

The scope of reforestation has broadened considerably as conservation and other related interests have become more diversified. Most urgent at present is the need of reforestation for the vast areas of denuded land in Ohio from which soil and moisture losses are so great that they endanger the well-being of people through floods, silted reservoirs, and loss of fertility of cropland. Those lands must be reforested extensively to correct this acute situation and eventually be converted into hardwood forests to prevent their remaining a public burden indefinitely.

Forest plantations, particularly of conifers, also have intensive uses, in which the planting itself serves the desired purpose. Windbreaks, decorative plantings in parks, and protective plantings about reservoirs[4] are good examples of intensive uses. In addition, plantations are established for such

[4]Hardwood litter stains water, and sanitary engineers recommend pines for planting around reservoirs to protect the water supply.

specific purposes as to provide cover and food for wild life; to furnish certain products, such as fence posts or Christmas trees; or to reenforce existing woodlots.

Windbreaks comprise an important type of intensive use, much needed in western Ohio. The number of windbreaks now in existence in that part of the State is small, and many of these have not yet attained sufficient height to provide protection from high winds. The older windbreaks, however, have proved themselves of great value.

Several different types of windbreaks, as to form, number of rows, and spacings, were encountered, and these are listed in tables 6 and 7. The most common type found was the straight line windbreak, consisting of one or more rows of trees. Other types appeared to be quite satisfactory, and varied according to the needs and preferences of the individual planters.

TABLE 6.—Forms of windbreaks occurring in western Ohio

Straight	Number	L- or V-shaped	Number	U-shaped	Number	Hollow square	Number
1 row	34	1 row	9	1 row	3	1 row	0
2 row	43	2 row	16	2 row	7	2 row	3
3 row	15	3 row	10	3 row	5	.....	.....
4 row	16	4 row	5	4 row	1	.....	.....
5 row	3	5 row	1	.....	.....	.....	.....
6 row	5	6 row	1	.....	.....	.....	.....
Total	116	Total	42	Total	.....	Total	3

The species which have been most satisfactory in windbreaks are Scotch, Austrian, and red pines, Norway spruce, arborvitae, and catalpa. Douglasfir and white pine have not been successful as windbreak species in Ohio.

Fig. 7.—Two-row Norway spruce windbreak, one row 32 years old, one row 16 years old, Bloomville, Seneca County

Table 7 indicates that many windbreaks are planted too closely for their optimum future development; nearly a third of them have the trees spaced only 3 feet apart or less. There are a number which are spaced at about 10 feet, however.

TABLE 7.—Spacings employed in windbreaks and lengths of windbreaks

Spacing of trees within rows	Number	Length of windbreak, in feet	Number
Trees per 100 feet		Under 100	21
		100-200	47
5-10	47	200-300	32
11-20	52	300-400	16
21-30	24	400-500	22
Over 30	54	Over 500	39
Total	177	Total	177

Table 7 also shows the length of windbreaks found. There are 61 which are over 400 feet in length and only 21 which are less than 100 feet in length.

COMPOSITION OF FOREST PLANTINGS

The prevailing practice among planters has been to make pure plantings. Three-quarters (76.4 per cent) of the plots studied are pure, about one-quarter mixtures. This ratio is approximately the same in all four regions.

The comparative frequency of occurrence of conifers and hardwoods follows the same trend; i. e., the conifers occur three times as frequently as the hardwoods. This composition varies with the different regions, however. In the northeast region, the conifers comprise 85 per cent of all plantings; in the southeast, 75 per cent; in the southwest, 53 per cent; and in the northwest, 55 per cent.

The five leading species among the conifers, red, Scotch, white, and Austrian pines and Norway spruce, comprise 90.3 per cent of the total frequency of occurrence of conifers in all plots and occur in the order named, for the State as a whole. The order of occurrence is the same in each region except the northwest, where white pine is fifth in rank instead of third as in the other regions.

The five leading hardwood species, black locust, catalpa, walnut, white ash, and tuliptree, comprise 86.4 per cent of the total frequency of hardwoods and rank in the order named. The only significant variation from this rank among the different regions is that tuliptree is third in the southeast region and fifth in the others.

The relative importance of the conifers and hardwoods as to area of planting is shown in table 8. It is impossible to break down the acreage of the conifers between species because of the mixtures found; and among the hardwoods, locust is the only one for which the area could be determined, since locust is practically always planted in pure stands.

Mixtures in privately owned plantings have been made partly with technical guidance, but more frequently by chance or individual preferences. The result has been a great variety of mixtures, many of little silvicultural value.

Approximately 65 per cent of the mixtures are composed of only two species; 20 per cent are three-species mixtures; and 15 per cent have four or more species in mixture.

TABLE 8.—Frequency of occurrence and area by types of plantings

		Northeast	Southeast	Southwest	Northwest	TOTAL
Conifers	Number of plots*	3,634	2,935	915	313	7,797
	Area, acres	3,221	2,579	836	142	6,778
	Percentage of total	84.1	75.6	50.6	55.2	.....
Black locust	Number of plots	212	507	211	33	963
	Area, acres	166	513	235	12	963
	Percentage of total	4.4	15.2	14.2	5.8	.....
Other hardwoods	Number of plots	448	458	605	221	1,732
	Area, acres	441	316	578	155	1,490
	Percentage of total	11.5	9.2	35.2	39.0	.....
Totals	Number of plots	4,294	3,900	1,731	567	10,492
	Area, acres	3,828	3,408	1,649	309	9,194
	Percentage of total	100.0	100.0	100.0	100.0	....

*The plots indicated are not plantings, but the survey units.

Red pine leads all other species in frequency of use, as 50 per cent of all mixed plots contain red pine. Scotch pine ranks second, occurring in 37 per cent of mixed plots, and white pine third, occurring in 27 per cent of the mixed plots.

Most common type of coniferous mixture is red pine-white pine, found 298 times, or in 14.4 per cent of all mixed plots. Most common hardwood mixture is walnut and white ash, occurring 22 times in the State.

Table 9 shows the types of mixtures most commonly found.

TABLE 9.—Mixtures commonly found

Mixture*	Number of plots	Per cent
Coniferous		
Red pine-white pine	298	14.4
Red pine-Scotch pine	266	12.8
Scotch pine-Austrian pine	153	7.3
Red pine-Scotch pine-Austrian pine	106	5.1
Red pine-Austrian pine	95	4.6
Red pine-Scotch pine-white pine	78	3.8
Scotch pine-white pine	51	2.5
Red pine-Corsican pine	44	2.1
Scotch pine-Norway spruce	28	1.3
White pine-Norway spruce	28	1.3
White pine-Austrian pine	26	1.2
Corsican pine-Norway spruce	24	1.2
Red pine-white pine-Austrian pine	20	1.0
Scotch pine-Austrian pine	18	.9
White pine-Corsican pine	14	.7
Hardwood		
Walnut-ash	22	1.1
Locust-catalpa	21	1.0
Walnut-locust	12	.6
Walnut-tuliptree	11	.6
Tuliptree-locust	10	.5
Tuliptree-white ash	10	.5

*There is no significance in the arrangement of species names in the mixtures

AGE OF PLANTINGS

The history of tree planting in Ohio is relatively short. During the period 1904 to 1938, inclusive, 29 million trees were shipped to cooperators, but 90 per cent of these were shipped during the period 1926 to 1938, inclusive Sixty-nine per cent of all trees were shipped in the last 10 years, and nearly a third of all trees were shipped as recently as the last 5 years. Since the age of the successful plantings studied follows this shipping record, 82 per cent of all plots found were less than 14 years old, and 70 per cent were only 10 years old or younger.

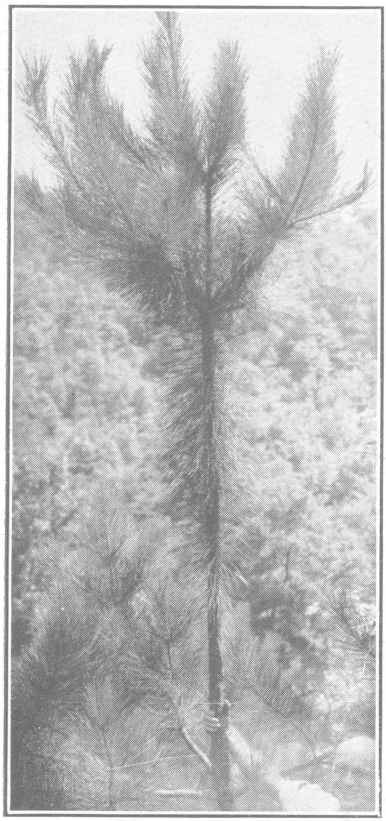

Fig. 8.—Five feet of growth of red pine in 1 year, Tuscarawas County, 1940

GROWTH AND SURVIVAL OF SPECIES

Growth and survival data were secured for all species found, and the results are presented as regional averages for each species in table 29. Forty-eight species were studied, although 11 species represent 77.5 per cent of the plots. These species, Scotch, white, red, and shortleaf pine and Norway spruce among the conifers and black locust, catalpa, white ash, black walnut, tuliptree, and red oak among the deciduous species, represent those species which will probably be of most importance in reforestation work in Ohio.

The discussion of the survival, growth rates, and adaptability of these species to the site conditions in the different regions will occupy the greater part of this publication.

Table 10 shows the survival and growth rates of the leading species arranged according to rank for the four regions.

Catalpa is the only species which is consistently near the top in all four regions for both survival and growth rate. Among the conifers, Scotch and white pine show rather consistently high rank except in southwestern Ohio, where white pine particularly drops in rank. In southern Ohio, the shortleaf pine ranks very high.

Norway spruce is rather low in rank in most instances, as is red oak. Walnut is low in eastern Ohio but higher in western Ohio, especially in the northwest region. Red pine is in about the middle in each region, except in

northwestern Ohio, where it is low. Tuliptree ranks relatively low in survival and high in growth rate in each region. Based on these data alone, it warrants consideration, and as more is learned regarding its requirements and methods of handling, it may prove to be one of the most important species to use.

TABLE 10.—Average annual height growth and percentage survival for 11 leading species, by regions

Species	Survival per cent	Species	Growth rate
Northeast			
Catalpa	82.0	Black locust	1.92
Scotch pine	78.1	Tuliptree	1.45
White pine	74.7	Catalpa	1.22
Norway spruce	73.2	Scotch pine	1.12
Red pine	72.2	Red oak	1.09
White ash	71.6	White pine	.91
Black locust	68.3	White ash	.90
Tuliptree	65.8	Red pine	.87
Walnut	65.7	Norway spruce	.70
Red oak	55.2	Walnut	.65
Southwest			
White ash	72.9	Black locust	2.03
Shortleaf pine	72.2	Catalpa	1.28
Catalpa	70.5	Tuliptree	1.21
Walnut	61.4	Scotch pine	1.05
Red pine	60.6	Red oak	.95
Scotch pine	59.7	Shortleaf pine	.94
Black locust	59.1	White ash	.90
White pine	58.4	Red pine	.86
Tuliptree	54.1	Walnut	.76
Red oak	49.6	White pine	.73
Norway spruce	46.8	Norway spruce	.62
Southeast			
Shortleaf pine	74.6	Black locust	2.03
White pine	74.1	Tuliptree	1.11
Catalpa	72.2	Catalpa	1.08
White ash	71.7	Scotch pine	.99
Scotch pine	69.7	Shortleaf pine	.98
Walnut	68.1	White pine	.88
Red pine	67.1	Red pine	.76
Norway spruce	66.8	Red oak	.60
Black locust	65.7	White ash	.58
Tuliptree	62.8	Walnut	.57
Red oak	53.0	Norway spruce	.54
Northwest			
Catalpa	76.3	Black locust	1.79
Scotch pine	67.7	Walnut	1.40
Walnut	65.1	Catalpa	1.31
White ash	63.1	White ash	1.23
Norway spruce	57.3	Tuliptree	1.23
White pine	56.3	Scotch pine	1.15
Black locust	49.6	White pine	.90
Red pine	49.4	Norway spruce	.77
Tuliptree	41.1	Red pine	.73
Red oak	30.3	Red oak	.71

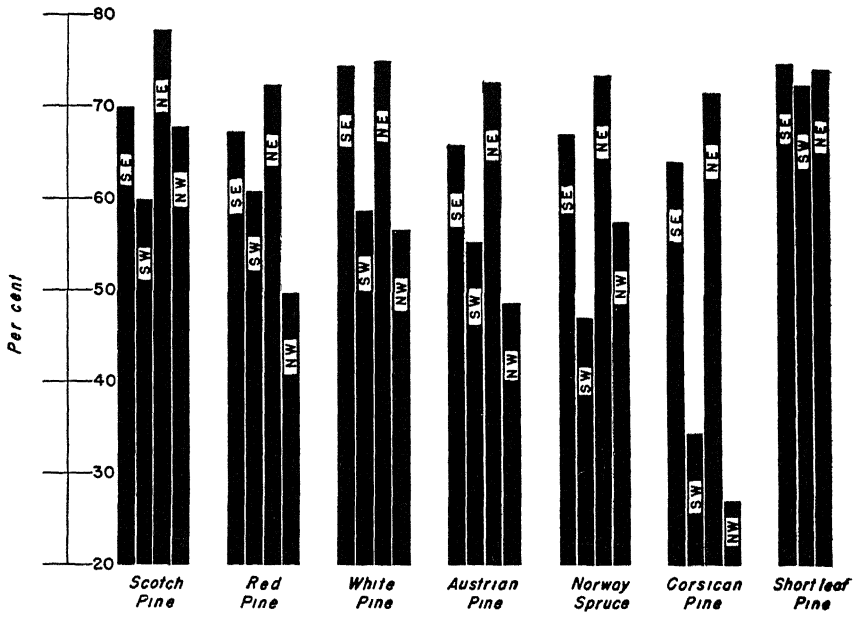

Fig. 9.—Average survival of 7 most frequently planted conifers, by regions

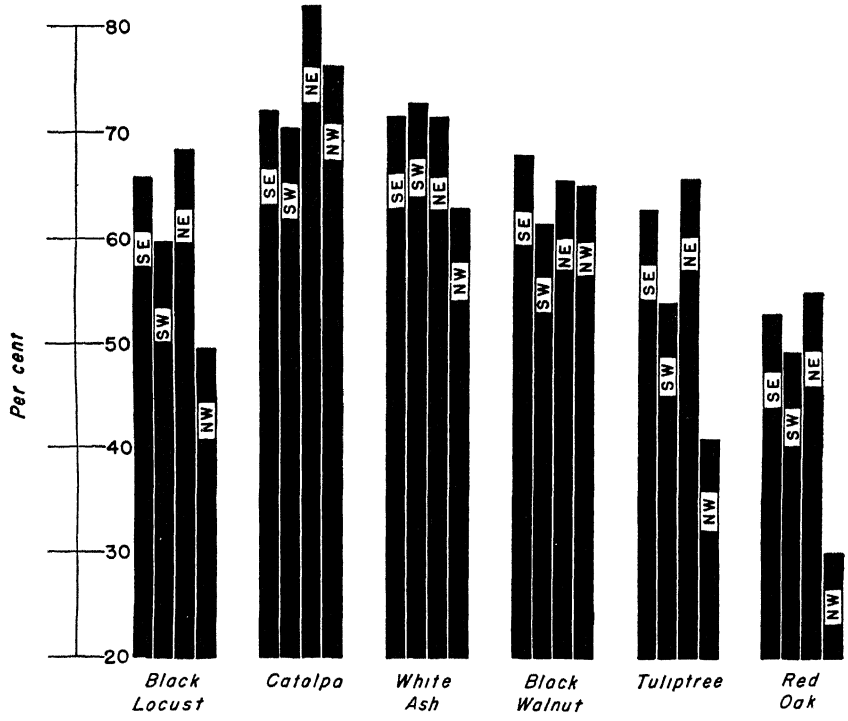

Fig. 10.—Average survival of 6 most frequently planted hardwoods, by regions

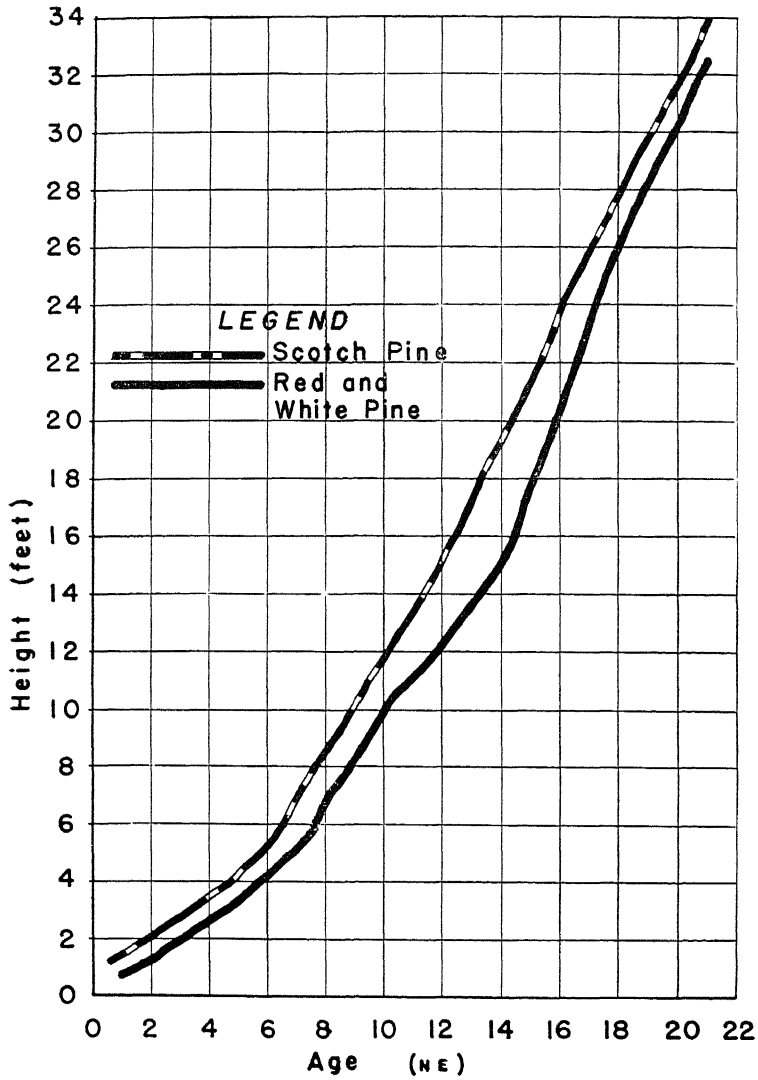

Fig. 11.—Average height of red, white, and Scotch pines, by age,* in the northeast region

*Ages shown in figures 11, 12, and 13 are from the time of planting.

