Forest planting handbook. 1932

Trenk, Fred B. (Fred Benjamin), 1900-
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On the front cover is reproduced a picture of the oldest known forest plantation in Wisconsin. It was planted in 1876 by Mr. Walter Ware on the farm he then owned in western Waushara county.

The planting commemorated the centennial of the Declaration of Independence in 1776. The picture was taken in 1928 when the plantation was 52 years old. Barn timbers were sawed from logs cut in this plantation before it was 50 years old.

Mr. Ware's observance of the centennial exemplifies the true spirit of the signers of the Declaration of Independence. While others looked backward, he built for the future, demonstrating that each man in his day and generation can do something worthy to be remembered.

STATE OF WISCONSIN

CONSERVATION DEPARTMENT

FOREST PLANTING HANDBOOK

by

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FOREWORD

The growth of forest consciousness in Wisconsin is well illustrated in the constantly increasing number of forest trees which have been planted in the state in each of the last few years. Governmental agencies, wood using industries, farmers and other landowners, schools and other educational groups—all these have been indicating their increased interest in reforestation by planting more and more trees each year.

Beginning in 1932, the state of Wisconsin increased its annual forest planting program tenfold. In carrying out this program, 10,000 acres of state owned land will be planted to forest trees each year.

County governments are exhibiting a keen and increasing interest in reforesting those lands now idle which are coming into the ownership of the county through tax delinquency.

The federal government is developing a comprehensive planting program on national forests in Wisconsin.

But regardless of the scope of the planting plans of governmental agencies, a great part in the task of reforesting Wisconsin's idle lands will remain for private enterprise. Most lands needing reforestation are privately owned.

It is the function of the state to point the way for reforestation and to establish demonstration areas in each of the sections which are adaptable to the production of raw material for specific wood using industries. It is expected that more and more wood working industries will follow the lead of the state and of those pioneer industries which have already undertaken extensive reforestation enterprises.

Individual owners of small tracts of land are recognizing in artificial reforestation a means of establishing a crop on some lands which would otherwise remain unproductive. Such owners will not engage in extensive planting operations requiring heavy machinery for soil preparation and large crews to carry on the work during the short planting

seasons. However, the aggregate acreage of all small areas which might be planted profitably is enormous.

Such owners need information on how and when to obtain trees for planting, what trees to plant with reference to specific conditions, how to plant, what care is necessary after planting, and what may be expected in the growth of plantations.

The present bulletin has been published primarily for the use of landowners interested in planting small plots. Particular emphasis has been given to the problems arising from specific conditions. Planting conditions in Wisconsin vary greatly. Consequently, a mere generalization of planting instructions is of little help. This bulletin considers and discusses 10 types of planting conditions, one of which will be applicable to any planting condition in Wisconsin.

The owner who intends to engage in reforestation work should identify his particular planting conditions with reference to the 10 specific conditions listed on page 17, each of which is described in detail in the pages immediately following.

PAUL D. KELLETER,
Conservation Director.

FOREST PLANTING IN WISCONSIN

Source of Planting Stock

The Wisconsin Conservation Department maintains at Trout Lake in the Northern State Forest, Vilas county, a forest tree seedling and transplant nursery. For several years approximately 1,500,000 trees grown in this nursery have been planted annually on state and county owned lands, and about an equal number have been sold for private reforestation projects in Wisconsin. A small quantity each year has been offered for free distribution to farmers who agreed to establish demonstration plantations under the direction of a county agricultural agent. Four H Club members who have enrolled as Junior Forest Rangers have also received free trees.

A specific agreement, which must be signed by every purchaser of trees, sets forth the limits placed upon the use and disposition of the trees. This reads as follows:

Agreement

In consideration of the fact that the state is furnishing trees at a nominal price to encourage reforestation, I agree as follows:
Definition:

By forest planting or reforestation, so far as this agreement is concerned, is meant the planting of trees for the establishment of a forest, or for the improvement of a forest now existing, or for similar forest uses, but not for ornamental or landscape purposes.

Shipment of trees will be limited to the following classes of landowners:

(1) Farmers, for planting on idle land or for windbreaks;
(2) Owners of land entered under the forest crop law;
(3) Landowners whose purpose of planting is the production of forest crops.

1. The trees received will be planted in Section _____, Township _____, Range _____, County _____, State of Wisconsin, and are not obtained for the purpose of resale.

2. I will not dig, cut off, or move these trees after planting until they are large enough to be sold for merchantable timber.

3. I will furnish reports to the conservation department when requested, and this planting may be inspected by the conservation department or its agents at any time.

4. I will protect the area from fire, trespass, and grazing.

5. In case of injury from insects or tree diseases, I will write to the State Entomologist, Madison, Wisconsin, for advice.

6. In planting white pine, I agree to remove all currant and gooseberry bushes, both wild and cultivated, from the area to be planted and from a 900 foot zone surrounding the area not later than June 1 following the planting.

(Signed) _____

Six species of trees are grown at the state nursery—white pine, Norway pine, Scotch pine, jack pine, Norway spruce, and white spruce. The Norway spruce and Scotch pine are trees of European origin; the other four species are native to Wisconsin.

Usually all of these species are available as seedlings up to three years of age, ranging from three to eight inches in height. The Norway and white pine, and the Norway and white spruce, may also be obtained as transplants; that is, trees taken up as seedlings and grown for one or two additional years in nursery rows. The transplanting operation results in a better developed root system and thicker stems. Prices for trees range from $3 per thousand for seedlings to $7 per thousand for transplants.

Nursery price lists and order blanks are issued by the conservation department early each fall, and trees may be purchased in the spring. The spring season opens about April 20, or as early as frost conditions in the ground permit the lifting of trees. Spring shipping ceases in the middle of May.

Many persons ask why it is undesirable to sow tree seeds directly on the ground to be planted, instead of growing and transplanting small trees; and why the conifers or evergreens are almost universally grown, instead of more hardwood or broad-leaved trees.

Repeated experiments in direct sowing of seed on areas to be planted have resulted in failure. In the few cases where direct sowing has produced a stand of trees, the cost has been too great. Planting of young trees has been found more certain and more economical, and is therefore the method recommended.

The conifers are chosen not only because the handling and planting of seed and growing the seedlings is more economical, but because they are much better adapted to soils of low fertility and rough planting conditions, which are characteristic of areas which are artificially reforested.

There are conditions under which the black walnut is suitable, together with other hardwood trees generally found with black walnut. This will be given special consideration later.

Planting Methods and Equipment

Local soil conditions such as blow sand, stony hillsides, or cut over pine lands, present problems in the details of planting. A more complete discussion of these problems is found beginning on page 17. There are certain fundamental practices to follow wherever trees are planted for forest purposes. These will be considered first.

Time of Year for Planting

Fall planting is satisfactory if limited to light, sandy soils on which there is little danger of frost "heaving," frequently caused by alternate freezing and thawing during the winter and early spring months. Spring planting is recommended on heavier soils, particularly in the southern part of the state, where the trees are not covered by snow continuously during the winter.

Fifteen year old Norway pine plantation on abandoned sandy field.

Fall planting should begin about September 1, and may continue until heavy frosts occur. Trees should never be planted in frozen ground. The spring planting season usually begins about April 20 in southern Wisconsin and about May 1 in the extreme northern counties. Spring planting should cease as soon as the terminal buds of the young trees have opened, and the new leaves have begun to grow. The spring planting season at any one place in the state does not last more than a month, and is usually limited to about 25 days.

Care of Planting Stock upon Arrival

Trees from the state and commercial nurseries are packed tightly in moist moss and are shipped in burlap bundles, or in crates. Because of the moist moss and the tight packing, which is conducive to heating, the trees may be damaged if permitted to remain packed too long. Consequently, it is most important that the package or crate of trees be opened as soon as possible after it is received by the purchaser, in order to permit circulation of air through the moss.

If a small shipment, 1,000 or 2,000 trees, has been received, which can ordinarily be planted in a few days, it is sufficient merely to loos-

(Photo by U. S. Forest Service)

Large shipments of trees which cannot be planted immediately should be unpacked and "heeled-in."

en the trees in the shipping bundle or crate, pour water on the moss around the roots, and keep the trees in a cool, shaded place until they are ready for planting. When a larger quantity of trees is received from the nursery, requiring a week or more for planting, complete unpacking and "heeling-in" are necessary.

To heel-in trees, a long shallow trench should be dug, with one face of the trench having a slope of 45 degrees. A depth of six inches for the trench is recommended, except for very large transplant stock, when the trench should be 10 or 12 inches deep. The trees are tied in bunches containing 25 or 50 trees each. The bunches *should be opened* and spread out on the sloping face of the trench, with the roots carefully spread out in the bottom of the trench. A thin layer of soil

should then be spaded from the opposite wall of the trench, and packed firmly against the roots and partly up the stems of the trees. After the soil is packed and smoothed off, it should lay at a 45 degree angle and is then ready to receive another row of trees, to be spread out as described for the first row. One thousand trees heeled-in in this manner will require about 12 feet of trenching. After the trees are heeled-in frequent watering and shade are necessary.

Preparing the Planting Site

Complete cultivation of the soil before planting is unnecessary; in fact it may hinder the growth of the young trees, because of the

Wherever possible trees should be planted in shallow furrows.

weeds which usually follow complete cultivation. In light, sandy soils, cultivation may cause blow areas and drifting of the soil.

Planting the trees in the bottom of shallow furrows proves most satisfactory and furrowing should be done wherever possible. Shallow furrows, preferably 14 or more inches wide, and not over three inches deep are the best. The trees should be planted next to the furrowed soil, in the bottom of the furrow, to provide a strip of cleared soil on both sides of them. Furrowing may be done in late summer or early fall, even though the planting may not be done until the following spring.

