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FOREST PLANTING
ON MICHIGAN FARMS

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A 42-year old white pine plantation yielding 16,000 board feet per acre. The larger trees are 13 to 15 inches in diameter and 60 feet tall. The stand has been thinned twice.

MICHIGAN STATE COLLEGE
Of Agriculture and Applied Science

EXTENSION DIVISION

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Forest plantations have a definite place on the Michigan farm that is managed with the object of making the most economical use of each acre of land. Many Michigan farms include some land that is so undesirable for the production of agricultural crops that it is unprofitable to use it for this purpose. Sandy soils, very stony soils, and lands with a steep sloping surface are of this class. There are also odd corners of better soil that cannot be managed conveniently with modern farm machinery, which, therefore, might well be eliminated from cultivation.

Since farm crops must be harvested annually, lands of low productive capacity are a special liability during periods when the price of farm products are depressed. If the expenditures on poor lands, in labor, seed, and fertilizer exceed the average gross income for depression and prosperous years, such

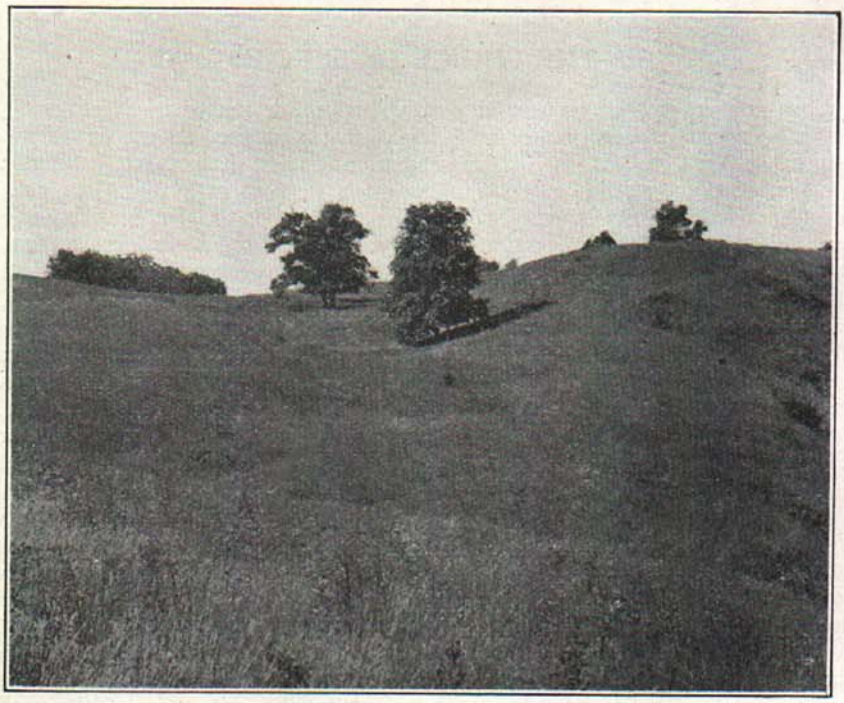

Fig. 1. Steep sloping lands which have deteriorated as a result of sheet erosion do not yield profits when used for agricultural crops but yield satisfactory crops of trees.

lands might better be put to some other use. These lands will usually yield acceptable crops of trees, producing cellulose and encouraging a larger crop of game animals and birds.

Forested areas provide shelter, protection, and food for wild life, which in some sections of the State is providing a source of income to farm owners. In addition, forests yield materials that are needed on the farm, fence posts and fuelwood while the stand is young, and lumber later. These products, as well as pulpwood and crossties, are in constant demand by timber users.

Trees are planted frequently for windbreaks or for the production of Christmas trees. This bulletin does not discuss these types of planting but is confined to a discussion of plantations established for the production of forest products including wood, game animals, birds, and fish. Windbreak, erosion control, and Christmas tree planting are discussed in other bulletins available for distribution by the Forestry Department.