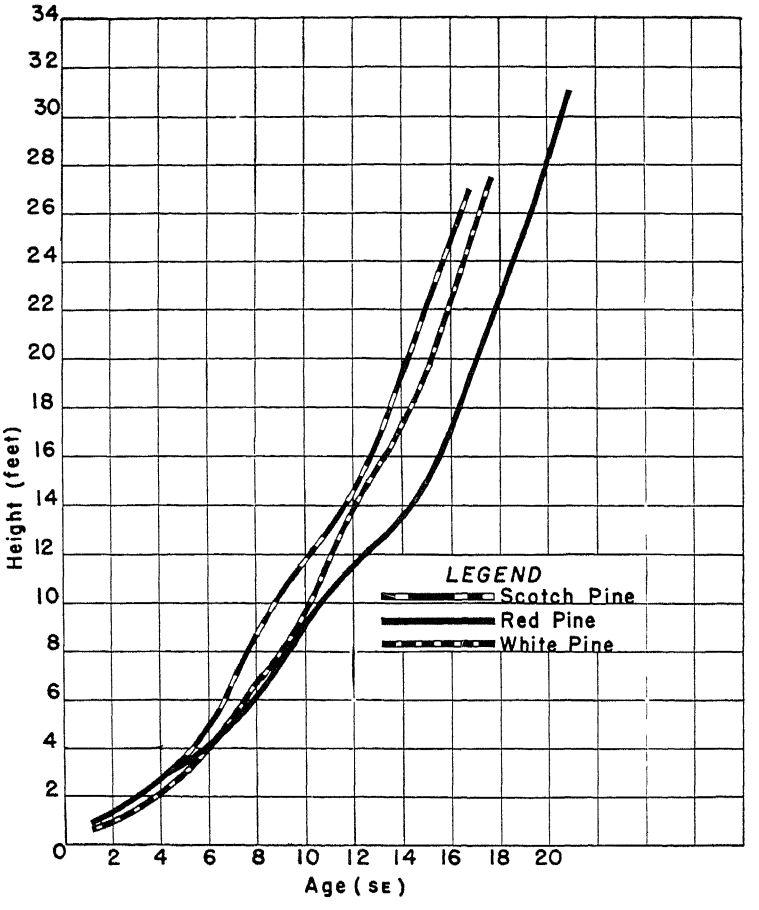

Fig. 12.—Average height of red, white, and Scotch pines, by age, in the southeast region

The best species, based on growth and survival, are apparently as follows:[5]

Northeast	Southeast	Southwest	Northwest
Catalpa	Shortleaf pine	Catalpa	Catalpa
Scotch pine	White pine	Shortleaf pine	Black walnut
White pine	Catalpa	Scotch pine	White ash
Red pine	Scotch pine	Black locust	Norway spruce
Tuliptree	Black locust	White ash	Scotch pine
Black locust	Red pine	Red pine	Tuliptree
White ash	Tuliptree	Tuliptree	
		Black walnut	

[5]This is not an exclusive list, as there are a number of additional factors to consider and additional species of local value; sugar maple in the northeast region and red oak and walnut on sites suited to them throughout Ohio are examples.

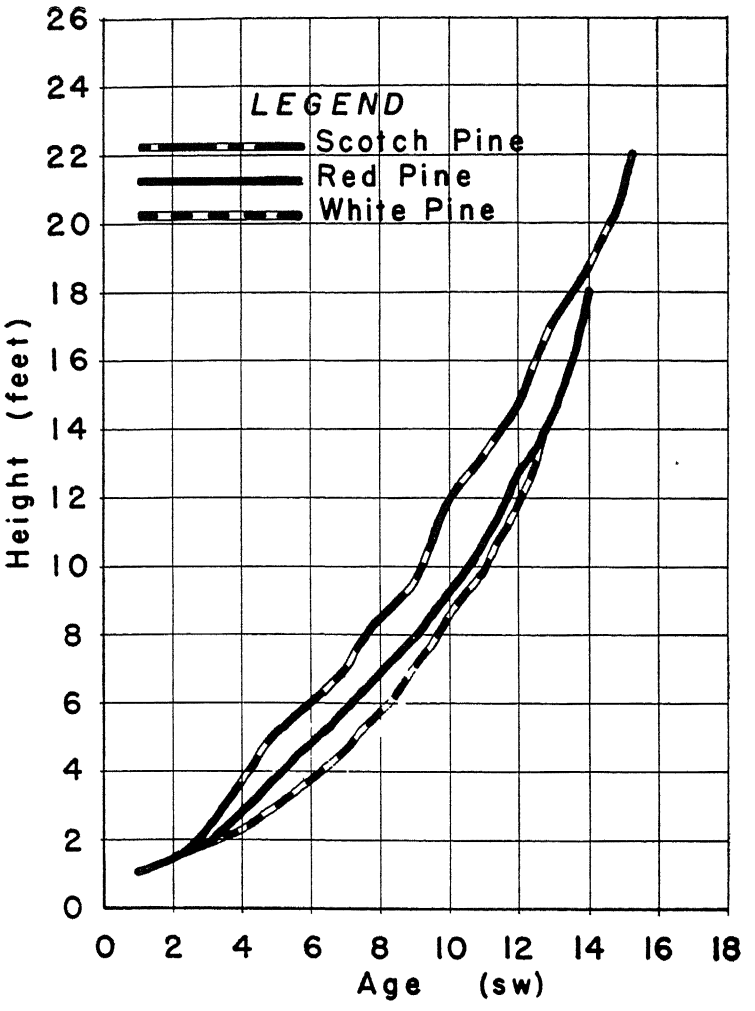

Fig. 13.—Average height of red, white, and Scotch pines, by age, in the southwest region

Very little can be said about species for which there is only a small amount of data. Some have definite site limitations and as a result have not been planted extensively or successfully. Many of the hardwoods, such as red birch, Kentucky coffeetree, redbud, cottonwood, and silver maple, are in this class. Others are exotics, or native to other parts of the United States. Typical of this group are European and Japanese larch, Japanese red pine, ponderosa pine, Douglasfir, and cypress. Most of these are not recommended for further reforestation use in Ohio.

Other criteria besides growth and survival enter into the determination of the value of a species for reforestation in any particular region. Scotch pine, for example, has produced its best results in the northeast region, but because of the damage being done to Scotch pine plantings in northeastern Ohio by the Zimmerman pine moth, it is not recommended for extensive planting in that region.

Growth data were obtained by averaging the growth rates of plots 3 years old and older. Since stands of 8 to 15 years and older grow more rapidly than stands of about 5 years of age, the average growth rate given in table 10 is apt to be low for most species. Figures 11, 12, and 13 show the increases in the growth rate of red, Scotch, and white pines which occur after 5 years of age. Although annual growth data, if available, would describe the growth rates more accurately, the method of treatment described serves to classify all species roughly, as to growth.

The summary of species results by regions brings to light certain comparisons which are believed to be significant. It is evident that conifers, as a group, have produced their poorest results in the northwest. Since both growth and survival are consistently low, the cause cannot be attributed to drought or to poor planting methods but must lie in site requirements of the species.

Among the hardwood species planted in the northwest region, white ash, black walnut, and elm have shown the best growth and survival. All these are known to be more tolerant of moist sites. Others, such as sugar maple, tuliptree, and red oak, have been planted successfully in Williams and Defiance Counties outside the Lacustrine section.

Catalpa occupies a position unique among all species planted in Ohio. Most of the catalpa plantings were established during the period from 1900 to 1910 by farmers whose primary aim was to maintain a source of supply of fence posts. It was standard practice to treat these plantings in the same manner in which crops were treated. The site was usually plowed, and frequently disked; the trees were carefully planted; and the plot was weeded for many years. High survivals resulted almost universally. It is probable that the same results could be produced with any species if the same painstaking care were exercised.

SITE PREPARATION AND SITE CONDITIONS

The information secured concerning the conditions at the time of planting was obtained in the majority of cases from the planters themselves. Seventy per cent of the forest plantings in Ohio have been set out in the past 10 years, and the men who did the planting usually were still available at the time of the survey. For older plantings, however, planting data were often no longer available, and in such instances no entries could be made regarding the ground preparation, planting methods, type of ground cover at the time of planting, and the like.

The effect of the various types of planting conditions on the different species will be discussed in the following paragraphs. It is recognized that in cases where data collected are based on the memories of the planters, discrepancies occur and tend to lessen the accuracy of the records. However, it appears that in some instances there is some correlation between the planting conditions and the growth and survival of the various species.

It should be noted (table 29) that the number of plots of the different species varies considerably by regions and that in some regions, notably the northwest, there are comparatively few plots of some species.

SITE PREPARATION

The methods of site preparation used were classified into three groups: plowing (including furrowing), clearing, and no preparation. The practices varied in the four regions, from the northwest region, where 69.0 per cent of the planting sites were plowed, to the southeast region, where only 5.6 per cent were plowed. Clearing was more commonly done in the northeast than in the other regions, largely because of the prevalence of hawthorn, wild apple, black cherry, and sumac in old fields. In that region, 24.4 per cent of all plots were cleared.

TABLE 11.—Method of site preparation

Region	Plowed		Cleared		None	
	Number	Per cent	Number	Per cent	Number	Per cent
			Conifers			
Northeast	385	14.6	680	25.8	1,565	59.6
Southeast	130	4.1	686	21.6	2,361	74.3
Southwest	163	23.5	176	25.3	353	51.2
Northwest	157	66.8	13	5.5	65	27.7
Total	835	12.4	1,554	23.1	4,344	64.5
			Hardwoods			
Northeast	95	20.7	72	15.7	291	63.6
Southeast	119	9.3	226	17.7	929	73.0
Southwest	289	48.0	84	13.9	229	38.0
Northwest	126	72.0	12	6.8	37	21.1
Total	629	25.1	394	15.7	1,486	59.2

The sites on which hardwoods were planted were more frequently plowed in all regions than if conifers were planted. This practice was most common in the southwest region and can be attributed to the practice there of plowing and cultivating catalpa planting sites, which represent 30 per cent of all hardwood plantings in that region. Of the catalpa plots, 83 per cent were plowed. In the northwest region, plowing of planting sites was common practice and was necessary because of the heavy sod which prevails there.

Clearing of planting sites was, on the other hand, less commonly done prior to planting hardwoods than conifers, reflecting the practice of using hardwoods, with the exception of catalpa, for interplanting in existing stands of native trees.

GROUND COVER AT TIME OF PLANTING

The most common type of ground cover on planting sites was found to be grass, in all but the northwest region. There, 63.8 per cent of all sites were bare at the time of planting. Next to grass in frequency were bare sites, then weeds. Relatively few areas had brush or tree cover at the time of planting.

Table 12 shows the frequency of occurrence of the different types of ground cover at the time of planting.

TABLE 12.—Types of ground cover at time of planting*

	Bare		Grass		Weeds		Brush		Trees	
	Number of plots	Per cent	Number of plots	Per cent	Number of plots	Per cent	Number of plots	Per cent	Number of plots	Per cent
Conifers										
Northeast	316	13.5	1,565	67.2	219	9.4	169	7.2	58	2.4
Southeast	228	7.4	1,954	63.4	349	11.3	463	15.0	90	2.9
Southwest	162	23.7	396	57.9	75	10.9	34	4.9	16	2.3
Northwest	138	59.2	79	33.9	14	6.0	.....	.....	2	.8
Total	844	13.3	3,994	63.2	657	10.4	666	10.5	166	2.6
Hardwoods										
Northeast	85	21.0	258	63.8	30	7.4	24	5.9	7	1.7
Southeast	226	10.4	763	62.0	161	11.6	108	13.1	38	2.9
Southwest	280	34.7	239	49.9	53	10.1	13	3.7	5	1.6
Northwest	120	63.8	32	27.5	17	7.7	.....	.....	2	1.0
Total	711	28.9	1,292	52.5	261	10.6	145	5.9	52	2.1
Grand total	1,555	17.7	5,286	60.2	918	10.4	811	9.2	218	2.5

*An effort was made in the field to break down further the types of ground cover into three degrees of density, but on analysis of the results, it was found that this practice so greatly increased the complexity of the problem that it made analysis almost impossible. It is recognized that there are many different types of grass and weed sods, but a grass sod is usually a lower sod above which the planted tree soon develops. Such sod is effective largely in reducing early survival; brush and trees present a more lasting competition.

PLANTING METHOD

An effort was made to determine the relative merits of the hole and cleft methods of planting, but it became apparent that this was an extremely uncertain classification in the memories of the planters. It was also subject to change, even within a given planting, and in different years. The final results bear out this uncertainty and show no consistency whatever in the results produced by these methods as recorded on the field sheets.

GROUND COVER AT TIME OF SURVEY

The ground cover at the time of the survey had changed in character from that which was present when the trees were planted. The number of plots which contained grass was, as yet, greater than any of the other types, but the plurality had diminished. Plots which had been bare were greatly reduced in number, whereas the number of weedy plots and plots containing brush or trees had increased. (Compare tables 12 and 13).

It is evident that the trend is toward weedy and brushy vegetation in the average planting and away from bare soil or grass. Although this vegetation is commonly classed as "competing", it is likely that some of it has a beneficial effect upon the planted trees in moderating site conditions. In addition, much of the competing vegetation may consist of valuable species of tree volunteers.

The detrimental influence of some types of vegetation tends to diminish as the plantings grow older. Grass and weeds, for example, present little competition to the faster-growing species after about the fifth year, but brush and trees may continue to be serious.

TABLE 13.—Ground cover at time of survey

	Bare		Grass		Weeds		Brush		Trees	
	Number of plots	Per cent	Number of plots	Per cent	Number of plots	Per cent	Number of plots	Per cent	Number of plots	Per cent
Conifers										
Northeast	400	11.2	1,651	46.2	639	17.8	716	19.9	178	4.9
Southeast	70	4.1	803	47.4	340	20.1	301	17.8	179	10.6
Southwest	70	7.7	443	49.0	199	22.0	145	16.0	48	5.3
Northwest	67	20.2	206	62.4	40	12.0	7	2.1	10	3.3
State	607	9.3	3,103	47.6	1,218	18.7	1,169	17.9	415	6.4
Hardwoods										
Northeast	50	8.0	286	45.7	133	21.2	98	15.7	59	9.4
Southeast	37	5.0	325	44.2	167	22.7	107	14.5	100	13.6
Southwest	70	9.3	380	50.2	167	22.1	80	10.6	58	7.8
Northwest	44	19.0	122	53.0	48	20.7	7	3.4	9	3.9
State	201	8.6	1,113	47.4	515	21.9	292	12.4	226	9.7
Grand total	808	9.1	4,216	47.6	1,733	19.6	1,461	16.5	641	7.2

Another factor which must be recognized is that many plantings of deciduous species have been made in open woods, where the native species were frequently the same as those planted. Such plantings, although successful, could not be studied because of the difficulty in differentiating between native and planted trees.

DRAINAGE

Drainage proved to be difficult to evaluate, and the immediate condition of the site tended to affect the decision of the supervisor. Sites visited in March or April appeared different from similar sites visited in August. Plant indicators were of some value in determining the type of drainage present. The term "dry site" proved to be a relative classification and varied with the regions. Usually, however, the drainage classification presented little difficulty, as the majority of plots were on hillsides. Of the total number of plots, 71.1 per cent were on hillsides, and practically the same number, 71.4 per cent of all plots, were recorded as being on dry sites.

Table 14 shows the distribution of plots according to drainage in each of the four regions. It will be noted that a larger percentage of the conifer plots than of the deciduous was found on dry sites in all but the southeast region, where they were equal.

The greater concentration of all species on dry areas in all regions is probably due to the common attempt on the part of the cooperators to plant trees on the best-drained areas possible.

TOPOGRAPHY

The topography of the average planting site varies throughout Ohio, as shown in table 15, and the data are indicative of the topography of the different regions. In the northwest region, only 13.9 per cent of the plantings are on hillsides; in the southwest, 51.0 per cent; in the northeast, 62.0 per cent; and in the southeast, 90.0 per cent.

TABLE 14.—Number of plots classified by drainage

	Wet		Medium		Dry	
	Number of plots	Per cent	Number of plots	Per cent	Number of plots	Per cent
Conifers						
Northeast	255	8.9	708	24.9	1,871	66.2
Southeast	136	4.3	424	13.3	2,622	82.4
Southwest	69	9.7	217	30.5	424	59.8
Northwest	6	2.3	41	16.0	209	81.7
Total	466	6.7	1,390	19.9	5,126	73.4
Deciduous						
Northeast	59	11.4	181	35.2	276	53.4
Southeast	76	5.5	170	12.2	1,147	82.3
Southwest	106	15.0	279	39.6	319	45.4
Northwest	14	6.1	71	31.5	141	62.4
Total	255	9.0	701	24.7	1,883	66.3

The records indicate that the conifers are more commonly found on hillsides in each of the four regions than are the deciduous species, but it is difficult to determine whether this location is due to the better adaptability of the conifers to drier sites or to the possibility that the deciduous species are more commonly planted on flat land.

TABLE 15.—Topography of planting sites

Region	Bottom		Hillside		Hilltop	
	Number of plots	Per cent	Number of plots	Per cent	Number of plots	Per cent
Conifers						
Northeast	303	10.7	1,772	62.9	742	26.3
Southeast	48	1.5	2,890	91.1	234	7.4
Southwest	99	13.9	434	61.0	178	25.0
Northwest	19	7.4	41	16.0	196	76.5
Total	469	6.7	5,137	73.9	1,350	19.4
Deciduous						
Northeast	96	19.1	286	56.9	120	23.9
Southeast	91	6.5	1,217	87.4	85	6.1
Southwest	206	29.3	287	40.8	209	29.7
Northwest	51	22.5	26	11.5	149	65.9
Total	444	15.7	1,816	64.3	563	19.9

Topography has apparently had a strong influence upon forest plantations in eastern, but very little in western, Ohio, where the differences between hilltop, hillside, and bottom land are very indistinct.

EXPOSURE

The exposure of the plots was recorded in the field under nine categories: north, northeast, east, southeast, south, southwest, west, northwest, and none, or level. The number of plots recorded under each exposure is shown in table 16.

