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The Rainbow Forest Plantations

Guide to Experimental Plots
and
Report of Progress
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The Rainbow Forest Plantations

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and

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By

HENRY W. HICOCK

INTRODUCTION

HISTORY AND DESCRIPTION OF TRACT.

The Rainbow Forest Plantations of the Connecticut Agricultural Experiment Station occupy approximately 100 acres in the towns of Windsor and East Granby, about one-half mile west of the village of Rainbow. The land was purchased at a low figure because its value for field crops had been demonstrated to be very low. As a matter of fact, cultivation had been given up several years prior to its acquisition by the Station and it was in various stages of reversion to forest growth. During recent years adjoining property, on which the soil differs but very little from that on the greater part of the Station land, has been cleared and utilized for the production of shade grown tobacco. The land now occupied by the plantations would probably yield a greater return per acre if utilized for shade tobacco instead of for the production of forest crops.

The tract lies on a practically level bench about 100 feet in elevation above the Farmington River and 160 to 180 feet above sea level. The soil* on the major portion of the area is what was originally mapped by the U. S. Bureau of Soils in 1899 as "Windsor Sand", which name was changed in their Bulletin 96 to "Merrimac Coarse Sand." It is part of a deep deposit of glacial outwash material which forms an extensive plain in this portion of the state. The soil is a coarse sand, containing less than 10% of silt and clay, and the texture is very nearly the same to the depth of many feet. The surface soil contains sufficient organic matter to give it a medium brown color to a depth of 5 to 7 inches. The subsoil is of a yellowish color to a depth of about 3 feet, where it grades gradually to the dull gray which is imparted to it by the

*Notes on soil conditions furnished by Mr. M. F. Morgan of the Dept. of Soils, Connecticut Agricultural Experiment Station.

undiscolored coarse granules of impure quartz sand which predominate.

In small local areas (referred to in the plot descriptions as "barren areas") near the western border of the tract, especially in Plots 16, 44 and 45, the soil is somewhat coarser than is the rule, and contains so little silt and clay that it has even less coherence than usual. On such areas all plant growth is either much stunted or is altogether lacking. The change from these areas to those that support a normal plant growth is very abrupt. Trees planted on the sterile spots either grow very slowly or do not survive at all. Red pine seems to make a little better growth on them than does white, but the needles of both are yellow and in general the trees are crooked and sickly.

On the higher ground in the northeastern portion of the tract, especially in Plots 68 and 69 and in the northern portions of Plots 59 and 60, the soil is finer in texture consisting of about 7 inches of medium brown loamy sand surface soil, with a yellow subsoil of a similar texture to a depth of about $2\frac{1}{2}$ feet overlying the unweathered glacial till. The latter is made up largely of a mass of red shale and sandstone rock fragments of moderate size (less than 6 inches in diameter), with a considerable admixture of grayish sand and fine gravel. This soil type was identified in the 1899 Bureau of Soils Survey as "Enfield Sandy Loam" but this name was changed to "Manchester Fine Sand" in U. S. Bureau of Soils Bulletin 96.

The natural forest growth of the region is inferior hardwoods (mostly grey birch and oaks) and pitch pine, with some chestnut and white pine. The latter species is the only one to make good growth although the chestnut did well before it was attacked by the blight. Land abandoned for agriculture first seeds in to broom sedge and similar plants, followed by grey birch and pitch pine. Later stages of reversion show a diminution of grey birch and an increase of inferior oaks and pitch pine, with some white pine coming in.

The plantations were begun in 1901 on the present tract and in 1902 on another known as Mundy Hollow. The latter was abandoned after a few years. The plans were made for the first Forester of the Station, Mr. Walter Mulford, by the U. S. Forest Service, and comprised an elaborate series of experiments in artificial regeneration of hardwoods and conifers by seeding and planting. The tract was divided up into plots varying in size from $\frac{1}{4}$ acre to 6 acres in area, a large percentage of them averaging about 1 acre. Wherever feasible, the plots were laid off as rectangles. Numerous methods were tried out. These are described later under individual plots, insofar as the results of these methods are now present. Many of the earlier experiments were complete failures and in such cases no specific reference is made to them in this publication but the reader is referred to Reports of the Station for the years 1906, 1907 and 1912.

Some method of artificial regeneration has been undertaken nearly every year since the plantations were started, the amount varying with the funds available, until at present practically the entire tract is under some kind of forest cover.

For a number of years a nursery was operated in connection with the tract but this practice was abandoned and stock procured either from the Station nursery at Mt. Carmel or by purchase from commercial nurseries.

The plantations have always been used as a field laboratory for the study of insects and fungi by the Entomological and Botanical Departments of the Station, and since 1919 as an object of field study by students from the Yale School of Forestry, who have laid off sample plots and made thinnings in some of the older stands. This work is recorded under individual plots.

The tract has been under the general oversight of a local resident since its inception. Mr. Judson Leonard had charge from 1901 to 1909; Mr. Henry Palmer, from 1909 to 1920. Mr. Frederick M. Snow, the present superintendent, lives near the end of the Rainbow trolley line and about $\frac{1}{2}$ mile from the plantations. He will be glad to aid visitors in every way possible. Forestry operations have so far consisted of planting, cleaning, a small amount of thinning and control of the white pine weevil. Such work has been done either by the local superintendent, by members of the staff of the Forestry Department or by students from the Yale School of Forestry.

As yet the tract has not produced sufficient revenue to pay expenses, although carrying charges have been considerably lessened by the sale of cordwood from cleanings, of some chestnut and large pitch pine for saw-logs, of overtopped spruce for Christmas trees and of Mugho pine for ornamental purposes. In time the tract as a whole should become nearly self-supporting although it will probably never be wholly so.

Only a small amount of planting is needed to bring the entire tract under a forest cover. Future operations will consist of thinning the older stands as they need it, of weevil control, of cleanings and other improvement cuttings, of pruning experiments, of experiments in the most effective methods of cutting hardwoods to obviate rapid sprouting, etc.

The amount of damage from various causes has been relatively small. A rather elaborate system of exterior and interior fire lines, which are harrowed frequently, has been instrumental in keeping the burned area under 6 acres during the last 22 years. Rodents kept the red oak cut back so that experiments with this species are almost a complete failure. Several species of insects have proved troublesome but in only one case has an insect destroyed the entire value of an experiment. The locust borer, *Cyllene robiniae*, mined the trunks and limbs of the black locust so severely that the experiments with this species have been

abandoned. The insect requiring the most work to control is the white pine weevil, *Pissodes strobi*, which attacks the terminal shoot of white pine, Japanese red pine, Mugho pine and Norway spruce, thus deforming the stem. White pine is most severely attacked, followed by the others in the order named. Cutting and burning the infested leaders is the most practical method of control. This work is needed annually. Norway spruce seems to recover better from the injury than do the pines. The spruce gall, *Chermes abietes*, has made much of the Norway spruce unsightly and has probably impaired the growth to some extent although no stunting is apparent and no trees have been killed. The chestnut blight, *Endothia parasitica*, persistently kills back the chestnut trees used in the early experiments. Two rusts have also been found on different species of pines. One, *Peridermium cerebrum*, found on jack pine, has for its alternate host, various species of oaks. This rust was evidently brought in from Michigan on the planting stock and no new outbreaks have been found. The other rust, *Peridermium pyriforme*, which has for alternate hosts two species of toadflax, *Comandra pallida* and *C. umbellata*, has been found on Austrian, Scotch and bull pine. On the first two species it does not seem to have done much damage beyond deforming a few trees. The bull pine, however, seems more susceptible. A few trees die from the disease each year and indications are that the species will eventually be killed out here.

DESCRIPTION OF PLOTS.

Following is a description of the seventy plots which make up the tract. A preliminary survey was made by Mr. S. E. Parker in March, 1923 and all measurements and counts are as of that date unless otherwise noted. Heights were taken with a 10 foot pole or with a Faustmann hypsometer, and diameters with a diameter tape.

Plot 1. Exotic conifers. Area about .7 acre. Planted in the spring of 1907 by sections as follows: east side, Austrian pine, 2 year seedlings, spaced 5 x 5 feet; center, European larch, 2 year seedlings, 5 x 6 feet; west side, Scotch pine, 2 year seedlings, 6 x 6 feet. In 1911 a fire destroyed about $\frac{2}{3}$ of the plot and in 1913 the blanks were filled with Douglas fir, 7 year transplants and Chinese arbor-vitae, 6 year transplants. Two partial rows of Japanese red pine planted about 1913 occur on the west side of the plot. A description of this species under Plot 5 will cover this part of Plot 1. The arbor-vitae was a complete failure and the fir, coming from Pacific Coast seed, was not hardy and is represented by a few stunted trees. The failure of these two species has left the stand quite open and irregular although some native pitch pine helps to increase the density. Scotch pine has made the best growth, averaging 23 feet tall and 3 inches in diameter. The

trees are fairly uniform in size but are somewhat crooked. Austrian pine has done fairly well, averaging 9 feet tall and 1.4 inches in diameter. The larch averages 1 foot taller than the Austrian pine but individuals vary greatly, some equaling the Scotch pine in height while others are mere shrubs. The plot was cleaned by lopping hardwood brush in 1919. Several individuals of Scotch and Austrian pine infected with *Peridermium pyriforme* (See page 106) were removed in 1910.

Plot 2. White pine. Area .8 acre. Planted in the spring of 1907 with 2 year seedlings, spaced 6 x 6, 5 x 5, 4 x 4, and 3 x 3 feet. In 1911 a fire destroyed the north end of the plot including the 4 x 4 and 3 x 3 foot spacings and in the spring of 1913 blanks were filled with 8 year white pine transplants spaced 5 x 5 feet, thereby destroying the value of the original experiment in different spacings. On the unburned south end only about ten per cent of the trees are missing and the stand is just closing. Only a few trees have any dead limbs. The average size on the 6 x 6 foot spacing is height 13 feet, diameter 2.0 inches and on the 5 x 5 foot, height 9 feet; diameter 1.9 inches. The 1913 planting averages 5.5 feet high but is very open and irregular owing to the failure of about 50% of the trees. Weevil damage (See page 106) amounts to 25% for the plot as a whole. A more recent fire (1923) destroyed about $\frac{1}{3}$ of the 1913 planting. The plot was cleaned by lopping birch in 1919.