Careful planning of the plantation is of utmost importance. Without a definite scheme which gives consideration to the local soil and climatic conditions as well as the purpose for which the trees are to be grown, the project is likely to be a failure. Such diverse conditions exist in Michigan that the technic which applies to one farm may not fit any adjacent farm. The following factors should be carefully weighed before ordering planting stock: (1) The choice of species, (2) pure vs. mixed stands, (3) the size of planting stock, (4) the season of planting, and (5) the spacing.

THE CHOICE OF SPECIES

Some 85 species of trees and many shrubs are native to Michigan. All of these are not equally desirable for forest planting. Some of them are limited to certain sections of the State and therefore have limited use. Others have very little value or make such slow growth that they are not recommended. A few species which are not native to Michigan have been used with success. *The selection of the correct species for each planting site is one of the most important factors in determining the ultimate success of the plantation.*

Soil and geographic location determine the species which may be used. Certain species that are native only to the southern part of the State cannot be planted with success in northern Michigan. Likewise some of the northern species cannot be used with success in southern Michigan. Locally, the soil determines to a large extent whether a certain species will grow satisfactorily. The species must be well adapted to the soil if satisfactory growth is to continue throughout the life of the tree or shrub.

Good survival and rapid growth during the first few years do not necessarily indicate what will take place later. In general, the pines are better adapted to the sandier and coarser soils than broadleaved plants or such conifers as the spruces, balsam fir, and northern white cedar. If the soil has not deteriorated too badly because of erosion or severe cropping, the native trees and shrubs present will give a satisfactory indication of the species that are well adapted to the site.

Too much attention should not be given to the character of the surface soil alone. It will be found upon examination that a soil is made up of layers which differ from one another in texture and color. The nature of

the soil to a depth of four feet should be examined to determine the site adaptability. If there is any doubt about the type of soil, it is suggested that a sample be taken from each layer of the profile, and this, together with a note on the position and thickness of each layer, be sent to the Forestry Department, Michigan State College, for the determination of species that might be grown there.

Since all species of trees and shrubs naturally do not have equal utility for all purposes, they should be selected carefully in order that those species most suitable for the desired use are chosen. Certain tree species are particularly valuable for pulpwood, others for fence posts, some for saw timber, still others for animal and bird food or shelter, a few for stream improvement, and many are valuable for more than one use. The readiness with which different products can be marketed locally should be investigated before making a decision on the species to be used for wood products.

Fig. 2. A planting operation in progress on light sandy soil. Trees are "heeled in" at the left.

Since some birds, animals, and fish are just as truly products of the forest as saw logs, pulpwood, fence posts, and other wood products, attention is directed in the following paragraphs to some of the factors which must be considered by those who wish successfully to make the plantation fit into a scheme of wild life management. Generally speaking, it will be difficult to manage the land in a way that will produce the maximum yield of both cellulose and wild life. There also is a limit for each area as to the number and kinds of animals, birds, and fish that can be produced. Where the chief object is to produce specific wood products, those trees which will yield the maximum crops of such material should be planted in the correct quantity and other trees and shrubs should be used only as fillers in an effort to maintain or to increase the number and kinds of wild life.

However, if a specific type of wild life management is the chief objective, those species which will especially favor such animal life as birds, or fish should be planted extensively. In many types of wild life management, some land adjacent to a forest plantation will have to be handled to provide a maximum of food, shelter, and nesting places by the planting of such food plants as flax, hemp, Sudan grass, millets, soy beans, cowpeas, sun-

flowers, sorghum, buckwheat, and corn*. Many shrubs and small trees have special value for food and provide protection to birds and smaller animals. These are discussed later in the bulletin under "Miscellaneous Species" page 15.

The water in many streams flowing through agricultural sections becomes warm in summer because of the lack of adequate shading. Partial stream improvement can be effected through the planting of the proper trees and shrubs along the stream banks. Where stream banks are eroding and gravel or silt is washed into the stream to cover spawning beds and feeding bottoms or to fill deep hide-ways, permanent relief can be secured only by the encouragement or the planting of vegetative cover, usually trees and shrubs.