The presence of sod, when a plantation is set out, is a retarding factor in the survival and rate of growth of the young trees, because of the large amount of moisture absorbed by the roots of the sod, which robs the young trees of this necessary moisture. Studies made in several older plantations* show the influence of sod, when it is not properly removed, in retarding the growth of the young trees. Four

*—by W. W. Morris, Wisconsin Department of Agriculture and Markets

Norway pine plantations, all on light sandy soil, planted under three different conditions of soil preparation, showed the following annual height growth up to the fifteenth year.

TABLE I

Table Showing Effect of No Preparation of Soil, as Compared to Careful Methods of Planting, on Height Growth of Plantations

	No Soil Preparation		Soil Prepared	
Age	State Planting Norway pine Boulder Flats Slit Method Sod not removed Soil: Plainfield sand	Wilson Plantation Norway pine near Gordon Slit method Soil: Plainfield sand	Nye–Hayes planting Norway pine Wascott Plowed and cultivated Soil: Plainfield sand	State Planting Star Lake Norway pine Sod removed in spots 18" square Soil: Vilas sandy loam
Years	Inches	Inches	Inches	Inches
1	2	3	2	2
2	2	4	2	4
3	3	4	4	7
4	5	5	11	9
5	5	5	10	8
6	8	6	17	8
7	6	6	20	15
8	5	7	16	19
9	5	8	26	16
10	5	10	22	21
11	8	11	22	26
12	10	13	20	21
13	7	14	23	18
14	11	12	25	22
Total	82"	108"	220"	196"
	6.8'	9'	18.3'	16.3'
	% of Nye–Hayes 37%	% of Nye–Hayes 49%	Height growth 100%	% of Nye–Hayes 89%

Where furrowing is not possible, and there is much sod, matted roots, or weed growth present, "scalping" a plot for each tree is necessary. Scalping consists of removing the sod or matted roots with a grubhoe or spade from an area one and one-half to two feet square. The tree should be planted in the center of the cleared spot.

Spacing

The spacing of trees may be determined by local planting conditions as will be discussed more fully later. For most conditions and species of trees, a six by six foot spacing is recommended. This requires 1,210 trees per acre. Check rows, to secure this exact spacing, are not necessary. If the furrows are plowed six feet apart, and the trees are planted approximately six feet apart in the furrows, a satisfactory spacing will be secured. With this spacing scattered losses, even running as high as 15 per cent, will not make replanting necessary. This density also permits the most favorable growing room for the trees during their first 25 or 30 years. After this growth, a light thinning may be necessary, but the trees cut out as a result of thinning will be large enough to have some market value.

Planting Tools and Equipment

A team of horses and a moderately heavy plow are satisfactory for furrowing. The equipment needed for planting the trees is: a bucket for transporting the trees from the heeling-in place to the planting crews; a heavy straight-bitted spade or planting spud for light soil; a grubhoe for heavy and stony soil. Water sufficiently deep to cover the roots should be kept in the buckets used to carry the trees.

Organizing the Planting Crew

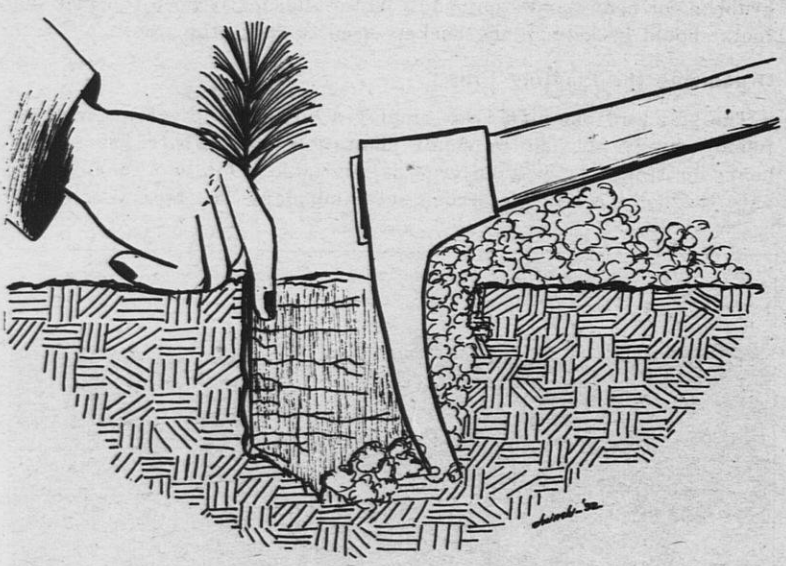
The standard one-man crew employed on large operations may be found equally efficient in small plantations, but where the soil is heavy or stony, a two-man crew is advisable. One man should prepare the holes, while the second sets and plants the tree. For every

Forest planting demonstration conducted by county agent. Planting by two man crews with an extra man carrying seedlings.

three to five crews, there should be one man or boy to carry the trees. When 10 or more men are engaged in planting, it is advisable to have a crew foreman. Since planting crews may become careless in their work, a constant check on the care with which trees are planted is obviously a part of the foreman's job.

After furrowing or scalping, one member of the crew opens the planting hole with the spade or grubhoe. The second places the tree in the hole. The second man may also pack the soil around the roots and finish up the actual planting. It has also been found advisable, where a simple slit has been made in heavy soil, for the man with the spade to close the hole by forcing the spade into the ground an inch or two from the original thrust, and to pry the soil against the roots of the tree.

Where furrows have been plowed, it is a simple matter to keep the crews in line. When furrowing is impossible, it is much more difficult to maintain straight lines and uniform spacing. One way to insure straight rows and even spacing is to set three or more poles or guide stakes in line toward the far end of the first row to be planted, yet



Set the tree against the vertical face of the planting hole to secure correct depth. Avoid bunching or doubling back of roots.

within full view of the planting crew. One crew should be assigned to this row, and after beginning, the second crew should be started off six feet from the first row. A third crew may be started six feet from the second row, and so on. Such a system requires that the first crew set the pace for all, that it keep in careful alignment with the stakes, and that each crew pay careful attention to the spacing between the row it is planting and the row next to it.

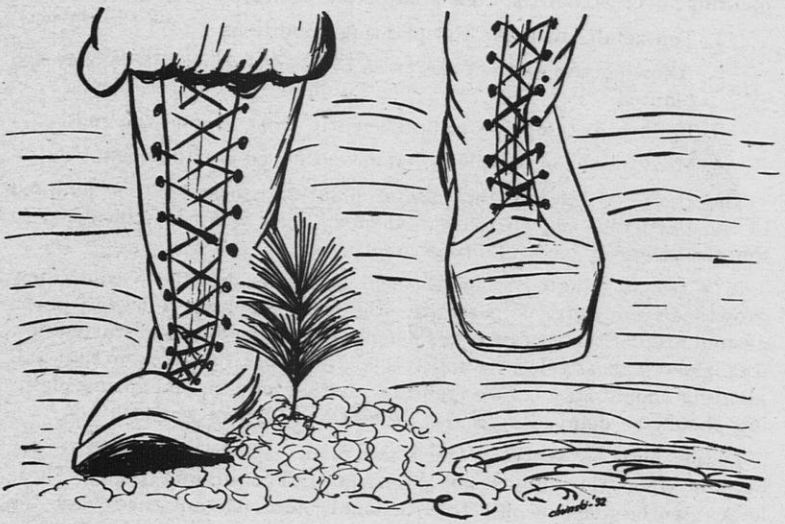
Planting the Trees

Each tree should be planted about one-half inch deeper than it grew in the nursery. The old soil line can be recognized readily by the paler colored bark on the stem of the tree. The hole or slit should be deep enough to care for the entire root system of the tree. The roots should be spread out in as near a normal position as possible, and particular care is necessary to prevent the ends of the roots from being curved upwards after placing in the hole.

The soil must be thoroughly packed around the roots of every tree. No tree should be allowed to dry out while it is being carried on the planting job.

Care after Planting

The cultivation of plantations hastens growth, but the cost of cultivating is too great to be recommended generally. A moderate amount of shade, especially with white pine and the spruces, has been found beneficial in preventing injury and loss which may be caused



Pack the soil firmly around the roots with full weight on the heel.

by too high soil temperature resulting from the full rays of the sun beating on the tender bark and on the unprotected soil near the roots of the trees.

Fire protection measures are the most important to consider after planting. The plantation should be directly accessible by a road or trail so that fire fighting equipment may be brought to it in case of a fire. It is advisable to clear a 15 foot fire strip or lane around each 40 acre plantation. If practicable, this strip should be plowed or disced every two or three years.

Livestock grazing must never be allowed as the trees are certain to be badly injured or destroyed by the trampling or browsing of the animals.

Causes of Failures in Plantations

There are four principal causes of failure of trees to survive after planting, over which the tree planter has control. They are:

1. Too small stock for the planting conditions
2. Allowing the roots of the trees to become dried before they are planted
3. Failure to tamp the soil sufficiently tight around the roots
4. Heavy sod not sufficiently removed at time of planting.

The choice of species and size of planting stock must be adapted to the particular planting area selected. This will be emphasized in the discussion of local planting conditions.

If a tree is planted when the soil is warm enough to cause new growth of root hairs, it becomes established quickly. However, if the ground around the roots freezes deeply before the tree has started new root growth, heavy loss is inevitable. It is for this reason that fall planting should stop before freezing weather sets in, and spring planting should be delayed until the ground has become warm.

Losses may be expected when the roots have been allowed to dry out, or when the soil is not properly packed around them. These losses can be avoided only by reasonable and constant care when the trees are planted. The importance of sod in causing losses is shown in the table on page 10.