Plot 3. Pitch pine. Area 1.3 acres. In 1902 seed sown on cultivated strips $1\frac{1}{2}$ feet wide and 4 feet apart as follows: on the south half at the rate of 2 pounds per acre and on the north half at the rate of 1 pound per acre. The seed was brushed in. On the south half a very dense stand resulted. Trees average 1 foot apart in the rows, 17 feet in height and 2 inches in diameter, and have dead limbs for 8 feet above ground. About 60% of the trees have died from crowding. The stand on the north half is not so dense. Trees average 6 feet apart in the rows, 15 feet in height and 3 inches in diameter, and have dead limbs for 3 feet above ground. Very few trees have died from crowding. Spacing in the rows is not uniform and the stand on both sections is very uneven, especially on the north half but here gaps are being filled by natural seeding. Several trees badly infected with *Peridermium pyriforme* were removed in 1910. On both sections the trees have the poor form characteristic of pitch pine in this region. Compare with Plot 49.

Plot 4. White pine—Red oak—Scotch pine. Area .7 acre. Planted in the spring of 1904 with red oak, 3 acorns in a hole, and white pine 2 year seedlings, spacing 6 x 6 feet, a solid row of oak alternating with a row of oak and pine mixed. Losses were small for the first three years. Since then rodents have kept the oak cut back so that at present only 40 % of them are living and of

these only 15% have made even fair growth. However, an occasional individual has done nearly as well as the pine showing that the species will grow on poor soil if not attacked by rodents. About 1913, gaps caused by failure in the oak on the south end of the plot were filled with Scotch pine; the north end remains unfilled, leaving the white pine spaced 12 x 12 feet. With this wide spacing the white pine is thick boled, badly deformed by weevil and shows dead branches for only 3-4 feet. Where Scotch pine has been used it has closed the stand and is approximating the white pine in height. It has dead branches for 3-4 feet above ground but it has not yet influenced the pruning of the white pine growing with it. Average sizes: heights,—white pine, 19 feet; red oak, 7 feet and Scotch pine, 16 feet: diameters,—white pine, 4.5 inches; red oak, 1.0 inch and Scotch pine, 3.0 inches. The north end of this plot may be compared with Plots 48 and 51 where red oak and white pine were planted together but with different arrangement of species and the south end with Plots 35, 36 and 37 where Scotch pine has been used as a filler in older white pine plantations..

Plot 5. Japanese red pine and White pine. Area 1.4 acres. Planted in the spring of 1910 with Japanese red pine 2 year seedlings, spaced 6 x 6 feet. The following summer was very dry and a 50% loss resulted. Blanks were filled in the spring of 1911 with 3 year transplants of the same species. Further failures resulted and in 1913 blanks were filled with white pine 4 year transplants. The present stand is practically complete and is made up of $\frac{2}{3}$ Japanese red and $\frac{1}{3}$ white pine. The plot is just about to close. It has been kept free of hardwood competition and is therefore open grown. The Japanese red pine shows a 10% damage by weevil as compared with 45% for the white pine. The latter averages 8 feet in height and the former 7 feet. The Japanese red pine does not appear to be a good tree to plant in the open because of its tendency to divide at the base into many stems. In the spring of 1924 all leaders, except one, were removed from each Japanese red pine in an attempt to make this species produce one good stem. The results of this work are not yet apparent but the plot may be compared with Plot 52 where this tree has been grown under similar conditions without reducing the number of leaders. The plot may also be compared with Plot 19 where the species was grown for about 10 years under a dense shade of birch. Japanese red pine has borne cones very prolifically for a number of years and many seedlings up to 10 inches tall are growing in the openings.

Plot 6. Western yellow (bull) pine and White pine. Area 2.7 acres. Planted in the spring of 1908 with bull pine 2 year seedlings, spaced 5 x 5 feet. Losses up to 1912 had amounted to 45% and in 1912 and 1913 blanks were filled with 4 year white pine transplants. Further losses have occurred and these have

not been filled, so that the present stand is 35% bull pine, 35% white pine and 30% blanks. The white pine, even though it has been very heavily damaged by weevil (65%), now equals the bull pine in height which now averages 6.5 feet. The bull pine is subject to attack by *Peridermium pyriforme*, a fungous disease which kills a few trees each year. In fact, it seems probable that this disease may eventually kill out the species here. Compare with Plot 66.

Plot 7. White pine. Area 2.3 acres. Planted in the fall of 1913 with 3 year transplants, spaced 6 x 6 feet, as a test of fall planting. The experiment was a complete success, over 95% of the trees being alive at present. The stand is irregular, the trees varying in height from 2 to 10 feet and averaging 6 feet. This unevenness is due to some extent to weevils, which have attacked 60% of the trees but numerous individuals are stunted without having been attacked by weevil. The stand apparently underwent a period of stagnation for about eight years and the irregularity may be due to the fact that some trees are recovering sooner than others. This stagnation period is characteristic of all white pine plantations on the tract. The species seems to grow slowly for a longer period after planting than most of the others used. The plot has had numerous weevil cuttings and was entirely cleared of birch in the winter of 1921-1922.

Plot 8a. Red pine and Norway spruce. Area 1.7 acres. Cleared in the winter of 1921-1922 of birch for cordwood and planted in the spring of 1922 with red pine and Norway spruce 3 year transplants, spaced 6 x 6 feet, and alternating by rows except the four rows on the west side which are all pine. Most of the birch was at the south end of the plot. The plantation is over 90% complete but the pine averages 18 inches tall and looks thrifty, whereas the spruce is only 6 inches in height and is yellow and sickly except where it received shade from small birch sprouts. It would seem that this mixture is not feasible in the open as the pine will probably suppress the spruce in the same way that the white pine did on Plot 69, leaving the red pine spaced 6 x 12 feet with the spruce forming an understory. The mixture might have been more successful under a heavy brush cover which would have held back the pine more than the spruce and acted as a nurse for the latter until it was well started. (See plot 42.)

Plot 8b. Norway spruce. Area 1.3 acres. Cleared with Plot 8a leaving a few scattering native white pines about 15 feet high. Planted in the spring of 1924 with 2 year seedlings, spaced 5 x 5 feet, as a Christmas tree experiment. The stock was small, the season dry, and only about 10% of the trees survived the first summer. Plot may be compared with Plot 18 where white spruce stock of the same size was planted under an overwood. The latter

plantation is over 90% complete thus demonstrating the value of cover during the early years.

Plot 8b contains much chestnut from an experiment started in 1903. It is interesting to note that this species, even though killed back repeatedly by blight, still persists on this poor leachy soil better than most of the hardwoods used, red oak and locust excepted.

Plot 9. Pitch pine and Hardwoods. Area about .6 acre. Natural growth, not planted.

Plot 10. Norway spruce. Area about .6 acre. Planted in 1912 under a stand of old growth chestnut. Spacing is irregular but averages about 8 x 8 feet. The chestnut died and was removed in 1922 leaving a younger growth, consisting principally of oak, as a cover for the spruce. This cover was opened up in the spring of 1923 to give the spruce more light and will be further reduced or removed at a later date. The spruce has grown slowly but the trees are healthy, except for a small amount of weevil damage, and show every indication of coming through and forming a stand. Spruce is very tolerant and while it will not make fast growth under dense shade it will persist for a long time and, when released, makes a good recovery and increases in size rapidly. Compare with Plot 42, an older spruce plantation under shade which has been reduced from time to time.

Plot 11. Native white pine. Birch cutting experiment. Area .7 acre. The north end of the plot has been devoted for some years to an experiment in bringing a scattered stand of natural reproduction of white pine through a heavy cover of old field grey birch. The pine is doing fairly well but has been badly weeviled and is of poor form.

In October, 1924, an experiment was started to determine the sprouting qualities of birch under different methods of cutting at different times of year. This experiment should give some valuable information on the best season to release plantations and the best cutting methods to use in order to get a minimum of sprouts. The experiment was laid out as a number of different series of four sections each, each series to be cut at a different time of year. One series was cut during October, 1924. Another will be cut in the spring of 1925, and still another in mid-summer, 1925. The four sections in each series are as follows:

- a. Check—no cutting.
- b. Birch cut off close to the ground.
- c. Birch lopped off 2 to 3 feet above ground.
- d. Birch lopped partly off and bent over so that the trees will still continue to live.

Plot 12. White pine. Area .6 acre. Planted in the spring of 1902 with 3 year seedlings, spaced 5 x 5 feet, under a cover of grey

birch 15 to 20 feet tall. Fail places were filled in the spring of 1904 with 3 year transplants. The cover was removed in 1910 and 1911 and a final release cutting was made in 1919. This is one of the best plantations of white pine on the tract. Because of the heavy cover for the first 10 years the average growth has not been rapid (average height 19 feet and diameter 3 inches) but the trees are of excellent form, uniform in size and with almost no injury from weevil. Dead limbs extend to 7 feet above the ground and are quite small. Annual height growth almost doubled after the cover was removed in 1910-11.

Plot 13. Norway spruce and Balsam fir. Area about 1.2 acres. In 1910, 71 balsam firs were planted along the northern border of Plots 11 and 12, and about 1916 the remainder of the plot with the exception of a narrow strip to the west of Plot 12 was planted with Norway spruce. Spacing is irregular but averages about 8 x 8 feet. Planting was done under a moderately heavy cover consisting of old pitch pine and a lower stand of hardwoods. Both spruce and fir average 5 feet tall and show the effect of too much shade. However, they are of good color and look healthy, and on removal of the overwood, should make an increased growth in height. The cover was thinned in the fall of 1923 to give the planted trees more light but a further thinning is needed as the cover is still too dense.

Plot 14. Scotch pine. Area 1.2 acres. Planted in the spring of 1907 with 2 year seedlings, spaced 5 x 6 feet, the trees set in furrows plowed through the brush to try out Scotch pine in competition with an advanced hardwood growth. A part of the brush was removed in 1910 and the balance in 1913. A second release cutting was made in 1919 and third in 1924. This should be the last one needed. In addition, several large chestnuts were removed from the south side in 1921. The experiment was only a partial success because, in spite of frequent releasings, the hardwoods killed out over $\frac{1}{3}$ of the pine. However, those that have survived have made good growth and are in sufficient numbers to form the final stand. Average height 22 feet; diameter 4.5 inches. Dead branches extend for 10 feet above the ground. This plot demonstrates very well the inadvisability of attempting to grow Scotch pine under any kind of cover. The species is very intolerant and cannot stand even moderate shade. Compare with Plot 23 which was kept entirely free of brush.