Extensive solid blocks of forest of a single species or age class are not best for the maximum propagation of game animals and birds. Variety in the cover is essential. Variation in age and character of the forest can be attained by the use of a maximum number of species planted over a long period of years. Generally speaking, three acres of forest for cellulose production interspersed with one acre of plants for food and shelter should provide a well balanced habitat for most associations of wild life.

It should be clearly recognized that any forest planting, but especially those composed largely of species favorable to animal and bird life, will occasionally result in some damage to agricultural crops growing in adjacent fields because the wild life that inhabits the forest area will secure part of its food in these fields. Conversely, in planting trees and shrubs primarily for bird and animal production, the maximum number can usually be secured only by leaving in adjacent fields food patches or actually planting such food patches.

Consideration also should be given to the ease with which a species can be grown. Susceptibility of a species to disease or insect attack necessitates, in some cases, the expenditure of funds to control the trouble. Insect or disease attack is often a local problem, therefore, the situation in each locality usually requires special study. For recommended control measures see the section "Care of the Plantation," page 34. The diseases and insects discussed in the following paragraphs are of considerable importance in Michigan and should be given consideration in preparing for the establishment of a plantation. Further information concerning these and others can be obtained upon request from the College.

The white pine blister rust is a serious disease wherever white pine and currant or gooseberry bushes occur in the same locality. The blister rust cannot infect white pine unless native currant or gooseberry bushes are within 900 feet of the tree. However, the cultivated black currant will spread the disease as far as a mile. The disease cannot spread from one tree to another, but must spend part of its life on currant or gooseberry bushes. The rust attacks the cambium, ultimately girdling the tree.

The western gall rust attacks western yellow pine in localities where sweet fern is abundant in the vegetation. This disease must have the sweet fern present if it is to attack the pine. When the disease attacks a tree less than 10 years old, death usually follows. The gall rust is less damaging on older trees. It attacks the cambium of the trunk, scarring the tree, but working very slowly. The damage to large trees is chiefly in the form of disfiguration of the trunk and slight depreciation of lumber quality.

*Seed mixture for food patches for wildlife, by P. F. English. Department of Conservation, Game Management Circular No. 1.

The white pine weevil attacks the terminal leader of white pine, causing deformity. This insect has not been abundant in Michigan, and the damage has been serious only in a few places. Damage appears to be most acute where growth is poorest. It is most likely to become a serious pest where extensive areas of pure white pine are planted. Small plantations on good sites are often free of infestation.

The locust borer attacks a single species, black locust. It works first in the cambium and ultimately bores into the wood. Lowered vitality is the result. In cases of very serious damage, trees may actually break down. The trees are most susceptible to attack while they are between one and six inches in diameter. A mixture of species with black locust reduces the likelihood of infestation.

The June-beetle attacks several of the hardwoods, but notably the oaks. It feeds on the foliage in the early part of the growing season, sometimes causing almost complete defoliation where the insects are abundant. This insect appears to have caused serious damage only in a few localities in southern Michigan. June-beetle attacks develop only where conditions are favorable to propagation and an undisturbed sod provides a particularly favorable condition.

The European pine-shoot moth was first noted in Michigan in 1930. In the United States, red pine seems to be the favorite host of this insect. It feeds chiefly on the buds of small trees, usually attacking the terminal bud first, and not infrequently boring into twigs to a depth of a half inch or more. Trees are sometimes killed by the attack. The pine-shoot moth usually does not travel from one locality to another.

The spruce bud-worm is a defoliator which attacks the spruces, balsam fir, and to a lesser degree white pine, Scotch pine, jack pine, tamarack, and hemlock. It feeds on the buds and new needles that have failed to harden early in the season. Partial defoliation usually results causing some reduction in growth. If defoliation continues for more than one season, the tree may be seriously injured or even die. Pure stands of balsam fir are most susceptible.

The larch sawfly, another of the defoliators, is a real menace to tamarack. This insect has so completely wiped out the old natural stands of tamarack that this species cannot be recommended generally for forest planting. The sawfly also attacks the introduced larches but they appear to be much less susceptible than the native tamarack.

The jack pine sawfly sometimes attacks jack pine, especially where there are extensive areas of pure jack pine. It is a defoliator similar to the larch sawfly but has not done such extensive damage as the latter.

