Forest Planting in Michigan
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White pine plantation at the Michigan State College, thirty years after planting. The trees average 8.7 inches in diameter and 54 feet in height.

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FOREST PLANTING IN MICHIGAN

By ALFRED K. CHITTENDEN

One of Michigan's greatest problems is that of replacing her forests. This is becoming increasingly important as the timber of the United States as a whole is being cut. Nature if given a chance will restore the forests of her own accord but this is a slow process and the composition of the second growth is often not of the best species. This means that if valuable forests are to come back a big share of the trees must be planted. Some of the land which should be growing trees has been cleared. Also some good farms contain areas upon which it does not pay to raise crops. Such spots, rather than being allowed to remain idle or to produce inferior crops, should be planted to trees.

Although trees will grow on the poorest soils, they, like farm crops, will do better on richer soils. So, while the forests will probably ultimately be confined to the poorer classes of soils which will not be needed for agriculture, it is better to plant forests in the meanwhile on the best lands available for the purpose.

Many Michigan farms have woodlots where planting can be done to great advantage to fill openings which have occurred or to introduce new and valuable species; and on many farms forest plantations may be established to the permanent improvement of the farm and its greater value in the future.

Trees are valuable as timber. In addition they are useful as windbreaks and shelterbelts, in the fixation of shifting sands, and to prevent erosion or gullying. And always they beautify the landscape.

In establishing a forest plantation the owner should know what trees are suited to the locality and soil and which of these trees will best answer the purpose he has in mind. Trees grow slowly as compared with other crops and it takes many years for them to reach maturity or sufficient size for utilization. Mistakes made in planting may become apparent only after many years and owing to such mistakes the objects for which the plantation was established may not be attained. It is with the purpose of helping landowners to select and properly plant trees suited to their purpose that this bulletin has been written.

Raising Trees From Seed

Trees may be established by planting or by seeding. Sowing seed broadcast or in prepared spots in the field where it is desired to have the trees grow is not usually very successful. Much of the seed will be destroyed by rodents or birds and that which germinates will have only small chances of survival. The seedlings that come up are quite

likely to be smothered by weeds or to suffer from drought. Many pounds of seed are scattered each year from standing trees. If only a small part of this seed grew, the ground would be over-stocked with little trees.

In order to obtain a satisfactory stand from seed sown broadcast, the seed bed should be carefully prepared and the weather conditions following the planting must be right. Certain heavy seeded trees, however, such as black walnut, butternut, oaks, hickories, and chestnut may be established by planting the seed in the ground where the tree is desired; but even with these species the seed is quite likely to be found by rodents and eaten or removed. For each tree desired, it is usually necessary to plant a number of seeds so that even if some

Fig. 2.—Boxed seed beds just planted. The slat screens keep birds from the seed and will provide half shade for the seedlings when they come up.

are destroyed one may survive. The best success is generally obtained by using small seedlings or transplants.

Instead of buying the trees for planting from a nursery, they may be raised on the farm. The seed bed should be located in the garden or where the seedlings can be readily watered when necessary. The best seed bed for evergreen trees is a rather sandy loam. It is not desirable to have the soil richer than is the soil where the trees are to be planted. The beds should be well drained, the soil loose and not too rich. Clay should be avoided, although a clay subsoil is not objectionable. On a clay soil the seedlings are liable to be injured by frost throw or heaving.

It is not probable that fertilization of the seed bed will be neces-

sary if only a few years' operations are contemplated. Tree seedlings do not make very heavy demands upon the soil. If the beds are to be used many times, however, a light application of well-rotted barnyard manure may be desirable every two years, or each time the seedlings are removed and new seed planted. The manure should be well spaded in, care being taken not to apply it too heavily. In the College nursery, a top dressing of well-rotted barnyard manure is used on the beds. It is allowed to stay there for several weeks and then the coarser part is raked off and the remainder spaded in. The beds are then raked and rolled and the seed planted. Well composted leaf litter is a good fertilizer. If continued operations are contemplated it is good practice, if possible, to change the location of the beds oc-

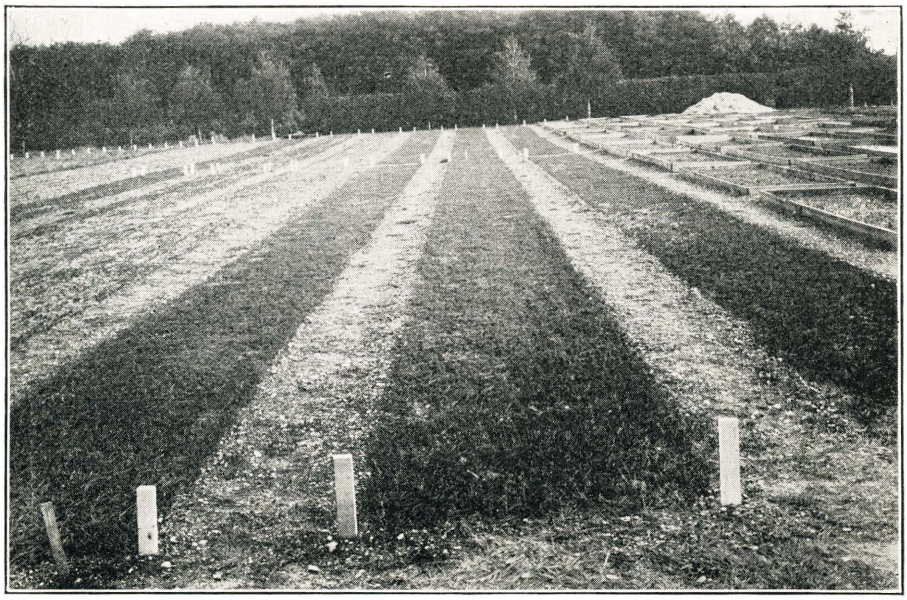

Fig. 3.—Unboxed seed beds. One-year-old Norway spruce seedlings. The beds are made four feet wide so as to permit easy weeding.

casionally and to use new ground in order to prevent disease and possible insect injury which may increase with continued use of the same ground for nursery purposes.