Plot 15. White pine. Area .9 acre. Planted in the spring of 1906 with 3 year seedlings, spaced 5 x 6 feet. This plot was started and has been treated in about the same manner as Plot 14, but the trees show far less injury from hardwood competition than do the Scotch pines. About 90% of the trees are still living and the result is a very dense stand with trees averaging 19 feet in height and 3.5 inches in diameter. Dead branches extend for

6 feet above ground. All brush was cleaned from the plot in 1913 and a second and final release cutting was made in 1919. Weevil damage has been very slight, probably because of the density of the stand and the fact that the trees were in brush for seven years. The stand offers a good example of the results of close spacing, i. e., good form with small side branches that are killed early. It is probably too dense for practical purposes as the first thinning will not yield enough to pay for making it. All vegetation has been shaded out and 2 to 3 inches of needles cover the ground.

Plot 16. White pine—Red pine—Japanese red pine. Area 3.7 acres. Spacing 5 x 5 feet. Planted in 1917 as follows: west side, pure red pine; center, white pine and Japanese red pine alternating by rows; and east side, red pine and white pine alternating by rows. The red pine has made the best growth, averaging 5 feet in height, followed by the white with 4 feet and the Japanese red with 3 feet. The stand is practically complete, blanks amounting to less than 15%. The white and the Japanese red pines have both been attacked by the weevil, the former more heavily than the latter. The Japanese red has developed the same bushy habit as in Plots 5 and 52, and is bearing cones prolifically but no seedlings were found. The stand has not yet closed although the pure red pine on the west side has nearly done so. Except immediately under the trees, the crowns have not killed out the vegetative cover. Numerous barren areas occur on this plot. (See page 104.)

Plot 17. Headquarters Site. Area .9 acre. The east end of this plot is used as a location for a portable headquarters cabin. The remainder of the plot which was formerly the old nursery site contains an assortment of many kinds of trees left in the old nursery rows, together with enough later plantings of red and white pine to make up a stand.

In October, 1924, an experiment in pruning young conifers was started directly behind the cabin in a planting of red pine made in the fall of 1919. The experiment includes some 50 trees divided about equally among 4 rows. The row nearest the cabin was pruned to leave a leader and two whorls of branches, the next to leave a leader and one whorl, the third to leave a leader and 3 whorls and the fourth left unpruned as a check. For row 1 (east), the live crown averages about $\frac{1}{2}$ the total height of the tree; for row 2, $\frac{1}{3}$ the height; for row 3, $\frac{1}{4}$ the height; and for row 4, the entire height. A whorl of branches is to be removed from each row (the check excepted) each year, the object being to find out how much the crowns can be reduced without diminishing the growing power of the trees.

Plot 18. White spruce. Area .7 acre. Planted in the spring of 1924 with 2 year seedlings, spaced 8 x 8 feet, under a cover made up of pitch pine 8 to 10 inches in diameter with an understory of

smaller hardwoods. Less than 10% of the trees had died at the end of the first growing season, demonstrating the fact that spruce (2 year stock) can be planted successfully on a leachy soil if given sufficient protection against drying out. This plot may be compared with 8b where small stock of Norway spruce was planted in the open, the result being almost a complete failure. The cover should be removed, or at least greatly reduced, within five years.

Plot 19. Japanese red pine. Area 1.2 acres. Planted in the spring of 1910 with 2 year seedlings, spaced 6 x 6 feet. Loss was heavy and blanks were filled in 1911 with 3 year transplants of the same species. There were further failures and at present the stand is only 50% stocked. In 1919 the hardwoods, which had completely outgrown the pine, were thinned but not heavily enough and in 1922 they were removed altogether. The interesting feature on this plot is that hardwood competition forced the pine to confine its growth normally to one stem. As a matter of fact this competition was so severe that it caused the pine to become very slender and crooked. Since releasing, however, the trees have recovered and made a much increased height growth. Weevil damage has amounted to very little and the production of cones has been small. This plot forms a very marked contrast to Plot 5 where this species was planted in the open. The average height on Plot 19 is 12 feet, nearly twice that on Plot 5. It would seem that the proper conditions under which to grow this tree successfully would be under a cover kept sufficiently dense to prevent the pine from producing several stems, but not dense enough to cause suppression and crooked, slender boles. The species seems to be fairly tolerant of shade, probably ranking with red pine in this respect.

Plots 20 and 21. White pine and Scotch pine. Area 1.3 acres each. Planted in the spring of 1910, using 4 year transplants of white pine and 2 year seedlings of Scotch pine. Spacing 5 x 5 feet, the species alternating by rows. Scattered white pine set out in 1904 were ignored in the 1910 planting. The experiment does not promise to be a success. The Scotch pine is growing faster than the white and probably will suppress it. In fact the Scotch pine compares favorably with the white planted in 1904. Failures have amounted to over 30%, chiefly in the white pine and the stand is ragged and has not closed. The Scotch pine has dead limbs for a height of 4 feet, while the white has no dead limbs. The Scotch pine averages 17 feet in height and 3 inches in diameter; the white averages 10 feet tall and 2½ inches in diameter (1904 planting excluded). Weevil damage in the white pine has been very slight, due probably to the fact that this species has always been shorter than the Scotch and therefore protected by it. These plots demonstrate that it is not feasible to plant white and Scotch

pine at the same time in mixture. Comparison may be made with Plots 4, 35, 36, 37 and 56 where Scotch pine was used as a filler in white pine plantations that were much older, and with Plot 34 where white pine was used as a filler in a Scotch pine stand that was several years older.

Plot 22. Red pine and White pine. Area .8 acre. Planted in the spring of 1902 with red pine 4 year transplants, spaced $4\frac{1}{2} \times 5$ feet (except for about 100 trees at the north end which are white pine apparently planted at the same time and with the same spacing). Failures in the red pine were filled in 1904 with the same species. The stand has but few blanks. The red pine averages 20 feet tall and 3.8 inches in diameter and the white, 16 feet tall and 2.4 inches in diameter. Red pine has dead branches for 7 feet above ground while the white has them for only 4 feet. The dead branches on the red pine are small, brittle and may be broken off easily though most of them still persist. The white pine has been damaged but very little by weevil, probably because this block of trees is almost completely surrounded by taller trees. This plot may be compared with Plots 23, 28 and 49, all of which were planted at the same time and under about the same conditions, but with different species. The spacing on Plot 22, as well as on Plots 23, 24 and 28, is too close from a practical standpoint. The first thinning will not yield enough returns to pay for making it. Theoretically, the narrow spacing is ideal insofar as it causes the trees to produce small side limbs which die early.

Plot 23. Scotch pine. Area .6 acre. Planted in the spring of 1902 with 3 year seedlings, spaced 4×5 feet. The plot has been kept free from hardwood competition and there have been practically no failures. Scotch pine has shown the best growth of any tree used on the tract, with the possible exception of black locust. Heights now average 29 feet and diameters 3.5 inches, while some individuals have reached a height of 33 feet and a diameter of 5 inches. Dead branches extend for 14 feet above the ground and are quite rotten, more so than those of red and white pine of the same age and spacing. The trees are of good form although there is the usual tendency of this species to make crooked boles. Scotch pine is quite intolerant, more so than either red or white pine. So far as can be judged from 20 years of growth, Scotch pine is an excellent tree for use on sandy soils provided it does not have to compete with hardwoods. Compare with Plot 14 for the effects of hardwood competition and with Plots 22, 24, 28 and 49 for the results from planting other species at the same time and under approximately the same conditions.

A few trees infected with *Peridermium pyriforme* have been removed from this plot but the disease does not seem to have made much headway and little trouble is expected from it with this species.

In 1919 students from the Yale School of Forestry laid off and thinned a sample plot covering .089 acre. After thinning there were left on this plot 122 trees which is at the rate of 1,370 per acre. The volume of these trees was 96.3 cu. ft.* of wood or 1,083 cu. ft. per acre.

In 1924 this sample plot was thinned again removing 50 trees or 562 per acre and 39.9 cu. ft. of wood or 448 cu. ft. per acre. After this second thinning there were left 72 trees or 808 per acre and 89.2 cu. ft. of wood or 1,002 cu. ft. per acre. The increase on this plot for the 5 years 1919-1924 had therefore been at the rate of 368 cu. ft. per acre, or 74 cu. ft. per acre per year.

In 1920 another sample plot covering .0804 acre was laid off as a check for the one described above and left unthinned. The number of trees on this plot was 167 or 2,077 per acre and the volume 111.9 cu. ft. or 1,392 cu. ft. per acre. This plot was remeasured again in 1924 at which time there were 151 trees (16 having died from natural causes) or 1,878 per acre. The volume of these was 135.05 cu. ft. of wood or 1,679 cu. ft. per acre. The increase for the four years 1920-1924 had therefore been 287 cu. ft. per acre or 72 cu. ft. per acre per year. Both sample plots will be remeasured and the thinned plot will be thinned again in 1929.

Plot 24. Austrian pine—Red pine—White pine. Area .4 acre. Planted as follows: south end, Austrian pine 4 year seedlings, spaced 4 x 5 feet, summer of 1902; center, red pine 4 year seedlings, spaced $4\frac{1}{2}$ x 5 feet, spring of 1902; north end, white pine, spaced $4\frac{1}{2}$ x 5 feet, 1905.

The plot is chiefly red pine, the Austrian and the white consisting of two blocks of about 100 trees and 50 trees respectively. The white pine being younger is not compared with the others. The Austrian averages 23 feet tall and 4 inches in diameter and the red 21 feet tall and 3 inches in diameter, but the former tends to have a crooked bole. The Austrian pine has dead branches for 10 feet above ground while the red pine has them for only seven. A carpet of needles 2 to 3 inches deep covers the ground and all vegetation has been shaded out. Red pine on this plot, as well as on Plot 22, has not grown as fast as Scotch pine on Plot 23, but is straight boled and generally of better form than the latter. The fact that the Austrian pine averages greater in height and diameter than the red pine may be due to the fact that the total number of the former is relatively small and a greater percentage of the trees border on roads which gives them more growing space. Austrian pine on Plot 24 has been subject to a small amount of infection by *Peridermium pyriforme* but little damage has resulted.

In 1920 students from the Yale School of Forestry laid off a sample plot covering .0919 acre in the red pine. The results of

*Volumes computed from Table 27, Bulletin 13, U. S. D. A., revised and extended to cover the sizes of trees found on this plot.

the counts and measurements were: number of trees 162 or 1,763 per acre; volume 82.4 cu. ft.* of wood or 897 cu. ft. per acre. This sample plot will be remeasured and thinned and a check plot established in 1925.