Other possible causes for failure of survival are:

1. Extreme drought immediately after planting
2. Heavy freezing of the ground immediately after the trees are planted
3. Heating of trees in bundles while in transit
4. Delay in unpacking
5. Setting the roots improperly in the holes (too deep, too shallow, or crushing the stem of the tree when packing the soil)
6. Flooding due to poor drainage or a very wet season
7. Low spots subject to late frosts (frost pockets)
8. Land wholly unsuited to the species of trees planted on it.

All of the above possible causes of loss, except the factors of drought and freezing, can be avoided if the stock is carefully chosen and the trees are properly planted.

Losses of trees after they have begun to grow occur, and these losses are sometimes difficult to prevent. During years of severe outbreaks of grub worms, young plantations have been attacked heavily. This was observed to be the cause of many trees dying in young plantations in southern Wisconsin during the summer of 1930. After the

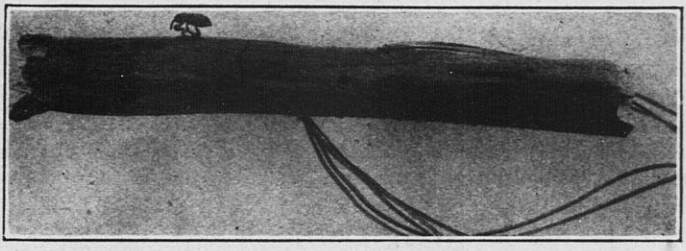
fifth year, the root system of most trees is sufficiently large to withstand some damage from grubs, without the tree dying.

Rabbit injury, porcupine injury, and in some cases deer injury, occur in northern counties. During some winters, especially when snowfall is light, the losses are more noticeable.

White Pine Weevil

Pissodes strobi

There are frequent outbreaks of the white pine weevil, one of the worst insect enemies of white pine in Wisconsin.* While this insect



A portion of a tip of a white pine with the exit holes of the white pine weevil. An adult weevil is on the twig.

does not usually kill the trees outright, by killing the terminal shoot of the main stem, it causes the trees to grow badly forked and crooked and may, under some conditions, render them valueless for lumber.

The weevils are reddish-brown, snout beetles about a quarter of an inch long with white markings on the wings. They pass the winter in the litter beneath the trees. In the spring they emerge and gather on the terminal shoots of the pine, generally on the trunk leader in preference to those of the branches. Here, near the tip, they feed on the bark and the female beetles soon cut tiny holes in it, placing their eggs in these chambers hollowed out of the inner bark. These eggs hatch into larvae which bore downward through the leader and by August have completed their feeding and are ready to pupate in these tunnels. The adult weevils soon emerge and cut their way out of the tunnels through the sides of the branches by making round holes through the walls. Later they hibernate, there being only one generation each year.

This insect can be prevented from doing serious injury under forest conditions. Trees growing in a dense stand are less subject to weeviling than those in open stands and also in dense stands the stimulation of straight growth is so strong that practically all weevil injury is outgrown. White pines growing under shade of hardwoods are not usu-

*The author is indebted to E. L. Chambers, State Entomologist, for information presented here on white pine weevil and white pine blister rust.

ally attacked and therefore the planting of white pine in mixtures with other pines or hardwoods seems to be the logical means of avoiding losses under forest conditions.

White Pine Blister Rust

Cronartium ribicola

The most serious disease of white pines is blister rust, which was brought into the United States from Europe on white pine planting stock. It was discovered in Wisconsin in 1915, when it was introduced on seedlings grown in Germany, purchased through an Illinois nursery, and since then it has been found in 22 counties in the state.

The rust is spread by wind-blown spores from infected trees to the leaves of currant and gooseberry bushes. From these bushes a different spore is blown to healthy white pine trees.

Blister rust is a deadly tree disease that attacks the white pines only. It can be controlled by removing the currant or gooseberry bushes from the area to be planted, and for a surrounding distance of 900 feet. The cultivated European black currant is extremely susceptible to this rust.

Before the trees are planted, a systematic check for wild bushes on the area is advised so that none will be missed. This check can best be made by a two to five man crew which can begin at a fence, working abreast, and follow parallel strips from this fence. The outside man on each strip should mark the edge of the strip with suitable markers, such as bits of paper which can be attached to limbs on trees or shrubs. On the next strip this paper can be removed by the inside man of the crew and used again on the following strip.

Currant and gooseberry bushes are most easily pulled in early spring immediately after the frost is out of the ground. An ordinary grubhoe can be used effectively in removing the large bushes, but extreme care should be taken so that the larger crown roots that may sprout are not left in the ground.

Other Insect Enemies

There are occasional outbreaks of the Scotch pine scale, the spruce bud-worm, the pine bark louse, and the larch sawfly, but they are by no means as destructive as to discourage the planting work.

The Best Plantation for Local Conditions

General information on planting methods and choice of trees is not sufficient, because there are extremely different planting conditions in various sections of Wisconsin, and each presents a different problem. Therefore, more specific suggestions are made for planting under these various conditions, and anyone intending to plant trees should refer to the particular local condition described in this section which most nearly applies to his planting area.

They are described under ten headings, as follows:

Drifting and river bottom sands,
Decomposed sandstone and the sand plains,
Limestone and kettle moraines,
Limestone talus slopes,
Eroding unglaciated soils,
Burned over, non-plowable lands,
Under-planting in the farm wood lot,
Under-planting of white birch-aspen lands,
Planting in old fields,
Swamps.

Each of these will be discussed with reference to

1. Future timber products or primary objective of the plantation
2. Choice of trees
3. Special changes in planting methods if any
4. Spacing of trees.

Drifting and River Bottom Sands

Drifting sand areas are not extensive anywhere in the state. However, there are numerous farms, principally along the Wisconsin and Black rivers and in the sand plains region of the state, where severe sand drifting makes extensive areas valueless. Holding soil rather than producing timber products is the primary objective for planting trees under these conditions. Jack pine is apparently the most desirable tree for such very sandy conditions, because it makes a fairly rapid growth, thus breaking the force of the wind and reducing the amount of sand-blowing. Soon after planting, jack pine also develops an extensive network of surface feeding roots, which further help to anchor the soil. Where there is a moderate amount of fertility in the soil, Norway pine and Scotch pine may be used in mixture with the jack pine.

Plowing furrows on blow or drifting sands is not desirable, and tree planting should never be started in the heart of the blow area. The plantation should be started on the windward side of the blow area. In many cases three or four rows of trees on the windward side will be sufficient to start a small windbreak, which in turn will create an

area of calm in the blow sand zone. A windbreak of trees will lessen the horizontal force of the wind for a distance of 20 times its height. Hence, by the time the block or row of trees on the windward side reaches 10 feet in height, it will be helpful in stopping the wind for a distance of 200 feet. Future plantings on the leeward of the original block of trees should be made on the blow sand spots as rapidly as they fall within this protected zone.

Planting a windbreak on drifting sand. See picture on opposite page.

A four by four-foot spacing instead of the standard six by six-foot spacing is recommended in blow sand areas. The earlier the roots and the crowns interlock, the more effective the plantation will be. Even with most favorable growing conditions, a number of years are required for trees at a six-foot spacing to close in on each other; on sandy soil this period is considerably longer.

The V-shaped slit type of planting hole is best adapted to sand, and may be made either with a flat planting bar or spade. Fall planting is desirable, because it gives the young trees full advantage of the moisture which may be in the soil at the opening of the growing season in the spring. Too often spring planting is delayed until much of the soil moisture has evaporated or drained away.

Decomposed Sandstone and the Sand Plains

Extensive areas of sandy soil in central and northern Wisconsin, resulting from the weathering of the sandstone hills, or from glacial lakes and deltas, have been so completely deforested as to need replanting if a valuable crop of trees is to be grown on them. Blow sand soils are found within this type. Where such sandy soils have remained comparatively undisturbed the objectives and methods of planting will be different than for strictly blow sand areas.

Because of their low fertility and susceptibility to drifting once they are broken, many of these soils are not desirable for agriculture. They are adapted to growing trees. Present markets indicate that for some time to come the growing of pulpwood products is the most promis-

ing use for trees planted on these soils, although the better types of sand may be used for growing white and Norway pines for lumber.

Because these sand soils vary so widely in fertility, water level, and degree of fineness of sand, several species of trees can be recommended. In the light sand areas and on recently eroded sand, such as are found among the sand hills of Monroe, Jackson, Juneau, Adams, and adjacent counties, Norway and jack pines are recommended for plant-

The same area as shown on preceding page taken five years later, indicating how pines checked sand drifting.

ing. A few Scotch pine plantations in this district have made as rapid a growth as jack pine, and when the seed was secured from northern Europe, the trees were straighter than jack pine. The full possibilities of Scotch pine in the United States have not been determined, but the experimental plantings on light sand already made appear promising.

On somewhat heavier glacial sands, such as are found in Oneida, Vilas, Wasburn, and Douglas counties, white pine, Norway pine, and Norway and white spruce have been planted with good results. The pines will produce saw logs and the spruce is particularly valuable for pulpwood.

This type requires no unusual planting methods. Wide, shallow furrows should be plowed, and a six by six-foot spacing is recommended where little or no tree growth is present. Scrub oak brush must be destroyed, especially near the planted trees. Where there is a scattered growth of pine and hardwood trees not exceeding 600 per acre, an eight by eight-foot spacing is satisfactory. This advance tree growth, even though it may be of low value, will serve to fill in around

the planted trees, promoting a more rapid height growth and clearer stems on the planted trees. If the present tree growth is too dense, either planting is impractical or unnecessary, or this growth must be partially removed by cutting or plowing.