Broadleaved tree seeds may be sown in rows and generally require no more attention than any cultivated field crop. Coniferous tree seeds on the other hand germinate and grow best in beds. These beds are usually made about 4 feet wide so that they can be easily weeded and they may be any length desired. It is not necessary to box the sides of the bed, although this is done in many nurseries. Boxing the beds will often insure a better stand of seedlings as it keeps the seeds from washing out and people from walking on the beds. It also makes it possible to screen the beds from birds which like to nip off the top of

the seedling when it comes up bearing the seed coat. The seed may be sown broadcast in the beds and covered with sterile sand to twice its thickness or it may be drilled in. Sterile soil can be procured by taking sand from several feet below the surface of the ground. This covering will materially reduce the attack of damping-off fungi which are found in nearly every soil. After being sanded, the beds are rolled, covered with burlap or mulch and kept well watered until the seeds germinate.

As soon as the first seedlings appear the burlap or mulch should be removed and the watering reduced. It is sometimes desirable to keep the seedlings in half shade. This is commonly done by placing slat screens made of lath over the beds. The shade cast by the slats reduces evaporation and thus watering is not so necessary. Coniferous seedlings often grow in the shade of large trees and the shading of the seedlings in the bed is merely a method of imitating nature. During cloudy or rainy weather the screens should be taken off and artificial watering omitted. Screening is only necessary during the first year and watering during the first one or two years. The screens should be removed about the first of September so as to allow the seedlings to harden for the winter. Trees that have been grown in the shade will not do well when planted in the sun. It is best to remove the screens gradually. This can be done by taking them off for a few hours each day and gradually extending the period.

Evergreen seedlings are susceptible to damping-off during the first few weeks. This trouble is caused by a number of fungi which work just beneath the surface of the ground and which injure the roots of the small seedlings, causing the plants to wilt. The disease spreads rapidly under favorable conditions and will often destroy several square feet of seedlings in one night. It usually occurs in June or July when the weather is warm and muggy. The fungi do not work much below the surface and so are likely to injure only small seedlings which do not have a deep enough root system to be below the point of attack.

Sterilization of the soil is the best method of preventing this injury. This may be accomplished by light applications of sulphuric acid immediately after the seeds are planted, at the rate of three-sixteenths of a fluid ounce in 1 quart of water per square foot of seed bed. The beds must be kept well watered during the germination period after this application as a concentration of the acid will result in injury to the roots of the seedlings. A 1 per cent formaldehyde solution, applied at the rate of three-fourths of a gallon per square foot of seed bed a week or more before planting the seed, is sometimes used. This is often very effective but this treatment may kill some of the seed if not carefully used.

The best results are obtained by using sterile soil for the top layer of the seed bed. If the top inch of the seed bed is made from sand obtained from a fresh dug pit at a distance of a couple of feet below the surface of the ground there should be little trouble from damping-off. No surface soil should be used on top of this but the seeds should be covered with the same sterile soil.

Damping-off of white pine can be further guarded against by planting the seed late in the fall so that the seedlings will come up early in the spring. By obtaining early germination the seedlings will de-

velop sufficiently before the danger period comes so as to be less subject to it.

Seed of elm and silver maple, which ripens in the spring, should be planted at that time. Seed of other species may be planted in the spring or late autumn. Certain species, such as the oaks, walnut, chestnut, basswood, and white pine are best planted in the fall just before winter sets in. They germinate slowly and may hold over for a year if planted in the spring. Norway spruce and red pine seed, which germinate readily, should be planted early in the spring. If seed is planted in the fall it may be destroyed by rodents during the winter and for this reason spring planting of most species is best.

The amount of seed sown in the bed depends on both the vitality of

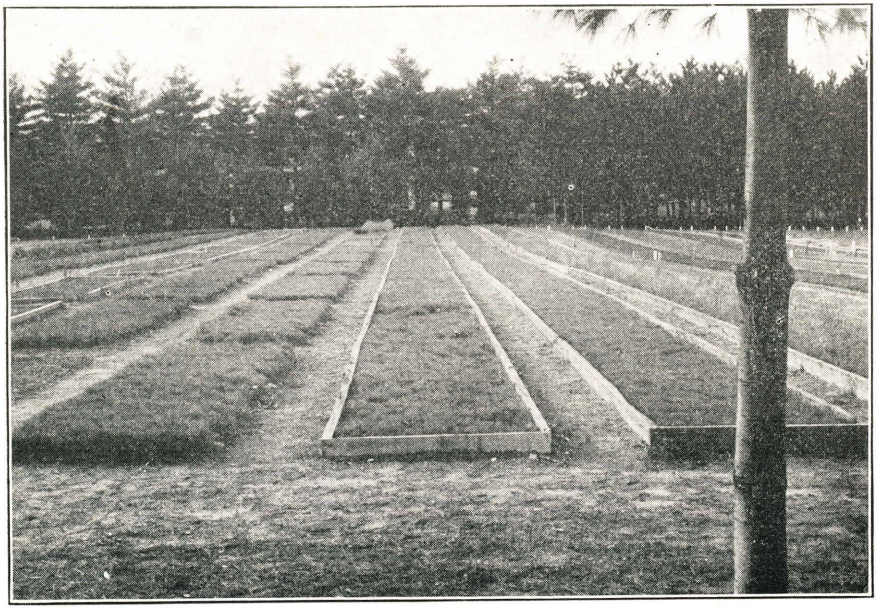

Fig. 4.—Two-year-old white pine seedlings. The boxes have been removed from some of the beds.

the seed and the number of years that the seedlings will be allowed to remain in the bed. Over-crowding materially reduces the size of the seedlings. Ordinarily, where it is desired to keep the seedlings in the bed for 2 years, 150 seedlings per square foot is a suitable density. However, the seedlings of Norway spruce, which are very small during the first few years, may be grown at the rate of 200 per square foot. The following table gives the number of seeds per pound and the average germination per cent as determined in tests at the Michigan State College. The table may be used to find the number of pounds or ounces of seed necessary to plant in order to obtain a desired number of seedlings.

Evergreen seedlings should be transplanted when 2 or 3 years old.

Table 1.—The average number per pound and the per cent of germination of tree seed.