RECOMMENDED SPECIES

Northern White Pine (*Pinus strobus*)

Northern white pine is adapted to a variety of soils but makes its best development on a sandy loam or loamy sand. It grows almost equally well on gravelly soils that contain some clay mixture. White pine will grow on a variety of other sites including light sand, heavy clay, and muck soils, but its growth on such sites is usually inferior. Other species are better adapted to such areas. It can be grown in any part of the State, but has two important enemies, white pine blister rust and white pine weevil. White pine is much slower in becoming established than red pine as it makes very slow growth

for the first few years after planting. Four or five years after planting, more rapid growth begins and from that time on, height growth of one foot to two feet per year can be expected. White pine can stand a moderate amount of crowding and overhead competition without any sacrifice in growth.

White pine is a very valuable tree for saw timber if allowed to grow to sufficient size. A period of 80 years is usually necessary to produce high grade lumber, although trees of sawlog size will develop in 40 to 50 years. White pine yields pulpwood in a shorter period but the profit now obtained from this species for pulpwood is less than that received for an equal quantity of lumber. However, trees removed in thinnings that are too small for sawlogs can be marketed advantageously for pulpwood.

Fig. 3. Seven years later (Figure 2). Four year white pine transplants spaced five by five feet, the crowns nearly form a closed canopy.

White pine, as well as other pines, is not to be recommended generally for extensive solid planting for bird and animal production. It is used by smaller birds for breeding purposes, and by both birds and animals for winter shelter, and the buds, seed, and foliage are used to a slight extent in the winter and spring for food. As the trees grow older, losing their lower limbs, and as the foliage becomes thinner, their value to birds and animals decreases.

Red (Norway) Pine (*Pinus resinosa*)

Red or Norway pine can be grown on the lighter soils. It is best adapted to well drained sands, sandy loams, loamy sands, and gravels. Although it will grow on heavy loam, silt, or clay soils, red pine does not make good development on such sites. On coarse textured soils having rapid drainage, this species withstands the dry condition better than white pine. It can be grown in any part of the State.

The red pine becomes established easily and fairly rapid growth often begins the second season after planting; it is not uncommon for red pine seedlings to make good growth during the first season if the weather is favorable. Its early growth greatly exceeds that of white pine, but, after four or five years, by which time the latter has attained rapid growth, there is little difference in the growth rate of the two species on comparable sites. Rapid height growth of red pine is not likely to continue for so long a period as that of white pine nor does it grow well in a dense stand.

Red pine has its highest value in the form of saw timber. It will yield the best grade of saw timber when grown on a rotation of 80 years or more. This species has much the same value for wild life production as white pine. It is not as prolific a seeder nor is its foliage as dense as white pine, hence furnishing less food for seed-eating birds and animals and less shelter.

Jack Pine (*Pinus banksiana*)

Jack pine can be grown on coarse textured dry soils where other species would fail to survive and grow. It does not appear to be so well adapted to the southern half as to the northern half of the State.

Jack pine becomes established with ease and begins rapid height growth within a year after planting. Growth is fairly rapid, but falls off noticeably after about 40 years. This species survives crowding fairly well, but its rate of growth decreases markedly under such conditions. It does not attain such large size as white or red pine, nor does it produce such good quality lumber. It is a satisfactory pulpwood tree, and during the past few years, there has been an increasing demand for jack pine for that purpose. Jack pine can be used also for box boards. It furnishes excellent protection to wild life but has little value for food.

Scotch Pine (*Pinus sylvestris*)

Scotch pine, a tree introduced from Europe, has characteristics and requirements similar to those of jack pine. Trees grown from seed collected in central Germany are usually very crooked while those grown from seed collected in Finland or the Baltic provinces of Russia, known as the Riga variety, are usually of good form. Scotch pine can be used with success on dry coarse textured sands. Growth is of course, better on the more fertile soils. This species appears to be best adapted to the southern part of the State where jack pine does not grow so well.