Planting holes in the form of V-shaped slits are most generally made, and produce good survival on these light soils. Planting may be done in spring or fall, and either seedling or transplant stock is satisfactory.

Jack and Norway pine should be planted in pure plantations; that is, either all jack pine or all Norway pine. When Norway spruce is planted for pulpwood, on the more fertile and moist sands for instance, it may be planted pure, but a mixed plantation of white pine and Norway spruce is desirable. By the time the spruce is large enough for pulpwood, the plantation will need thinning, and harvesting the spruce will provide the necessary thinning. The white pine will then be at the proper density for saw log production. The mixture should consist of 50 per cent pine and 50 per cent spruce.

Limestone and Kettle Moraines

The steep hills and numerous poorly drained pockets in the eastern counties of the state are known as kettle moraines. The soil consists largely of small limestone boulders, unlike the hard granite boulders generally found in moraines. The soil has poor moisture-holding capacity, is generally low in humus, and has a strong lime reaction. Originally it was forested with hardwood trees, principally the oaks, but it is now largely in pasture. In many places the pasture is of little value, because the grass burns out in even moderately dry weather. Frequently erosion follows the loss of the grass. Attempts to reforest such pastures have generally resulted in a heavy loss of trees.

There are two purposes for reforesting these hills, (1) soil protection, and (2) the production of fuelwood and construction material for farm use. The choice of trees is extremely limited, as only few species can grow under such unfavorable soil conditions. Norway pine will grow near the base of the hills, on top of the hills, and in light shade of any scattering hardwood trees which may still be growing. On the drier, exposed sections of the hillsides, Scotch pine appears best suited. This tree withstands droughts in the dry limestone soil better than Norway pine, and the wood is of about equal value for use on the farm.

Plowing furrows along the contours of the hill (that is, plowing so that rain water will not start ditching) is advisable wherever soil conditions will permit. The furrows should be thrown downhill. A grubhoe is necessary for digging the holes, whether the ground has been furrowed. The trees should be spaced six feet apart.

Limestone Talus Slopes

Many of the steep slopes in southwestern and western Wisconsin, particularly near the Mississippi river, are composed of broken and weathered limestone. Where such slopes have proven unsatisfactory

for grazing, owners should consider the advisability of planting them to trees. These slopes differ widely in their content of organic matter or humus, and these differences affect the moisture-holding capacity and fertility of the soil. Trees may be grown for saw log purposes on slopes of good fertility. On the drier slopes the principal objectives of a plantation are to reduce rapid run-off and erosion from rains, to protect the numerous springs which abound in this region of the state, and to provide minor wood products such as fuel.

The original tree growth and the direction of the slope are the best indicators of what species should be selected for planting. Southwestern and western exposures or slopes are the most difficult to plant to any species. The soil is always drier, but the persistence of white birch on northwest slopes, red cedar, and in some places burr oak indicate that tree growth is possible. The choice of trees here will almost always be limited to Scotch pine and jack pine, the jack pine included only where sandy areas occur on the slopes. Trees requiring liberal amounts of soil moisture, such as the spruces, should never be planted on these exposed areas.

In northwestern and northern slopes where basswood and red oak trees were found originally, the soil is deeper and is usually more moist. These slopes are well adapted to white pine, white spruce, Norway spruce, and Norway pine. On one such slope in La Crosse county a 60-year old plantation from seed, consisting of white pine, Norway spruce, and Scotch pine has made an excellent growth. If there is an open growth of hardwood trees now present, the choice of trees should be limited to white pine and Norway or white spruce.

On the exposed, stony dry slopes, furrowing is usually impossible, and the grubhoe is necessary to prepare the planting holes. Here it is particularly important that loose top soil, instead of bare stones, be placed in contact with the roots. Unless the trees have a little shade from scattered birch or oak trees, straw or brush placed around the planted trees will help prevent too high soil temperatures and extreme dryness, which are the principal causes for failure of trees to grow on these exposed slopes. When the trees have grown for a few years, and have formed a mat of dead needles on the soil above their roots, danger of loss from these causes decreases.

Eroding Unglaciated Soils

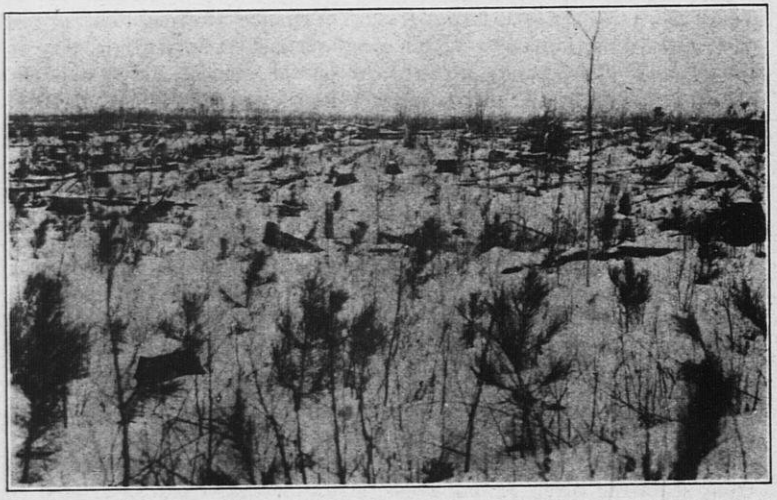
Southwestern Wisconsin is unglaciated and has an erosion problem more general in extent than any other region of the state. This problem is particularly serious in the places where soil was originally deposited either by winds or by water. Here deep gullies may start and will ultimately undermine large trees. In many other sections, surface or sheet erosion, as contrasted with gullying, constantly depletes soil fertility.

Where gullies are the principal problem, reforestation is a measure of prevention more than it is a remedy. However, reforestation can be used to supplement other engineering remedies such as the Adams

dam. The sheet or surface erosion planting situation is essentially similar to that of the old or abandoned field. Methods of planting old fields, and choice of species are discussed on page 25.

Burned Over, Non-plowable Lands

The heavy, very stony glacial soils, characteristic of some uncleared regions in northern Wisconsin which have been cut over and badly burned over, can be successfully replanted. They present difficult situations which add to the cost of reforestation. Because of their extreme stoniness, and frequently because of dead and down timber, plowing of furrows is impossible. Yet the soil is usually fertile, and is capable of growing timber stands of the very highest quality. On



A three year old plantation of Norway pine on stony, cut and burned over land.

this type of soil, timber crops may be grown for saw logs on a rather long rotation, as well as for pulpwood on shorter rotations.

White pine, Norway pine, Norway spruce, and white spruce are the species best adapted to these soils, but mixing of species at the time of planting is not an important factor because hardwood growth, principally sugar maple, birch, basswood, and ash is certain to occur in varying degrees to compete with the conifers. This produces a highly desirable mixture. The conifers and the basswood, generally faster growing than the other hardwoods, will furnish the first harvest to be followed from 20 to 40 years later by a cutting of the remaining hardwoods. Generally the spruces will be adapted to the heavy, moist soils on the lower parts of the glacial hills, while the pines should be planted on the upper slopes and on tops of hills.

The grubhoe is the most necessary tool for planting on this heavy soil. Frequently there is a thick layer of partly decayed duff which

must be scalped off. This precaution is important even though it increases the cost of planting.

When young hardwoods, including basswood, maple, and birch were present before the burn, an eight by eight-foot spacing is quite satisfactory. This reduced number of trees per acre helps to offset the higher planting costs due to the greater time required to plant each tree.

Under-planting in the Farm Wood Lot

Farmers in the southern half of the state, observing a gradual thinning out of their grazed wood lots with no young trees coming on, are turning to artificial reforestation. Although these wood lots consist of hardwoods, usually oaks and hickories, the conifers such as white pine, and white and Norway spruce should be used for planting, possibly with some black locust to provide fence post material. The conifers withstand the shade of the remaining trees, they grow more rapidly than hardwoods under these conditions, they are not attacked by the serious root diseases which appear to be especially harmful to several species of oaks, and they are valuable for lumber or pulpwood.

White pine should be chosen for the lighter soils, and where the most open conditions of tree growth prevail. White and Norway spruce can endure somewhat heavier shade, and should be planted on the heavier soils, but after the plantation is established the density of the over-topping hardwoods should not exceed a 40 per cent shading of the ground. Probably no owner will attempt to measure the density of shade exactly, but it can be estimated fairly accurately. Roughly, it means that at noon in summer time not over two-fifths of the ground is shaded.

The system of planting trees in rows is discarded, and instead only the openings in the wood lot are filled in with planted trees, at such a density that the trees are about six feet apart. Transplant stock must be used because with its better developed root system it can withstand the partial shade and competition from roots of other plants, where seedling stock would fail.

Sometimes portions of wood lots have been clear cut, followed by attempts at pasturing, in which hardwood sprouts, briars, hazel or alder have nearly taken possession. Planted trees cannot break through such advance growth if the tres are planted in the midst of it, even if the area has been burned off previously. Planting must be restricted to the open spots, but under extremely brushy conditions success with plantations is impossible.

Under-planting of White Birch-Aspen Lands

The most extensive forest types in northern Wisconsin are white birch and aspen. They have resulted invariably from heavy burns following logging operations. Field surveys indicate that a low percentage of the land included in the aspen type has a satisfactory amount of the more valuable conifers mixed with the aspen, and it appears

that the white birch type has even a lower percentage. On the heavier soils the other hardwoods are frequently found mixed with the aspen, so that the future of these lands as producers of valuable forest products is not as hopeless as may first appear. But in many places underplanting is a sound investment, with the ultimate conversion of the aspen stand into a stand of conifers. The primary objective of such an undertaking is the growing of saw timber or pulpwood products.