Plot 25. White pine, wild stock. Area .8 acre. Planted in the spring of 1902 with collected seedlings 8 to 18 inches tall from Granby. Fail places were filled in 1903 with hardwoods, which died and were replaced with wild stock in 1905. Spacing $4\frac{1}{2} \times 5\frac{1}{2}$ feet. Practically all the pines planted are present but a considerable number are dead from crowding. Heights average 23 feet and diameters 4 inches. Dead branches extend for 7 feet above ground and are small but quite persistent. Weevil damage has been relatively small, due possibly to close spacing. As an experiment in the use of wild stock this plot is a success but at present it would probably cost more to collect such stock than to buy it from a nursery. Compare with red, Scotch and Austrian pine on Plots 22, 23 and 24, and with other white pine from nursery stock on Plots 12 and 28.

Note. The form of the crowns on Plot 25 is quite different from those on Plot 28 which was planted at the same time but with nursery stock. On the latter plot the side branches are quite long, project nearly in a horizontal plane, are interlocking and are dead for 9 feet above ground. The crowns of the wild stock have short slender branches which tend to grow upward. They do not seem to have interfered with each other greatly and are dead for only 7 feet above ground. The general appearance of Plot 25 closely resembles that on 12 where nursery stock was planted and remained for nearly 10 years under a dense cover.

Plot 26. White pine with various spacings. Area 1.2 acres. Planted in the spring of 1903 with 2 year transplants spaced 6 x 6 feet on the south end, 5 x 5 feet in the center, and 4 x 4 feet on the north end. Failures amounting to about 10% occurred in each section. At the end of 10 years the trees with the 4 x 4 foot spacing had made the best growth but at 20 years the 6 x 6 foot spacing had produced larger trees than either of the others, the average being 20 feet in height and 4.3 inches in diameter. The 5 x 5 foot spacing is next with a height of 16 feet and a diameter of 3.5 inches, and the 4 x 4 foot spacing last with a height of 14 feet and a diameter of 2.2 inches. The trees with the 4 x 4 foot spacing showed the greatest height growth between the 8th and 12th years, falling off after that time. Those with the 6 x 6 foot spacing have grown rapidly since the fifth year. Those in the 5 x 5 foot section have grown slowly during the entire period. Damage by weevil has been heaviest in the 6 x 6 foot spacing and lightest in the 4 x 4 foot.

*Volumes computed from Table 27, Bulletin 13, U. S. D. A., revised and extended to cover the sizes of trees found on this plot.

Vegetation has been killed out in all three sections and 2 to 3 inches of needles cover the ground. With all three spacings, trees have dead limbs for 7 feet above ground, but this amounts to about 50% of the total height in the 4 x 4 foot section and only 30% in the 6 x 6 foot. All dead limbs are quite firm. Those on the 6 x 6 foot spacing are much larger than on the others. Because it results in less injury from weevil and in the production of small side branches, the 4 x 4 foot spacing would be more satisfactory if thinnings could be made at about the fifteenth year. As this is not feasible, it is probably better to grow this species with a wider spacing, attempting to get protection from weevil and to prevent the growth of side limbs by using a hardwood cover, and thinning it gradually for the first 15 years.

Plot 27. White pine. Area 1.0 acre. Planted in the spring of 1904 with white pine 2 year seedlings and chestnut 1 year seedlings, 2 rows of pine and 2 rows of chestnut, spacing 5 x 5 feet. The chestnut failed and the chestnut rows were filled in the spring of 1910 with white pine 4 year transplants spaced 6 feet apart in the rows. The results of using white pine as a filler in an older plantation of the same species are not entirely satisfactory. The older pines are bushy with no dead limbs and have been heavily damaged by weevil. They average 17 feet in height and 4.4 inches in diameter while the 1910 trees average 11 feet in height and 1.8 inches in diameter. The latter show only a 10% damage by weevil and are generally of good form. The plot as a whole is quite ragged and uneven and has not closed. The 1910 planting may, because of better protection from weevil and side crowding from the 1904 trees, develop into a stand of good form but the final results will probably not be as good as if the stand were even-aged throughout. This plot may be compared with Plots 4, 35, 36, 37 and 56 where Scotch pine was used as a late filler.

Plot 28. White pine. Area 1.6 acres. Planted in the spring of 1902 with 3 year seedlings and 4 year transplants. Failures were replaced 1904-5 with transplants. A part of this plot was cultivated and fertilized for several seasons but no results of this treatment are apparent. Spacing 4 x 5 feet although many trees are only 3 feet apart and often two or more were planted together. The resultant stand is very dense and many trees are dying from lack of space. Average height, 19 feet; diameter, 3.5 inches. Dead branches extend for 9 feet above the ground and are small but persistent. Weevil damage has been slight. The stand shows the effect of too keen competition and should be thinned immediately in order not to further reduce the amount of living crown. This plot does not compare favorably with Plots 22, 23 or 24 where red and Scotch pine were planted at the same time and with about the same spacing. The stand should have been thinned at 15 years. All vegetation has been shaded out and several inches of needles cover the ground. (See note under Plot 25.)

In 1920 students from the Yale School of Forestry laid off a sample plot covering $\frac{1}{8}$ of an acre. The results of the counts and measurements were: number of trees 245 or 1,960 per acre, volume 95.6 cu. ft.* of wood or 764.8 cu. ft. per acre. This sample plot will be remeasured and thinned and a check plot established in 1925.

Plot 29. White pine. Area 2.3 acres. Planted in the fall of 1907 with 3 year transplants, spaced 5 x 5 feet, to test the results of fall planting. The experiment is a moderate success, less than 25% having failed. The stand as a whole, however, is quite ragged and uneven due to the blanks and to the fact that some individuals have grown very slowly. Weevil damage has been quite heavy. Crowns have not closed enough to kill the lower branches and shade out herbaceous growth. The plot was cleared of birch in 1919. Heights average 15 feet and diameters 3.5 inches. For other examples of fall planting see Plots 7 and 69a.

Plot 30. Jack pine. Area .3 acre. Planted in the spring of 1908 with seedlings from Michigan 1 to 2 feet high, spaced 5 x 5 feet. A 50% failure resulted and the present stand is rather open and uneven. It has not yet closed sufficiently to kill the lower branches or to shade out herbaceous cover. Although a few individuals have done well, generally the trees have crooked boles and long side branches. Average height, 16 feet; diameter, 3 inches. In 1910 several trees infected with *Peridermium cerebrum* (See page 106) were removed. This disease was evidently introduced with the stock as no further infections have been found. This pine is bearing cones prolifically and many seedlings up to 12 inches tall may be found in the openings. The plot should be compared with Plot 47 where Jack pine was used as a late filler.

Plot 31. Scotch pine. Area .3 acre. Planted in the spring of 1903 with green ash 1 year seedlings, spaced 10 x 10 feet. In the spring of 1904 Scotch pine 2 year seedlings were planted 5 feet apart in solid rows between the ash rows and alternating with the ash in the rows, making the final spacing 5 x 5 feet. The ash failed thereby reducing the density 25% and this, plus a 5% failure in the pine, leaves the plot about 70% stocked. The stand is very dense and has completely closed. Average height 25 feet; diameter 4.8 inches. Dead limbs extend for 12 feet above ground and the lower ones, though still persisting are quite rotten. They seem to be a little larger than on Plot 23. From the appearance of this plot it would seem that Scotch pine may be planted with a much wider spacing, 7 x 7 or 8 x 8 feet, and still close and prune satisfactorily. The effect of this would be to delay the first thinning until the stand was 30-35 years old when the operation

*Volumes computed from Table 27, Bulletin 13, U. S. D. A., revised and extended to cover the sizes of trees found on this plot.

PLATE I



b. Plot 69. Norway spruce and white pine planted in 1905 in the open. The pine has overtopped 90% of the spruce.



a. Plot 38. Douglas fir and white pine planted in 1903. Note the great variation in size of the fir.

PLATE II



a. Plot 5. Japanese red pine planted in 1910. Note the bushy habit of this species when grown in the open.



b. Plot 42. Norway spruce and white pine planted in 1906 under an overwood which has since been removed. The spruce is holding its own with the pine. Compare with Plate I b.

PLATE III



a. Plot 30. Jack pine planted in 1908.



b. Plot 68. White pine planted in 1905.

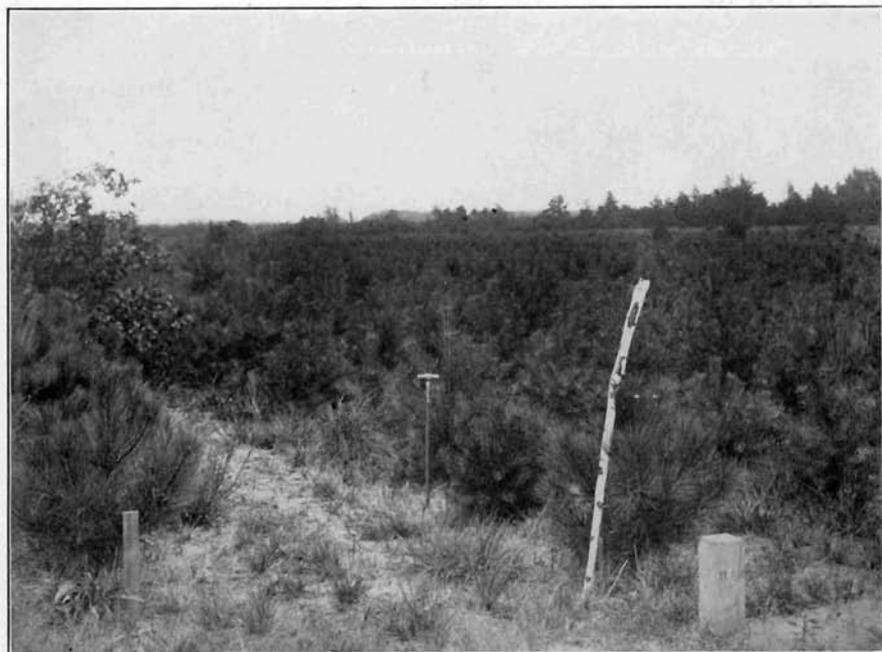
PLATE IV



a. Fire line between Plots 60 and 68 in 1912. Compare with Plate VII b.



b. Looking north across Plot 23 in 1903, one year after Scotch pine was planted. Note character of ground cover.