TABLE 16.—Occurrence of plots by exposure

Region	Exposure									Total
	None	North	Northeast	East	Southeast	South	Southwest	West	Northwest	
Northeast	802	355	260	337	269	384	273	410	264	3,354
Southeast	160	504	356	597	505	697	472	820	480	4,591
Southwest	378	152	97	156	72	166	102	207	88	1,418
Northwest	413	10	6	12	14	11	2	13	1	482
Total	1,753	1,021	719	1,102	860	1,258	849	1,450	833	9,845

Number of plots on the four cardinal exposures	4,831
Number of plots on the four alternate exposures	3,261
Number of plots on level land	1,753
Total	9,845

It is evident from table 16 that the most common tendency was to record exposures according to the cardinal directions. (Sixty per cent of the plots, excluding those on level land, were recorded as on the four cardinal exposures.) This tendency is most pronounced in the northwest region, where slopes are so gentle that it is difficult to discern the exact exposure, least pronounced in the hilly regions.

It is apparent also that the south and west exposures contain more plots than do any of the other exposures, especially in the hilly sections. This finding was true of the important species studied, with but few exceptions. In the northeast region, only Corsican pine and black locust plots occurred more frequently on north and east exposures. In the southeast region, shortleaf pine, catalpa, white ash, and tuliptree; in the southwest region, red pine and white pine; and in the northwest region, red pine and white ash, occurred most frequently on north and east exposures.

INFLUENCE OF SITE AND OTHER FACTORS

The site, and other factors studied, namely, site preparation, ground cover at time of planting, planting method, age of planting stock used, drainage, topography, exposure, and ground cover found on the site at the time of survey, are discussed briefly in their relationship to the principal species planted.

Criteria used in determining the influence, if any, a given factor may have on a certain species were: average annual growth rate[6] and average survival. These averages were secured for each factor independently of all other factors excepting species and region. For instance, all white pine plantings in a given region which had northern exposures were grouped, and the average growth and survival were determined. The same procedure was followed for each of the other exposures. The exposures having the highest averages were tabulated by regions for each species, and any consistent grouping could be observed.

Erratic data or the absence of apparent grouping of data has been considered, tentatively, as showing that factor to be ineffective. This tentative method may well be incorrect. However, where there is a consistent superiority of one factor in all or most regions, there is probably some justification for believing that factor to be significant.

[6]The growth rate was determined by dividing the total height by the age since planting in the permanent site. All plantings 1 and 2 years of age were excluded in this computation.

On the basis of these assumptions, a study was made of the data tabulated by species, regions, and site factors, to determine the presence or absence of such groupings. The following discussion is the result of that study.

WHITE PINE

Site preparation.—Plowing produced the best average growth in all four regions and best average survival in western Ohio. In the eastern regions, the best average survival was on areas which had been cleared or had no treatment.

Ground cover at time of planting.—Bare sites appeared to produce the best growth in most regions and the best survival in western Ohio. Some cover of weeds or brush seemed to give better survival in eastern Ohio, in conformity with the results observed under "Site Preparation."

Planting method.—Data not conclusive.

Age of planting stock.—Four- or five-year-old trees were consistently better than younger stock in eastern Ohio. In the western regions, the data indicate that 2- or 3-year trees are best.

Drainage.—The best average survival in eastern Ohio was found on sites of moderate drainage, and the best average growth on sites having good drainage. In southwestern Ohio, moderate drainage, and in northwestern Ohio, good drainage, were indicated as being best. Wet sites produced the poorest results consistently.

Topography.—The best average survival was found on hillside or bottom land sites in all regions and the best average growth on hilltops in all regions, in conformity with the results observed as to the drainage requirements of white pine.

Exposure.—The data show no conclusive results as to the exposure requirements of white pine. Best average growth and survival were found chiefly on the northwest to southeast exposures (clockwise), but it was in these same quadrants that the poorest average growth and survival were found.[7]

Ground cover at time of survey.—The best average growth was found on bare sites in all four regions; the best average survival, where there was some vegetation (weeds and grass in eastern Ohio; brush in western Ohio). The poorest results were consistently found under tree cover. White and shortleaf pines appeared to be the only evergreens studied which could survive in competition with native timber.

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[7]The following examples of the best and poorest averages may serve to clarify this apparent anomaly:

Northeast region

Best growth	Level land	Best survival	Northeast exposure
Poorest growth	Northeast exposure	Poorest survival	Level land

Northwest region

Best growth	Southeast exposure	Best survival	Level land
Poorest growth	South exposure	Poorest survival	Northeast exposure

Southeast region

Best growth	West exposure	Best survival	Level land
Poorest growth	East exposure	Poorest survival	North exposure

Southwest region

Best growth	Northwest exposure	Best survival	West exposure
Poorest growth	Southeast exposure	Poorest survival	Level land

RED PINE

Site preparation.—The difference or spread of data between the best and poorest averages was very small in the case of site preparation with red pine. Plowing appeared to yield somewhat better growth rates, but hardly significantly so.

Ground cover at time of planting.—It is apparent from the data secured that a tall or heavy shade over red pines at the time of planting was detrimental, affecting both growth rate and survival in all four regions; a bare site or low competing cover yielded best results.

Planting method.—Data not conclusive.

Age of planting stock.—The older stock (4- or 5-year) was indicated as best; 2- and 3-year trees produced poorer results consistently.

Drainage.—Red pine plantings made on well-drained sites had the best average growth rate and survival in all but the northwest region, where the poorly drained sites appeared to be better.

Topography.—Hillside or hilltop sites appeared to produce the best growth and survival for the most part.

Exposure.—The northwest to east exposures appeared to give best results in all but the northwest region, where south exposures were by far the best, and north unsatisfactory.

Ground cover at time of survey.—Red pine indicated clearly a need for little or no competition from other vegetation when young. Bare sites were best in all regions; brush or tree competition greatly reduced the average growth and survival.

SCOTCH PINE

Site preparation.—Plowing of the planting sites produced the best results in all four regions, but the differences between the best and the poorest averages in all regions were very slight. It is, therefore, problematical whether plowing is warranted.

Ground cover at time of planting.—Scotch pine data indicate that this species requires bare or nearly bare sites during its first years; sites with tree competition consistently showed much lower growth and survival averages.

Planting method.—Data were not conclusive, although the cleft method appeared to be the poorer.

Age of planting stock.—The data indicate that there is little advantage of 4- or 5-year-old trees over 3-year-old trees, or 3-year-old over 2-year-old stock.

Drainage.—Scotch pine plantings indicated less reaction to drainage conditions than any of the other evergreens, although well-drained sites were apparently somewhat better than the wetter sites.

Topography.—The influence of topography on either growth rate or survival was slight.

Exposure.—Exposures of north to east (clockwise) produced somewhat better results than those of southeast, south, or southwest.

Ground cover at time of survey.—Bare sites showed the best average growth and survival in all four regions; sites with tree competition were uniformly inferior. In most instances, the differences were great.

SHORTLEAF PINE

The data for this species are inadequate except in the southeast region, and there is little opportunity for the comparisons made with the other species.

Site preparation.—There appeared to be little effect on growth or survival due to site preparation.

Ground cover at time of planting.—Grass or weeds seemed to be better than bare sites, although there was little difference in the averages.

Planting method.—The data are not conclusive as to the effect of the hole or cleft methods of planting. The average growth rate for cleft-planted plots was higher than that for plots planted by the hole method, but the survival was lower.

Age of planting stock.—Two-year-old stock produced somewhat slower growth and lower survival than older trees.

Drainage.—Well-drained sites are clearly indicated as preferable for this species.

Topography.—There was only a slight advantage in survival averages for bottom land sites over hillside sites, but there was a greater difference in growth rate averages for the hillside over bottom land plots.

Exposure.—South or southeast exposures appeared to be somewhat better.

Ground cover at time of survey.—A low type of competing cover (grass) appeared to be better than brush. No plots that were bare at the time of survey were reported.

NORWAY SPRUCE

Site preparation.—Plowing was clearly indicated as being preferable in most cases.

Ground cover at time of planting.—In all but the northeastern region the best survival and growth rate averages were found on bare sites. In the northeast, weeds or grass were somewhat better, although not conclusively so.

Planting method.—The data are not conclusive.

Age of planting stock.—Four- or five-year-old trees were clearly superior to younger trees.

Drainage.—In southeastern Ohio, the plots having poor drainage had better growth and survival averages, but in the other regions, poor drainage produced the poorest results usually. Moderate drainage appeared to be as good as, or better than, extremely dry sites.

Topography.—The data appear to show no consistent influence of topography on spruce.

Exposure.—South or southeast exposures appeared to be somewhat better, except in the southwest region, where west exposures had the best averages.

Ground cover at time of survey.—Bare sites seemed to be the best, except in northwestern Ohio, where brushy sites were somewhat better.

BLACK LOCUST

Site preparation.—Plowing of the site produced the best average growth rate and survival in all regions.

Ground cover at time of planting.—Bare sites were clearly the best in all four regions.

Planting method.—The data are inconsistent.

Age of planting stock.—Only 1-year seedlings were used.

Topography.—Hillside or hilltop sites appeared to be superior to bottom land sites, except in southeastern Ohio.

Exposure.—Southern exposures appeared to be best, northern exposures the poorest.

Ground cover at time of survey.—Bare sites or sites with low vegetation were best; brushy or tree competition produced poorest results.

BLACK WALNUT

Site preparation.—The data are not conclusive.

Ground cover at time of planting.—The data are erratic.

Planting method.—The data are not conclusive.

Age of planting stock.—Nuts are frequently planted, or 1-year seedlings are used. Rarely could plots be studied where nuts were used, as it is the common practice to scatter them throughout a woods.

Drainage.—Moderate or poor drainage was indicated as being better than dry sites.

Topography.—Bottom land sites were clearly the best.

Exposure.—Level land or sites with a western or northwestern exposure appeared to be best. Southern or eastern exposures were the poorest in all regions.

Ground cover at time of survey.—The data are erratic but show comparatively little spread between the best and poorest averages.

CATALPA[8]

Site preparation.—Plowing is apparently the preferable treatment.

Ground cover at time of planting.—Bare sites produced better average growth and survival in western Ohio; in eastern Ohio weedy sods appeared best.

Planting method.—The data are erratic.

Age of planting stock.—Only 1-year seedlings are used.

Drainage.—Sites having only moderate drainage produced the best average growth and survival in all regions.

Topography.—The bottom land sites seemed to produce the poorest results in all regions.

Exposure.—In southern Ohio, south or southeastern exposures appeared to be best; in northern Ohio, north or eastern exposures produced the best average growth and survival.

Ground cover at time of survey.—Bare sites are apparently best in most instances, although the northwest region produces somewhat better growth and survival under brush or tree competition.

TULIPTREE[9]

Site preparation.—There is some evidence to show that plowing may be best.

Ground cover at time of planting.—Bare sites appeared to be somewhat better, especially in northern Ohio.

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[8]Plots of this species are not numerous in eastern Ohio but are plentiful in the western regions.

[9]This and the following species are not represented by adequate numbers of plots to yield significant information

Planting method.—No conclusions can be drawn from these data.

Age of planting stock.—In northeastern Ohio, 2- or 3-year-old trees appeared to be best, but in other regions, 1-year-old seedlings were as good.

Drainage.—Moderate to damp sites appeared to be best in all regions.

Topography.—In all but the northwest region (where there were only 14 plots) the best average growth rate was found on bottom land sites, the best average survival, on hilltop or hillside sites.

Exposure.—Plots with northwest, north, and northeast exposures apparently are superior to those with southeast, south, and southwest exposures.

Ground cover at time of survey.—There is little consistency in the data as to this factor, indicating possibly greater tolerance of the tuliptree toward competing vegetation of the different types.

WHITE ASH

Site **preparation.**—No conclusive data.

Ground cover at time of planting.—Apparently bare sites are less advantageous than some cover, particularly brush or trees.

Planting method.—Data not conclusive.

Age of planting stock.—Trees older than 1 year of age produced better results in all regions.

Drainage.—Good to moderate drainage was much superior to wet sites in all regions.

Topography.—Bottom land sites produced the poorest average growth and survival in all four regions.

Exposure.—The south, southwest, and west exposures appeared to be less satisfactory than the northwest, north, and east in all regions.

Ground cover at time of survey.—The data are erratic and inconclusive.

RED OAK

Ground cover at time of planting.—Brush cover appeared best in all regions except the northwest, where bare sites produced the best results.

Drainage.—Moderate to dry sites appeared to be better than wet areas.

Topography.—Hillsides or hilltops were better than bottom land sites.

Exposure.—Northern exposures were much superior to south or west.

Ground cover at time of survey.—Brush and trees appeared to be superior to grass or weed cover.

OTHER INFLUENCES

Wherever it was possible to do so, insects, diseases, and other factors affecting plantings were identified and recorded. No special effort was made to obtain a complete list of insects and diseases, since many counties were surveyed during the winter months, when observation and identification of injuries were practically impossible, and since this information was incidental to the principal objectives of the survey.

The observations recorded are from the notes of county supervisors and pertain only to the location and types of injuries found.

INSECTS

Zimmerman pine moth, *Dioryctria zimmermani* **Grt.**—Zimmerman pine moth has been found principally in northeastern Ohio, although it is also reported in other sections of the State. In northern Ohio, the larvae of the Zimmerman moth work mainly in the cambium and in the whorls of the branches; in the southern part of the State, for the most part they infest the twigs, killing the terminals and laterals back for a distance of 10 to 12 inches.

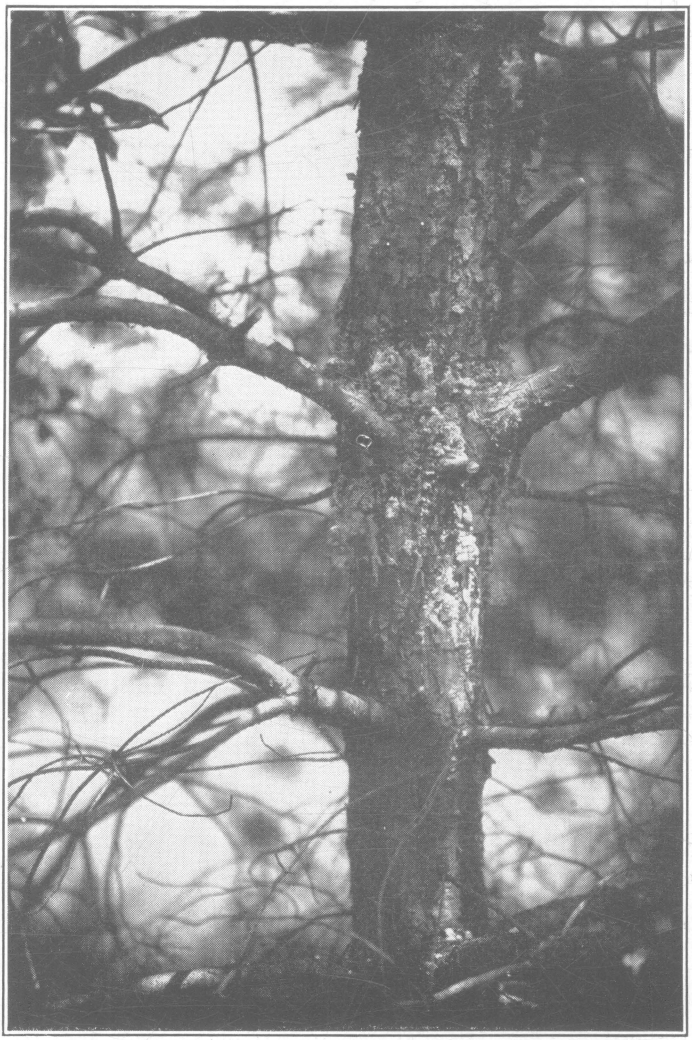

Fig. 14.—Zimmerman pine moth damage on Scotch pine

Note increased diameter of stem above the pitch mass, due to girdling action of the borer.

Species most commonly attacked by the pine moth are Scotch, Austrian, Corsican, and ponderosa pines. Red pine is also reported attacked, but to a lesser degree, and white pine thus far appears to be immune.

TABLE 17.—Reported occurrence of Zimmerman pine moth

Northeast	Number of plantings attacked	Southeast	Number of plantings attacked	Southwest	Number of plantings attacked	Northwest	Number of plantings attacked
Cuyahoga	17	Perry	5	Marion	1	Wood	2
Lake	13	Pike	1	Adams	1	Lucas	1
Geauga	11	Athens	1				
Summit	5						
Richland	3						
Mahoning	2						
Erie	1						
Stark	1						

European pine shoot moth, *Rhyacionia bouliana* **(Schiff).**—The European pine shoot moth was found principally in Cuyahoga, Lake, and Geauga Counties. Its work is very similar to that of the Nantucket pine tipmoth, which is known to occur in southern Ohio. Both insects mine the growing shoot, causing it to wilt and die. Frequently a healthy lateral shoot assumes the position of leader when the leader is killed.

TABLE 18.—Reported occurrence of European pine shoot moth

County	Number of plantings
Lake	36
Cuyahoga	29
Geauga	17

Sawflies.—Pine sawflies have been reported in forest plantations as shown in table 19. Several species of sawflies are known to occur in Ohio, chief of which are Abbott's sawfly, *Neodiprion pinetum*, and the Leconte, or red-headed sawfly, *N. lecontei*. The former is usually found on white pine, the latter on the yellow pines. No attempt was made to identify the species of sawflies found during the survey, however. Most of the attacks reported were light, although in some cases, a few individual trees were completely defoliated. Sawfly larvae were found during all the summer months because of the overlapping of broods of some species.

Bag worm, *Thrydopteryx ephemeraeformis*, **Haw.**—Many species, including both hardwoods and conifers, are attacked by the bagworm in natural stands and in plantations. Arborvitae is particularly susceptible. Nowhere did this insect appear in numbers sufficiently large to cause serious damage to entire plantings. The species reported attacked in plantings are red, white, Scotch, and shortleaf pines, European larch, and Norway spruce. Concentrations of the insect were greatest in the southern-most sections of the State and decreased toward the north. It was not found north of Licking County.