Species	No. of seeds per lb.	Germination per cent
American elm	94,000	32
Balsam fir	44,000	30
Basswood (whitewood)	5,000	2
Beech	1,400	40
Black cherry	4,500	12
Black locust	26,000	52
Black walnut	25	90
Box elder (ash-leaved maple)	12,700	2
Chestnut	135	65
Hackberry	2,600	20
Hardy catalpa	19,000	31
Hemlock	175,000	15
Honey locust	2,800	40
Jack pine	80,300	63
Norway spruce	58,000	80
Red cedar	17,500	10
Red oak	130	69
Red pine (Norway pine)	65,500	65
Shagbark hickory	90	82
Silver maple	15,000	34
Sugar maple (hard maple)	7,000	20
Sycamore (button ball)	168,000	37
Tulip tree (yellow poplar)	18,300	1
White ash	6,200	10
White cedar (arborvitae)	300,000	21
White oak	200	71
White pine	27,200	32
White spruce (cat spruce)	250,000	14
Yellow birch	400,000	29

If it is not desired to plant them immediately in the field, they should be set out in transplant rows. They may be placed 4 or more inches apart in these rows, depending upon the length of time they will be left there. Transplanting causes the trees to develop bushy root systems. If they are allowed to remain too long in the seed beds the roots will become long and spindly, making transplanting more difficult.

The use of wild stock, that is, trees taken from the woods or fields, is not usually very successful. Small trees may be successfully transplanted if they have been taken from open places where they have grown in the sunlight. Trees taken from the shade are not likely to succeed when planted in the open, as they have become accustomed to the greater moisture found in the shade. The root system of wild stock is generally straggly and difficult to transplant. Broadleaved trees may be cut back in the tops so as to counterbalance loss of roots but the tops of evergreens should not be cut off. The cost of obtaining small wild stock may be greater than the cost of nursery grown trees.

Time To Plant

The best time for transplanting is in the spring as soon as the frost is out of the ground and until growth starts. Trees should be transplanted only while they are dormant. Broadleaved trees may be transplanted at any time when the leaves are off, so they may be planted in the late fall. If evergreens are transplanted in the late fall, unless they are mulched or covered with snow during the winter months, they are likely to evaporate moisture from their foliage while

the roots, which have not yet become established in the soil, are unable to supply more moisture. As a result they may dry out and die. Evergreens may sometimes be successfully transplanted the latter part of August or early in September as, if weather conditions are favorable following the planting, they will become established before cold weather sets in. Evergreens are more delicate than broadleaved trees and must be handled more carefully. Some of the broadleaved trees, such as elm, poplar, and silver maple have a great deal of vitality and will stand considerable carelessness and exposure in transplanting. Small evergreens, such as 2-year-old seedlings which are only a few inches high, may be safely transplanted in the late fall in those parts of the State where there is sufficient snow on the ground in winter to cover them and keep them from drying out.

Field Planting

For field planting it is usually desirable to use small seedlings 2 or 3 years old or small transplants about 4 years old. The latter have the better root system and being a little larger are best for planting on shifting sands or where there is danger of the soil being blown away or being blown over the plants and where the planting site demands a little stronger tree. There are a number of forest nurseries which sell small trees, sometimes called "lining-out" stock, suitable for forest plantations. The cost of planting increases rapidly with the size of the trees. Two-year-old seedlings may be planted at small cost and there is less danger of their loss through drying out. In transplanting large trees, there is always some injury to the roots which can be avoided in the case of small seedlings.

If the trees have been received from a nursery the packages should be opened upon arrival and the trees planted immediately if possible. If this cannot be done a trench should be dug in a shady place and the plants bedded in. They should be placed in the trench singly so that all the roots will be covered with dirt. They may be kept in this way for several weeks if necessary before planting. In case the roots are very dry when the trees are received they should be puddled, that is, dipped into a mixture of clay and water about the consistency of paint. Unless the roots are dry, however, puddling is likely to do more harm than good as it may wash off the dirt that adheres to the root hairs without coating them with a new layer of mud. Broadleaved trees will often recuperate if soaked for a time in water even if they are quite dry when received.

In carrying the small trees about, the roots should be kept moist and protected from the sun. It is best to carry them in a bucket or basket, keeping the roots covered with a piece of wet burlap or moss.

In planting, the holes should be made slightly deeper than necessary to take the roots when spread in a natural position. The trees should be set a little deeper in the ground than they were in the nursery. They should be planted perpendicularly with the roots well spread out. The fine, moist soil should be packed around the roots and then the coarser soil drawn in the hole and firmed. A layer of loose soil should be scraped around the trees in order to retain the soil moisture. It is seldom necessary to use water in planting small forest stock but if used it should be applied liberally.

The tools ordinarily used in forest planting are the spade, the grub hoe or mattock, and the planting iron or dibble. A planting iron consists of an iron wedge 3 or 4 inches wide fastened to an iron bar. The tool is driven into the ground and then worked back and forth in order to make a wedge-shaped opening. The seedling is planted in this slit and the hole closed by inserting the planting iron just in front or behind the plant and swaying it so as to close the hole in which the tree was planted. The second hole should then be filled by tramping on it so as to prevent the soil around the tree from drying out. If a spade or round pointed shovel is used, it should be driven into the soil just opposite to the method used in digging. The seedling is then inserted back of the shovel and the remaining operations are the same as those given for the planting iron.

Fig. 5.—Irregular furrows ready for tree planting.

When field planting is being done on a large scale in a fairly open field, planting in furrows has been found to give the best results from the standpoint of economy in cost and labor and also to give a high per cent of survival. It is best adapted to small seedlings where it is not necessary to dig a large hole for the tree. Furrows are plowed at more or less regular intervals across the field, spacing them approximately the proper distance apart but making no particular effort to have them absolutely regular. The trees are then planted in the furrows with a spade, round pointed shovel, mattock or dibble. The advantages of this method are that it is rapid and does away with the competition of weeds for a few years. The furrows should be about 12 inches wide and from 2 to 3 inches deep. On rolling ground or side hills the furrows should follow the contour lines so as to avoid washing.

Where the field is very stony or covered with many stumps or much brush it may not be practicable to run furrows and planting in holes made with a spade or mattock is necessary.