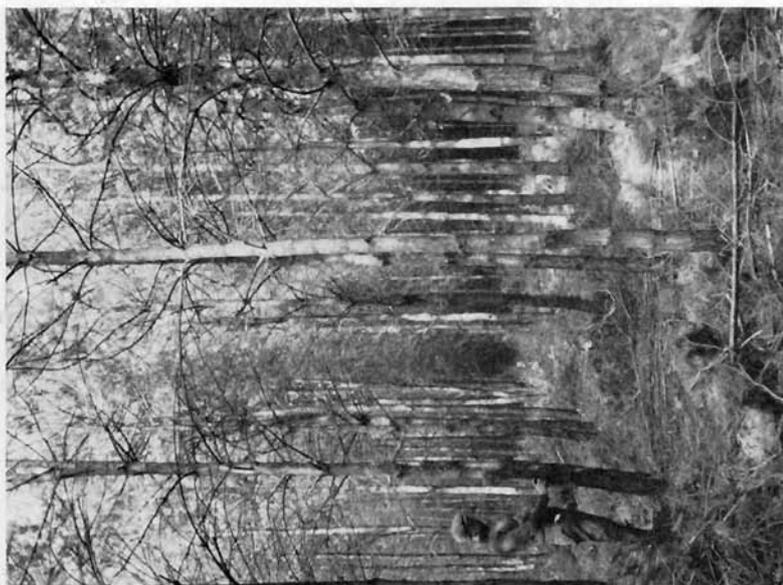


a. Red and Scotch pine on Plots 22 and 23 in 1905.



b. Red and Scotch pine on Plots 22 and 23 in 1912.

PLATE VI



a.

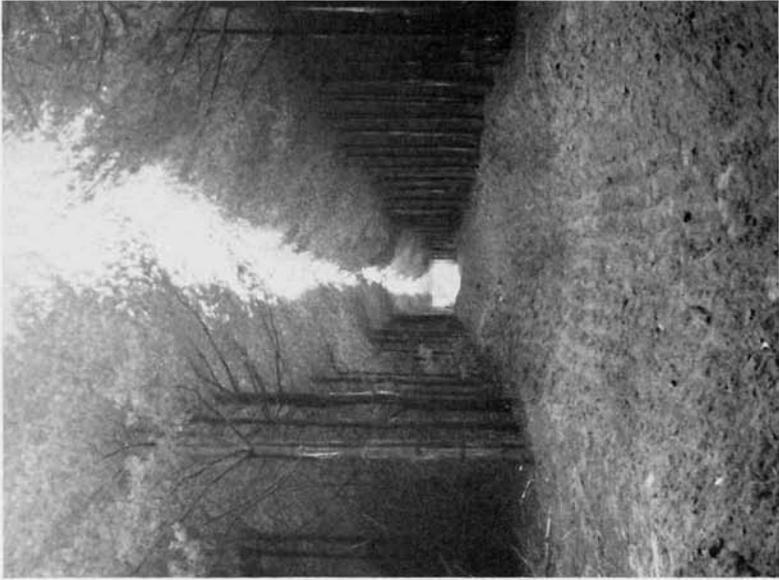
Plot 23. Scotch pine planted in 1902.
a. Thinned in 1919 and 1924.



b.

b. Left unthinned as a check.

PLATE VII



b. Fire line between Plots 60 and 68. See Plate IV a.



a. Plot 24. Red pine planted in 1902. Compare with Plate VI.

PLATE VIII



a. Plot 6. Bull pine planted in 1908, white pine in 1913. Bull pine with the axe leaning against it was killed by the rust.



b. Plot 16. Red pine planted in 1917.

would probably more than pay for itself. The trees are bearing cones prolifically and seedlings up to seven years old may be found around the edges of the plot. All vegetation has been shaded out and a carpet of needles several inches deep covers the ground. Compare with Plot 23.

Plot 32. Norway spruce. Area 1.5 acres. Planted in the spring of 1905 with 2 year seedlings, spaced 5 x 5 feet, under an open growth of pitch pine and hardwoods. The ground had been burned over just before planting. A second fire burned over a portion of the area in 1907 and in 1910 blanks were filled with 4 year transplants. In 1911 a 50% failure had resulted and in 1913 all blanks were filled with 7 year transplants after removing a part of the overwood. In 1923 a fire burned over about $\frac{1}{3}$ of the plot near the East Granby highway. This has not been replanted. Exclusive of the recent burn the plot is now only about 50% stocked. The trees seem well established but average only 4 feet in height and show the effect of too dense cover. With the removal of the overwood the stand should recover and increase in height rapidly although it will always be quite open. A few trees of another species, probably white spruce, occur near the southern edge of the plot, also an occasional balsam fir. Many trees, both of Norway and the other spruce, are heavily infested with galls. (See page 106.)

Plot 33. White pine. Area 2.1 acres. Planted in 1905 with 2 year seedlings, spaced 5 x 5 feet, under a medium dense shade of pitch pine and hardwoods. The overwood was thinned in 1913 and birch was lopped back on the west side in 1923. The white pine has not made a rapid growth but the plot is 80% stocked (excluding a 1923 burn covering about a half acre) and the trees are of good form and have not been damaged to any extent by weevil. The white pines are growing into the crowns of the pitch pines and the latter should be removed. Heights average 11 feet; diameters 1.7 inches.

Plot 34. Scotch pine—White pine—Mountain pine. Area .9 acre. Planted in the spring of 1911 with 4 year Scotch pine transplants and 3 year mountain pine seedlings, spaced 6 x 6 feet. About 90% of the latter failed and the blanks were filled in the spring of 1913 with 5 year white pine transplants. About 20% of the Scotch and 10% of the white pine are missing. After the failure of the mountain pine the experiment resolved itself into determining the value of white pine as a filler in an older Scotch pine stand. The results are not promising. The Scotch pine has made a very rapid growth and has spread out so that it nearly closes over the white pine. In fact, it is quite probable that in a few years it will completely suppress the white and form a pure Scotch pine stand spaced 6 x 12 feet. This may prove a desirable density for Scotch pine as it will delay the need of thinning.

The Scotch pine now averages 11 feet in height and 3.1 inches in diameter, while the white is only 6 feet tall. The white pine has been weeviled but very little. As a whole the stand has not closed sufficiently to shade out herbaceous growth or to form a litter of needles. Compare with Plots 4, 35, 36, 37 and 56 where Scotch pine was used as a filler in an older white pine stand.

Note. The mountain pine proved to be of the Mugho variety. Mugho pine when crowded, will abandon its prostrate habit and send up a single stem. In several cases it has reached a height of 6 feet or more. It is attacked to a slight extent by the white pine weevil.

Plot 35. White pine and Scotch pine. Area 2.0 acres. The experiments started in 1903 as an example of mixed planting by groups. Two year transplants of white pine and various hardwoods were planted with a spacing of $4\frac{1}{2} \times 5$ feet and mixed by grouping 3 to 10 trees of each species together. Blanks in the pine were filled with 3 year transplants in 1904. The hardwoods practically all failed and in the spring of 1911 were replaced with Scotch pine 3 year transplants. The present stand is about $\frac{1}{4}$ white and $\frac{3}{4}$ Scotch pine minus a few blanks caused by failures. The white pine because of its greater age has made a bushy growth with long side branches. It averages 15 feet in height and 3.4 inches in diameter. Weevil damage has been quite heavy. The Scotch pine has grown rapidly and has nearly caught up with the white. It averages 13 feet in height and 3.2 inches in diameter. The stand is just closing and few trees show any dead branches. Herbaceous growth has been shaded out and 1 to 2 inches of needles cover the ground. The Scotch pine should overtake the white in a few years and it remains to be seen whether it will eventually suppress the white or not. The plot was thoroughly cleaned by lopping birch and girdling pitch pine in 1924. Compare with Plots 4, 34, 36, 37 and 56.

Plot 36. White pine and Scotch pine. Area .9 acre. Planted in the spring of 1903 with white pine 2 year transplants and maple seedlings alternating in the row and spaced 6×6 feet. Pine blanks were filled in 1904 with 3 year transplants. The maple failed and was replaced in 1908 with 2 year Scotch pine seedlings. The Scotch pine now averages 18 feet in height and 3.8 inches in diameter and the white, 16 feet in height and 3 inches in diameter. The stand has just closed. All herbaceous growth has been shaded out and 1 to 2 inches of needles cover the ground. Scotch pine has dead branches for a height of 5 feet and white pine for 3 feet. The Scotch was probably used too soon as a filler. It looks now as though it would soon close over and suppress the white, although the latter may respond to crowding with an increased height growth. Compare with Plots 4, 34, 35, 37 and 56.

In 1923 students from the Yale School of Forestry laid off a sample plot covering $\frac{1}{4}$ acre. The results of the counts and measurements were: number of trees—white pine 162, Scotch pine 125 or 648 and 500 trees per acre, respectively. Volume—white pine 57.4 cu. ft. of wood*, Scotch pine 66.8 cu. ft. or 229.6 cu. ft. and 267.2 cu. ft. per acre, respectively. This sample plot will be remeasured and thinned and a check plot established in 1928.

Plot 37. White pine and Scotch pine. Area 1.0 acre. Planted in the spring of 1903 with white pine 2 year transplants and maple seedlings, spaced 6 x 6 feet, solid rows of maple alternating with a row of maple and pine mixed. The maple was a failure and was replaced in 1911 with 3 year transplants of Scotch pine. Not over 10% of blanks now exist. The Scotch pine has surpassed the white in diameter and in height. It now averages 16 feet tall and 2.8 inches in diameter, while the white is 12 feet tall and 2.2 inches in diameter. The Scotch pine has dead limbs for 3 feet above the ground but the white has live limbs clear to the ground. The stand has closed, shading out herbaceous growth. About 1 inch of litter covers the ground. The white pine shows little weevil injury. Just why the Scotch pine is ahead of the white on this plot and behind it on Plot 35 is not apparent unless the grouping of the white pine on Plot 35 was more stimulating to height growth than the 12 x 12 foot spacing on Plot 37. Compare with Plots 4, 34, 35, 36 and 56.

Plot 38. White pine and Douglas fir. Area .4 acre. Planted in the spring of 1903, spacing 5 x 5 feet, the two species alternating in the rows. The pine has grown faster than the fir and now averages 18 feet tall and 4.6 inches in diameter, while the fir averages 10 feet tall and 1.3 inches in diameter. The early growth of the fir was very slow. This may have been due to the stock not being hardy because many trees have been killed back and deformed. However, the species seems to recover from this and to send up a new leader without any apparent deformation of the stem. The fir has not developed evenly, individuals varying from 1 to 16 feet in height. Some of this irregularity has been caused by suppression by pine. Fir produces a very narrow compact crown while pine, when given sufficient room, produces a wide crown. The result of this is that the stand has just closed and both species have live limbs clear to the ground. The fir seems quite tolerant and shows a considerable tendency to push through the pine crowns. Side limbs on the pine were cut back to favor the fir in 1923 and more of this work will be done in the future. During the last 5 years the fir has shown a greatly increased height

*Volumes computed from Table 27, Bulletin 13, U. S. D. A., revised and extended to cover the sizes of trees found on this plot.

growth and may in time catch up with the pine. It has held its own with the pine better than did Norway spruce planted under about the same conditions on Plot 69.