Oyster shell scale, *Lepidosaphes ulmi* **L.**—Oyster shell scale has been found in plantings throughout the State. Several hardwoods are attacked in natural stands; in plantings, ash is particularly susceptible to injury. In

TABLE 19.—Occurrence of sawfly injury

County	Species attacked	Number of plantings reported	County	Species attacked	Number of plantings reported
Northeast			Southeast		
Ashland	White pine	1	Carroll	White pine	3
Columbiana	White pine	3	Coshocton	White pine	3
Cuyahoga	White pine	1	Fairfield	Scotch pine	3
Erie	White pine	5	Guernsey	Ponderosa pine	1
Geauga	White pine	1		Jack pine	1
Huron	White pine	1	Holmes	Red pine	1
Mahoning	White pine	4	Jefferson	Pitch pine	1
Stark	White pine	2		Scotch pine	2
Summit	White pine	4	Meigs	Shortleaf pine	2
Trumbull	White pine	1	Muskingum	Red pine	1
Wayne	White pine	2	Ross	Shortleaf pine	1
			Tuscarawas	White pine	7
				Scotch pine	1
Northwest			Southwest		
Fulton	Scotch pine	1	Allen	White pine	1
	Austrian pine	1	Clark	White pine	1
	White pine	1	Crawford	White pine	2
Hancock	White pine	2	Greene	White pine	2
Lucas	White pine	2	Hardin	White pine	1
Ottawa	White pine	1	Knox	White pine	1
Paulding	Scotch pine	1	Licking	White pine	2
Putnam	White pine	1		Shortleaf pine	2
Seneca	Austrian pine	2		Scotch pine	2
	Scotch pine	2	Morrow	White pine	1
	White pine	1	Wyandot	White pine	1
Williams	Austrian pine	1			
	Red pine	1			

TABLE 20.—Occurrence of bagworm injury

Southeast		Southwest	
County	Number of infestations reported	County	Number of infestations reported
Athens	2	Clermont	1
Gallia	2	Hamilton	3
Jackson	4	Highland	1
Morgan	3	Licking	1
Perry	1		
Washington	1		

addition, oyster shell scale was found in the southwest on sugar maple, in the southeast on catalpa, and in the northeast on walnut and cottonwood. Ash is the only species on which it was found in the northwest region.

Pine bark aphid, *Adelges pinicorticis* **Fitch.**—The pine bark aphid, or woolly aphid, was reported only in the eastern part of the State. In the southeast, it was found on red, white, and shortleaf pines; in the northeast, on red, Scotch, and white pines and Norway spruce. In none of the plantings where it was found was it causing fatal injury, although it is known to be capable of killing trees when it attacks in large numbers.

Locust borer and locust twig borer.—Practically all black locust plantings in Ohio are affected to some extent by the locust borer,*Cyllene robiniae* Forst., and by the locust twig borer, *Ecdytolpha insiticana* Zell. Intensity of attack of both insects has been observed to vary with the vigor and the growth rate

of the trees, which, in turn, vary with the site quality. Since locust is used largely for erosion control in Ohio, on sites which are of low fertility, such plantings are usually heavily infested with both the locust borer and the twig borer. Growth under these conditions is very slow. On fertile, well-drained sites, however, growth is rapid, and although such plantings are also attacked, the damage is usually less severe.

Locust leaf beetle, *Chalepus dorsalis* **Thumb.**—The locust leaf beetle which occurs in southeastern Ohio was reported in one planting in Jefferson County; the infestation was not heavy.

Catalpa sphinx moth, *Ceratomia catalpae* **Brd.**—Many catalpa plantings, in all parts of the State, were reported attacked by the catalpa sphinx, and although this pest is capable of killing entire catalpa groves by defoliation, no instances of such heavy infestation were found in the plantings examined.

Bark beetles.—Bark beetle infestations were reported in several plantings, usually limited to a small number of trees which had been weakened previously by some other cause. One of these was tentatively identified in the larval stage by Mr. J. S. Houser, Chief Entomologist at the Ohio Agricultural Experiment Station, as *Dendroctonus terebrans* **Oliv.** The infestation had occurred on Scotch pine in Athens County. A similar injury was reported on the Carpenter Test Farm in Meigs County. The cause of the initial weakening was not given in this case, but in Guernsey County, a red pine planting occupying an exceedingly acid, poorly-drained soil was attacked by bark beetles which killed the trees. Other bark beetle infestations were found in Morrow County on red pine, in Jackson County on Corsican pine, and in Gallia County on Scotch pine.

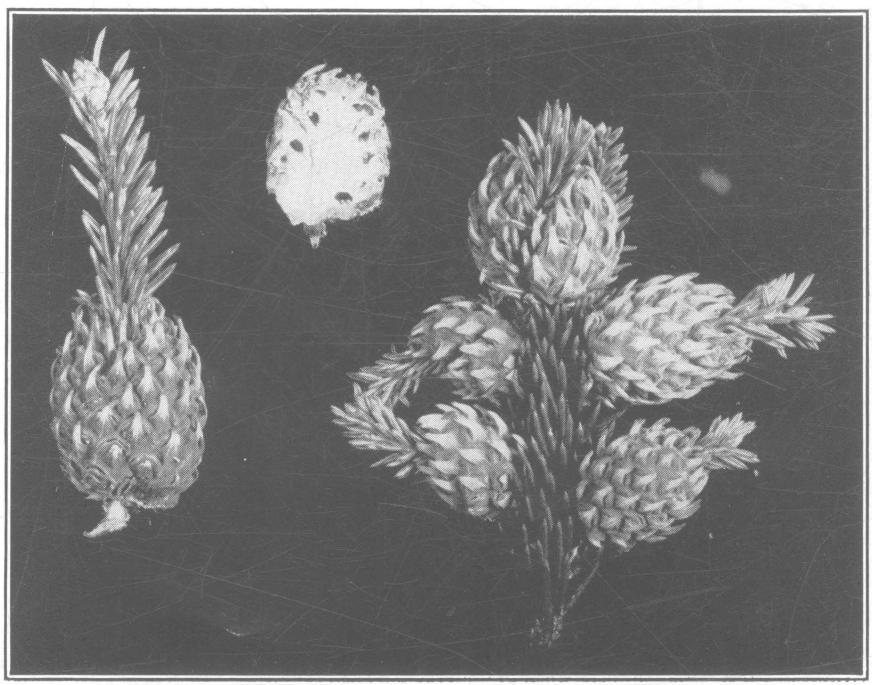

Fig. 15.—Spruce pineapple galls, caused by pineapple gall aphid

Miscellaneous insect injuries.—In many plantings, positive identification of insects or insect injuries was impossible because of the time of year or because of the stage of life cycle in which the insect happened to be. In such cases, notes were taken on the nature of the injury and the species on which it occurred.

A cambium borer whose work resembled that of the Zimmerman pine moth was reported on white pine in Ashtabula County. Whether this species represents a new host of the Zimmerman moth or whether the injury was caused by another insect is unknown.

White pine weevil was reported in one young planting in Licking County. Identification was not positive, however.[10]

Scotch pine was found attacked by a pitch moth in Geauga and Summit Counties. This moth appeared to be different from the Zimmerman moth in the nature of its work.

A bark borer was reported on catalpa in Morgan County and on walnut in Perry County. In both cases only a few trees were attacked. It is believed that these trees had been weakened previously by a local condition and that the borers represented a secondary pest.

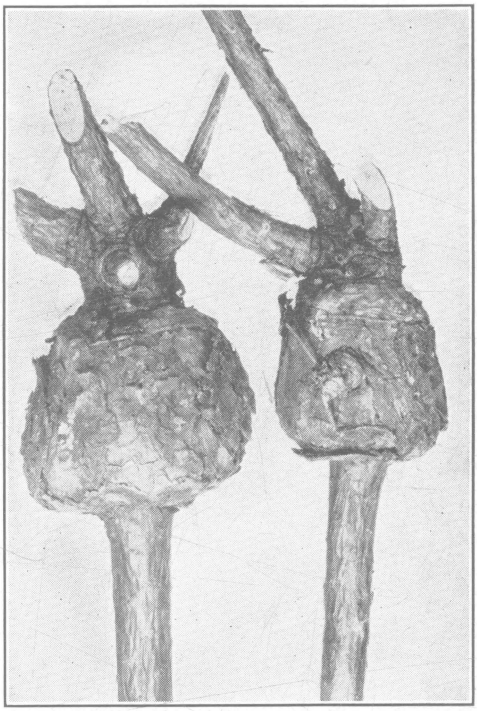

Fig. 16.—Galls, *Cronartium quercus*, on Scotch pine, Jackson County

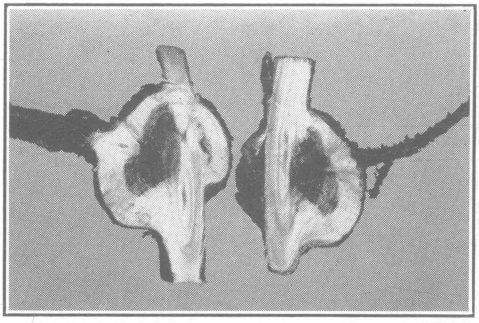

Fig. 17.—Section of gall, *C. quercus*, on Scotch pine, Jackson County

Ants.—Ant hills were found in plantings throughout the State, and the trees in the immediate vicinity of these hills usually were dead.

Unless ant hills are numerous within a planting, however, they do not cause sufficient damage to warrant control measures.

DISEASES

Needle blight.—Needle blight is a fungous disease which has been found on all species of pines in practically all sections of the

[10]The white pine weevil was also found in Hocking County in a white pine planting by Dr. J. B. Polivka, Assistant Entomologist, Ohio Agricultural Experiment Station.

TABLE 21.—Reported occurrence of needle blight

County	Species infected	Number of plantings reported	County	Species infected	Number of plantings reported
Southeast			Southwest		
Athens	Corsican pine	1	Clermont	Red pine	1
	White pine	1	Crawford	White pine	1
Carroll	Red pine	3		Red pine	1
	Scotch pine	1	Licking	White pine	2
Coshocton	Corsican pine	1		Scotch pine	1
Gallia	Corsican pine	1	Miami	Austrian pine	1
Guernsey	Scotch pine	1	Montgomery	Scotch pine	1
Hocking	Austrian pine	1	Morrow	Red pine	1
Noble	Corsican pine	1		Scotch pine	1
Tuscarawas	Austrian pine	1			
Northeast					
Ashland	Austrian pine	1	Richland	White pine	6
	White pine	2	Summit	Scotch pine	1
Cuyahoga	Red pine	1			

State. The blight appears in the form of a brown spot on a needle and spreads until the entire needle turns brown.

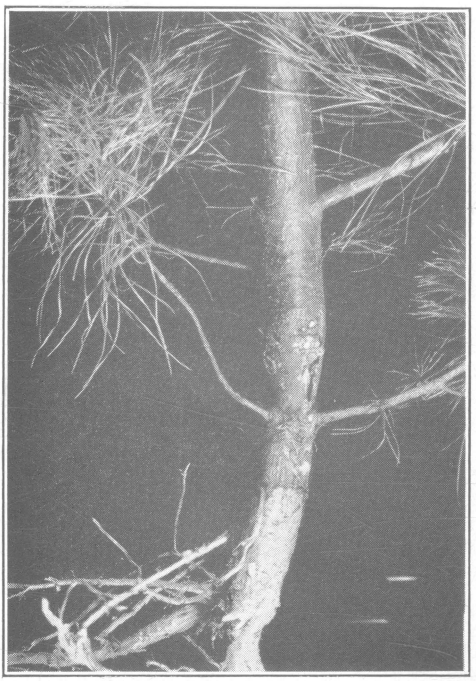

Fig. 18.—White pine killed by ants

White pine Blister Rust.[11]— Blister rust infection has been found on currant or gooseberry plants throughout northern Ohio; infected pines have been found in Ashland, Carroll, Cuyahoga, Geauga, Holmes, Knox, and Wayne Counties in the last few years. The damage caused by blister rust has been checked in each instance. Preventive measures on all future plantings should be taken by planting the pine in areas free from currant and gooseberries or in eradicating these plants for a distance of 300 to 900 feet from the pine stands. Further information can be obtained from the State Forester or the State Leader of Blister Rust Control, Ohio Agricultural Experiment Station.

[11]Cooperative white pine blister rust control work between the Ohio Agricultural Experiment Station, Division of Forestry, the Ohio Department of Agriculture, and the Federal Bureau of Entomology and Plant Quarantine has resulted in the protection of 11,343 acres of planted and native white pine. Currant and gooseberry bushes have been removed from 164,916 acres of control zone surrounding this pine. (Figures, furnished by the Bureau of Entomology and Plant Quarantine, include areas worked up to January 1, 1941.)

OTHER INJURIOUS AGENCIES

Rodents.—The relative amount of rodent injury sustained by a planting is determined largely by the relation of its location to centers of rodent population. The species of trees in plantings are also important, since some rodents are known to be selective.

Cottontail rabbits have been particularly destructive in young hardwood plantings, nipping buds and young twigs and sometimes girdling larger trees. Usually they do not molest coniferous plantings, although a few instances have been reported in which rabbits have cut off the growing tips of young pines. These were not eaten but were left on the ground near the trees. Coniferous species on which rodent damage has been reported include all the pines and Norway spruce.

Because of the great differences in the number of plantings of various species of hardwoods, some of which are represented by only one or two plots, it is impossible to make comparisons as to their relative susceptibility to rabbit damage. Of the species reported injured by rodents, tuliptree was the most frequently attacked. White ash, red oak, elm, catalpa, walnut, locust, and sweetgum were also attacked.

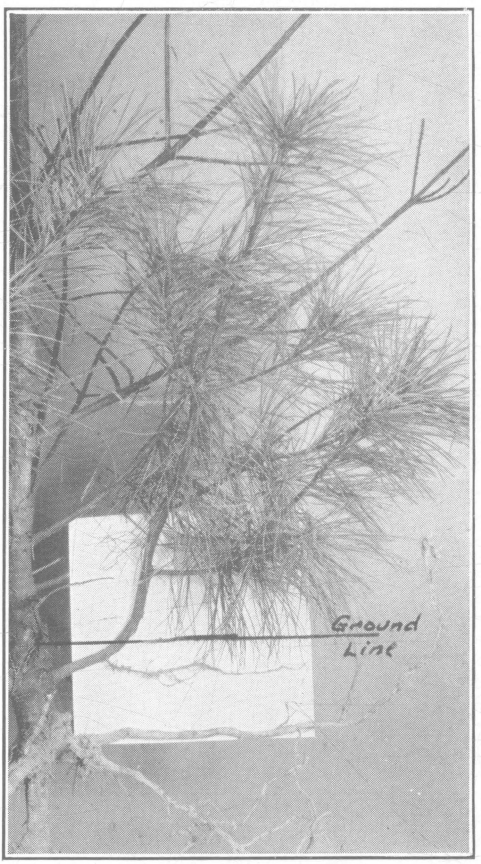

Fig. 19.—White pine injured (possibly by ants) near ground line. A branch located below the injury had been covered with soil during planting and was beginning to develop a separate root system, Carrollton, Carroll County

Mice are more destructive to conifers than to hardwoods and have an apparent preference for Austrian pine. In the northeast region, for example, 21 plantings were reported injured by mice. Many of these contained several species, but the frequency of attack was as follows: Austrian pine, 11; Scotch pine, 7; red pine, 4; Corsican pine, 2; white pine, 1; black locust, 1; white ash, 1; white elm, 1. This preference for Austrian pine is found throughout the State, and in many plantings containing Austrian pine in mixture with other species, mice have been known to girdle only the Austrian pine, leaving the other species unharmed. This situation is found in young plantings only. Thick bark on trees 10 years old or older protects them from serious injury.

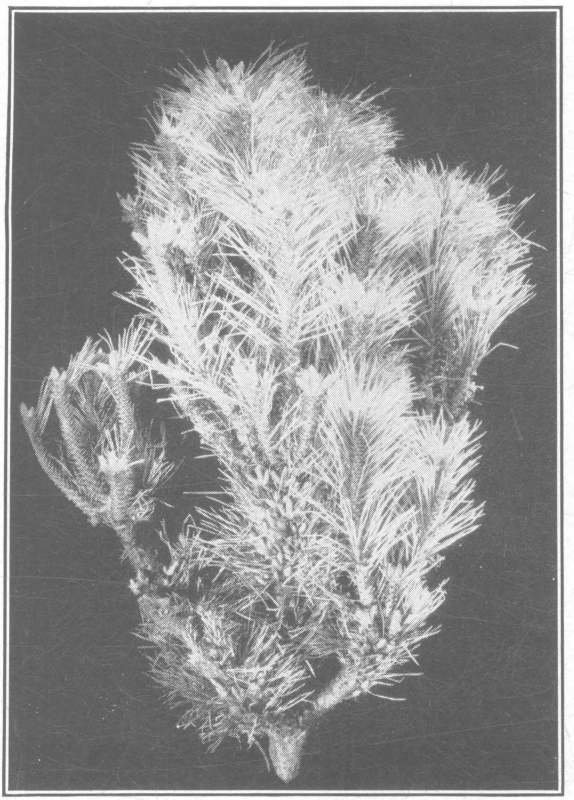

Fig. 20.—Witches'-broom on Scotch pine, frequently reported in northeastern Ohio

Ground hogs sometimes injure planted trees by gnawing the bark, but very few such attacks have been reported, and no preference is shown for any species. In the plantings reported, only a few trees of each species were injured. The species damaged were sugar maple, Austrian pine, red pine, and Scotch pine.

Grazing.—Plantings which are grazed have exhibited the following types of injuries, listed in approximate order of their importance:

Breakage and trampling.

Browsing. Livestock are particularly destructive to young hardwood plantings of such species as tuliptree, oak, white ash, and maple. Walnut, catalpa, and Osageorange are usually unmolested. Contrary to widespread belief, coniferous plantings are frequently browsed by cattle. Tender growing tips may be nipped or chewed off, and trees so attacked become misshapen if they are not killed.

Compacted soil. Injuries resulting from soil compaction are of two forms: (a) pathological, injury allowing the introduction of decay fungi to roots of trees, and (b) physical, decreasing soil pore space so that decreased aeration and moisture-holding capacity result.

Destruction of hardwood volunteers.

Rubbed bark.

About 4 per cent of the plantings in the State have been grazed, many of them so heavily as to cause their complete destruction.

Table 22 shows that the number of plantings which are able to survive the effects of grazing is small, and that most grazed plantings are destroyed. However, the table also shows that grazing is a comparatively small factor affecting plantations.