The cost of planting varies greatly with the size of the stock, the method used, the character of the land to be planted, the spacing, and the experience or aptitude of the men doing the work. One man should plant from 1,000 to 1,500 small seedlings per day. When the land is fairly clear, with few obstructions such as stumps or rocks, planting in furrows is cheapest.

On an operation in Menominee County, where 3 acres were planted with 2-year-old seedlings, the cost was as follows:

3,000 trees at $4.00 per M.	$12.00
Plowing furrows	4.00
Planting	24.00
Total	$40.00

or $13.33 per acre.

On an operation in Allegan County, where 16 acres were planted the cost was as follows:

14,500 trees, spruce and pine	$64.50
Express on trees	10.00
Labor, planting with spades	82.49
Total	$156.99

or $9.81 per acre.

The cost of planting varies with the size of the operation. Where a large area is being planted the cost per acre is less than where only a few acres are planted. Thus on the Michigan National Forest near East Tawas, the cost of planting, including trees, making the furrows, transportation, supervision, and other operations averaged $3.32 per acre over a 6 year period. The planting was done at the rate of 707 trees per acre and on a large scale, about 10,500 acres being planted during the 6 years.

The cost for small operations will vary from $8.00 to $30 an acre, depending upon the size of the stock and the number used. If 2-year-old seedling stock is used at the rate of 1,000 to the acre, and the field is fairly clear, an average cost would be about $10 per acre which would include the cost of the trees.

It is often not realized how long it takes for trees to reach merchantable size or that trees in a plantation behave differently than those in the open. A tree planted in the open, for shade or ornament, tends to branch low down and to retain its lower branches. Trees planted in close formation tend to grow tall with few side branches. The first tree will produce but little and poor grade lumber. The latter will yield more timber of higher grade. Trees planted close together are forced to grow straight and form only a few strong side branches because the light comes from overhead. The leaves on the side branches die from lack of light and the branches themselves fall off

in time. This is called self-pruning and is a result of close spacing. Some trees, such as the spruce, hemlock, and beech will stand a large amount of shade without losing their foliage. Such trees may be used for underplanting in underbrush or under light shade. Other trees, like the red pine, birch, and yellow poplar will not stand much shade and should be planted only in the open. It is often desirable to use a mixture rather than a single species, as the danger of loss from insects or fungi will be reduced and better utilization may be made of the soil. For this purpose a tree tolerant of shade may be alternated with one demanding light.

In forest planting the trees are commonly spaced 6 by 6 feet apart. The spacing of the trees should vary with the light requirements of the species and with the rate of growth. Trees that require a large amount of light for their development should be spaced further apart than those which will grow in the shade. Thus European larch and Carolina poplar should be spaced about 10 by 10 feet as otherwise they will crowd each other at an early age and many of them will be killed. Trees such as Norway spruce and white pine may be planted closer together. Close planting results in the trees growing straighter but they will not develop very large crowns and so diameter growth will be retarded. A very close spacing also presents problems in thinning at an early age when the material removed will have little or no value. A wider spacing requires less trees per acre and the cost of planting is therefore less.

The number of plants required to the acre with various spacings are as follows:

4 x 4 feet	2,720
5 x 5 feet	1,740
6 x 6 feet	1,210
7 x 7 feet	890
8 x 8 feet	680
10 x 10 feet	436

Preparation of the ground before planting is not usually necessary. The chief advantage of plowing and fitting the area is in the reduction of fire danger. There should be a little higher per cent of survival where the ground is fitted before planting, and, where cultivation is carried on for a few years, the growth of the trees is somewhat stimulated. The growth in spruce plantations has been increased about one-fourth during the first 5 years by cultivating. It is not probable that cultivation would have much effect upon the growth after the first 5 or 6 years and in a long-time plantation where the trees would be allowed to remain for 30 or 40 years the effect of cultivation would be negligible. In Christmas tree plantations cultivation is often desirable as it will save about one year in five.

Soil Requirements

In establishing a forest plantation the object of the planting should be borne fully in mind. Mistakes made in the selection of the species may mean a loss of many years. Trees differ in their soil and moisture requirements. Some will do well on sandy soil. Others require deep moist soil.

Trees may be classified according to the soils upon which they grow best. Only those trees should be selected for planting which are adapted to the soil in question. It should be noted, however, that trees will grow upon a great variety of soils and that the moisture conditions are of prime importance. The following list shows the general type of soil upon which certain species of trees may ordinarily be planted:

Light sand—Jack pine, Scotch pine, red pine, poplars, box elder, Austrian pine.
Gravel—Red pine, Scotch pine, Norway spruce, chestnut.
Sandy loam—White pine, red pine, Norway spruce, white spruce, red oak, poplars, maple, black locust.
Loam—Norway spruce, white spruce, white pine, European larch, white ash, oaks, maples, beech.
Heavy soil—Walnut, hickories, ash, basswood, silver maple.
Swamp soil—Silver maple, sycamore, tamarack, balsam, white cedar.

Trees For Various Purposes

Trees may be classified according to their ability to produce wood for certain purposes in the shortest time, as follows:

Lumber—White pine, red pine, basswood, white ash, black walnut.
Pulp—White spruce, Norway spruce, poplar, basswood, larch, Jack pine.
Excelsior bolts—Basswood, poplars, willow, soft maple, white pine.
Poles and posts—Larch, red pine, red oak, Jack pine, catalpa, chestnut, mulberry, sassafras.
Ties—Larch, red oak, Jack pine, red pine, chestnut.

Trees For Planting

Trees grow at different rates depending on the species and the location or character of the soil and climate where they are planted. Some species, like the Jack pine, grow rapidly at first but are later surpassed by other species such as the red and white pines. Some trees are comparatively short-lived and while they may grow rapidly for a number of years do not last long enough to give satisfaction. The Carolina poplar is one of the fastest growing trees in Michigan but it is short-lived and is subject to attack by the poplar borer which is likely to destroy it. The black locust, also, is subject to attack by an insect, the locust borer, which practically precludes its successful planting in some parts of the State. The silver maple is a fast growing tree but is comparatively short-lived and the wood is of little value. The oaks and sugar maples are slow growing trees. The following are some of the more important trees for forest planting in the State.