On account of the differences in crown habit it would seem advisable either to plant the fir about 5 years before the pine with the same spacing or to plant the two species at the same time with a closer spacing.

Plot 39. White pine. Area .7 acre. Planted in the spring of 1903 with white pine and hardwoods, the latter forming 75% of the mixture. The spacing was originally 5 x 5 feet but the hardwoods have failed and the pine is now spaced 10 x 10 feet. The results of this wide spacing are not entirely satisfactory. The pine shows a 50% injury by weevil. The stand is just closing, the side branches are large and long and have died for only a few feet above ground. Heights average 17 feet and diameter, 4.6 inches. All birch was removed from the plot in 1924. It is somewhat difficult to predict what the final results will be but it looks as if these short, large boled trees would produce a heavy yield of inferior lumber. A thinning will not be needed for at least another 10 years. Compare with Plots 4 and 59 for other examples of wide spacing and with Plot 28 for close spacing.

Plot 40. Red pine. Area .9 acre. Planted in the spring of 1924 with 2 year seedlings, spaced 8 x 8 feet, under a dense cover made up of grey birch and scattered trees from a red oak experiment which was a failure because rodents kept the trees cut back. At the end of the first growing season less than 10% of the red pines had failed. The plan is to remove all hardwood cover for cordwood after about 5 years.

Plot 41. White pine and Norway spruce. Area .2 acre. Planted in the spring of 1906 with 2 year seedlings, spaced 5 x 6 feet, under light brush, the species alternating by rows. Fifty per cent of the pine and 20% of the spruce failed. The birch cover was thinned in 1919 and completely removed in 1924. Both the pine and the spruce have been badly weeviled, probably because the plot is very narrow and open to a road on one side. The spruce is also attacked by galls. The two species average about the same in height, 12 feet, but the pine averages 3.5 inches in diameter and the spruce only 1 inch. Spruce has shown a greatly increased height growth in the last 5 years. Neither species shows dead limbs and in general the plot is quite ragged and has not closed. It may be compared with Plot 69 where these two species were planted in the open and the pine suppressed practically all the spruce.

Plot 42. White pine and Norway spruce. Area 2.6 acres. Planted in the spring of 1906 with 2 year seedlings, spaced 5 x 6 feet, the two species alternating by rows. Blanks were filled in

1911 with 5 year white pine transplants. At the time of planting an overwood of pitch pine and hardwoods, which varied in density from heavy on the south end to very open on the north end, covered the area. One acre in the densest portion of the overwood at the south end was cleared in 1911. In 1919, hardwood sprouts from the cutting in 1911, which has overtopped the planted trees, were thinned to give the conifers more light. The plot is now about 75% stocked and is rather uneven. The pine averages 15 feet in height and 2 inches in diameter and the spruce 11 feet in height and 1 inch in diameter. Neither species show dead branches for over 2 feet above ground. Both have been heavily damaged by weevil but the spruce is less deformed by the injury than the pine. The spruce is also heavily infested with galls. The effect of the cover has been to hold back the pine more than the spruce allowing the latter to hold its own with the pine. During the last few years the spruce has increased height growth enormously. Comparison may be made with Plot 69 where these two species were planted in the open.

Plot 43. White pine and Norway spruce. Area 4.2 acres. Planted in the spring of 1905 with 2 year seedlings, spaced 5 x 6 feet, the two species alternating by rows, Blanks were filled with 5 year white pine transplants in 1911. A medium dense overwood, chiefly pitch pine, covered the entire plot. This was removed from the south end in 1923. Both species have grown more slowly than on Plot 42 on which the cover was removed at an earlier date. The pine averages 10 feet tall and the spruce 6 feet. However, weevil damage has been very slight for both species and while the trees are not as large as on Plot 42 they are of much better form. Compare with Plot 69.

Plot 44. White pine. Areas 3.1 acres. Planted in the spring of 1906 with white pine 2 year seedlings, pure on the west side and mixed with maple on the east side. Spacing 6 x 5 feet. The maple failed and blanks were filled in 1910 with 4 year white pine transplants. Failures were filled again in 1911 with 5 year white pine transplants. An overwood of pitch pine and grey birch, varying in density from nothing at the south end to moderately dense in the middle and on the north end, covers the area. Over 80% of the trees are present. In the open they average 14 feet tall and 4.5 inches in diameter and under the overwood, 10 feet tall and one inch in diameter. Only in a few places has the stand closed and live limbs extend to the ground. Herbaceous growth has not been shaded out. A little spruce occurs at the north end, evidently an extension of Plot 43. The most marked feature is the almost entire absence of weevil injury and the smallness of side branches on the portion of the plot under the overwood. A cover of pitch pine is less harmful than is grey birch because its branches are stiff and therefore do not whip the white

pine tops as badly as do those of the birch. Several barren areas (see page 104) occur on Plot 44.

Plot 45. Mountain pine. Area 4.6 acres. Planted in the spring of 1912 with mountain pine, spaced 6 x 6 feet. The stock proved to be the Mugho variety of mountain pine and has been sold for ornamental purposes (See note on Mugho pine under Plot 34). A few Corsican pines from a planting which was made in 1910 and which was almost a complete failure, are scattered over the plot. They have made fair growth but are open grown and bushy. Barren areas (see page 104) similar to those in Plot 44 occur in Plot 45.

Plot 46. White pine—Norway spruce—Jack pine. Area .7 acre. Planted in the spring of 1906 with 2 year seedlings of white pine and spruce, spaced 5 x 6 feet, and alternated by rows. In 1908 fail places were filled with Jack pine. The composition of the plot is now 50% Jack pine, 25% white pine and 25% spruce. Jack pine has grown faster than the other two species averaging 21 feet in height and 4 inches in diameter. The white pine averages 18 feet high and 4.5 inches in diameter and the spruce, 10 feet high and 1.5 inches in diameter. Both spruce and white pine show a small amount of damage by weevil and the former is often infested with galls. The stand is almost entirely closed but there is only a small amount of litter. Jack pine has dead branches extending for 8 feet above ground, and white pine for 5 feet. Spruce has no dead branches. For the first ten years the spruce grew quite slowly but since that time, except where it was heavily shaded, it has increased its height growth enormously, often making 2-3 feet a year. Under stiff competition Jack pine develops well, forming a straight bole and small side branches which die early. This plot demonstrates its value as a late filler, for which it compares favorably with Scotch pine. About 2 cords of birch were removed from the plot in 1919 and a final release cutting was made in 1924. Spruce trees completely covered by pine will be sold as Christmas trees. This plan will also be followed on Plots 42 and 43. Compare Jack pine on this plot with that on Plots 30 and 47 where this tree grew more or less in open stands. Compare the white pine and spruce with that on Plots 41, 42, 43 and 69.

Plot 47. Douglas fir—Jack pine—Norway spruce. Area .9 acre. Planted in the spring of 1903 with Douglas fir and several hardwoods mixed at random and spaced 5 x 5 feet. Practically all the hardwoods failed and blanks were filled in 1908 with Jack pine. The fir is all on the east side of the plot and with the Jack pine and some spruce planted at a latter date forms a fairly good stand. The west side contains a scattering of Jack pine and a volunteer growth of birch and other hardwoods. Some chestnut

from the early hardwood experiment still persists but is kept killed back by the blight. The west side should be used for another experiment. The fir has developed in all respects about as it did on Plot 38. The spruce, being much younger, is mostly overtopped. Jack pine has developed much as it did on Plot 30 where it was open grown, i.e., it produced long side branches and crooked boles. It is bearing cones prolifically and numerous seedlings up to 7 feet tall may be found in the openings. The stand on the west side has not closed sufficiently to shade out herbaceous growth and there is almost no needle litter.

Plot 48. Red oak and White pine. Area .9 acre. Planted in the spring of 1904 with oak 1 year seedlings and pine 2 year seedlings, spaced 6 x 6 feet, 4 rows of oak alternating with 2 rows of pine. Eighty-five per cent of the oak and 70% of the pine are living but 50% of the oak have been kept cut back by rodents. These trees were excluded in the measurements. Oaks not attacked by rodents have done better than the pines and are crowding the latter severely. Oak averages 20 feet in height and 2 inches in diameter and pine averages 18 feet in height and 4 inches in diameter. The best oak on the tract is to be found on this plot. About half the pines have been injured by weevil and are of poor form. The thrifty oaks have dead branches for a height of 10 feet, but dead branches on the pine do not extend over 2 feet above the ground. Most of the pine limbs are small. The stand, as a whole, has closed and most of the herbaceous growth, except brake ferns, has been shaded out. There is very little litter on the ground. Considerable birch in the mixture helps to make the canopy quite dense. This plot is in need of thinning to give the better oak and pine a chance. Compare with Plots 4 and 51.

Plot 49. Pitch pine. Area .9 acre. Planted in the spring of 1903 with 2 year transplants, spaced 5 x 5 feet. Over 90% of the original trees are still living (except on thinned sample plot described below) but the stand is not thrifty. Average height, 15 feet; diameter, 3 inches.

In 1921 students from the Yale School of Forestry laid off and measured two sample plots of $\frac{1}{16}$ acre each and thinned one of them. The results of the counts and measurements for the unthinned plot were—number of trees, 131 or at the rate of 2,096 per acre; volume, 26 cu. ft.* of wood or 416 cu. ft. per acre: for the thinned plot—number of trees before thinning, 130 or 2,080 per acre; after thinning, 78 or 1,248 per acre: volume before thinning, 29.4 cu. ft. or 470.4 cu. ft. per acre; after thinning, 20.5 cu. ft. or 328 cu. ft. per acre. These sample plots will be remeasured and the thinned plot thinned again in 1926.

*Volumes computed from Table 27, Bulletin 13, U. S. D. A., revised and extended to cover the sizes of trees found on this plot.

The unthinned pitch pine on Plot 49 has apparently stagnated although the stand does not seem at all dense. Live crowns have been reduced to $\frac{1}{3}$ the total height of the tree. Pitch pine seems fairly tolerant of shade of older pitch pine but it does not seem able to stand side crowding. On this plot all trees had an equal amount of growing space and have developed about equally with no marked differentiation into crown classes. On the south half of Plot 3 this species has grown under quite different conditions, more nearly approximating those in nature. The number of seedlings that started was very large and competition during the earlier years quite keen. The stronger individuals developed rapidly, suppressing the weaker trees, thereby obtaining more room for the development of their crowns.

On the sample plot thinned in 1921, crowns are deeper and the trees are generally healthier than on the remainder of the area. Compare Plot 49 with Plots 3, 22, 23 and 28.