TABLE 22.—Grazing in forest plantations

	Northeast	Southeast	Southwest	Northwest
Number of successful plantings grazed	18	10	6	4
Per cent of all successful plantings	2	.8	1.0	1.6
Number of plantings destroyed by grazing	74	113	65	14
Per cent of all destroyed plantings	4.5	5.6	6.5	5.1
Total number of grazed plantings	92	123	71	18
Per cent of total plantings	3.6	3.8	4.5	3.4

Floods.—The reforestation of stream banks is an important step toward the prevention of floods, but the establishment of plantings along streams, particularly on flat bottom land sites, is often difficult when streams overflow their banks periodically. Plantings are usually washed out during the first 2 or 3 years of their existence. After that they are not easily dislodged. Frequent flooding has caused the death of a few plantings for lack of proper soil aeration.

Fires.—Fires have not been a serious problem in the State as a whole. In the majority of counties in which fire damage was reported, the number of plantings damaged was small, usually not more than two or three. In Tuscarawas County, however, 14 plantings were reported damaged by fires, indicating an unusually high fire hazard in that county. Tuscarawas County is one of the leading counties in the United States in the production of coal, brick, and tile. These industries are widely scattered in the rural regions, and fires occur commonly in the vicinity of manufacturing and mining plants, frequently escaping onto adjoining land.

The most common causes of fires in the State, however, were escaped grass and brush fires. As a precautionary measure, owners of plantings should maintain plowed fire lines around their plantings, and large planted areas should be dissected by roads or fire lanes.

Weather.—There is a distinct correlation between weather conditions, particularly the amount of precipitation occurring during the growing season, and the early survival of forest plantations. Several dry seasons have occurred during recent years, of which the 1930, 1934, and 1936 seasons were the most notable. Precipitation data for those 3 years are shown in table 23.

TABLE 23.—Comparison of precipitation during 1930, 1934, and 1936 with normal*

	Northern Division‡		Middle division‡		Southern division‡		State	
	Annual precipitation	Departure from normal	Annual precipitation	Departure from normal	Annual precipitation	Departure from normal	Annual precipitation	Departure from normal
1930.....	28.48	—7.28	26.71	—11.59	25.02	—15.02	26.74	—11.29
1934.....	26.21	—9.55	25.70	—12.60	27.96	—12.08	26.61	—11.42
1936	30.79	—4.97	34.64	— 3.66	35.16	— 4.88	33 52	— 4.51
Normal†....	35.76	. .... .	38.30	.. ..	40.04	. .....	38.03§	... .

*Climatological Data, Ohio Sec., Vol. XLIII, No. 13, U. S. Weather Bureau; and Patton, C. A., 1939. Fifty Years of Ohio Weather, Ohio Agr. Exp. Sta. Bull. 608.
†Based upon 55 years of records.
‡The Northern division of the Weather Bureau corresponds to the Northeast and the Northwest regions of the survey; the Middle and Southern divisions combined coincide with the combined Southeast and Southwest regions.
§Records of 85 weather stations.

Figure 21 illustrates the effect of weather upon planting results. The curve of number of plots by year of planting follows that of tree shipments only in a general way. Large variations of tree shipments, as in the period from 1925 to 1927 and 1932 to 1935, are reflected in the curve of number of plots, but the close correlation is between the number of plots and the precipitation curve, particularly from 1930 to 1938. In 1938, the number of plots dropped from that in 1937, following the trend in precipitation rather than the trend of tree shipments, which increased. In 1937, a slight increase in tree

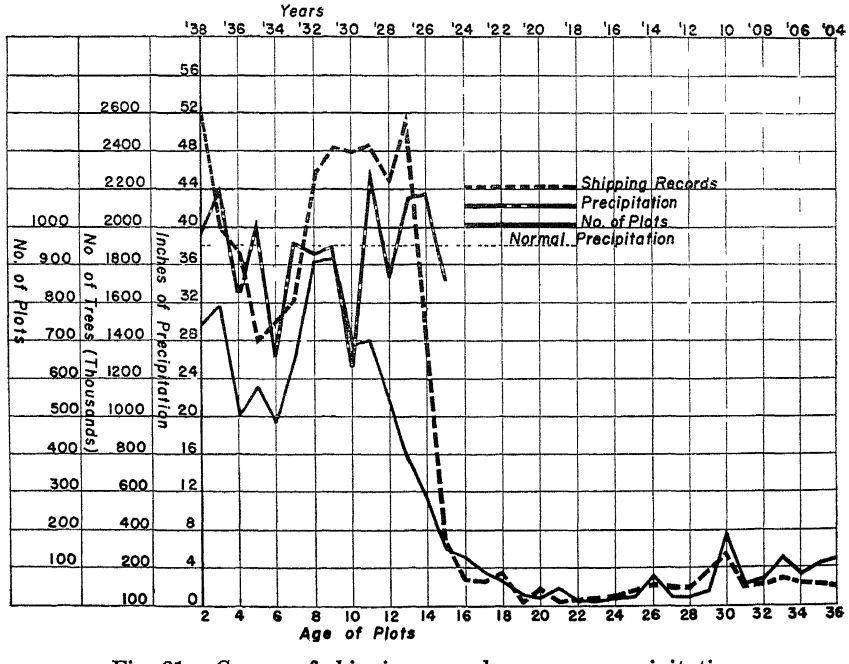

Fig. 21.—Curves of shipping records, average precipitation, and total number of plots found

shipments over 1936 was accompanied by a large increase in number of plots, due, apparently, to favorable weather conditions. The opposite was true in 1936, which was a very dry year. In 1934, a drop in tree shipments from those of previous years, together with unfavorable weather conditions, produced a large slump in number of plots.

TABLE 24.—The establishment of forest plantations during 2 selected drought years

	1930	1934
Total number of cooperators	935	777
Number whose plantings showed 80 per cent or more survival	41	39
Per cent of total	4.4	5.0
Number who had planted trees prior to drought years	24	24
Number who planted trees after drought years	27	33

The position of the curves in 1930 requires some clarification. In 1928, two large organizations, the Cleveland and the Akron Metropolitan Park Boards, embarked upon a vast planting program which lasted until 1932, when shipments to the parks began to decline. Most of the park plantings were established by trained planting crews who were closely supervised, with the result that uniformly high survivals were obtained even in the drought year of 1930.

An examination of the field records has revealed that about 5 per cent of the cooperators who planted trees during 2 selected dry years, 1930 and 1934, obtained 80 per cent or better survivals. More than half of these had planted

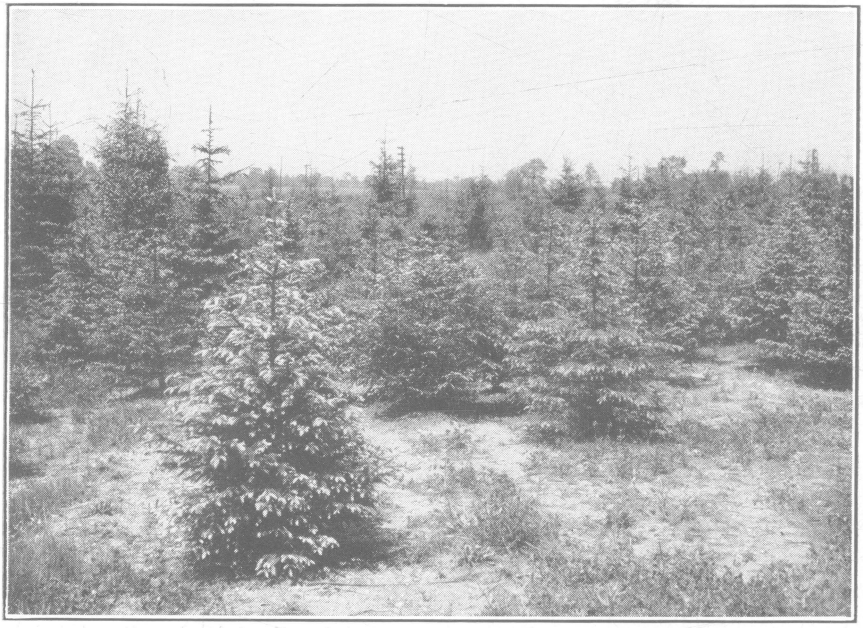

Fig. 22.—Late frost damage on Norway spruce, Medina County

The new growth on the branches and leaders was all frozen and subsequently turned yellow, as shown.

trees before those years and were, therefore, drawing upon previous experience. An even larger number continued to plant after the drought years. These cooperators have proved that it is possible to overcome the effects of unfavorable weather conditions by careful planting procedure.

Another form of weather influence is frost. Early fall and late spring frosts have injured plantings to a certain extent, and black walnut and Norway spruce are the species most commonly affected.

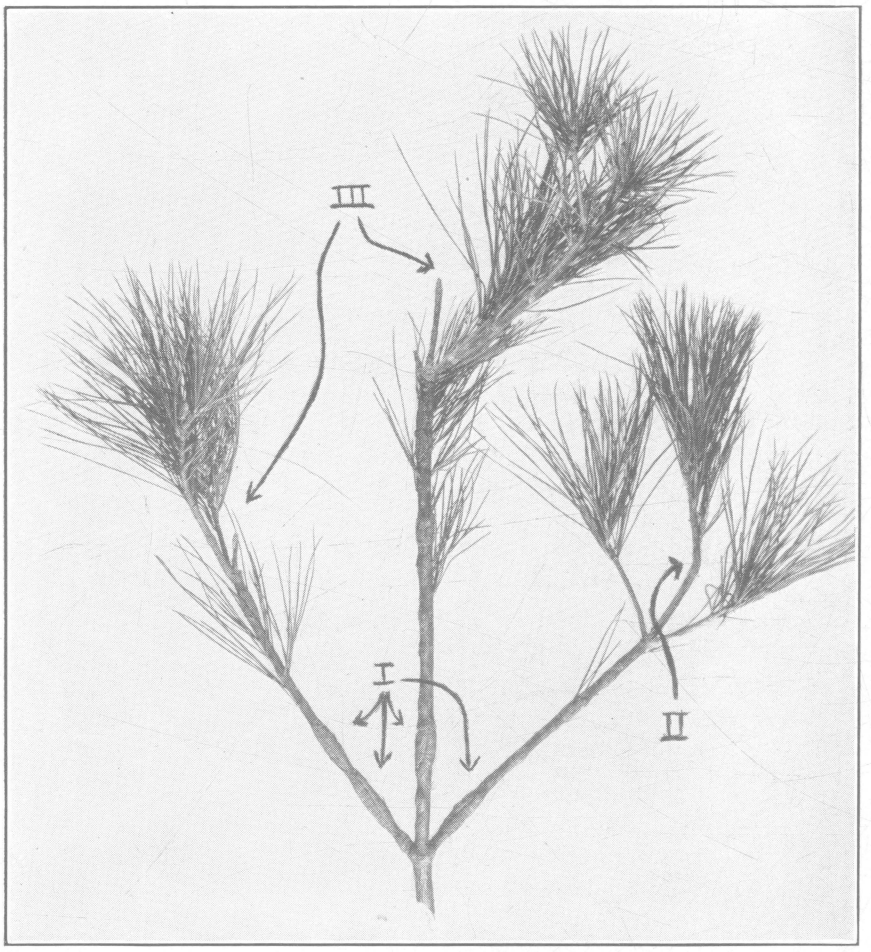

Fig. 23.—Three types of injury caused by hailstorm

I, Lesions caused by pelting hail
II, Deformed branches
III, Broken branches

The stand from which this sample was taken contained white pine, hemlock, and red pine. White pine was injured most seriously, hemlock next, and red pine least.

Hail occasionally injures plantations; in rare cases, severely. Breakage and deformation of new growth are the most common and serious types of injury.

VOLUNTEERS IN FOREST PLANTATIONS

Forest planting has been carried on in the United States for a number of years by far-sighted people who believe that our forest resources are exhaustible and should be replaced and that a new protective cover is necessary on many sites which have been denuded.

The objectives of these forest planting projects have varied with different areas and different conditions. In the Lake States, forest plantations are regarded as an end in themselves, to be treated as permanent forests and allowed to mature in essentially the same form as that in which they were planted. Paul Rudolf has stated that "planting studies in this (Lake States) region should aim more and more to develop methods of after care necessary to bring plantations through to maturity."[12]

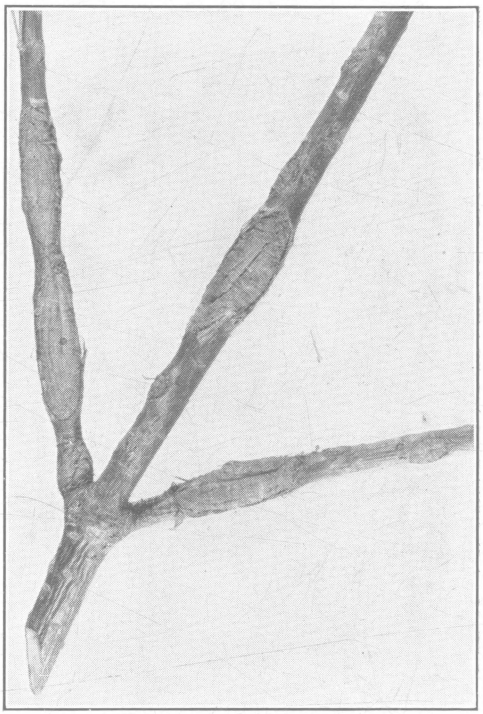

Fig. 24.—Hail damage on white pine

These lesions appeared on the underside of the branches, and only on the north side of the trees, indicating that the trees had been bent over by a strong wind, and the undersides of the branches pelted by hail. This is a section of the sample shown in the preceding figure.

A theory which is not new, but which is just beginning to gain general recognition, is that pine plantings in the central hardwood region are not always the ultimate goal of reforestation. Those who are now planting pine forests in this region may have no clear conception as to the final course of their development, but they are finding that pine stands are difficult to maintain in pure form. Eighty per cent of the plots examined by the survey contained some hardwood volunteer growth. This trend has been recognized by a number of foresters and ecologists. The Indiana Department of Conservation states in a recent publication that "there is some evidence to support the idea that these stands of pines will be followed by the native hardwoods. Seedlings of native hardwoods are already establishing under the pines in many older pine plantations."[13]

[12]Rudolf, P. O., et al. 1940. Digest of Research Findings in Reforestation During 1940. Lake States Forest Experiment Station. Unpublished Document.

[13]Hoosier Tree Planters' Manual. Indiana Department of Conservation. Division of Forestry. 1941.

Fig. 25.—Deformation of red pine roots at the time of planting, still evident years later

Practically all the early planting in Ohio was for the specific purpose of post production. Later the realization grew that there were areas needing forest cover, but the idea persisted, and still persists, that the planted trees must, themselves, be harvested profitably in a comparatively few years.

Present-day reforestation is being carried out principally with pines, because they are the species best suited to creating a forest cover quickly under the usually impoverished conditions found. The possibility, however, that many of these planted trees may never become merchantable must be considered.

There are a number of areas in Ohio where the original planted pines may reach maturity and in some instances reproduce and establish a stabilized forest. Shortleaf pine on the dry south and west slopes of a few counties along the Ohio River and white pine in a number of ravines and hillsides in central and northern Ohio may do so. Hemlock also is likely to succeed in deep ravines in eastern Ohio.

The balance of the pine plantings probably cannot be considered as permanent, stabilized forests unless a change in composition takes place. The present survey has revealed that this change is taking place in nearly all plantings in Ohio, through natural seeding of hardwoods. This section is devoted to a study of the factors affecting volunteer reproduction, and of the methods of promoting the process of conversion to a stabilized hardwood forest.

FACTORS AFFECTING INFILTRATION OF VOLUNTEERS

Availability of seed.—The quantity and species of seeds that fall within a forest planting are dependent primarily upon the proximity of seed trees and vary according to the forest types and also by regions. In western Ohio, for example, there are extensive areas where trees are absent or scattered, whereas in eastern Ohio trees are plentiful and few areas would be very far from seed trees of several species.

Fig. 26.—A good example of the type of area that needs no planting. This field was cleared of its hardwood growth, and pines were planted. The native species sprouted and seeded in so densely, however, that the pines were eliminated by the competition.

The volunteer species and the number of plots in which they were reported are listed in table 25, by regions. It will be noted that there are only 4 species among the leading 10 which are found in all 4 regions, namely, elm, black cherry, hawthorn, and white ash. There are several others that occur nearly as frequently in all regions, sugar maple, black walnut, sassafras, hickory, and white oak. Hawthorn is one of the most common species found in all but the northwest region, where it was found in only four plots.

TABLE 25.—Volunteer species, probable agencies of dissemination, and number of plots in which reported

Northeast region

Rank	Species	Number of plots	Agency*	Rank	Species	Number of plots	Agency*
1	Black cherry	1,368	B	25	Black oak	23	
2	Hawthorn	773	B A R	26	Willow	19	W
3	Elm	773	W	27	Redcedar	17	B
4	Sugar maple	731	W	28	Hemlock	16	W
5	White ash	574	W	29	Butternut	14	R
6	Wild apple	506	B A R	30	Birch	12	W
7	Sumac	265	B	31	Buckeye	10	R
8	White oak	235	R	32	Blackgum	10	B
9	Black locust	205	W B	33	Pin oak	9	R
10	Dogwood	202	B	34	Hazelnut	8	R
11	Red maple	187	W	35	Pawpaw	7	A B
12	Hickory	180	R	36	Cottonwood	7	W
13	Red oak	169	R	37	Sweetgum	4	W
14	Tuliptree	160	W	38	Witchhazel	4	B W
15	Black walnut	106	R	39	Black ash	4	W
16	Sassafras	79	B	40	Spicewood	3	B
17	Aspen	59	W	41	Honeylocust	3	A B W
18	Beech	59	R	42	Scarlet oak	3	W
19	Elderberry	52	B	43	Boxelder	3	W
20	Basswood	51	W	44	Chestnut oak	2	R
21	Sycamore	40	W	45	Green ash	2	W
22	Hophornbeam	38	W	46	Shingle oak	1	R
23	Am. hornbeam	29	W	47	Sourwood	1	B W
24	Chestnut	24					

*Key: B—birds; R—rodents; A—other animals; W—wind.