White Pine (Pinus Strobus)

White pine has been widely used for forest planting in Michigan. It is a native of the State and does well on almost any soil except heavy clay or very wet soils. It grows quite rapidly after it has

passed the seedling stage and in good locations will grow two feet in height a year. The lumber is valuable. Box boards will be produced in about 30 years. For forest plantations it is best to use small seedlings, 2-year-old stock, spacing the trees 6 by 6 feet apart or using even a wider spacing up to 10 by 10 feet. The white pine does not prune itself of its lower branches very readily even with the crowding resulting from a close spacing and so in small plantations a rather wide spacing may be used and the trees pruned by hand as far up as can be readily reached.

The planting of white pine should be limited to certain localities, as it is subject to a disease, the white pine blister rust, which has one generation on white pine and the next on currant or gooseberry bushes. This disease has gained considerable headway in the east and in adjoining states, but so far has not appeared to any considerable extent in Michigan. It can only spread when the two hosts, currants or gooseberries, either wild or cultivated, and white pine, are within a few hundred yards of each other. In many localities in Michigan currants and gooseberries are of commercial importance and in such localities white pine should not be planted, since, if the disease appears, one of the hosts must be destroyed in order to eradicate it.

Red or Norway Pine (Pinus resinosa)

Red or Norway pine is very similar in rate of growth to white pine but it will do better on poorer, sandier soils. The wood is quite similar to the white pine, though a little heavier and harder, and is used for the same purposes. The red pine has thinner foliage than the white pine, it prunes itself of side branches better and is not subject to serious injury by insects or fungi. Owing to scarcity of seed, red pine seedlings are difficult to obtain but where they can be secured it is one of the best trees for forest plantations. A spacing of 8 by 8 feet may be used as the trees will prune themselves of side branches quite readily. A wide spacing reduces the number of trees required per acre and so reduces the cost and labor of planting. This is of importance in the case of red pine as the planting stock is scarce and more expensive than some other trees. It is often planted in mixture with white pine or Norway spruce, the species being alternated in a spacing of 6 by 6 feet.

Jack Pine (Pinus divaricata)

Jack pine will do well on dry sandy soil. It is a tree which grows rapidly at first but slows down later on and never reaches a large size. The wood is soft and light, and not durable in contact with the soil unless it has been treated with creosote or some preservative. After such treatment it may be used for fence posts. The wood is now being used for paper pulp and should be more extensively planted, especially on the poorer soils.

Scotch Pine (Pinus silvestris)

Scotch pine is not a native of Michigan but has been used quite extensively in the State. It does well on dry sandy soil. It is very

similar to Jack pine in rate of growth but tends to become crooked with many side branches. Two-year-old seedlings are a good size for field planting with a spacing of 6 by 6 feet. Much of the Scotch pine which has been planted in this country has had its source in seed collected in central Germany. It is said that trees from this seed do not produce as good a quality of timber as trees grown from seed collected in the Baltic provinces of Russia, called the Riga variety. This is the variety which should be planted if possible. Scotch pine may be planted on the very poorest soils in the southern part of the State.

Austrian Pine (Pinus Austriaca)

Austrian pine is somewhat similar to Scotch pine in soil requirements, doing well on the poorer types of soil. It produces a straighter stem than Scotch pine and the lumber is of a little better quality. This tree is used also for windbreaks, especially as a substitute for white pine in those counties where white pine blister rust is to be feared. Austrian pine does not stand shade and therefore a shade enduring species may be planted with it in mixture or it may be planted in pure stands with a 6 by 6 foot spacing.

White Spruce (Picea canadensis)

This tree is a native of northern Michigan. It grows on a wide range of soils but does best on moist, well drained, sandy loam. It succeeds better in the northern part of the State than Norway spruce, which has been more extensively planted. It is the best tree to use for pulpwood plantations. It grows fairly rapidly, stands considerable shade, and may be used as a filler in plantations of cottonwood, black walnut, and European larch. For pulpwood plantations, it is best planted by itself with a spacing of about 6 by 6 feet.

Norway Spruce (Picea excelsa)

Norway spruce, while not a native of this country has been extensively planted, chiefly for ornament. It is a fast growing tree and the wood is valuable for paper pulp. It does well on nearly all soils, except clay or very dry soils. It forms a dense, persistent crown, and is therefore suitable for windbreaks. It is used for Christmas trees and is the best tree to plant for this purpose. It reaches Christmas tree size in about 6 years if small transplants are used for planting. It may often be used with advantage as a filler in plantations of other species and at the end of a few years may be cut out and sold for Christmas trees. Four-year-old transplants are best. For Christmas tree plantations a spacing of 4 by 4 feet is good, giving more trees to the acre than a wider spacing, and as the trees will be utilized at an early age they will not become too crowded. For the production of timber a spacing of 6 by 6 feet is best.

European Larch (Larix Europaea)

European larch is similar to the native tamarack but is not quite so subject to defoliation by the larch saw-fly. It is a deciduous conifer, losing its foliage in the winter. It does best on fairly fertile, well

drained soils. It will not succeed in swamps as will the native tamarack. It grows rapidly and the wood is heavy and durable in contact with the soil. It should produce fence posts in about 20 years. Extensive plantations are not advisable owing to danger of the larch saw-fly but it can be used as a filler with other species. Two-year-old seedlings are a good size to use. A spacing of about 10 by 10 feet is advisable, as the tree will not stand any shade and closely spaced stands result in the death or stunting of the trees. Or a spacing of 12 by 12 feet may be used, interplanting with a shade-bearing, slower growing species, such as red oak or Norway spruce. Larch starts growth early in the spring and is subject to injury by late frosts. It is best transplanted in the fall.

American Elm (Ulmus Americana)

American elm is one of the fast growing hardwoods. It does best on a fairly fertile soil, but will grow on poorer sites. The tree is hardy, vigorous and produces valuable lumber. It may be planted in mixture with basswood, tulip, maple, or ash, or in pure stands 6 by 6 feet apart.

Basswood (Tilia Americana)

This tree grows rapidly in all parts of the State on good soil. The wood is valuable. It is strong for its weight and has many special uses besides being in demand for excelsior bolts. The basswood is a good tree to plant in favorable locations, either in pure stands or mixed with other species. Small seedlings are best to use, with a spacing of 6 by 6 feet.