Aspen or birch stands constitute what may be called a nurse crop if they are very scattered, if they have grown beyond the age of small brush into trees six or eight inches in diameter, or if they are sufficiently dense so that over-crowding and dying of some trees has taken

This picture and the one on the following page show how aspen stands can be converted to white pine or spruce by proper underplanting. This picture shows white pine growing under aspen.

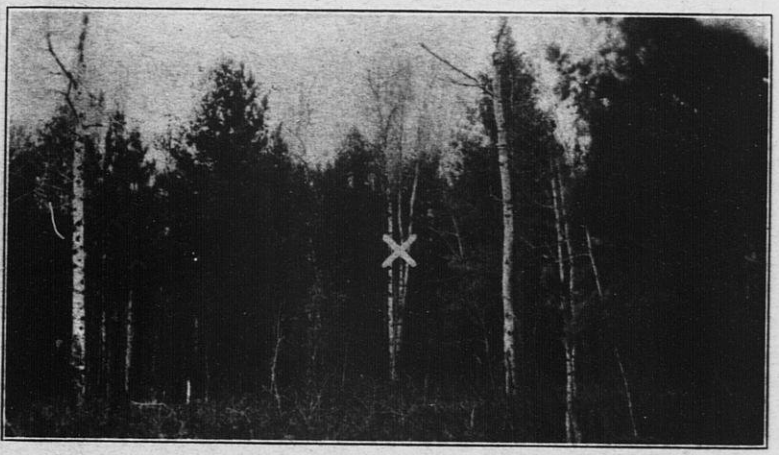
place. Such stands tend to protect rather than hinder the growth of young coniferous and hardwood trees. If the density of the aspen is such that not over 50 per cent of the ground is shaded, under-planting may be begun safely.

The quality of the aspen trees themselves is a very good indicator of what trees can best be used in under-planting. Short, low branching aspen trees, rather open-growing, frequently with cankered or deformed limbs and bark, indicate light soils where white pine and, in more open conditions, Norway pine may be planted. The taller, straighter thickets of aspen always indicate soils of good quality. On these soils the more shade-resistant trees, the white or the Norway spruce, should be planted. White pine is the first choice for underplanting white birch. The spruces may be planted where the soil is moist and not too sandy. Norway pine is best for planting in the more open areas.

Furrowing is usually impossible, and it may not be possible to follow even a moderately straight alignment of trees in rows. A spac-

ing of eight by eight feet is sufficiently close. It is important to make the most use of any small openings in the thicket for the placing of the trees and to plant the trees well into the mineral soil, rather than just into the duff of partly decayed aspen or birch leaves. The grub-hoe is necessary for making proper holes and removing duff and matted roots.

Gradual thinning out of over-topping aspen or birch is necessary, and the products so cut may be useful for excelsior or pulpwood.



Same area as shown in the picture on the opposite page. This view was taken nine years later and shows how the white pine is predominating. Crosses indicate same tree to enable close comparison.

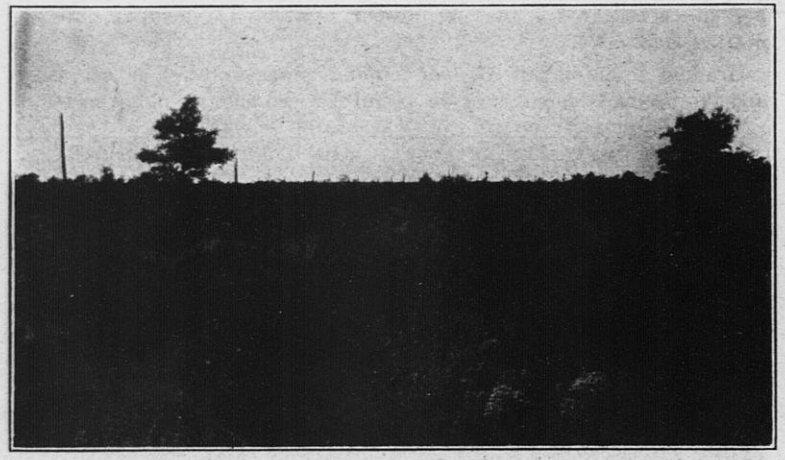
Planting in Old Fields

Portions of cleared lands to be reforested may represent a wide group of soil types, some of which have been described previously in this series of planting conditions. Plots unsuitable for plowing or pasturing because of stoniness or inaccessibility are the ones most likely to be planted by farmers. The soil on such areas may be sandy and light, or very stony as in the kettle moraine district. Suggestions made previously for planting sandy and light, or stony soils are applicable here.

There are a few features characteristic of old fields which justify a separate discussion. Frequently old fields are badly infested with weeds, including the Canada thistle and quack grass. Ultimately planted trees will smother out weeds, if the young trees are able to withstand the first eight or ten years of competition from the weeds. This may mean partial cultivation to destroy the most detrimental weeds nearest the young trees. This partial cultivation is facilitated by planting the trees in rows.

Furrowing is always advisable and especially where there is any sod. If the old field is on a hillside, the furrows should be plowed in a way not to start gullies or ditches. The standard six by six-foot

spacing is desirable. The choice of trees will be determined by the soil—jack pine or Scotch pine for very sandy soils, Norway pine and white pine for the moderately sandy soils, and the spruces for heav-



Four year old jack pine plantation on Plainfield sand.

ier soils of moderate fertility. Mixed plantings of two or more species, where the soil is at all variable, are preferable to plantations of a single species.

Swamps

Swamps are considered here, not because they are suitable planting areas, but because advice about planting partially drained or undrained swamps is frequently requested. Practically all swamps are unsuitable for planting, both because of the cost and difficulty of getting trees started, and the slow rate of growth.

Swamps are not suitable for planting if water collects on the surface during much of the growing season, or if the vegetation consists more of rushes and sedges than of grass and the broad-leaved weeds. If the true grasses and broad-leaved weeds thrive, planting is possible and black spruce, white cedar, or tamarack are the best species to plant.

The following table summarizes the suggestions offered with reference to the most suitable plantation for different conditions.

TAB LE II

Planting Types, Objectives, and Recommended Practices

Planting Type	Objective	Choice of Species	Land Preparation & Planting Methods	Spacing
Blow sand	Prevent soil drifting	Jack pine Scotch pine	None; planting spud or spade	Irregular, with reference to location of blow pits
Sand plains and ridges	Pulpwood and timber	White pine Norway pine Scotch pine Jack pine White spruce	Furrowing Planting spud or spade	6 x 6 or wider if scattered growth is present
Kettle moraines	Fuelwood and farm needs; conserving moisture	Norway pine Scotch pine Jack pine	None; scalping sod; Mattock	6 x 6 or irregular
Limestone hills	Fuelwood and farm needs; conserving moisture	Jack pine Scotch pine	None Mattock	Irregular
Eroding soils	Timber; soil conservation Fuelwood	White pine Norway spruce White spruce	Furrowing cleared hillsides Mattock	6 x 6 or irregular
Stony, heavy burned-over soils	Pulpwood and timber	White pine White spruce Norway pine Norway spruce	None Mattock	6 x 6 or irregular
Under-planting: the farm wood lot	Fuelwood and farm needs	White pine White spruce Norway spruce	Furrowing if possible; remove brush Mattock	Irregular
Under-planting: birch–aspen	Pulpwood and timber	White pine Norway pine White spruce Norway spruce	None Mattock	Irregular
Old fields	Pulpwood; fuelwood; timber	Any of usual species, depending upon type of soil	Furrowing Spade or planting spud for light soils Mattock for heavy soils	6 x 6

Planting Costs

The wide variety of conditions under which planting may be done suggest a rather wide range of planting costs. The following tabular summary, based upon age and species of planting stock, and a density of 1,200 trees per acre represents the range within which one may reasonably expect to keep his planting costs. It should be observed that while furrowing may at first appear to increase planting costs, it will actually help to reduce costs. The amount of practice a planting crew has had is always an important factor in relative costs. For that reason small plantations, completed before the planting crew has become proficient in its work cost more per acre than larger plantations.

TABLE III
Cost of Plantation

Kind of Tree	Age of Stock	Cost per Thousand trees	Total Labor and Tree costs per acre; 6 x 6 spacing; 1200 trees
White pine or Norway pine	2 yr. seedlings	$3.00	Furrow–slit $ 5–$ 7
	3 yr. seedlings	$4.00	Hole (Grubhoe) $ 9–$12
	2–2 transplants	$6.00	
Norway spruce or White spruce	2 yr. seedlings	$3.00	Furrow–slit $ 7–$ 9
	3 yr. seedlings	$4.00	Hole (Grubhoe) $12–$15
	2–2 transplants	$7.00	
Jack pine	2 yr. seedlings	$3.00	Furrow–slit $ 5–$ 7
Scotch pine	2 yr. seedlings	$3.00	Furrow–slit $ 5–$ 7
	2–2 transplants	$7.00	Hole (Grubhoe) $ 9–$12

Plantations for Special Products and Purposes

Trees are frequently planted for purposes other than lumber, pulpwood, or firewood. These include walnut groves, Christmas tree plantations, and windbreaks. Although the fundamental principles of forest planting apply to all such cases, there are certain modifications for each which should be followed in order to secure best results.

The Walnut Grove

Walnut trees are adapted to the rich moist bottom lands in the southern half of the state. They should never be planted on ridges or dry slopes, because of the extremely slow growth they will make on these unfavorable soils.

In addition to the right kind of soil, the success of a walnut plantation is influenced by two other factors—the planting of pre-treated nuts or of seedlings not more than two years old, and a mixing of the walnuts with other trees.