Summary

Agency	Number of species	Total frequency	Per cent of total
Wind	23	2,922	29.7
Birds	15	3,495	35.6
Rodents	16	2,122	21.6
Other animals	4	1,289	13.1
Total		9,828	100.0

TABLE 25.—Volunteer species, probable agencies of dissemination, and number of plots in which reported—Continued

Southeast region

Rank	Species	Number of plots	Agency*	Rank	Species	Number of plots	Agency*
1	Elm	1,100	W	24	Beech	60	R
2	Black cherry	962	B	25	Chestnut	52	R
3	Sassafras	712	B	26	Sycamore	50	W
4	Sumac	626	B	27	Pawpaw	49	B A
5	White ash	613	W	28	Honeylocust	43	W A B
6	Hawthorn	551	B A R	29	Boxelder	36	W
7	Black locust	524	W B	30	Hazelnut	34	R
8	Hickory	514	R	31	Am. hornbeam	32	W
9	Dogwood	482	B	32	Buckeye	29	R
10	Wild apple	420	B A R	33	Hophornbeam	22	W
11	Sugar maple	406	W	34	Butternut	22	R
12	Red maple	307	W	35	Elderberry	21	B
13	Tuliptree	293	W	36	Birch	20	W
14	Red oak	271	R	37	Black oak	12	R
15	Black walnut	264	R	38	Spicewood	11	B
16	White oak	235	R	39	Willow	9	W
17	Persimmon	153	A R	40	Chinkapin oak	7	R
18	Scrub pine	134	W	41	Red oak	7	B
19	Blackgum	112	B	42	Shingle oak	4	R
20	Sourwood	101	B W	43	Mulberry	4	B
21	Redbud	91	B W	44	Black ash	4	W
22	Aspen	86	W	45	Bladdernut	3	R
23	Sweetgum	81	W	46	Basswood	2	W

*Key: B—birds; R—rodents; A—other animals; W—wind.

Summary

Agency	Number of species	Total frequency	Per cent of total
Wind	20	3,954	31.5
Birds	16	4,716	37.8
Rodents	16	2,631	21.0
Other animals	5	1,216	9.7
Total		12,517	100.0

TABLE 25.—Volunteer species, probable agencies of dissemination, and number of plots in which reported—Continued

Southwest region

Rank	Species	Number of plots	Agency*	Rank	Species	Number of plots	Agency*
1	Elm	432	W	25	Aspen	20	W
2	Black cherry	332	B	26	Redbud	20	W B
3	White ash	266	W	27	Sycamore	19	W
4	Hawthorn	168	B A R	28	Hackberry	16	B
5	Sugar maple	163	W	29	Mulberry	16	B
6	Black locust	148	W B	30	Basswood	13	B W
7	Black walnut	144	R	31	Butternut	13	R
8	Hickory	96	R	32	Blackgum	11	B
9	Sumac	76	B	33	Serviceberry	11	B
10	White oak	67	R	34	Black ash	11	W
11	Red oak	61	R	35	Hazelnut	10	R
12	Wild apple	59	B A R	36	Sweetgum	8	W
13	Redcedar	59	B	37	Birch	7	W
14	Red maple	51	W	38	Chestnut	6	R
15	Dogwood	48	B	39	Am. hornbeam	6	W
16	Honeylocust	44	W B	40	Chestnut oak	5	R
17	Sassafras	41	B	41	Shingle oak	5	R
18	Boxelder	39	W	42	Ailanthus	4	W
19	Pawpaw	34	B A	43	Cottonwood	3	W
20	Buckeye	25	R	44	Pin oak	3	R
21	Hophornbeam	25	W	45	Willow	3	W
22	Beech	24	R	46	Persimmon	3	A R
23	Black oak	22	R	47	Spicewood	2	B
24	Tuliptree	21	W	48	Bladdernut	1	R
				49	Scrub pine	1	W

*Key: B—birds; R—rodents; A—other animals; W—wind.

Summary

Agency	Number of species	Total frequency	Per cent of total
Wind	23	1,307	38.6
Birds	17	1,098	32.5
Rodents	17	712	21.1
Other animals	4	264	7.8
Total		3,381	100.0

TABLE 25.—Volunteer species, probable agencies of dissemination, and number of plots in which reported—Concluded

Northwest region

Rank	Species	Number of plots	Agency*	Rank	Species	Number of plots	Agency*
1	Elm	50	W	11	Dogwood	4	B
2	Sugar maple	23	W	12	Black locust	4	W B
3	White ash	15	W	13	Tuliptree	3	W
4	White oak	12	R	14	Sycamore	2	W
5	Hickory	9	R	15	Red maple	1	W
6	Black cherry	7	B	16	Sassafras	1	B
7	Red oak	6	R	17	Black walnut	1	R
8	Wild apple	5	B A R	18	Cottonwood	1	W
9	Elderberry	4	B	19	Mulberry	1	B
10	Hawthorn	4	B A R	20	Aspen	1	W

*Key: B—birds; R—rodents; A—other animals; W—wind.

Summary

Agency	Number of species	Total frequency	Per cent of total
Wind	9	100	56.8
Birds	8	30	17.1
Rodents	6	37	21.0
Other animals	2	7	5.1
Total	.....	176	100.0

White oak was reported more frequently than red oak in all but the southeast region, where the red oak occurred somewhat more frequently. Tuliptree, red maple, and dogwood were found commonly in eastern Ohio but less frequently in the southwest and northwest regions.

Basswood is not found commonly among the volunteers, although this species is found in native forests nearly as commonly as black walnut, which is one of the leading species of volunteers, partly because basswood reproduces largely by sprouts, and also because it is rarely found in pastured woods or near buildings or in fence rows, whereas walnut is commonly found in these locations. Thus, walnut seed trees are frequently closer to plantings than basswood.

It will be noted that the 10 leading species of volunteers in each region are, with but one exception, species which produce abundant seed crops annually. In the northwest region, white oak appears among the 10 leading volunteers because this species is one of the more common of the native trees and because the total number of volunteer species is relatively small.

Seed dissemination agencies.—The factor next most important to the availability of seed in influencing the occurrence of volunteers in plantings is the type of agency available to disseminate the seed.

The agencies which disseminate seed of trees and large shrubs are as follows:

Wind
Birds
Rodents
Other animals
Water
Gravity

The first three agencies are of primary importance in the introduction of volunteers into plantings; the others are comparatively unimportant. The latter two agencies may influence all species but are of little effect usually in introducing seed into a forest plantation, so that for the purposes of this study they will be disregarded.

Table 25 lists by regions the species of volunteers reported in forest plantings, the number of plots in which they were reported, and the agencies which are commonly instrumental in their dispersal.

Wind, as a seed disseminating agency, is instrumental in distributing the seeds of more species than any of the other agencies; birds and rodents rank second; other animals, last.

The species distributed by birds are, for the most part, the less valuable trees, including black cherry, dogwood, black locust, honeylocust, redcedar, blackgum, and a number of other species commonly classed as weed trees.

Wind distributes the seed of a number of important timber species, including white ash, tuliptree, the maples, and elms, and several others of secondary importance, namely, black locust, honeylocust, sycamore, willow, cottonwood, hemlock, pines, and basswood.

Rodents distribute fewer species, but a larger percentage of them are commercially valuable. These include all the oaks, walnut, butternut, hickories, and beech. Other animals as disseminating agencies are relatively unimportant, and the species they disseminate are not valuable commercially.

The seed dissemination summaries in table 25 indicate some regional differences. In eastern Ohio, on the basis of frequency of plots affected, birds appeared to rank first as an agency of seed distribution, followed by wind as a secondary agency. In the western part of the State, the order was reversed, with wind in first place. Rodents appeared in third place in all regions.

Density of planting.—The stand per acre of volunteers is also affected by the density of the planting. Planting density is actually a composite factor, including the number of trees per acre, the size of the individual trees, and the density of the foliage, all of which influence the amount of growing space available for volunteers. Only the number of stems per acre is considered in this discussion, however. Density is closely correlated with age, as well, and the two must be considered together in measuring their influence.

Table 26 shows the distribution of all plots in the northeast, southeast, and southwest regions by density of planting and density of volunteers, in each of three age groups. The figures are in percentages, and the total number of plots in each planting density class is indicated. The northwest region was not included in this tabulation because of the scarcity of data. The age classes shown in the table do not include the 1- to 5-year-old plantings, since the density of the plantings at this age has little influence on the density of volunteers.

It will be noted that in the first two age classes, the percentage of plots which have no volunteers tends to increase as the density of the plantings increases, whereas in the oldest group there is little change. The optimum spacing is apparently 400 to 800 planted trees per acre at 6 to 15 years of age; that is, at this density there are fewer plots containing no volunteers than at any other density.

Among the plots which contain volunteers, the optimum density of the planting again appears to be 400 to 800 trees, with only a few exceptions.

Thus, the plantings containing more than 800 or less than 400 trees per acre are more likely to contain fewer volunteers, or no volunteers, than plantings containing 400 to 800 trees.

TABLE 26.—Relation between density of planted trees and density of volunteers, by age classes of planted trees

Density of volunteers per acre	Density of planting: 1-400 Per cent	400-800 Per cent	800-1,200 Per cent	Over 1,200 Per cent
6-15 years				
0	14.6	14.0	21.1	26.1
1-400	47.4	46.1	44.9	40.0
400-800	16.6	17.6	13.6	14.3
800-1,200	8.7	7.7	7.6	7.6
Over 1,200	12.7	14.6	12.8	12.0
	100.0	100.0	100.0	100.0
Total number of plots	1,214	1,769	1,100	498
16-25 years				
0	9.9	12.8	11.9	24.1
1-400	34.0	34.7	37.3	20.7
400-800	19.3	24.1	22.4	7.0
800-1,200	18.4	8.5	7.5	24.1
Over 1,200	18.4	19.9	20.9	24.1
	100.0	100.0	100.0	100.0
Total number of plots	103	141	67	29
26-35 years				
0	19.5	24.6	25.4	22.2
1-400	38.3	37.0	46.3	50.0
400-800	23.8	14.3	13.4	11.1
800-1,200	6.5	8.8	4.5	5.6
Over 1,200	11.9	15.3	10.4	11.1
	100.0	100.0	100.0	100.0
Total number of plots	185	216	67	18

Age of planting.—The volunteers in a planting undergo a change in density and species paralleling the age of the planting. The influence of age of planting upon the density of volunteers is shown in table 27, which represents the distribution, by age of planting, of plots containing volunteers of varying densities. The data are given in percentages to facilitate the comparison of trends among different types of plantings.

Among all types of plantings, i. e., conifers, hardwoods, and locust, most of the plots in the 1- to 5-year age class contain few or no volunteers. As the plantings grow older, site conditions become more favorable, and the percentage of plots containing no volunteers decreases, particularly among the conifers.

Some differences can be observed in the behavior of the data under different types of plantings. A literal interpretation of the high points in the data would indicate that under conifers, for example, there is a rapid rate of volunteer development between the ages of 15 and 25 years, whereas in locust plantings, there appears to be only a slight increase in the number of volunteers with age. The other hardwoods indicate no discernible trends. Practically all the hardwood plantings of about 20 years of age and over are catalpa, most of

which are pastured. The same thing is largely true of the black locust plantings. Up to this age, the data indicate an increase in number of volunteers similar to the increase found in conifer plantings.

TABLE 27.—Relation of density of volunteers and age of planting, by type of planting

Density of volunteers	Age of planting: 1-5 years Per cent	6-15 years Per cent	16-25 years Per cent	26-30 years Per cent
Conifers				
0	30.8	18.4	12.8	5.9
1-200	35.1	29.5	20.9	17.6
200-500	13.3	19.8	18.6	23.5
500-1,000	10.3	17.2	18.6	25.0
Over 1,000	10.5	15.1	29.1	28.0
	100.0	100.0	100.0	100.0
Total number of plots	1,835	3,714	172	68
Black locust				
0	30.8	9.9	11.1	16.3
1-200	33.7	29.6	27.8	33.8
200-500	16.7	23.3	31.5	20.0
500-1,000	8.3	18.1	22.2	21.3
Over 1,000	10.5	19.1	7.4	8.6
	100.0	100.0	100.0	100.0
Total number of plots	312	463	54	80
Other hardwoods				
0	30.5	16.5	21.5	26.8
1-200	37.2	31.9	29.0	27.4
200-500	15.1	19.5	12.2	15.1
500-1.000	3.8	16.1	16.8	16.2
Over 1,000	13.4	16.0	20.5	14.5
	100.0	100.0	100.0	100.0
Total number of plots	239	508	107	358

The data indicate that volunteers increase in number, with some exceptions in locust plantings, as the plantings grow older. In coniferous stands, for example, only 10 per cent of the 1- to 5-year-old plots contained 500 to 1,000 volunteers per acre, whereas 25 per cent of the 26- to 35-year-old stands were found to contain this density of volunteers. Similar advances can be seen in the other density classes. In hardwood plantings, there is a slight decrease in plots containing 1 to 200 volunteers per acre; the 200-500 group remains fairly constant, and a distinct gain is found in the 500-1,000 group. Black locust shows smaller advances in these densities and a decrease in percentage of plots containing more than 1,000 volunteers.

Simultaneously with the change in the density of volunteers, a change in the relative quantity of valuable timber species occurring as volunteers is noted. During the first few years of the life of a planting, volunteers, if present, are apt to consist almost entirely of hardy species whose seed is either wind- or bird-borne. The heavier-seeded, and generally more desirable, species, from the standpoint of timber value, make their appearance later, gaining in relative importance as time goes on.

The volunteer species which appear most commonly in plantings of different types are listed in table 28 in accordance with their frequency of occurrence in plantations of different ages. In this classification, the first 5-year period is considered a period of establishment of the plantings, during which the trees are small and exert a minimum of influence upon the site. The next periods are classified into 10-year intervals, which illustrate more clearly the changing influence of the planting upon the site and upon the volunteers.

The influence of the planting upon the species of volunteers may be evaluated by comparing the relative positions of the valuable species[14] within the different age classes. A second method is to determine what percentage of the total volunteer frequency is composed of valuable species. These two methods can be illustrated. Sugar maple, for example, in coniferous stands in the southeast region is thirteenth in order of frequency of occurrence in the 1- to 5-year-old plantings; twelfth in the 6- to 15-year-old plantings; fifth in the 16- to 25-year-old stands; and first in the 26- to 35-year-old plantings. Not all species indicate as clear-cut trends as this, but in all regions and under all types of plantings, the more valuable species rise in relative importance as the plantings grow older.

A decline in importance of certain weed species, such as hawthorn, wild apple, dogwood, and sassafras, is also in evidence, although there is a lack of consistency in some cases.

As pointed out previously, few plantings in the older age classes were found, and of those found, many were grazed. These conditions are believed to account for many of the inconsistencies found.

More consistency was found in the second method of comparison. The total percentages of occurrence of the valuable species in each age class were compared with the total percentages of occurrence of all volunteers in that age class. Thus, in the northeast region under conifers in the 1- to 5-year-old age class, there were 918 occurrences of all volunteer species. Of these, 260, or 28 per cent, consisted of valuable species, including sugar maple, white ash, white oak, tuliptree, red oak, hickory, and black walnut. In the 6- to 15-year-old class, 35 per cent of all occurrences were valuable species, and in the 26- to 35-year classifications, 45 per cent were valuable species.

The greatest gain in relative importance of valuable species appears in nearly all cases between the 6- to 15- and the 16- to 25-year periods. This is the period of rapid development of the planting into a forest. It is also a period of rapid improvement of the site resulting from the change in ground cover from grass or brush to a characteristic forest litter.

The data also suggest a reason why greater gains are not shown in the 26- to 35-year class. It is apparent in practically all cases that elm and black cherry rank highest in frequency of occurrence among the volunteers. These species establish themselves early and assume a position of dominance from which they are not readily dislodged by natural processes. It is quite probable that light cuttings performed during the period of rapid development to release overtopped valuable species from the domination of elm or cherry would materially increase the gains made by the other species and hasten the formation of a normal hardwood forest.

[14]Valuable species in this discussion include all species for which there is a good market in Ohio. Those which occurred as volunteers are sugar maple, white ash, red and white oaks, hickories, walnut, tuliptree, beech, and basswood.