Black Locust (Robinia pseudacacia)

Black locust is one of the fastest growing hardwoods. It makes excellent fuel and is one of the best fence post woods. It grows well on the poorer types of soil. It is especially valuable for planting in poor soils subject to erosion and for sand dune work. Unfortunately this tree is subject to attack by the locust borer. In some localities of the State this insect is very bad, especially in the southern part. The work of the insect can be overcome to some extent by mixing the locust with some other tree in planting or by a close spacing of 4 by 4 feet if planted pure.

Black Walnut (Juglans nigra)

Black walnut is one of the best hardwoods to plant in the southern part of the State on fairly moist, fertile soil. It grows quite rapidly, the wood is very valuable and was in much demand during the war for gun stocks and airplane propellers. Owing to this demand a great deal of black walnut was cut and its replacement is desirable. The heartwood is durable in contact with the soil and makes good fence posts. In addition to its timber value the nuts are edible. There is a great difference in the nuts, some are small, some thick-shelled, and some are comparatively thin-shelled. The trees cannot be depended upon to come true to the seed and so in order to produce a good quality of nuts grafting is necessary.

The black walnut develops a strong taproot early in life making it difficult to transplant large trees. The seed may be planted where the trees are desired but squirrels are very likely to dig them out. It is best to plant the nuts in the garden in the fall and the shucks may be left on. The small trees should be transplanted to their permanent locations when one year old. For forest plantations, a spacing of 8 by 8 feet is good, interplanting with Norway spruce or red oak so as to force the black walnut to grow straight, as otherwise it will develop many low branches. For nut production a wider spacing, not less than 30 by 30 feet, should be used. The low branching resulting from wide spacing may not destroy the value of the timber, as black walnut crotches are often valuable for veneer stock. The Stabler and Thomas are the best varieties known for planting in Michigan for nut culture at the present time.

Catalpa (Catalpa speciosa)

Catalpa will succeed in the southern part of the State but is subject to frost injury further north. It must have moist, well drained, fertile soil. Under favorable conditions it grows rapidly and the wood makes durable fence posts. It does not reach large size and requires pruning in order to make a straight stem. The seed should be soaked for 24 hours in water before planting. It should be planted only in the southern counties. The trees may be cut back to the ground early in the following spring after planting. The resulting sprouts will grow vigorously. The lower side branches should be pruned for a few years in order to force the tree to grow straight. The trees should be planted about 6 by 6 feet apart.

Chestnut (Castanea dentata)

Chestnut is hardy in the southern part of the State. It does well on rather poor, sandy soil but grows faster on better soils. The wood is very durable in contact with the ground and makes good fence posts as well as valuable lumber. The nuts should be stratified in moist sand over winter and planted in the garden in rows in the spring. The trees should be set out in their permanent places when 1 or 2 years old. The trees begin bearing nuts when about 12 years old. For forest plantations a spacing of 6 by 6 feet is best. Where nuts are desired a much wider spacing, not less than 24 by 24 feet, is advisable. The price of the nuts on the market is high owing to the fact that the trees in the east have been largely destroyed by the chestnut blight disease which has resulted in a great reduction of the supply. Trees for planting should be obtained from within the State owing to danger of introducing this disease.

Cottonwood or Carolina Poplar (Populus deltoides)

Cottonwood, also called Carolina poplar, is the fastest growing tree in Michigan. It does best on moist soils but will succeed on sandy sites as well because it can send its roots a long way in search of moisture. For this reason it is a good tree to plant on the sand dunes in order to hold the sand in place. The wood is soft and light, not strong, and decays rapidly in the ground. When used for fence posts it should

be treated with creosote. Posts so treated will give good service. It is used for packing boxes, wood pulp, and excelsior.

The cottonwood and poplars are subject to attack by an insect, the poplar borer, which has destroyed many plantations, but where the trees have been planted on a small scale they have not been seriously damaged.

Cottonwood, like willow, will start naturally from cuttings. These should be made from fresh twigs, last year's growth. They should be from 10 to 18 inches long, and may be planted at once, butt end down, or they may be first rooted in nursery rows. They should be planted so that about 2 inches protrude from the ground and 1 or 2 buds should be above or near the surface. The holes may be made with a rod about the diameter of the cuttings, but care must be taken to see that the cutting does not hang loosely in the hole, as in such a case, decay is likely to start. It is best to plant the cuttings vertically or with just a slight slant so that the soil can be firmed around them by tramping. They should not be planted by pushing them into the ground, except in very light soils, as the bark may be torn and decay result.

For plantations a spacing of 12 by 12 feet is advisable, underplanting with spruce or sugar maple if desired. For sand dune planting a closer spacing is desirable. Willows may be started in the same way as cottonwood cuttings.

Red Oak (Quercus Rubra)

Red oak does well on rather sandy soil in the southern half of the State. The other oaks grow too slowly for profitable planting. The acorns may be planted directly in the field or small seedlings may be used with a spacing of about 6 by 6 feet. If the acorns are planted in the field, 3 or 4 should be planted near together in prepared spots. They may be coated with red lead to prevent destruction by rodents. The red oak does not make durable fence posts unless treated with a preservative. It should make posts under favorable conditions in about 30 years. This tree is one of the most valuable for reforestation purposes in the southern part of the State. It is a fairly rapid grower and produces good lumber and fuel.

Silver Maple (Acer saccharinum)

Silver maple grows rapidly but is short-lived and is of little value at present. As fence posts become scarcer, however, non-durable wood of fast growing species will undoubtedly be used and treated with creosote or wood preservative in order to lengthen its life. Silver maple will be a good tree for such use. It grows best on moist soils. It is used chiefly for excelsior bolts and where a rapid growing shade tree is desired, but even then it is rather undesirable. A spacing of about 7 by 7 feet is advisable for forest plantations.

Sugar Maple (Acer saccharum)

Sugar maple has been planted to some extent in Michigan for sugar bushes and woodlots. It does well on any good soil but it grows rather

slowly and takes many years to reach merchantable size. It is an excellent tree for roadside or street planting where large sized stock can be used. For timber production, a spacing of 6 by 6 feet is advisable in order to make the trees prune themselves. For sugar bushes, a spacing of 10 by 10 feet is better. Sugar maple may be planted in small openings in existing woodlots where it is desired to increase the percentage of this species. Many sugar bushes can be improved in this manner.