Pre-treating consists preferably of controlled temperatures and moisture treatment for 40 to 50 days before planting. Walnuts which are allowed to dry out over winter before planting in the spring will germinate very poorly if at all. They may be carried over winter successfully if they are mixed with an equal volume of moist sand, placed in a shallow crate, and either buried about 15 inches in the ground or covered out-of-doors with a compost of leaves or straw. The nuts may also be stored in a cool, moist place until about March 1. This should be followed by storage at a constant temperature of 36°—38° F., in a mixture of wet sand until about April 20, when they will be ready for direct planting in the field or in nursery beds. This latter method is practical when it is possible to use commercial refrigerator space, and it has the advantages of complete temperature control, prevention of loss by rodents, and the recovery of nuts which may have become dried out when not stratified.

If the nuts are to be planted in a garden seed bed, they should be sown three inches apart in drill rows eight inches apart, in well prepared soil. They should be planted about two inches deep and the soil covered with burlap until the nuts germinate. The young seedlings need no particular care, other than reasonable weeding, and watering in case of extreme drought.

The planting site in the field should be furrowed at six-foot intervals. Not over 30 per cent of the trees planted should be walnuts. The other trees recommended for planting with walnuts are ash, basswood, sycamore, red or swamp maple, or American elm. They should be planted as one-year or two-year old seedlings. Walnuts do not grow naturally in pure stands, and the results observed in many pure plantations set out in the past 25 years in various parts of the Mississippi valley indicate that trees in a pure plantation do not thrive after they

reach an age of 20 to 25 years. On the other hand, walnut trees growing in mixture with other trees generally maintain a very satisfactory rate of growth. A grove containing as many as 300 walnut trees per acre, if mixed with other trees, is sufficient for either nut or timber production, and as the stand becomes crowded, the other hardwoods may be thinned out for fuelwood.

If seedling stock is used, the long tap roots of the young trees should be cut back to a length not to exceed 10 inches. Planting should be completed before the trees leaf out. A spade or grubhoe is most serviceable for making the planting holes.

Stratified or pre-treated seed requires planting between April 20 and May 1. The nuts should be planted about two inches deep, and covered with loose soil. A shovel should be used to loosen the soil to a depth of 10 inches. The other hardwoods may be planted at this time, in the same way that walnut seedlings are planted.

Christmas Tree Groves

The frequently asked question, "Is it profitable to grow Christmas trees in a plantation?" has no widely applicable answer. Well-shaped, freshly-cut trees from a plantation have a distinct advantage over wild trees cut weeks in advance of the holiday season. Wild trees sell for only a few cents each on the stump. The much higher prices finally paid by the customer include transportation costs and wholesaler and retailer profits. Whether plantation grown trees can compete with wild trees depends upon the plantation being near enough to a large market to reduce transportation costs, a volume of production sufficiently large to meet wholesalers' requirements, or an assured direct retail market.

Assuming the prospective Christmas tree planter has satisfied himself of the economic soundness of the venture, some information on the choice of trees, source and sizes of stock, planting methods, and care of the plantation are of value.

Choice of Trees

Although there are many kinds of trees marketed for Christmas trees, the choice for planting in Wisconsin is quite limited. Norway spruce will probably be most commonly planted for this purpose, principally because of the economy possible in obtaining seedling stock. It makes a fairly rapid and uniform growth. It is unwise to stimulate faster growth by the use of fertilizers, because this will produce tall, open-grown trees which are not nearly as desirable for Christmas trees as the compact, closely-grown trees. The native white spruce is very similar in appearance to the Norway spruce. It has somewhat shorter needles, grows more slowly, and therefore is generally more compact. Some markets will not accept this tree because of a reputed offensive odor given off by it after it has been kept in a warm room for several days. The black spruce of our northern swamps probably would be an excellent tree in a plantation where the soil is moist and has a high percentage of humus or peat.

Douglas fir, a tree of the Rocky Mountains and Pacific slopes, possesses ideal form, compactness and ability to retain its needles. It is rather slow growing, except on reasonably fertile and moist soils. The northern Rocky Mountain variety rather than that from the Pacific slopes must be used as only this variety is adapted to Wisconsin conditions.

Balsam fir is sold extensively in the markets because it is an excellent tree, and if successfully planted it should bring a profitable return. However, balsam is not always easy to plant. It grows rather slowly at first and if grown too closely or crowded by weeds, it sheds the needles of its lower branches, a condition which must be avoided in a Christmas tree.

All of these trees require moderately good soil. Distinctly sandy soils must be avoided. It is not true that any worn-out fields on the farm are suitable for growing Christmas trees. The soil may be of low fertility, but it should be a loam or gravelly loam soil, well-drained but moist. Badly eroded soil, from which the greater part of the plant food has been carried away, will not produce well-shaped, deep-colored trees.

Source and Size of Stock

Section two of the agreement between the conservation department and purchasers of trees requires that the purchaser "will not dig, cut off, or move these trees after planting until they are large enough to be sold for merchantable timber." This definitely applies to Christmas tree plantings, and therefore trees from the state nursery cannot be planted for Christmas tree purposes. Moreover, although there is an increasing demand for living Christmas trees, the resale of young trees purchased from the conservation department is forbidden. The trees, therefore, will either have to be grown from seed or be purchased from a private nursery.

Considerable care and skill is required in growing evergreen trees from seed, and losses of trees are often high during the first year of growth in the seed bed. Methods of seeding and seed bed construction will not be discussed here, but interested persons are referred to the United States Department of Agriculture Farmers' Bulletin No. 1453, "Growing and Planting of Coniferous Trees on the Farm." Other references will be found in the appendix of this bulletin.

Private nurserymen usually have for sale, at special prices for large lot deliveries, one or more of the suitable Christmas tree species. They may be either seedlings or small trees once transplanted. The transplants are preferable, because they grow more rapidly immediately after planting and losses in planting are usually lower.

Planting Methods

Some soil preparation is desirable. If the soil between the rows is to be cropped for several years, the whole plantation area should be plowed and the trees planted in rows, preferably in check rows, in the cultivated soil. The planting, cultivating, and harvesting of a possible

intermediate crop, such as sweet corn, pop corn, or a root crop will provide sufficient cultivation of the trees. If no intermediate crop is to be grown, then the soil should be prepared in advance of the planting by plowing three 10-inch furrows for each row, and planting the trees in rows in the middle furrow. This will permit light cultivation and some weeding with a hoe. A spacing of four feet by four feet is recommended.

Care of the Plantation

Cultivation will hasten the growth of the trees, but too rapid growth produces long annual leaders, with a few scattered branches. This feature is distinctly undesirable in Christmas trees. For this reason, cultivation should be carried on only to the extent that the worst of the weeds are kept down, and the surface soil above the roots of the trees is kept reasonably loose, to conserve the soil moisture. Three or four light cultivations a year for the first four years are sufficient. After the fifth year one or two cultivations each year will suffice. At this age the trees naturally begin to increase their rate of height growth. The soil should never be limed, and even fertilization is not desirable. On heavy soils where frost heaving is common, it is well to keep the young trees mulched with straw or weeds from December 1 to April 1 for the first four or five years.

Probable Date of Harvest

If small, living Christmas trees are wanted, the first trees suitable for this market will be large enough by the fourth year after planting. There will be wide variations in the rate of growth of trees in the same plantation, and some trees may be held profitably until the twelfth or fifteenth year after planting. Trees of this age would make large living Christmas trees for church, school, or home grounds, and they would be equally salable for Christmas trees for interiors. Under most conditions, the whole crop may be harvested within 12 years.

Windbreaks

Conifers have long been used for planting around farmsteads to protect the house and the buildings from strong winter winds. Three factors contribute largely to the success of a tree plantation designed for this purpose, namely preparation of the soil, the choice of species, and the spacing and number of rows of trees in the windbreak.

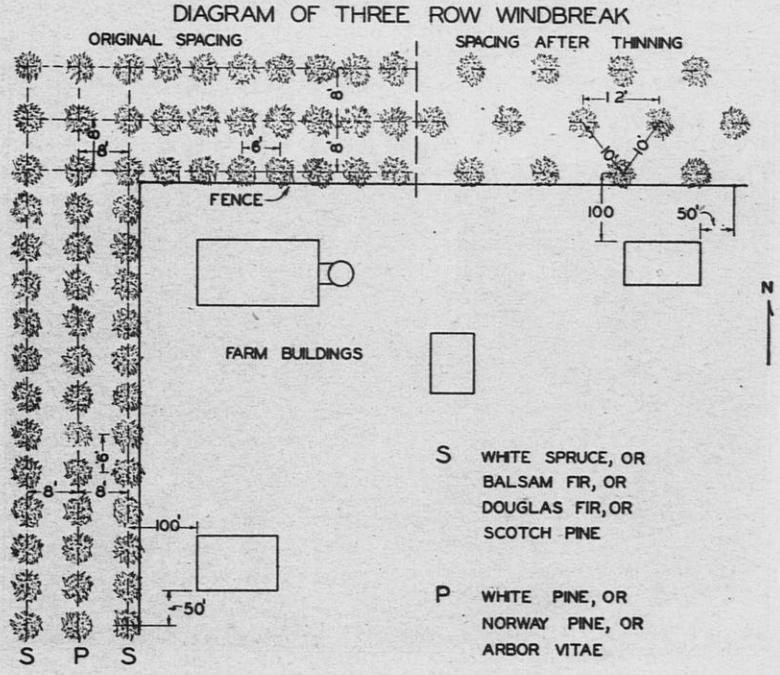
In a windbreak the most rapid height growth possible is desired, and consequently thorough preparation of the soil is important. The area selected for the windbreak should be plowed deeply in the fall of the year. At this time also the area should be well fertilized with rotted livestock or poultry manure. This preliminary preparation should be followed by thorough discing in the spring.