Scotch pine becomes established easily and makes rapid growth almost from the start. Height growth varies from one foot to two and one-half feet annually, depending on the quality of the site. This species does not withstand crowding satisfactorily.

Scotch pine can be utilized to best advantage, for pulpwood, and should produce a crop in 30 to 40 years. Scotch pine is inferior as a lumber tree. It has no advantage over other pines for bird and animal production.

Western Yellow Pine (*Pinus ponderosa*)

Western yellow pine, a species native to the western United States, has been grown with success in some sections of the southern part of the State. It makes fairly good growth on the sandier soils, and moderately rapid growth, from one foot to one and one-half feet, on the better sandy loams. This pine withstands drought better than the native pines during the first year. Western yellow pine cannot be recommended for northern Michigan

nor for along the shore of Lake Michigan because of the general prevalence of sweet fern, the alternate host for the western gall rust.

Western yellow pine is a very good tree for saw timber. The wood is similar to that of the red pine. It will probably produce lumber of good quality in about 80 years. This tree makes poor growth when crowded and it is similar in value to red pine for wild life production.

White Spruce (*Picea glauca*)

White spruce can be used successfully only in the upper peninsula and the northern half of the lower peninsula. It grows most satisfactorily on sandy loam soils with slow drainage, although it grows well on some sandy loams or clay loams with free drainage. White spruce grows slowly for the first few years, and makes moderately rapid growth thereafter, height growth in later life varying from one foot to one and one-half feet annually. It withstands crowding exceptionally well.

White spruce is a very satisfactory tree for pulpwood, for which it is in constant demand. Satisfactory yields of pulpwood can be produced in about 40 years. It is inferior for saw timber. White spruce is satisfactory as a Christmas tree. This is a special use that is discussed in another bulletin which may be secured from this Station upon request.

White spruce, as well as other spruces, is superior to the pines for protection in that the lower limbs are retained longer and the foliage is denser. The new foliage in the spring is browsed to a limited extent by grazing animals and the buds and seed furnish food for such animals and birds as squirrels and grouse.

Norway Spruce (*Picea excelsa*)

Norway spruce, another of the trees introduced from Europe, grows well in the southern half of Michigan. This spruce is best adapted to well drained sandy loams or gravels. It begins rapid growth within a year or two after being planted and continues to grow rapidly for 40 to 50 years. On an average site, height growth is about one foot to one and one-half feet annually. It grows fairly well in a crowded stand.

Norway spruce is an excellent pulpwood tree, growing to pulpwood size in 30 to 40 years. It is also fairly satisfactory as a Christmas tree. This is a special use which is discussed in another bulletin available upon request from this Station.

Black Spruce (*Picea mariana*)

Black spruce is essentially a northern tree but it can be grown successfully to a limited extent on certain swamp sites in the southern part of the State. It occurs naturally on soils where drainage is slow, occupying low-lying sands, peat, and muck. On the poorest drained-soils or on sites overlain by a thick layer of sphagnum moss, the growth of black spruce is extremely slow. This species is not a rapid growing tree on any site but makes fair growth on soils which are not too wet. It prefers cool situations and is therefore best adapted to use in the northern half of the State. Black spruce, because it will grow on wet sites where other trees will not grow successfully, has a place in the planting program in spite of its slow growth. This species survives without difficulty in very dense stands but a high density should not be encouraged because the result is stagnation in growth and poor root development which is conducive to windfall.

Black spruce is a valuable tree for pulpwood. It seldom attains large enough size to be used for saw timber. On the very best sites, it may be possible to produce a good yield of pulpwood in 60 years, but on average sites a period of 80 to 100 years may be necessary.

Balsam Fir (*Abies balsamea*)

Balsam fir is somewhat similar in its site requirements to white spruce and it grows naturally in mixture with the latter on many sites. Sandy loam soils with slow drainage are the soils to which it is best adapted, but it also grows satisfactorily on sandy loams or clay loams with free drainage.

Balsam fir grows more rapidly than white spruce, especially during early life, although rapid growth is characteristic until maturity. However, it matures earlier than spruce and commonly becomes infected by a trunk rot before an age of 50 years which later causes serious deterioration of the heartwood. On rotations of less than 50 years, such as would be used for pulpwood, this is not a serious menace. This species is tolerant of crowding.