Tulip Tree (Liriodendron tulipifera)

Tulip tree, also called white wood and yellow poplar, is another valuable tree for reforestation work. It is a fast grower on the better classes of soils and produces a light, strong, easily worked lumber, valuable for many purposes. The tree demands plenty of light and the seedlings should be spaced about 8 by 8 feet apart. It may be planted in mixture with a more shade enduring tree.

White Ash (Fraxinus Americana)

White ash is one of the faster growing hardwoods which produce valuable lumber. It does well on the better soils, where it may be mixed with pines or other species. It makes good fence posts if treated with preservative. It is probably better to plant it in mixture with other species than by itself. White ash is one of our most valuable hardwoods. It can be utilized when about 8 inches in diameter, thus bringing early returns.

Sand Dunes

Sand dunes may be classed as shore dunes or those occurring along the lake shore, and inland blows, or shifting sands which occur inland from the coast. Inland blows are much easier to control than shore dunes as they are usually smaller and not so exposed to high winds. The best results are obtained by the use of hardwood cuttings such as willow and several varieties of poplar which are stuck in the sand a foot or more apart. Poplar has in many cases made a growth of 4 to 8 feet a year after it has once become established. Willows, while not making such rapid growth, are able to withstand the burying action of the sand as well as poplar.

After hardwoods have been once established, the work may be followed up by evergreen plantings such as Jack pine, Scotch pine, Austrian pine, red pine, white pine, and western yellow pine. This last tree has proved to be one of the best evergreens for this type of planting. It stands the burying action of the sand and seems to thrive under adverse conditions sending out its new growth of long thick leaves vigorously.

Shore dunes offer a bigger problem. Here it is essential that the loose sand become somewhat fixed. This may be accomplished in several ways. One method sometimes used with considerable success is to drill in rye during the fall. It should be drilled at right angles to the wind and enough complete fertilizer put with it to give it a good start. The rye serves to hold the sand until the native plants and

grasses get a start. It is sometimes necessary to repeat the operation once or twice.

Another method used in tying down the sand is to scatter brush over the area. Brush will remain for 2 or 3 years before it decays and by this time other plants will have come in. Cuttings of trees should be planted in with the rye or in between the scattered brush. The rye and brush serve to hold the sand while the cuttings become established. It may be necessary to protect the cuttings for several years especially if the native plants and grasses do not get a start. After the cuttings have been once established and are growing, other trees may be planted. The various pines mentioned above may be used. Evergreens do not develop so rapidly at first as the various broad-leaved trees and cuttings and so are more easily blown out of the sand unless protected. Their large tops subject them to swaying by the wind and also may cause excessive transpiration resulting in the tops drying out and the trees finally dying.

Almost every tree native to Michigan may be found growing in the dunes, but certain trees thrive better than others. There are poplars, willows, some of the oaks, black locust, and the light-soil evergreens. For sand dune plantings, trees may be spaced 6 by 6 feet or a little closer. In the case of evergreens, transplants rather than seedlings should be used.

Growth of Plantations

In considering the growth of forest plantations the amount of timber that is produced per acre is a better indication of the profitableness of the planting than is the growth of individual trees. A plantation of European larch will not produce so much timber to the acre as will a plantation of white pine. The white pine can be grown closer together than the larch and while an individual tree in the open does not grow so fast the plantation will produce more timber to the acre.

The diameter growth of trees in forest plantations is an indication, however, of the results that may be expected. A plantation of mixed species was made at the Michigan State College in 1877 as an arboretum. The trees were planted with a spacing of 4 by 4 feet and were never thinned. The soil upon which the trees were planted was sandy. After 45 years of tree growth it was covered with a 6 inch layer of litter and humus. The following table gives the average and maximum diameter of some of the principal species 45 years after the plantation was established:

Table 2.—Growth in diameter during 45 years.

Species	Average diameter inches	Maximum diameter inches
Chestnut	11	16
Black locust	11	17
Basswood	10	15
Red oak	9	11
Black walnut	9	12
Butternut	9	11
Catalpa	9	17
American elm	9	16
European larch	9	14
White ash	8	10
White oak	7.5	10
Sugar maple	7	11
Shellbark hickory	7	9
Norway spruce	6.5	9

In 1896 a plantation of white pine was established at the College. The plantation covers about three and a half acres, located on sandy and gravelly soil. The trees were 5 years old at the time of planting. The spacing distance was 8 by 12 feet, requiring 454 trees to the acre. Measurements have been made on a sample acre at approximately 5 year intervals. The following table gives the number of trees per acre, the diameter of the average tree and the mean annual growth per acre.

Table 3.—Rate of growth per acre of pine plantation.

Date	Total age, years	Number of trees per acre	Diameter of average tree, inches	Height of average tree, feet	Volume per acre, long cords	Mean annual growth per acre since 1896, long cords
1916	25	399	7.17	34.4	17.7	.70
1921	30	387	8.09	45.3	30.5	1.01
1925	34	381	8.70	54.0	42.8	1.26

The gradual decrease in the number of trees per acre is due to the crowding of the trees with increasing size and the suppression and dying of certain trees to make room for others. As the trees increase in size they become crowded and the crowns do not have room to develop, so ultimately the growth in diameter falls off. A thinning should be made so as to open up the crowns of the remaining trees and to give them more side-light. A thinning was made in this plantation in 1926. The following table shows the average dimensions of the trees taken out:

Table 4.—Trees cut per acre in the thinning.

Number of trees removed	Diameter of average tree, inches	Height of average tree, feet	Total volume removed per acre, long cords
128	7.3	49	9.1

Thus about one-fifth of the trees by volume and about one-third of the trees in number were removed in the thinning.

No large openings in the plantation were made. There are now 253 trees per acre in the plantation. These trees have sufficient room to develop larger crowns and with larger crowns will come faster diameter growth. The height growth of the trees has not shown any tendency to decrease. During the past 9 years it has averaged 2.2 feet per year. With more room for the development of lateral crowns. however, it is to be expected that the height growth will fall off to some extent.