TABLE 28.—Occurrence of volunteers, by age and type of planting

Northeast region

1-5 years	Number of plots	6-15 years	Number of plots	16-25 years	Number of plots	26-35 years	Number of plots
Conifers							
Black cherry	230	Black cherry	795	Black cherry	61	Black cherry	16
Hawthorn	121	Elm	457	White ash	54	Sugar maple	15
Elm	110	Sugar maple	451	Sugar maple	50	White ash	14
Sugar maple	83	Hawthorn	407	Hawthorn	42	Elm	12
Wild apple	82	White ash	367	Elm	32	Hawthorn	9
White ash	56	Wild apple	352	Wild apple	25	Hickory	9
Sumac	48	Sumac	176	Hickory	20	Red maple	5
White oak	43	Dogwood	125	White oak	18	Sumac	3
Red maple	29	White oak	119	Tulip tree	13	White oak	3
Tulip tree	24	Red oak	108	Dogwood	11	Basswood	3
Dogwood	20	Hickory	100	Aspen	11	Elder	3
Red oak	20	Tuliptree	95	Red maple	10	Wild apple	2
Hickory	19	Red maple	92	Basswood	8	Dogwood	2
Black locust	18	Black locust	79	Sumac	8	Black locust	2
Black walnut	15	Black walnut	67	Black locust	5	Spicebush	2
Total	918	Total	3,790	Total	368	Total	100
Total occurrences of valuable species	260	Total occurrences of valuable species	1,360	Total occurrences of valuable species	163	Total occurrences of valuable species	44
Per cent of all occurrences	28	Per cent of all occurrences	35	Per cent of all occurrences	44	Per cent of all occurrences	44
Black locust							
Black cherry	24	Black cherry	59	Black cherry	7	Black cherry	9
Hawthorn	10	Black locust	39	Sugar maple	7	Black locust	7
Elm	9	Elm	38	Red maple	6	White ash	5
Wild apple	7	Sugar maple	36	Elm	4	Hawthorn	5
White oak	7	Hawthorn	19	Black locust	4	White oak	4
Sugar maple	6	White ash	18	Hawthorn	3	Sugar maple	4
Black locust	4	Wild apple	14	White oak	3	Elm	4
Dogwood	3	Tuliptree	11	Hickory	3	Hickory	3
White ash	3	White oak	10	White ash	2	Dogwood	1
Hickory	3	Sumac	10	Dogwood	2	Red oak	1
Hophornbeam	3	Red maple	9	Black oak	2	Chestnut	1
Red oak	3	Dogwood	6	Walnut	2	Sassafras	1
Red maple	2	Red oak	6	Sumac	2		
Black walnut	2	Hickory	6	Tuliptree	1		
Sumac	1	Sassafras	3	Sassafras	1		
Total	87	Total	284	Total	49	Total	45
Total occurrences of valuable species	24	Total occurrences of valuable species	87	Total occurrences of valuable species	18	Total occurrences of valuable species	17
Per cent of all occurrences	28	Per cent of all occurrences	29	Per cent of all occurrences	37	Per cent of all occurrences	38

TABLE 28.—Occurrence of volunteers, by age and type of planting

Northeast region—Continued

1-5 years	Number of plots	6-15 years	Number of plots	16-25 years	Number of plots	26-35 years	Number of plots
			Other hardwoods				
Black cherry	20	Black cherry	90	Black cherry	16	Black cherry	23
Sugar maple	9	Elm	62	White ash	9	Elm	15
Elm	6	Sugar maple	39	Elm	9	Hawthorn	14
Hawthorn	6	Hawthorn	27	Black locust	9	Sugar maple	14
Red maple	6	Black locust	25	Hawthorn	7	White ash	6
Wild apple	5	White ash	23	Red maple	7	Dogwood	6
White ash	5	Red oak	19	Walnut	6	Hophornbeam	4
Sumac	3	White oak	15	Sugar maple	6	Wild apple	3
Black locust	2	Dogwood	15	Tuliptree	6	Red oak	3
Tuliptree	2	Red maple	13	Dogwood	5	White oak	3
White oak	2	Sumac	11	White oak	4	Black locust	3
Dogwood	1	Wild apple	10	Hickory	4	Tuliptree	2
		Hickory	8	Wild apple	3	Sumac	1
		Basswood	6	Beech	3	Hickory	1
		Walnut	5	Basswood	2		
Total	67	Total	368	Total	96	Total	98
Total occurrences of valuable species	18	Total occurrences of valuable species	115	Total occurrences of valuable species	40	Total occurrences of valuable species	30
Per cent of all occurrences	26	Per cent of all occurrences	31	Per cent of all occurrences	42	Per cent of all occurrences	30

Southeast region

			Conifers				
Elm	230	Elm	525	Elm	27	Sugar maple	60
Black cherry	190	Black cherry	515	Black cherry	25	Dogwood	53
Sassafras	150	Sumac	375	Sassafras	23	Sassafras	45
White ash	132	Sassafras	369	Hickory	21	Sourwood	39
Black locust	127	Hawthorn	287	Sugar maple	21	Black cherry	38
Hawthorn	127	White ash	263	Dogwood	14	Hickory	34
Wild apple	116	Wild apple	236	White ash	13	Red oak	34
Sumac	112	Dogwood	232	Sumac	11	Scrub pine	25
Hickory	109	Hickory	221	White oak	10	Elm	24
Dogwood	96	Black locust	218	Red oak	9	Tuliptree	22
Red maple	66	Red maple	173	Black locust	8	Hawthorn	21
Black walnut	57	Sugar maple	172	Black walnut	7	Am. hornbeam	15
Sugar maple	50	Tuliptree	157	Redbud	7	White ash	13
Tuliptree	48	Red oak	118	Aspen	6	Wild apple	10
Red oak	46	White oak	107	Sourwood	6	Black walnut	9
Total	1,656	Total	3,968	Total	208	Total	442
Total occurrences of valuable species	442	Total occurrences of valuable species	1,038	Total occurrences of valuable species	81	Total occurrences of valuable species	172
Per cent of all occurrences	37	Per cent of all occurrences	26	Per cent of all occurrences	29	Per cent of all occurrences	39

TABLE 28.—Occurrence of volunteers, by age and type of planting

Southeast region—Continued

1-5 years	Number of plots	6-15 years	Number of plots	16-25 years	Number of plots	26-35 years	Number of plots
Black locust							
Elm	46	Elm	105	Elm	12	Elm	19
Sassafras	32	Black cherry	84	White ash	9	White ash	12
Sumac	30	Black locust	80	Hickory	8	Hickory	8
Hawthorn	29	White ash	76	Black locust	6	Black cherry	7
White ash	27	Sumac	42	Red oak	5	White oak	5
Hickory	23	Hickory	41	Black cherry	4	Black walnut	5
Black locust	20	Sassafras	41	White oak	4	Dogwood	4
Dogwood	18	Hawthorn	36	Sassafras	4	Wild apple	4
Black cherry	18	Black walnut	34	Hawthorn	3	Hawthorn	4
Wild apple	15	Sugar maple	31	Sugar maple	3	Red oak	4
White oak	15	Dogwood	26	Wild apple	2	Dogwood	4
Red oak	13	Red oak	24	Sumac	2	Sugar maple	3
Tuliptree	13	Red maple	22	Black walnut	2	Red maple	3
Black walnut	12	Tuliptree	21	Red maple	2	Redbud	2
Red maple	11	White oak	20	Beech	2	Tuliptree	2
Total	322	Total	683	Total	68	Total	86
Total occurrences of valuable species	103	Total occurrences of valuable species	247	Total occurrences of valuable species	33	Total occurrences of valuable species	39
Per cent of all occurrences	32	Per cent of all occurrences	36	Per cent of all occurrences	49	Per cent of all occurrences	45
Other hardwoods							
Elm	20	Elm	33	Elm	8	Elm	60
Black locust	11	Black cherry	33	Hawthorn	5	White ash	38
Sassafras	9	Sassafras	16	Hickory	5	Black cherry	36
Black cherry	7	White ash	16	Sumac	5	Sugar maple	32
White ash	7	Black locust	14	Redbud	4	Hickory	31
Dogwood	6	Sugar maple	13	Black cherry	4	Hawthorn	25
Sugar maple	5	Sumac	12	Sugar maple	4	Black locust	24
Black walnut	4	Red maple	12	Red oak	4	Dogwood	19
Honeylocust	4	Dogwood	9	Sassafras	4	Black walnut	15
White oak	4	Black walnut	9	White ash	3	Sassafras	14
Hickory	3	Hawthorn	8	White oak	3	White oak	14
Sumac	3	White oak	7	Aspen	3	Tuliptree	11
Hawthorn	3	Tuliptree	7	Buckeye	3	Redbud	8
Tuliptree	3	Wild apple	5	Tuliptree	3	Blackgum	8
Pawpaw	3	Red oak	5	Hophornbeam	3	Beech	6
Total	92	Total	199	Total	61	Total	341
Total occurrences of valuable species	26	Total occurrences of valuable species	57	Total occurrences of valuable species	22	Total occurrences of valuable species	147
Per cent of all occurrences	28	Per cent of all occurrences	29	Per cent of all occurrences	36	Per cent of all occurrences	43

TABLE 28.—Occurrence of volunteers, by age and type of planting

Southwest region

1-5 years	Number of plots	6-15 years	Number of plots	16-25 years	Number of plots	26-35 years	Number of plots
Conifers							
Black cherry	58	Elm	131	Elm	5	Black cherry	3
Elm	57	Black cherry	127	Black cherry	3	Elm	2
White ash	29	White ash	81	Sugar maple	3	Hackberry	2
Hawthorn	29	Hawthorn	65	Tuliptree	3	Black locust	2
Wild apple	19	Sumac	45	Hackberry	2	Tuliptree	2
Black walnut	18	Sugar maple	44	Black locust	2	White ash	2
Red oak	18	Black walnut	43	Redcedar	2	Sassafras	1
Red maple	18	Dogwood	29	Hawthorn	2	Black walnut	1
White oak	16	Hickory	29	White ash	2	Hawthorn	1
Black locust	15	Black locust	28	Sassafras	1	Red maple	1
Sugar maple	14	Red maple	27	Black walnut	1		
Redcedar	14	Wild apple	27	Red maple	1		
Sumac	12	White oak	19				
Sassafras	9	Redcedar	17				
Hazelnut	9	Honeylocust	16				
Total	335	Total	728	Total	27	Total	17
Total occurrences of valuable species	95	Total occurrences of valuable species	216	Total occurrences of valuable species	9	Total occurrences of valuable species	5
Per cent of all occurrences	28	Per cent of all occurrences	30	Per cent of all occurrences	33	Per cent of all occurrences	29
Black locust							
Elm	15	Elm	43	White ash	3	Elm	13
Black locust	15	Black locust	33	Black locust	3	White ash	9
Black cherry	12	White ash	29	Elm	2	Black locust	9
White ash	10	Black cherry	25	Black cherry	1	Black walnut	6
Black walnut	8	Hawthorn	15	Black walnut	1	Sugar maple	6
Hickory	6	Sugar maple	15	Redcedar	1	Black cherry	5
Sugar maple	5	Hickory	8			Hickory	4
Wild apple	3	Red oak	4			Red oak	4
White oak	3	Redcedar	4			Sassafras	3
Dogwood	2	Hophornbeam	4			Buckeye	3
Red oak	2	Dogwood	3			Hawthorn	2
Red maple	2	Sassafras	3			Tuliptree	2
Blackgum	2	Red maple	2			Pawpaw	2
Boxelder	2	White oak	2			Redcedar	2
Redcedar	2	Sumac	2			Redbud	1
Total	89	Total	192	Total	11	Total	71
Total occurrences of valuable species	34	Total occurrences of valuable species	58	Total occurrences of valuable species	4	Total occurrences of valuable species	31
Per cent of all occurrences	38	Per cent of all occurrences	30	Per cent of all occurrences	36	Per cent of all occurrences	44

TABLE 28.—Occurrence of volunteers, by age and type of planting

Southwest region—Continued

1-5 years	Number of plots	6-15 years	Number of plots	16-25 years	Number of plots	26-35 years	Number of plots
			Other hardwoods				
Elm	24	Elm	56	Elm	8	Elm	67
Black cherry	17	Black cherry	36	White ash	7	Sugar maple	42
White ash	14	White ash	33	Sugar maple	6	White ash	41
Black walnut	14	Hawthorn	23	Wild cherry	5	Wild cherry	37
Hawthorn	11	Sugar maple	19	Hawthorn	4	Hawthorn	25
Sumac	9	Honeylocust	15	Hickory	4	Black locust	20
Hickory	9	Hickory	13	Boxelder	4	Black walnut	17
White oak	7	Black walnut	13	Black locust	3	Buckeye	16
Sassafras	6	Black locust	10	Black walnut	3	Hickory	15
Sugar maple	6	Red maple	7	Honeylocust	2	Red oak	9
Black locust	5	Redcedar	7	White oak	2	White oak	8
Red oak	4	Redbud	5	Sumac	1	Boxelder	8
Tulip tree	4	Wild apple	5	Red oak	1	Mulberry	7
Black oak	4	White oak	5	Hophornbeam	1	Redcedar	6
Sycamore	4	Red oak	5	Wild apple	1	Red maple	5
Total	138	Total	252	Total	52	Total	322
Total occurrences of valuable species	58	Total occurrences of valuable species	88	Total occurrences of valuable species	23	Total occurrences of valuable species	132
Per cent of all occurrences	42	Per cent of all occurrences	35	Per cent of all occurrences	44	Per cent of all occurrences	41

VALUE OF VOLUNTEERS

One of the chief goals of reforestation in Ohio is the establishment of forest cover where it is needed, and the establishment of hardwood volunteers in plantations constitutes an important step in the direction of this objective. Such species as hawthorn, wild apple, elm, sassafras, and the like, although commonly referred to as undesirables, fill an important place in the vegetation succession, preparing the site for species of greater value. These natural processes can be aided and guided by occasional improvement operations directed toward increasing the stand of valuable hardwood species native to the locality, at the expense of all others, including, in some instances, the planted trees.

METHODS OF ENCOURAGING VOLUNTEERS

Some modification of existing planting practices is desirable in order to increase the numbers of volunteers in plantations. It has been found that many species of hardwoods occur in greater numbers on exposed mineral soil or in leaf mold than in sod.[15] Furrowing of planting sites exposes a larger area of mineral soil than does the scalping method of ground preparation and, in addition, provides a series of catch basins in which hardwood leaf litter collects and forms a mulch. Heavy seeded species, particularly, are found in greater numbers in the bottoms of furrows than in the undisturbed sod.

The number of volunteers in a planting has been shown to be influenced also by the density of the planting; the optimum density is 400 to 800 trees

[15]Paton, R. R. Effect of furrowing on hardwood reproduction. Ohio Agr. Exp. Sta. Bimo. Bull. Sept.-Oct., 1941.

per acre. If the trees are planted evenly, these densities would call for spacings of 7 feet by 7 feet to 10 feet by 10 feet. Some allowance should be made for normal mortality, however, and on this basis the 7-foot spacing (890 trees per acre) or the 8-foot spacing (680 trees per acre) is preferable. The 6-foot spacing, which has been commonly used in the past, requires a density of 1,210 trees per acre. The normal expected mortality of 20 per cent still leaves the stand with a greater density than is considered most favorable for the establishment of volunteers.

In the past, replanting has been regarded as essential wherever mortality in plantations appeared to be excessive. From the viewpoint outlined, however, replanting should be done only if the density falls below 400 trees per acre and if no volunteers have come in to compensate for this loss. Steep slopes constitute an exception to this rule, however. There, the maintenance of cover is an important consideration, and inasmuch as volunteers cannot be relied upon to fill the openings quickly, the original density of the planted trees should be maintained by replanting if necessary.

A modification of the wide-spacing plan is the establishment of small groups of 100 to 300 trees or strips of trees traversing the area at right angles to the direction of prevailing winds and leaving intervening gaps to be occupied by volunteers. This method is particularly adapted to reforestation of large tracts, since fewer trees are required than with standard methods, and the work proceeds rapidly.

Some difference has been observed between the species of pine in their influence upon volunteers. More volunteers have appeared in stands of Scotch and shortleaf pines, which are light-foliaged, than in the heavy foliaged red, Austrian, or Corsican pine stands. This factor is directly connected with the density of planting, discussed earlier in this section.

Finally, some protective measures in the form of improvement and release operations are desirable to retain certain valuable species in the stand. A dense cover of elm or cherry, for example, should be opened up gradually to provide growing space for less agressive but more valuable species, such as ash, sugar maple, or oak. Wherever it appears to be desirable, even the planted trees can be pruned or removed entirely.

CONCLUSIONS AND RECOMMENDATIONS

Plowing or furrowing appears to produce better results in the preparation of planting sites than alternative methods and is recommended where practicable. Probable reason for the superiority of plowing over other methods is that it leaves the soil in the best possible condition for root growth.

Brush, tree, or weed cover at the time of planting usually has a retarding influence upon conifers and most hardwoods; bare sites produced the best results in the majority of cases reported in the survey. The superiority of bare or grass-covered sites over the taller forms of vegetation is particularly pronounced in the southeast and southwest regions but is true of the entire State.

Absence of heavy or tall competing vegetation continues to be beneficial well into the early development periods of the planting, but this condition is difficult to maintain. Grass, weeds, and brush are the most common forms of vegetation to come in after planting, and in most cases they act as competitive influences rather than beneficial or protective agencies. The survival data for white pine indicate that this species has some tolerance for weedy or brushy vegetation, but better results on bare sites are indicated by the growth data. Several of the important hardwood species, white ash, walnut, and red oak, indicated better growth and survival under weedy or brushy cover. Sugar maple produced its best growth and survival under trees, and tuliptree also seemed to tolerate other forms of vegetation.

Cultural operations in the plantations can, and should, be flexible. The planted trees need not receive first consideration simply because they have been planted. When volunteers make their appearance and begin to compete for space, full consideration must be given to species, form, and value in determining which trees should be removed.

Although information concerning the age of planting stock was erratic, survey results obtained with some of the more widely used species indicated that older stock produced better results. Four- or five-year transplant stock appeared preferable among conifers, except shortleaf pine, and 2-year seedlings or transplants of white ash, tuliptree, red oak, and sugar maple were superior to 1-year seedlings.[16]

A certain amount of the variation in the data regarding drainage is attributable to the lack of standardization of the terms describing this factor. Considerable variation in their interpretation is known to have occurred in different parts of the State. Nevertheless, the data indicate that areas which are characteristically poorly drained should be avoided in general reforestation practice and should be given special consideration when they are to be planted. Conifers, as a group, showed little tolerance for wet soils and were more successful on medium- to well-drained areas. Hardwoods also seemed to do better under good drainage conditions, but among both groups, certain species indicated no decisive requirements. Scotch pine was one of these; in most cases, good drainage appeared to be best, but the margin of difference in growth and survival data between good and poor drainage was frequently small. In the southeast region, poorly drained sites produced the best growth;

[16]One-year seedlings of these species grown in Ohio forest nurseries are usually approximately a foot or less in height. Taller (15- to 18-inch) stock is indicated as being preferable, a condition which requires leaving the trees in the seedbeds 1 more year or transplanting for another year or two. Local nursery conditions tend to require different practices from year to year.

well-drained sites, the best survival. In the northwest, the situation was reversed. It must be concluded, therefore, that within certain limits, drainage is not an important factor with this species. Similarly, tuliptree and black walnut varied considerably, showing some tolerance for more moist situations. None of these species is likely to succeed in swampy situations, however, where aeration may be very limited or cut off entirely.

Topography is important in so far as it influences drainage, exposure, and fertility and, therefore, should be considered only in relation to these factors.

The data have not shown any well-defined relationship between exposure and growth or survival, but there are some indications that some exposures might be superior to others for certain species. The following list shows the exposures which seem to be as good as or better than others for the species named:

Species	Best exposures
White pine	Northwest to southeast (clockwise)
Red pine	Northwest to east
Scotch pine	North to east
Shortleaf pine	South or southeast
Norway spruce	South or southeast
Black locust	South
Black walnut	Level or west or northwest
Catalpa	Southern Ohio, south or southeast Northern Ohio, north or east
Tuliptree	Northwest, north, northeast
Red oak	North

Many of the insects found in plantations cause relatively slight damage and need cause no concern unless they become epidemic. The destruction caused by a few insect species, however, will require the adoption of limited control measures. Two methods of control can be used in plantations:

The species most seriously injured can be replaced, in localities affected, by species which are not susceptible or are less susceptible to injury from the insect in question. This method is recommended for the control of the Zimmerman pine moth in northeastern Ohio. Scotch, Austrian, Corsican, and ponderosa pines are very susceptible to attack; red and white pines and Norway spruce are relatively unmolested. It is advisable, therefore, to discontinue extensive plantings of Scotch, Austrian, Corsican, and ponderosa pines and rely primarily on red and white pines, Norway spruce, and hardwoods for planting in northeastern Ohio.