Balsam fir is in demand chiefly for pulpwood, merchantable crops of which will be produced in less than 40 years. This species is similar to spruce in its value for animal and bird production. It is more palatable as browse during the winter months, especially for moose.

European Larch (*Larix europaea*)

European larch, a species introduced into this country from Europe, has the same general appearance as the native tamarack but they differ in site requirements in that the European tree requires a well drained soil. It is best adapted to deep sandy loam or loam soils and so far as known, European larch can be grown throughout the State.

European larch makes very rapid growth, undoubtedly exceeding in this respect any conifer that can be planted in Michigan, but grows slowly and ultimately dies if crowded by other trees.

The wood of the European larch is heavy and hard, and is durable in contact with the soil. It is satisfactory for fence posts, poles and ties, but it is less desirable for saw timber. It should produce fence posts in about 20 years. Because larch sheds its needles and has rather thin foliage it is not so desirable as other conifers for animal and bird production.

Northern White Cedar (*Thuja occidentalis*)

Northern white cedar is well adapted to muck soils, mineral soils of high moisture content, and certain upland soils that have limestone in the parent material. It is primarily a northern tree, being best suited to the northern two-thirds of the lower peninsula and to the upper peninsula. Cedar is a slow growing tree but probably no more so than most of the species which can be grown on similar sites.

White cedar is a valuable tree because of the durability of the wood and the forage value of its needles for winter deer food. It makes an excellent fence post and if grown to larger size is valuable for telephone poles and shingles. This species will reach fence post size in 30 to 40 years on an average site. Because the foliage is retained close to the ground for many years cedar furnishes food and shelter for animals and birds for a long period. It survives in a very dense stand.

Black Locust (*Robinia pseudoacacia*)

Black locust has been grown with success in southern Michigan. Soils with a neutral or alkaline reaction are superior to acid soils for this species, although it becomes established readily on even the poorest well-drained sites. However, its growth and form are so inferior on poor soil and it is so susceptible to attack by the locust borer that the tree cannot be expected to yield valuable forest products on such sites. To make satisfactory growth, black locust demands a surface soil that is loose and well drained but moist, and a subsoil that is sufficiently loose to allow for free movement of moisture. A compact subsoil is especially unfavorable.

Black locust is a very rapid growing tree, height growth of two to three feet per year being common. Rapid growth begins during the first year and continues for 30 to 40 years.

The wood of black locust is very hard and durable, being one of the few woods that without preservative treatment will resist decay for many years even when in contact with the soil. Hence, black locust is especially good for fence posts. It will yield a large number of posts per acre in 20 years. This tree produces prolific supplies of seed which is available during the winter months, making it valuable as a source of food for animals and birds. Also, the blossoms of locust are excellent sources of honey. It's leaves are toxic to grazing animals but if other food is available, animals will not graze it extensively.

Basswood (*Tilia glabra*)

Basswood grows naturally throughout the State. This tree is best adapted to sandy loam soils that have enough clay in the subsoil to prevent too free drainage. It also grows well on loam and silt loam soils.

Basswood is one of the most rapid growing of the native hardwoods, height growth of one foot to two feet per year being typical of average sites. Rapid growth continues into late life. In later years, trunk rot is likely to reduce its merchantability. Basswood has its greatest utility for excelsior bolts and saw timber, good sized sawlogs being produced in 60 to 80 years. It can be used for fuelwood but is less desirable for that purpose than some of the denser hardwoods. In some localities, basswood is used for pulpwood, but such demand has not developed in Michigan. This species is valuable as a source of squirrel food since it produces a nut-like seed in abundance almost annually. Its foliage and twigs are of value for browse and the blossoms yield an excellent honey.

Red Oak (*Quercus borealis*)

Red oak is adapted to sandy loams and loams underlain within a few feet of the surface by gravel or a gravelly sandy clay. It reaches its best development in southern Michigan.