Plot 50. Red oak. Area .9 acre. Originally an experiment with red oak but rodents kept the trees cut back so badly that the result is almost a total failure. An occasional individual has not been attacked and has made good growth but these are so scattering as to be worthless as a test of this species. A volunteer stand of birch and pitch pine has taken possession of the plot.

Plot 51. Red oak and White pine. Area .9 acre. Planted in the spring of 1904 with oak 1 year seedlings and pine 2 year seedlings, spaced 6 x 6 feet, two rows of oak alternating with one row of pine. Practically all the oak are present but $\frac{2}{3}$ of them have been cut back by rodents. Those not cut back are ahead of the pine but are so scattering as to make the pine appear to be spaced 6 x 18 feet. The thrifty oak averages 19 feet in height and 2 inches in diameter, and the pine 17 feet in height and 5 inches in diameter. About 20% of the pine failed. Those living have been badly weeviled and are of poor form. They have closed in the rows but not between them. Herbaceous vegetation has not been killed out except directly under the pine and there is little litter on the ground. Compare with Plots 4 and 48.

Plot 52. White pine and Japanese red pine. Area .9 acre. Planted in the spring of 1910 with 2 year seedlings, spaced 6 x 6 feet, the two species alternating by rows. Loss in the Japanese red pine was heavy and blanks were filled about 1914 with white pine. The present stand is fully stocked and is 25% Japanese red and 75% white pine. Both species average 7 feet in height. Both have been weeviled, the white the more heavily than the other. The plot was thoroughly cleaned of birch in 1923. Crowns are just commencing to close, much herbaceous cover is still present and there is no litter on the ground. This plot is similar to Plot 5 and has received practically the same treatment except that the

leaders on the Japanese red pine have not been pruned back but left for comparison with Plot 5. Comparison may also be made with Plot 19.

Plot 53. White pine. Area .2 acre. Planted in the spring of 1905 with 2 year seedlings, spaced 5 x 5 feet. Blanks were filled in 1910 with three year transplants. All birch was removed by lopping in 1923. Several large pitch pine and clumps of birch held back or killed the white pine on part of the plot so that the stand is rather irregular and only about half the original number of trees is present. Dead branches extend for 4 feet above ground but are firm. Crowns have closed, resulting in a forest floor without vegetation and covered with 2 to 3 inches of needles. Fifty per cent of the trees have been damaged by weevil. Average height, 13 feet; diameter, 3.3 inches.

Plot 54. White pine and Japanese black pine. Area .9 acre. Planted in the spring of 1910 with 3 year seedlings of white pine and 2 year seedlings of Japanese black pine, spaced 6 x 6 feet, and alternating by rows. The Japanese species was apparently not hardy and 90% of it failed. Those living are only 2 feet tall and tend to have a prostrate habit. Twenty-five per cent of the white pine failed also so that the stand is only 40% stocked. The white pine has been heavily weeviled and is bushy and of poor form. It averages 7 feet in height. The plot was cleared of birch in 1923. Pitch pine is scattered over the plot but is not sufficiently dense to stimulate the white pine.

Plot 55. White pine. Area .9 acre. Planted in the spring of 1903 with 2 year seedlings from Maine, alternating in the rows with beech, spacing 6 x 6 feet. The beech failed and the experiment has become one of pure pine with a spacing of 8½ x 8½ feet. The stand is complete and is just closing. Lower limbs are just beginning to die and ground vegetation is almost completely shaded out. Average height, 17 feet; diameter, 4.5 inches. Fifty per cent of the trees have been injured by weevil. Diameter growth has been consistently large over the whole plot and the stand is thrifty, and in good condition except for weevil damage.

Plot 56. White pine and Scotch pine. Area .9 acre. Planted in the spring of 1903 with white pine 2 year seedlings and beech, spaced 6 x 6 feet, a solid row of beech alternating with a row of beech and pine mixed. In 1911 the beech was replaced with Scotch pine 3 year transplants. The white pine has made a large diameter growth averaging 4.5 inches, but a poor height growth, averaging only 17 feet. The Scotch pine, although 8 years younger, averages 16 feet in height and 3 inches in diameter. The mixture contains about 80% Scotch and 20% white pine. The stand has just closed and dead branches extend for 4 feet above ground. They are large and heavy on the white pine but short and slender

on the Scotch. Half the white pine has been damaged by weevil. Practically all ground cover has been shaded out and 2 to 3 inches of needles cover the ground. Compare with Plots 4, 34, 35, 36 and 37.

Plot 57. Red pine. Area .9 acre. Cleared of a scattered stand of large grey birches in the fall of 1923 and planted in the spring of 1924 with 2 year seedlings, spaced 8 x 8 feet. At the end of the first growing season less than 10% had failed. Compare with Plot 40 for a plantation of red pine made at the same time under heavy cover.

Plot 58. Black locust. Area 1.0 acre. Planted in the spring of 1903 with 1 year seedlings with various spacings. As far as growth is concerned this species has done better than any other used in the plantations, attaining a height of 35 feet and a diameter of 6 to 7 inches and reproducing itself prolifically. However, damage from the locust borer (See page 105) was so great that in the fall of 1923 the stand was removed for cordwood and the experiment abandoned. During the last growing season, sprouts have reached a height of 10 feet.

Plot 59. White pine. Area 1.0 acre. Planted partly in the spring of 1903 with white pine 2 year seedlings and partly in 1904 with white pine 3 year transplants alternating in the row with black birch and spaced 5 x 5 feet. A small portion of the plot was pure pine. The birch failed leaving the pine spaced about 7 x 7 feet on the average, although the spacing is somewhat irregular. Heights average 25 feet; diameters, 6 inches. Dead branches extend for 10 feet above ground and are moderately large and quite firm. Weevils have caused many crooked boles but in spite of this a good height growth has been maintained and the stand appears in good condition. Practically all herbaceous vegetation has been shaded out and 2 to 3 inches of needles cover the ground. This plot may be compared with Plot 39 for white pine with a wider spacing and with Plot 28 for a closer spacing.

In 1922 students from the Yale School of Forestry laid off two sample plots of $\frac{1}{4}$ acre each. One of these was thinned and the other left as a check. Measurements and counts were as follows: check plot, number of trees, 187 or at the rate of 748 per acre; volume, 219.1 cu. ft.* of wood or 876.4 cu. ft. per acre. Thinned plot, number of trees before thinning, 216 or 864 per acre; after thinning, 158 trees or 632 per acre; volume before thinning, 249.9 cu. ft. of wood or 999.6 cu. ft. per acre; after thinning 208.0 cu. ft. or 832 cu. ft. per acre. Both plots will be remeasured and the thinned plot will be thinned again in 1927.

*Volumes computed from Table 27, Bulletin 13, U. S. D. A., revised and extended to cover the sizes of trees found on this plot.

Plot 60. White pine. Area 2.1 acres. Planted in the spring of 1905, together with Plot 68, with 2 year seedlings, 3 year transplants and wild seedlings from Stafford. Spacing was 5 x 5 and 6 x 6 feet, and trees were set in old furrows and on mounds between. Both plots are the same in all respects and are described together. Both are in excellent condition. Trees average 20 feet in height and 4 inches in diameter. Weevil damage has been comparatively slight and little damage seems to have been done until the trees were 12 feet or more in height. Dead branches extend for 10 feet above ground and are small but quite firm. Herbaceous vegetation has been shaded out and several inches of needles cover the ground. Competition has not been too keen but a thinning is needed to prevent the stand becoming stagnated. These two plots contain the best growth of white pine on the tract.

Plot 61. White pine. Area 2.2 acres. Planted in the spring of 1913 with 5 year transplants, spaced 5 x 6 feet. A few clumps of chestnut sprouts still persist from a previous experiment. A moderately dense stand of grey birch covered the pine until 1923 when it was entirely removed by lopping. This cover does not seem to have been sufficiently dense to protect the pine from weevil as 30 to 40% of the trees have been damaged. Practically the entire planting survives. The stand has not yet closed, and bunch grass and other herbaceous growth still persists. The pine averages 9 feet in height and, in competition with birch sprouts that have come up since the cutting in 1923, should make a good height growth and produce only small side branches.

Plot 62. White pine and Scotch pine. Area 5.1 acres. Planted in the spring of 1907 with 2 year seedlings of white pine, spaced 5 x 5 feet. In 1922 a fire destroyed about 50% of the plot facing Plots 61-64 (measurements and counts exclude this burn). The stand has just closed and some herbaceous cover still persists. Plot was cleaned of birch in 1919. Weevil damage has been quite heavy averaging 35%. Average height, 17 feet; diameter, 3 inches.

The burn was replanted in the spring of 1924 with white and Scotch pine 2 year seedlings. The season was dry, the fire had reduced the tract to a barren sand plain, the stock was small and a very heavy loss resulted during the first growing season.

Plot 63. Red pine and White pine. Area 2.6 acres. Planted in 1917. The species were planted alternately 6 feet apart, in rows 10 feet apart with the idea that at some later date Scotch pine or some other species would be used as a late filler. This has not yet been done. The plot was cleaned of a heavy cover of birch in the spring of 1923. About 95% of the original trees are living. The red pine appears more thrifty and of better form than the white because the latter has been severely injured by weevil. Both species average 5.5 feet tall. The stand is just closing in the rows but not between.

Plot 64. Scotch pine. Area, 1.3 acres. Planted in the spring of 1910 with 2 year seedlings, spaced 6 x 6 feet. Subsequent loss has been rather heavy, due partly to failures at the time of planting and partly to suppression by birch. The birch was thinned in 1923 and completely removed by lopping in 1924. A number of medium sized pitch pines were girdled in 1924. This should be the final release cutting as the Scotch pine can probably take care of itself from now on. The stand is just closing but is rather ragged. Trees average 15 feet in height and 2.5 inches in diameter, and have dead branches for 3 feet above ground. Herbaceous cover still persists and there is little litter on the ground. The extreme intolerance of Scotch pine and the effect of cover on this species are well illustrated.

Plot 65. Red pine. Area .8 acre. Planted in the spring of 1917 with red pine, spaced 5 x 5 feet. There were practically no failures and the stand is quite thrifty except on a few sterile spots (described under Plot 16). A small fire in 1922 destroyed about 75 trees near Plot 66. A heavy birch cover was removed in 1923 but the red pine does not seem to have been held back to any extent by its shade. A few medium sized pitch pines were girdled in the fall of 1924, thus removing the last of the cover from the red pine.