The planting of mixtures instead of pure stands may minimize or eliminate the damage caused by certain species of insects.

Control of rodent damage by silvicultural means is difficult. Rabbits and other rodents are somewhat selective in their feeding and prefer certain species to others, but when food grows scarce, they will attack almost all species. The problem must probably be approached from the standpoint of control of rodent populations in certain localities.

Flood damage to plantations can be minimized by planting moisture-tolerant species along stream banks where floods are known to occur.

Some form of protection from fire should be available for all plantations. Large plantings should be subdivided into plots, each surrounded by a fire lane or road.

The striking relationship between the number of successful plantings established annually and weather conditions, or, more specifically, precipitation, illustrates the influence of weather upon the success of reforestation. It has been asserted that a small percentage of cooperators have attained striking success in their reforestation efforts even during the most severe drought years through careful planting.

Density of the planting is the only one of the four factors affecting the occurrence of volunteers in forest plantations which is subject to control; availability of seed and seed transportation agencies vary by regions and locally within each region; and the age of the planting cannot be controlled either. It has been found that a concentration of 400 to 800 planted trees per acre is the optimum density for encouraging the largest number of volunteers, and this spacing should be adopted generally unless some specific condition requires different spacings.

Although the occurrence of volunteers can be controlled only indirectly, the species and individuals which remain to form a permanent part of the stand can and should be controlled by the planter. It has been shown that the species of the volunteers improve with time, but that the rate of improvement can be stimulated by careful thinnings and improvement cuttings. One of these should take place when the planting is about 10 years old, or shortly after the start of the period of rapid development. A second improvement cutting can be made, if necessary, when the planting is 20 to 25 years old, when the trees have reached the pole stage, and competition for space, both above and below the ground, is again growing keen. This work should be conducted with care by one who is capable of exercising good judgment in the removal of individuals from the stand.

Fig. 27.—The ultimate goal of a reforestation program in Ohio

CHECK LIST OF SPECIES REFERRED TO IN THE BULLETIN

Common name	Scientific name
Ailanthus	*Ailanthus altissima*
Apple, wild	*Malus pumila*
Arborvitae, eastern	*Thuja occidentalis*
Ash, black	*Fraxinus nigra*
Ash, European	*Fraxinus excelsior*
Ash, green	*Fraxinus pennsylvanica lanceolata*
Ash, white	*Fraxinus americana*
Aspen	*Populus* sp.
Baldcypress	*Taxodium distichum*
Basswood	*Tilia glabra*
Beech	*Fagus grandifolia*
American hornbeam	*Carpinus caroliniana*
Birch	*Betula* sp.
Birch, red	*Betula nigra*
Blackgum	*Nyssa sylvatica*
Bladdernut	*Staphylea* sp.
Boxelder	*Acer negundo*
Buckeye	*Aesculus glabra*
Butternut	*Juglans cinerea*
Catalpa, northern	*Catalpa speciosa*
Catalpa, southern	*Catalpa bignonioides*
Cherry, black	*Prunus serotina*
Chestnut	*Castanea dentata*
Coffeetree, Kentucky	*Gymnocladus dioicus*
Cottonwood	*Populus* sp.
Dogwood	*Cornus* sp.
Douglasfir	*Pseudotsuga taxifolia*
Elder, American	*Sambucus canadensis*
Elm	*Ulmus* sp.
Fir, balsam	*Abies balsamea*
Fir, noble	*Abies procera*
Hackberry	*Celtis occidentalis*
Hazelnut	*Corylis americana*
Hawthorn	*Crataegus* sp.
Hemlock, Canada	*Tsuga canadensis*
Hickory	*Carya* sp.
Honeylocust	*Gleditsia triacanthos*
Hophornbeam	*Ostrya virginiana*
Larch, eastern	*Larix laricina*
Larch, European	*Larix decidua*
Larch, Japanese	*Larix leptolepis*
Locust, black	*Robinia pseudoacacia*

Maple, red	*Acer rubrum*
Maple, silver	*Acer saccharinum*
Maple, sugar	*Acer saccharum*
Mulberry	*Morus* sp.
Oak, black	*Quercus velutina*
Oak, bur	*Quercus macrocarpa*
Oak, chestnut	*Quercus montana*
Oak, chinkapin	*Quercus muhlenbergi*
Oak, pin	*Quercus palustris*
Oak, red	*Quercus borealis*
Oak, scarlet	*Quercus coccinea*
Oak, shingle	*Quercus imbricaria*
Oak, swamp white	*Quercus bicolor*
Oak, white	*Quercus alba*
Osageorange	*Maclura pomifera*
Pawpaw	*Asimina triloba*
Persimmon	*Diospyros virginiana*
Pine, Austrian	*Pinus nigra*
Pine, Corsican	*Pinus nigra poiretiana*
Pine, jack	*Pinus banksiana*
Pine, Japanese red	*Pinus densiflora*
Pine, pitch	*Pinus rigida*
Pine, ponderosa	*Pinus ponderosa*
Pine, red	*Pinus resinosa*
Pine, Scotch	*Pinus sylvestris*
Pine, Virginia	*Pinus virginia*
Pine, shortleaf	*Pinus echinata*
Pine, eastern white	*Pinus strobus*
Redbud	*Cercis canadensis*
Redcedar, eastern	*Juniperus virginiana*
Sassafras	*Sassafras albidum*
Serviceberry	*Amelanchier canadensis*
Sourwood	*Oxydendrum arboreum*
Spicebush	*Lindera benzoin*
Spruce, Colorado	*Picea pungens*
Spruce, Norway	*Picea abies*
Spruce, white	*Picea glauca*
Sumac	*Rhus* sp.
Sweetgum	*Liquidambar styraciflua*
Sycamore	*Platanus occidentalis*
Tuliptree	*Liriodendron tulipifera*
Walnut, black	*Juglans nigra*
Willow	*Salix* sp.
Witchhazel	*Hamamelis virginiana*

TABLE 29.—Mean annual height growth and survival of species, by regions

Conifers

Species	Northeast region			Southeast region			Southwest region			Northwest region		
	Survival	Height growth	Number of plots	Survival	Height growth	Number of plots	Survival	Height growth	Number of plots	Survival	Height growth	Number of plots
Scotch pine	78.1	1.12	750	69.7	0.99	781	59.7	1.05	239	67.7	1.15	58
Red pine	72.2	.87	847	67.1	.76	996	60.6	.86	255	49.4	.73	70
White pine	74.7	.91	473	74.1	.88	402	58.4	.73	136	56.3	.90	30
Austrian pine	74.4	.98	340	65.8	.79	327	55.0	.84	120	48.4	.72	49
Corsican pine	71.3	.89	153	63.8	.83	38	34.1	.93	33	27.0	.86	6
Shortleaf pine	74.0	1.46	3	74.6	.98	68	72.2	.94	8	.....	.....	.....
Norway spruce	73.2	.70	331	66.8	.54	124	46.8	.62	90	57.3	.77	37
Arborvitae	81.2	.60	4	89.5	.70	15	97.5	.82	4	81.1	.88	15
Baldcypress	51.0	1.00	4	49.3	1.13	3	46.0	2.10	1	.....	.....	.....
Douglasfir	51.9	.69	16	71.0	.80	3	92.0	.40	2	44.5	.49	30
European larch	19.2	1.29	31	37.7	1.11	20	59.7	1.03	6	20.5	1.40	55
Japanese larch	65.0	1.10	5	18.7	1.47	9	54.0	2.00	1	40.5	1.40	3
Jack pine	81.6	1.52	49	77.7	.15	23	58.7	1.07	3	.....	.....	.....
Japanese red pine	53.5	1.45	4	70.0	1.20	3	.....	.....	.....	.....	.....	.....
Pitch pine	84.0	.99	2	72.2	1.09	10	86.0	1.10	3	.....	.....	.....
Ponderosa pine	43.2	.95	22	63.2	.79	15	41.7	.68	11	24.5	.66	3
Colorado spruce	82.0	.65	2	62.0	.55	2	.....	.....	.....	.....	.....	.....
White spruce	84.7	.58	23	.....	.....	.....	.....	.56	3	79.5	.70	3
Redcedar	.....	.92	8	.....	.....	.....	.....	.....	.....	.....	.....	.....
Balsam fir	.....	1.20	1	.....	.....	.....	.....	.....	.....	.....	.....	.....
Hemlock	68.0	1.25	17	.....	.....	.....	.....	.....	.....	.....	.....	.....
Noble fir	.....	1.20	1	.....	.....	.....	.....	.....	.....	.....	.....	.....
			3,086			2,839			915			359

TABLE 29.—Mean annual height growth and survival of species, by regions—Continued

Hardwoods

Species	Northeast region			Southeast region			Southwest region			Northwest region		
	Survival	Height growth	Number of plots	Survival	Height growth	Number of plots	Survival	Height growth	Number of plots	Survival	Height growth	Number of plots
Black locust	68.3	1.92	212	65.7	2.03	501	59.1	2.03	211	49.6	1.79	33
Catalpa	82.0	1.22	76	72.2	1.08	133	70.5	1.28	254	76.3	1.31	107
White ash	71.6	.90	84	71.7	.58	59	72.9	.90	98	63.1	1.23	23
Black walnut	65.7	.65	82	68.1	.57	55	61.4	.76	100	65.1	1.40	31
Tuliptree	65.8	1.45	62	62.8	1.11	125	54.1	1.21	52	41.1	1.23	14
Red oak	55.2	1.09	55	53.0	.60	35	49.6	.95	29	30.3	.71	8
Sugar maple	57.1	.91	30	32.7	.80	8	36.2	.96	12	48.7	1.31	8
Basswood	66.0	1.20	12				50.0		1			
Black cherry							41.0	.30	1	50.0	.70	2
Cottonwood	80.0	1.05	4				43.5	3.23	4			
Elm	76.5	1.30	19				76.1	1.41	14	79.0	1.32	7
Sweetgum	54.7	.83	3				40.3	1.10	3			
Red maple							62.0	1.20	2			
Mulberry	92.0	.80	1	43.3	.83	3	50.9	.92	13	81.7	1.00	7
Bur oak							21.0	.50	1			
White oak	52.3	.68	17	58.7	.64	21	54.0	.43	3			
Osageorange	71.8	.71	7	50.7	.42	3	40.8	.83	15	76.4	.96	11
Redbud							78.0	.90	1			
Kentucky coffeetree							14.0	.50	1			
European ash							38.0	1.40	1			
Black ash	82.0	.30	1									
Sycamore	19.0	.11	1	78.0	2.70	1						
Red birch		1.70	1									
Chestnut oak	90.0	1.10	1							11.0	.50	1
Silver maple											1.30	2
			668			944			816			254

TABLE 30.—Shipments of planting stock, by 5-year intervals

Northeast region

Species	1904-08	1909-13	1914-18	1919-23	1924-28	1929-33	1934-38	Total
Scotch pine	.....	2,150	3,430	18,600	577,885	1,203,440	671,583	2,477,088
Red pine	.....	960	5,575	9,420	959,605	1,360,815	758,095	3,094,470
White pine	50	17,585	23,735	22,770	508,942	296,680	499,520	1,369,282
Austrian pine	.....	820	2,285	1,118	61,955	965,090	206,675	1,237,943
Corsican pine	100	.....	955	310	537,772	305,025	99,150	943,312
Shortleaf pine	.....	.....	.....	.....	.....	1,300	12,325	13,625
Norway spruce	.....	6,020	32,235	12,810	385,042	747,145	227,550	1,410,802
Japanese larch	.....	185	500	500	18,325	17,900	.....	37,410
European larch	100	1,680	2,560	.....	17,050	40,500	.....	61,890
Conifer total	250	29,400	71,275	65,528	3,066,576	4,937,895	2,474,898	10,645,822
Cottonwood	.....	400	.....	.....	1,400	18,350	13,100	33 250
Black locust	23,793	16,375	3,935	30,710	128,520	237,645	370,250	811,228
Black walnut	500	1,273	.....	28,000	59,462	120,900	167,280	377,415
Tuliptree	1,000	8,325	8,320	24,875	87,705	48,600	98,065	276,890
White ash	3,000	8,555	4,220	6,200	64,325	106,100	83,315	275,715
Red oak	.....	3,395	13,447	853	182,785	47,300	27,425	275,205
White oak	.....	.....	.....	.....	74,100	12,625	31,950	118,675
Catalpa	82,096	40,618	1,275	2,150	27,350	3,500	14,800	171,789
Sugar maple	.....	900	50	1,695	71,705	10,100	28,897	113,347
Hardwood total	110,389	79,841	31,247	94,483	697,352	605,120	835,082	2,453,514
Grand total	110,639	109,241	102,522	160,011	3,763,928	5,543,015	3,309,980	13,099,336

TABLE 31.—Shipments of planting stock, by 5-year intervals

Southeast region

Species	1904-08	1909-13	1914-18	1919-23	1924-28	1929-33	1934-38	Total
Scotch pine		1,406	825	14,000	271,325	634,745	664,075	1,586,376
Red pine		2,453	4,750	6,325	313,850	1,055,325	947,475	2,330,178
White pine	2,550	16,288	32,310	42,900	105,650	115,150	598,100	912,948
Austrian pine		281	1,210	250	40,350	413,975	148,625	604,691
Corsican pine			650		207,250	88,925	18,400	315,225
Shortleaf pine				1,000	100	14,000	83,900	99,000
Norway spruce	530	7,946	8,450	850	117,970	272,674	129,200	537,620
Japanese larch		1,250	1,875		10,250	6,400		19,775
European larch		4,100	7,850		4,300	11,601		27,851
Conifer total	3,080	33,724	57,920	65,325	1,071,045	2,612,795	2,589,775	6,433,664
Cottonwood	25	670	1,400	25		16,800	16,100	35,020
Sugar maple			25		11,700	5,400	8,900	26,025
Black walnut		1,425		24,027	51,750	58,500	97,700	233,302
Tuliptree		3,802	11,150	19,100	100,850	49,500	163,600	348,002
White ash	3,050	3,790	1,650	800	30,700	53,150	75,500	168,640
Red oak		2,900	875		87,500	12,000	37,000	140,275
White oak		200			30,500	7,800	27,500	66,000
Catalpa	89,281	81,770	2,325	300	12,450	1,600	6,000	193,726
Black locust	57,951	72,127	6,215	94,950	400,740	331,700	642,825	1,606,508
Hardwood total	150,307	166,684	23,640	139,202	726,190	536,450	1,075,125	2,817,598
Grand total	153,387	200,408	81,560	204,527	1,797,235	3,149,245	3,664,900	9,251,262

TABLE 32.—Shipments of planting stock, by 5-year intervals

Southwest region

Species	1904-08	1909-13	1914-18	1919-23	1924-28	1929-33	1934-38	Total
Scotch pine	.....	1,900	1,602	6,950	122,535	271,250	263,410	667,647
Red pine	500	2,370	7,253	2,175	116,785	339,025	338,455	806,563
White pine	780	17,453	25,788	5,000	48,600	79,060	200,500	377,181
Austrian pine	.....	1,217	3,200	80	51,710	254,065	109,180	419,452
Corsican pine	.....	.....	700	25	94,720	46,500	20,900	162,845
Shortleaf pine	.....	.....	.....	.....	.....	5,300	109,400	114,700
Norway spruce	710	11,753	7,705	540	72,125	210,430	98,190	401,453
Japanese larch	.....	602	204	.....	5,250	4,025	500	10,581
European larch	.....	5,734	4,055	.....	2,200	21,150	.....	33,139
Miscellaneous conifers	25	17,500	31,256	4,855	51,396	38,062	15,598	158,692
Conifer total	2,015	58,529	81,763	19,625	565,321	1,268,867	1,156,133	3,152,253
Cottonwood	.....	1,885	1,300	750	800	24,958	5,650	35,343
Black locust	56,262	62,792	2,950	10,680	130,070	157,200	341,310	761,264
Black walnut	.....	5,335	2,000	25,475	39,875	153,000	160,800	386,485
Tuliptree	50	9,165	12,278	22,975	30,365	37,600	127,300	239,733
White ash	500	39,585	21,020	10,850	35,410	128,375	97,510	333,250
Red oak	.....	9,685	3,745	530	102,025	52,555	48,100	216,640
White oak	.....	500	10	2,025	11,165	23,300	44,250	81,250
Catalpa	230,125	178,173	7,716	2,200	22,575	8,200	13,000	461,989
Sugar maple	410	1,830	9	600	22,010	11,950	19,625	56,434
Osageorange	1,793	13,879	500	15,100	4,430	5,500	2,000	43,202
Hardwood total	289,140	322,829	51,528	91,185	398,725	602,638	859,545	2,615,590
Grand total	291,155	381,358	133,291	110,810	964,046	1,871,505	2,015,678	5,767,843

TABLE 33.—Shipments of planting stock, by 5-year intervals

Northwest region

Species	1904-08	1909-13	1914-18	1919-23	1924-28	1929-33	1934-38	Total
Scotch pine			50	930	28,050	39,815	49,018	117,863
Red pine		20	125	700	18,450	38,200	34,937	92,432
White pine		1,455	1,115	1,400	3,900	9,725	17,925	35,520
Austrian pine			225	30	5,350	27,970	24,759	58,334
Corsican pine					11,300	10,800	1,500	23,600
Douglasfir						4,600	6,830	11,430
Norway spruce		765	1,800	50	15,600	51,505	22,720	92,440
Japanese larch			200		1,800	2,100		4,100
European larch	200		700		900	3,050		4,850
Arborvitae					320	950	1,600	2,870
Conifer total	200	2,240	4,215	3,110	85,670	188,715	159,289	443,439
Black locust	12,875	2,900		3,150	9,400	9,350	23,139	60,814
Black walnut		350	375	3,300	16,525	10,025	24,770	55,345
Tuliptree		480	600	3,050	5,500	5,800	4,772	20,202
White ash	1,485	2,975	525	800	5,625	13,900	20,935	46,245
Red oak		1,030	225	250	7,350	5,350	2,250	16,455
White oak					1,100	800		1,900
Catalpa	64,904	55,755	3,765	100	9,100	3,025	3,300	139,949
Sugar maple		570	47	200	3,650	1,400	7,720	13,587
Hardwood total	79,264	64,060	5,537	10,850	58,250	49,650	86,886	354,497
Grand total	79,464	66,300	9,752	13,960	143,920	238,365	246,175	797,936