The best distance for a windbreak is from 100 feet to 125 feet from the buildings to be protected, with the rows of trees extending 50 feet beyond the buildings or yard to be protected. Two rows of trees in a

windbreak are advisable and three rows are preferable. Trees should be spaced six feet apart in rows that are eight feet apart. Trees should be in check rows, instead of staggered.

On all light sandy soils white pine, Norway pine, and Scotch pine are the best trees, although on all bad blow sand areas jack or Scotch pine might be used on the outside row, the row most directly exposed to the full force of the wind.

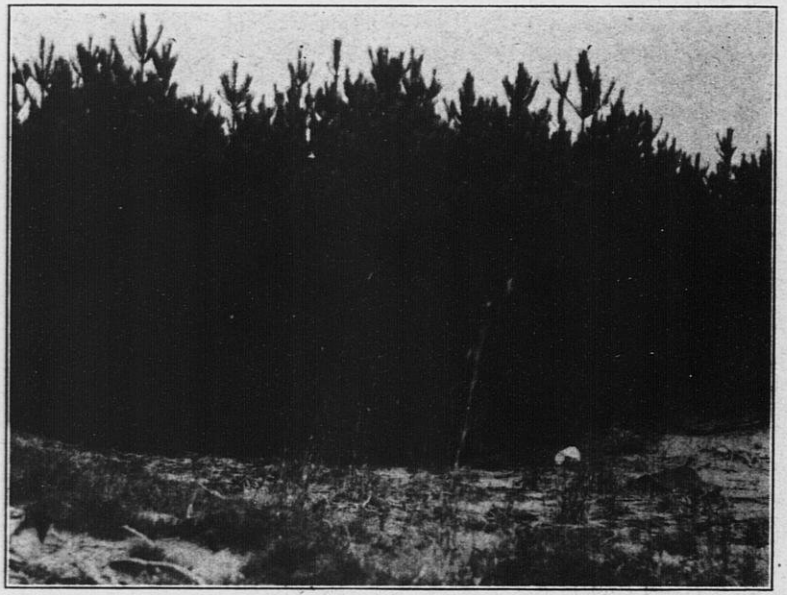
On moist, clay or loam soils Norway or white spruce may be planted with the white or Norway pine. Other trees which make compact



windbreaks and grow well on good soils are white cedar or arbor vitae, balsam fir, and Douglas fir of the northern Rocky Mountain variety. The Colorado blue spruce makes a very compact windbreak, but its rate of growth is so slow that many years elapse before it becomes serviceable.

It is well to use at least two kinds of trees in a windbreak. One row of the spruces or firs in the windward, or outside row, and one or two rows of the white or Norway pine on the leeward or protected side of the plantation make an excellent combination. The spruce trees generally maintain their side branches down to the ground when grown in the open, thus effectively stopping wind from driving through under the trees; and the pines, because of more rapid growth, make the windbreak effective at a comparatively early date. In addi-

tion, any serious disease or insect is not as likely to destroy all species of trees in a windbreak as it is to center its activities on just one species. In the event of such an outbreak the windbreak of several species will not be completely destroyed.



Norway pine planted at the edge of a blow pit stops the drifting of the sand.

How Fast Does a Plantation Grow?

There are many plantations of different species of trees in Wisconsin which, although they are making a promising growth, are not large enough to be measured for cubic volume growth. There are also a few outstanding plantations made before there was much general interest in forest planting, which offer a very reliable basis for suggesting what we may expect from plantations made today. These include the Walter Ware plantation of white pine near Hancock; white and Norway pine in the Gebhardt plantation in the vicinity of Millston; white, Norway, and Scotch pine at the Nye-Hayes plantation near Wascott; Norway and Scotch pine at Star Lake in the Northern State Forest; and Norway spruce in the Louis Frank plantation at Prescott. Measurements made during the summer and early fall of 1931 in all of these older plantations, and in 25 others more than 14 years of age, are used to show height and diameter growth under varying soil conditions. The Norway spruce plantation at Prescott is used to indicate in more detail the growth of the average tree in a spruce plantation growing on a silt loam soil, the soil for which spruce is best adapted.

Height Growth

Height growth is generally considered a site index, the quality of the location as influenced by the soil, climate, and topography. Generally speaking, rapid height growth indicates favorable site conditions. However, density, or degree of stocking has a great effect on height growth. The greater the number of trees up to a certain maximum, the more rapid the height growth, but at the expense of diameter growth. The method of planting and care of the plantation after planting affect height growth. Insufficient removing of ground cover which allows too great root competition, too much shade, or both, retards height growth. Cultivation after planting enhances it.

The following table shows the approximate height growth which may be expected from a stand of white, Norway, and Scotch pine in Wisconsin up to 21 years of age for white and Scotch pine, and 23 years for Norway. It is based on measurements in six white pine plantations, 10 Norway pine plantations, and 10 Scotch pine plantations.

The author is indebted to W. W. Morris, of the State Department of Agriculture and Markets, for the information presented here on growth of plantations.

TABLE IV

Average Plantation Growth of White, Norway, and Scotch Pine in Wisconsin

	White Pine		Norway Pine		Scotch Pine	
Total age Years	Approx. range in ht. gr. per year Inches	Average total height growth Feet	Approx. range in ht. gr. per year Inches	Average total height Feet	Approx. range in ht. gr. per year Inches	Average total height Feet
1	1.0– 5.5	.21	1– 6	.24	1– 6	.24
2	2.0– 8.0	.61	1– 7	.58	1– 7	.56
3	3.0– 9.0	1.10	3– 9	1.09	3– 9	1.07
4	6.0–12.0	1.86	5–11	1.77	5–11	1.42
5	4.0–10.0	2.47	5–11	2.43	6–12	2.48
6	4.0–10.0	3.22	5–11	3.07	7–13	3.35
7	9.0–15.0	4.10	10–16	4.12	9–15	4.40
8	11.0–17.0	5.27	12–18	5.37	10–16	5.53
9	15.0–21.0	6.75	12–18	6.63	13–19	6.83
10	19.0–25.0	8.55	14–20	8.06	15–21	8.37
11	18.0–24.0	10.32	17–23	9.71	15–21	9.89
12	18.0–24.0	12.12	16–22	11.32	14–20	11.35
13	17.0–23.0	13.78	18–24	13.08	16–22	12.92
14	17.0–23.0	15.46	19–25	14.91	16–22	14.53
15	17.0–23.0	17.17	18–24	16.66	17–23	16.16
16	13.0–19.0	18.54	18–24	18.42	17–23	17.82
17	13.0–19.0	19.89	16–22	20.02	18–24	19.53
18	12.0–18.0	21.14	15–21	21.56	18–24	21.27
19	12.0–18.0	22.43	18–24	23.32	18–24	23.04
20	11.0–17.0	23.60	22–28	25.41	17–23	24.71
21	12.0–18.0	24.85	21–27	27.41*	12–18	25.96
22			21–27	29.41*		
23			18–24	31.16*		

*Averages for one plantation only.

The foregoing table indicates that the period of active height growth for young white pine plantations in Wisconsin commences about the tenth year. Norway pine appears to begin its period of rapid growth about its eleventh year. Scotch pine seems to increase more uniformly in height growth every year than the others, reaching a fairly stable rate about the nineteenth year.

Diameter Growth

Density of the plantation and quality of soil are important factors in affecting diameter growth. The greater the number of trees present the smaller the diameter, and the more the height growth is forced at expense of diameter growth. Even on the poorest Plainfield sand good diameter growth is found when the stand is not planted too densely. However, the influence of soil and other site factors on diameter growth can be seen in the white pine plantation at Nelson Dewey State Park. Here there is a closely planted stand growing in a space which averages about 22 square feet to the tree on a silt loam soil. This plantation has not been attacked by the weevil. Because of this and its greater density, its height growth is considerably above the average. The average diameter of this 16 year old stand is 4.1 inches, which is .6 of an inch above the average for all observed plantations of white pine in Wisconsin at this age. This favorable height growth and diameter must be largely attributed to the soil.

Interior and exterior views of white pine plantation 34 years old, averaging 40 feet in height. Plantation is located north of Hancock in Waushara county. Average tree in the foreground, eight inches in diameter breast high. The largest tree in the plantation is 12 inches in diameter breast high.

The following table shows the relationship of age and average diameter of all plantations studied, and is a fair indication of what we may expect from most planted stands, if they are reasonably well stocked.

TABLE V

Table of Average Diameter and Age for White, Norway, and Scotch Pine and Norway Spruce Plantations in Wisconsin

Plantation Age	White Pine Average Diameter Breast High (4½ feet)	Norway Pine Average Diameter Breast High (4½ feet)	Scotch Pine Average Diameter Breast High (4½ feet)	Norway Spruce Average Diameter Breast High (4½ feet)
Years	Inches	Inches	Inches	Inches
5	0	0	0	0
10	1.2	1.2	1.2	1.0
15	3.3	3.4	3.2	2.0
20	5.1	5.3	5.2	3.4
25	6.4	6.9	7.2	4.7
30	7.4	8.4		6.0
35	8.2	9.7		7.0
40	8.9			8.0
45	9.5			
50	10.0			
55	10.3			
60	10.7			

Note: Add two or three years for total age from seed for the pines and three or four years for spruce.