Plot 66. Western yellow (bull) pine. Area 1.5 acres. Planted in the spring of 1908 with 2 year seedlings, spaced 5 x 5 feet. This plot is similar in all respect to Plot 6 except that the blanks, which amount to about 45%, have not been filled. The trees average 11 feet tall, somewhat larger than on Plot 6 but in general development has been similar to that on Plot 6. Bull pine seems to be quite intolerant. Individuals growing in the shade are stunted and, even when growing in the open, the lower branches die from the shade of those above. A ground fire burned over a small area in this plot in 1922 killing the bull pine completely. This species appears to be at least as susceptible to injury by ground fires as red pine.

Plot 67. Native pitch pine. Area .1 acre. No treatment.

Plot 68. White pine. Area 4.3 acres. (See Plot 60.)

Plot 69. White pine and Norway spruce. Area 3.6 acres. Planted in the spring of 1905 with 2 year seedlings, spaced 5 x 5 feet, the two species alternating in the row. Ninety per cent of the pine and 60% of the spruce lived but the pine has grown much the faster of the two and has overtopped about 90% of the spruce completely, making the plot in effect one of pure pine with a spacing of about 7 x 7 feet over an understory of spruce. In a few instances the spruce has grown rapidly and will probably catch up to the pine. The latter has long, heavy side branches which have died for 8 feet above ground but still persist. Weevils have

injured about 30% of the pines. Average sizes: pine, 22 feet tall and 4.5 inches in diameter; spruce, 5 feet tall. Overtopped spruce trees are being removed and sold for Christmas trees as fast as a market can be found for them. This plot demonstrates the fact that it is not feasible to plant spruce and pine in the open at the same time, as the pine grows much faster and completely overtops the spruce. Compare with Plots 41, 42 and 43 where an overwood has held back the pine more than the spruce, enabling the latter to hold its own with the pine. In 1913 a fire burned over about an acre in Plot 69 along the East Granby highway (See Plot 69a).

Plot 69a. Red pine. Area about 1.0 acre. Planted in the fall of 1920 with 3 year transplants, spaced 6 x 6 feet, under a scattering cover of grey birch as a test of fall planting. The experiment was a complete success. Ninety-five per cent of the trees are still living and the average height is 2½ feet. A few spruce and pine from the 1905 planting are scattered over the plot. All hardwood growth was removed by lopping in the fall of 1924.

Plot 70. Austrian pine. Planted in the spring of 1908 with 2 year seedlings, spaced 6 x 6 feet. The trees suffered heavily from drought and winter injury and at present less than 25% of the original planting is present. Heights vary from 2 to 10 feet and average about 3 feet. Most of the trees have crooked boles and, in general, appear sickly and show poor development. The plot was thoroughly cleaned by lopping back the hardwoods in 1923.

CONCLUSIONS.

Seeding versus planting. In general it may be said that experiments in regeneration by seeding were not successful. The seed of many species, both coniferous and hardwood, were sown by various methods but results were so poor that regeneration by seeding was soon abandoned. Even during the most favorable seasons the moisture conditions in the surface soil are very poor and it is often several years before any vegetation appears on land abandoned for cultivation. Grey birch, which usually reproduces quite prolifically on bare soil, does not come in readily on bare areas in this region. Planting, on the other hand has been quite successful. When this method has failed, the cause can usually be traced to using unsuitable species or to some other reason.

Hardwoods versus conifers. Of the many experiments with hardwood species, only three were successful enough to warrant comment. Red oak, black locust and chestnut seemed to thrive on poor soil when not attacked by enemies. Unfortunately all three species have been subject to animal, insect or fungous injury and are almost complete failures. The other hardwoods used have either died out completely or are represented by a few

stunted specimens. The conifers, on the other hand, have done well. Some have done better than others but only in one or two cases can an experiment with conifers be called a complete failure. From this it is apparent that the tract is far better suited to coniferous than to hardwood growth, mainly because the former are far less exacting in their moisture requirements than the latter.

Conifers. Three species stand out conspicuously above all others used. They are red, white and Scotch pine. Of these Scotch pine has grown the fastest during the juvenile period, i.e., the first 20 years. However, it is an European species and has not been brought to maturity in this country as a timber tree. There is, therefore, some uncertainty as to just how it will develop between the twentieth year and the time it is ready to cut. Should later development prove satisfactory, its value for planting on poor soils in this country may be very great on account of its rapid growth. Its worst fault seems to be a tendency to form crooked boles. One of the greatest values is as a filler in older plantations of other species where failures have occurred. The wood is somewhat similar to that of red pine and is a little harder and heavier than that of white pine.

The growth of red and white pine is about the same. White pine is a well-known species and its wood is very valuable, more so than that of red pine, although, where they grow naturally together, both species are marketed as white pine. Red pine has no serious enemies. Its form is normally very good and it prunes itself better than white pine under the same conditions. The latter has several enemies, the worst of which in this region is the weevil. This insect causes a large percentage of the trees to form crooked boles which yield inferior lumber. For these reasons the red pine is considered the better of the two species.

Norway spruce, another European species, has done very well when planted under shade sufficiently dense to act as a nurse but not heavy enough to suppress the trees. As in the case of Scotch pine, there are no stands old enough to furnish data on what its later development will be.

Jack pine, which grows naturally on very poor soil in the Lake States, has not done well in pure stands where it forms crooked boles and long side branches. When used as a filler in older stands where it is obliged to grow rapidly in order to survive it does well, having much better form than when grown pure.

Western yellow (bull) pine is not recommended for this kind of site. It has grown slowly and is subject to a fungous disease which threatens to kill out the species here.

Two other European pines, Austrian and Corsican, have not proved satisfactory. In one instance Austrian pine did fairly well but in general losses with both species were heavy at the time of planting and the experiments with them are failures.

Pitch pine has proved as unsatisfactory as it is when it grows naturally. Its form is not good, its growth is slow and on the whole it may be called a worthless species in this region.

Of the two Japanese pines used, the Japanese black was a total failure because it was not hardy. The Japanese red pine shows considerable promise if handled properly. It has a strong tendency when quite young to divide at the base into several stems and form a bushy tree. When severely crowded, however, this species will normally produce only one stem and in such cases the trees make an excellent height growth.

The value of Douglas fir on sandy soil is questionable. The development of this species is exceedingly variable, some individuals having done very well while others are much stunted. During the last five years this tree has shown up much better than it did previously.

The European larch is another tree which varies greatly in growth, some individuals having equalled the Scotch pine in size while others are mere shrubs. Its value on poor soil is probably small.

White spruce has been used too recently to furnish any data on how it will develop.

The other conifers found on the tract, two species of fir and one of arbor-vitae, are too few in numbers to merit comment.

Hardwoods. Only three of the hardwoods used need mention. They are red oak, black locust and chestnut. When not attacked by rodents red oak makes a height growth equal to white pine and is of good form, indicating that this species is adapted to poor soils. However, rabbits kept so many trees cut back that the stands are open and the experiments are failures. Without exception, black locust made the best growth of any species used on the tract but the trees were so completely mined by the locust borer that the plantation had to be abandoned. Chestnut once grew naturally on the tract. It is difficult to say what the results of artificial regeneration of this species might have been. The fact that much chestnut still persists, even after being killed back repeatedly by the blight, indicates that this tree might have been profitably grown on this site.

Other hardwoods used, but which were complete failures, were white oak, green ash,* tulip,* black birch, hard maple,* beech, catalpa, cotton wood, white ash and hickory.*

*No trees of these species were found in the 1924 survey.

LIST OF SPECIES USED ON EXPERIMENTAL PLOTS.

Following is a list giving the common and scientific names and the plot locations of the species used in the experiments.

White pine; *Pinus strobus*, L.*

Plot 2, 4, 5, 6, 7, 11, 12, 15, 16, 17, 20, 21, 22, 24, 25, 26, 27, 28, 29, 33, 34, 35, 36, 37, 38, 39, 41, 42, 43, 44, 46, 48, 51, 52, 53, 54, 55, 56, 59, 60, 61, 62, 63, 68, 69.

Red pine; *Pinus resinosa*, Ait.

Plot 8a, 16, 17, 22, 24, 40, 57, 63, 65, 69a.

Scotch pine; *Pinus sylvestris*, L.

Plot 1, 4, 14, 17, 20, 21, 23, 31, 34, 35, 36, 37, 56, 62, 64.

Pitch pine; *Pinus rigida*, Mill.*

Plot 3, 49.

Austrian pine; *Pinus Laricio* var. *austriaca*, Endl.

Plot 1, 24, 70.

Corsican pine; *Pinus Laricio*, Poir.

Plot 45.

Jack pine; *Pinus divaricata*, Du Mont de Cours.

Plot 30, 46, 47.

Western yellow pine; *Pinus ponderosa*, Laws.

Plot 6, 66.

Japanese red pine; *Pinus densiflora*, Sieb & Zucc.

Plot 1, 5, 10, 19, 52.

Japanese black pine; *Pinus Thunbergii*, Parl.

Plot 54.

Mountain pine; *Pinus montana*, Mill.

Plot 34, 45.

Mugho pine; *Pinus montana* var. *Mughus*, Willk.

Plot 17, 34, 45.

Douglas fir; *Pseudotsuga Douglasii*, Carr.

Plot 1, 17, 38, 47.

Balsam fir; *Abies balsamea*, Poir.

Plot 13, 32.

White fir; *Abies concolor*, Lindl. & Gord.

Plot 17.

European larch; *Larix europea*, de C.

Plot 1, 17.

Arbor-vitae; *Thuja* sp.

Plot 17.

- Norway spruce; *Picea excelsa*, L.
Plot 8a, 8b, 10, 32, 41, 42, 43, 44, 46, 47, 69.
- White spruce; *Picea canadensis*, Mill.
Plot 18, 32.
- Red oak; *Quercus rubra*, L.
Plot 4, 17, 40, 48, 50, 51.
- White oak; *Quercus alba*, L.*
Plot 17.
- White ash; *Fraxinus americana*, L.
Plot 17.
- Black birch; *Betula lenta*, L.
Plot 59.
- Grey birch; *Betula populifolia*, Marsh.*
on nearly every plot.
- Beech; *Fagus americana*, Sweet.
Plot 20, 21, 55, 56, 57.
- Catalpa; *Catalpa* sp.
Plot 5.
- Cottonwood; *Populus deltoides*, Marsh.
Plot 6.
- Basswood; *Tilia americana*, L.
Plot 47.
- Chestnut; *Castanea dentata*, Borkh.*
Plot 7, 8a, 8b, 27, 57, 61, 63, 64, 65, 66.
- Black locust; *Robinia Pseudacacia*, L.
Plot 17, 19, 57, 58, 59.

*Found growing naturally, as well as where used in experiments.