Fig. 6.—Thinning in 35-year-old white pine plantation. About one-third of the trees were removed so as to make more room for the remaining trees to develop.

The unusually wide spacing with which the plantation was established is the reason for the early rapid diameter growth. With a closer spacing thinnings are necessary at an early age. It is desirable, however, to crowd the trees a little so as to force them to grow straight and tall, otherwise they will be largely crowns with heavy side branches and only a short clear length.

The following table gives the diameter and height of the average tree and the diameter of the maximum tree for a few existing plantations in the southern part of the State. The yield in timber is given in cubic feet. A standard cord of wood contains 128 cubic feet of space of which, in a stacked cord, about 30 per cent is air space between the sticks, so that an average standard cord contains about 90 cubic feet of solid wood.

Table 5.—Growth of forest plantations.

Species	Age, years	Number of trees per acre	Diameter average tree, inches	Diameter maximum tree, inches	Height average tree, feet	Yield per acre, cubic feet
White pine	8	500	1.3	2.7	9	.....
White pine	12	600	2.2	5.0	15	300
White pine	18	680	6.0	9.0	28	1,600
White pine	24	416	8.2	12.2	42	2,580
Norway spruce	20	1,120	5.0	8.0	24	1,456
Mixed hardwoods	42	162	9.0	.....	50	2,264
Black locust	10	620	3.0	8.0	16	173
Black walnut	23	524	3.0	10.0	20	260
Catalpa	11	1,280	3.1	7.3	23	760
Catalpa	12	834	4.0	8.0	24	*850
Catalpa	25	100	10.0	15.0	45	810
Carolina poplar	9	700	3.5	6.0	28	700
Honey locust	23	260	5.0	12.0	40	650
White ash	10	2,800	1.0	1.5	12	.....

*About 80 fence posts having already been taken out.

Figures of the yield per acre of some plantations in other states are given below. These data have been compiled from various Government and State reports.

Scotch pine and larch, New York, 25 years old, 13,000 board feet per acre.
Scotch pine, New York, 35 years old, 27,000 board feet per acre.
Silver maple, Illinois, 9 years old, 16.2 cords per acre.
Silver maple, Iowa, 20 years old, 20.1 cords per acre.
Black walnut, Indiana, 12 years old, 7.5 cords per acre.
Black walnut, Illinois, 38 years old, 33.8 cords per acre.
White pine, Iowa, 21 years old, 4,760 board feet per acre.
White pine, New York, 28 years old, 24,000 board feet per acre.
White pine, Massachusetts, 38 years old, 29,000 board feet per acre.
White pine, Massachusetts, 43 years old, 37,716 board feet per acre.
White pine, Massachusetts, 55 years old, 43,796 board feet per acre.
Norway spruce, New York, 22 years old, 10,000 board feet per acre.

Windbreaks

Windbreaks and shelterbelts are usually planted either as a shelter from the wind or as a screen to hide some unsightly object or to mark a boundary line.

Windbreaks diminish evaporation from soil and plants for some distance on their leeward side by keeping off the wind which has about as much drying power as has the sun. They break the force of the wind for some distance on the leeward side and thus tend to prevent windfall of fruit in orchards. The influence of a windbreak is proportional to its height and density. Its influence cannot be expected to extend more than 10 times the height of the trees.

The shade cast by the windbreak has a damaging effect on crops if they are planted close to it, and the roots of the trees, if far reaching, may sap the soil moisture for some distance on either side. Species should therefore be used which have compact or deep reaching root systems rather than spreading roots. A single row of trees is not as satisfactory as a double or triple row. The wind comes through it and the snows drift badly behind it. A windbreak should not be planted

closer than 100 feet from buildings, as otherwise the snow which drifts on the lee side may be a nuisance.

The kind of tree to use depends somewhat on the purpose of the windbreak. If it is to prevent windfall in an orchard, broadleaved trees may be used, as the windbreak will not be needed in the winter when it is leafless. Generally, however, windbreaks are desired to be serviceable both in winter and summer, especially where they are planted around buildings. For this reason a tree that retains its foliage all winter and which makes a dense screen is desirable. Evergreens are most commonly used. A tree that grows rapidly is usually preferred, as the windbreak will be of little service until the trees reach a fair height, and a slow-growing tree, while suitable for a hedge, will take too long to reach serviceable size.

The white pine and Norway spruce are the trees most commonly used in Michigan for this purpose. They both grow rapidly, about 2 feet in height a year under favorable conditions. They will do well on almost any soil except pure sand or moist, heavy clay. They have dense, evergreen foliage, and they retain their lower branches for a great many years unless planted in close formation. They have compact root systems which do not spread out under adjacent crops as do the roots of the Carolina poplar and the silver maple. On very sandy soil the red pine and Jack pine are better trees to use as they will do better on such soil than will the white pine or Norway spruce.

The white pine is a better tree for a windbreak than the Norway spruce because the top of the tree is flatter. The Norway spruce is a conical or spire-like tree, and so unless there are several rows, the tops of the trees do not close in together and do not make such a dense solid screen as does the white pine. Where there is danger of white pine blister rust, that is, in the vicinity of currant or gooseberry bushes, Austrian pine may be used in place of white pine.

For a good windbreak there should be a double or triple row of trees, alternating the trees in the rows and spacing them 8 or 10 feet apart, with about 8 feet between the rows. If a single row of trees is used a closer spacing, about 6 feet, is better so that the branches will interlace and make a dense screen.

The osage orange has been used quite extensively for windbreaks in the southern part of the State. It does not become a large tree but it sprouts readily and the wood is very durable and makes good fence posts. It can be cut back about every 15 years, utilizing the wood for posts, and it will grow up again from the stumps. It is, however, very difficult to get rid of an osage orange hedge, and unless it is cared for it is likely to send up shoots from the roots and gradually encroach on neighboring fields. It also takes a great deal of food and moisture from the soil.

In planting a windbreak it is usually desirable to use good-sized trees. Five or 6-year-old transplants, from 2 to 3 feet tall, are best. Not a great many trees are needed and, while there is a better chance of success with small trees in starting plantations where the trees cannot be cared for, it is usually possible in the case of a windbreak to water the trees if necessary.