Based on diameter measurements of 2,455 Norway pine in 11 plantations, 2,185 Scotch pine in 12 plantations, 2,861 white pine in nine plantations and five windbreaks, and diameter measurements of 559 Norway spruce and a complete stem analysis of 69 Norway spruce. With the exception of two white pine plantations, all were growing on sandy soils, mostly Plainfield sand. At the age of 25 years, all pine plantations averaged six inches or more in diameter. At 30 years pine plantations in any section of the state should safely average over seven inches. Scotch pine averages about one and one-half inches greater in diameter than Norway, and one inch greater than white pine at 30 years of age.

The last readings on Norway and Scotch pine were obtained by projecting the curve, as no plantations of over 30 years of age were obtainable for these two species.

The average spacing for white pine was 8 x 8 feet, or 64 square feet per tree, for Norway pine 6 x 6 feet, or 36 square feet, and for Scotch pine 5 x 6 feet, or 30 square feet per tree. The exact spacing of the plantation of Norway spruce is not known but it was quite close, possibly 4 x 4 feet, mixed with Scotch pine, which has died out.

Volume Production and Yield per Acre

The amount of merchantable material that a stand produces in a given time is the chief basis for determining the value of a forest plantation. Therefore, knowledge of what a few Wisconsin plantations have produced is helpful in indicating future volume growth. This volume is generally expressed either in cubic feet, cords, or board feet. The most accurate method of showing what a stand contains is to determine its contents in cubic feet. Board foot measure is used for large dimension stuff and saw logs, but does not show accurately the true amount of material actually found in a log, especially in small sizes. However, a stand may contain a considerable volume in cubic feet and yet not be merchantable because it has not yet reached sufficient size to be taken as a merchantable product. It is important therefore to know what sizes, and especially the minimum sizes, that material for various uses are marketable.

In Wisconsin, pulpwood is the chief use for small size material, and this is measured by the cord. The minimum size product taken at present is a stick four inches in diameter at the small end and eight feet in length. These dimensions are first attained by pine plantations when the tree is about six inches in diameter breast high. Some trees of this size will appear in the stand at about 18 years, but the average time required to attain this diameter is 25 years. Young plantations of pine produce an eight foot stick with a two inch top at about 13 years of age. It has been found in a study of a Norway spruce plantation that the tops from a four inch diameter point in the tree to a two inch diameter point contain from one per cent of the total cubic foot volume for a 10 inch tree to 16 per cent for a five inch tree. This means that at an age of 30 years and a diameter of six inches, for every seven cords taken for pulp, one cord is left in the woods, if the trees are cut to a four inch top instead of to a two inch top.

Example Plantation*

This plantation of 0.84 of an acre was planted 38 years ago with young Norway spruce seedlings, the seed of which had been sent to this country from Germany. It is probably the only wood lot plantation of Norway spruce of merchantable size in this state. It is growing on a silt loam soil. Originally Scotch pine was planted intermixed with the spruce, the probable spacing of all species being about 4 x 4 feet. The Scotch pine did not survive and now only the spruce are left with five European larch which have also made an excellent growth. A rough eye estimate of the density would place it at approximately 80 per cent of a fully stocked stand.

The average diameter of the stand is 7.7 inches diameter breast high. Four and one-half cords of eight foot peeled sticks were thinned from this stand for pulp during the summer of 1931 and two cords were cut about two years previous to this thinning.

The average growth in this plantation shows that an eight foot stick, four inches inside bark at small end, was produced in about 23 years.

At present there is left on this small plantation 39 cords of spruce figured to a diameter of two inches in the top of the tree, which is equivalent to 47 cords per acre. Adding the six and one-half cords already removed, there is a total of 54 cords per acre which this stand of Norway spruce has produced at a plantation age of 38 years, averaging 1.4 cords per acre per year throughout its life. Trees range from four to 13 inches in diameter at breast height. The average total height is 55 feet, and there is an average of four and one-half eight foot pulpwood sticks per tree, when figured to a four inch top. The total number of trees now left (acre basis) is 506. Of this number 438 trees are merchantable and 68 trees are suppressed. The cubic volume of the average tree remaining (not including the suppressed

*Norway Spruce Plantation at Prescott, Pierce county, Wisconsin.

Table VI

Average Cubic Volume Per Acre Produced in Plantations of Norway, White, and Scotch Pines in Wisconsin, at Five Year Age Intervals

Norway Pine				White Pine				Scotch Pine			
Age in Plant. Years	Vol. cu. ft. per acre	No. of solid cu. ft. per cd.	No. of cords per acre	Age in Plant. Years	Vol. cu. ft. per acre	No. of solid cu. ft. per cd.	No. of cords per acre	Age in Plant. Years	Vol. cu. ft. per acre	No. of solid cu. ft. per cd.	No. of cords per acre
5				5				5			
10	150	67	2.2	10	130	67	1.9	10	100	67	1.6
15	600	69	8.7	15	450	69	6.5	15	500	68	7.3
20	1,375	71	19.3	20	1,000	71	14.1	20	1,270	69	18.4
25	2,600	73	35.6	25	2,060	73	29.0	25	2,200	71	30.0
30	5,850	78	50.0	30	3,250	76	42.7				
				35	4,625	78	59.3				

Note: Taken to a two inch diameter at the top. No volume measured in a tree that did not have an eight foot stick with a two inch top. Each species reaches the height of four and a half feet in about seven years, at which time the tree begins to put on diameter breast high, and potential volume begins, but is not shown in table until a stick eight feet long with a two inch top is produced. Although this early volume is probably not a merchantable volume, it is potentially present, and as soon as a definite size is reached, (as for instance 6″ D. B. H.) it enters the merchantable class.

trees) is 8.1 cubic feet figured to a two inch top and 7.6 cubic feet to a four inch top, the latter figure representing the present merchantable volume per tree.

Complete stem analyses were made on 69 trees. The trees were cut into eight foot lengths, and the volume computed to two inch and to four inch tops. The growth as determined from the stem analyses follows:

Table VII

Growth Table for Average Norway Spruce Tree Based on Age at Stump

Louis Frank Plantation, Prescott, Wis.

Age at Stump	Diameter inside Bark at Stump	Diameter Breast High (outside bark)	Total Height Above Stump	Height from Stump to 2" Top	Height from Stump to 4" Top	Volume to 2" Top D. I. B.	Volume to 4" Top D. I. B.
Years	Inches	Inches	Feet	Feet	Feet	Cu. Ft.	Cu. Ft.
5	.2	.0	2				
10	1.3	1.0	5				
15	2.7	2.0	14				
20	4.3	3.2	25	17		.1	
25	6.2	4.8	38	30	16	2.1	1.7
30	7.8	6.0	46	38	27	4.3	3.8
35	8.8	7.0	51	42	32	6.5	6.0
40	9.5	8.0	57	45	37	8.7	8.4
45	10.1	8.9	60	47	41	11.0	10.7

Notes: 1. D. I. B. means diameter inside bark.
2. Figures for age of 45 are taken from a slightly projected curve, extending beyond the actual age of the stand.
3. Height of stump is one-half foot.

Growth on Principal Soil Types

Plantations were studied in five different soil types, (1) Plainfield sand, (2) Vilas sand, (3) Vilas sandy loam, (4) loam, and (5) silt loam. On all of these soil types pine made rapid growth and no soil type or region of the state was studied that would not warrant growing timber upon it, from the standpoint of financial returns. The most rapid volume production observed was for a mixed plantation of Norway and white pine 29 years of age growing on a worn out field of Plainfield sand. The most rapid growth for a 15 year old plantation of white and Scotch pines was found on a silt loam soil in Nelson Dewey State Park.

The following table summarizes the height growth found in plantations of pine on the principal soil types, representative of those which will be most generally used, in northern and central Wisconsin.

TABLE VIII

Average Annual Height Growth (inches) of Trees in Plantations of White, Norway, and Scotch Pines, on Four Representative Types of Soils

Species	Locations	Average height growth per year on:				Age of Plantation in which average growth was determined
		Silt or loam	Vilas sandy loam	Vilas sand	Plainfield sand	
White pine	Nelson Dewey Grant county	21.1				14
	Devil's Lake Sauk county	19.6				15
	Weaver plantation Oneida county		16.7			19
	Hancock Waushara county				14.3	28
Norway pine	Nye–Hayes, Gordon Douglas county				16.5	15
	State plantation Star Lake, unpruned		16.9			19
	Gebhardt plantation Millston, Jackson county				14.7	23
	State plantation Muskellunge lake, Vilas co.			12.4		18
Scotch pine	Nelson Dewey Grant county	20.0				14
	Weaver plantation, Woodruff Oneida county		14.0			19
	State plantation Muskellunge lake, Vilas co.			12.2		18
	State plantation Boulder Junction, Vilas co.				11.8	16

Since the rate of height growth of trees in a fully stocked plantation is a very good indication of the soil quality from a timber growing standpoint, the foregoing table represents the relative productivity of these several soil types, for the same species of trees.

BIBLIOGRAPHY

Forest Planting in the Lake States

U. S. Department of Agriculture Bulletin 1497

Growing and Planting Hardwood Seedlings on the Farm

U. S. Department of Agriculture Farmers' Bulletin 1123

Growing and Planting Coniferous Trees on the Farm

U. S. Department of Agriculture Farmers' Bulletin 1453

Planting and Care of Street Trees

U. S. Department of Agriculture Farmers' Bulletin 1209

Christmas Trees—A Crop for the Farm

U. S. Department of Agriculture Farmers' Bulletin 1664

The Farm Windbreak—Its Planning and Planting

Radio circular, College of Agriculture, University of Wisconsin

Tree Planting Book

The American Tree Association, Washington, D. C.

INDEX OF TABLES

GENERAL INDEX

Eighteen year old pine plantation on a farmed out field in central Wisconsin.

"He that plants trees loves others beside himself."

ANCIENT PROVERB.