Red oak becomes established rather easily if the newly planted tree does not have to compete with grass or other heavy vegetation. It is a rapid growing tree, its growth being exceeded by very few hardwoods. Height growth of one and one-half to two feet per year, and diameter growth of one inch to one and one-half inches per decade occur on soils of average fertility.

Red oak is a valuable timber tree. It produces good quality lumber, is sufficiently hard and durable to make good fence posts, cross-ties, and piling, and it makes good fuel wood. Red oak will yield fence posts in 25 to 35

years and saw timber in 60 to 80 years. Its acorns furnish excellent food for some animals and for the larger seed-eating birds, such as pheasants, during the fall and winter months.

White Ash (*Fraxinus americana*)

White ash is adapted to good quality soils such as the better sandy loams that do not have too free drainage, loams and silt loams. This tree will grow in any part of the State where soil conditions are right except in the extreme northern part of the State.

White ash is one of the rapid growing hardwoods, height growth of one foot to one and one-half feet annually and diameter growth of more than one inch in ten years being typical. It will survive a moderate degree of crowding.

White ash is one of the most valuable timber trees because of its rapid growth and the desirable characteristics of its wood. The wood is very strong, and is, therefore, particularly desirable for tool handle and implement stock. It makes excellent lumber, is fairly satisfactory for fence posts, and makes good fuel wood, although good quality trees are too valuable to be used for the latter purposes. The seed of all species of ash is desirable squirrel food, but the sparse foliage of the tree makes it less desirable for wild life shelter.

Yellow Poplar (*Liriodendron tulipifera*)

Yellow poplar cannot be expected to make satisfactory growth north of the southern two or three tiers of counties. It demands a fertile soil, making its best growth on moist but well-drained loams and silt loams. Satisfactory growth occurs also on some of the sandy loam soils that have enough clay in the subsoil to conserve soil moisture. Yellow poplar grows rapidly on sites to which it is adapted if it has ample growing space. This species is very sensitive to crowding.

Yellow poplar is one of the most valuable lumber trees. In some sections of the country it is utilized for pulpwood, but, this use has not developed in Michigan. The wood is not satisfactory for fence posts because of its softness and non-durability. Neither is it a particularly good fuelwood. Its seed is a favorite food of the rodent family during the fall and winter months.

Sugar Maple (*Acer saccharum*)

Sugar maple is well adapted to a variety of moist well drained sandy loams and loams. It can be grown successfully throughout the State wherever the right type of soil exists. Its growth varies from moderately rapid in the southern part of the State to rather slow in the northern parts. This species survives intense crowding exceptionally well.

Sugar maple is an excellent lumber tree, the wood being especially valuable for flooring and furniture. It is also satisfactory for fence posts or cross ties, but must be treated with a preservative to give long service. The wood is excellent for fuelwood. Sugar maple has a distinctive use for sugar bush plantings. Its leaves and twigs furnish a limited amount of browse and its dense foliage gives a heavy shade making this species a desirable hardwood for animal and bird shelter.

Fig. 4. Sugar maple planted for a sugar bush should be spaced widely (20-ft. x 20-ft.) to allow for ample crown development.

Black Walnut (*Juglans nigra*)

Black walnut is limited in use to the moist loam and silt loam soils of southern Michigan. It will grow on less fertile soils and in the more northern sections of the State, but its growth is slow and its form and development inferior. Moderately rapid to rapid growth is characteristic on the more favorable sites. Black walnut is not adapted to planting in pure stands. In plantation form not more than 25 per cent of the trees should be walnut, the remainder other hardwoods. It makes excellent growth when planted either as single isolated trees or small groups of three.

Black walnut is a tree of outstanding value for lumber. Sawlogs with a diameter of 18 inches can be produced in a period of 50 to 60 years on the better sites. The nuts of the tree are a favorite food of squirrels. Since black walnut does not propagate true to form from seed, grafted stock should be used for the production of nuts for the market.

Catalpa (*Catalpa speciosa*)

Catalpa can be grown successfully only in the southern part of the State, although along Lake Michigan a more northern limit appears feasible. It is best adapted to moist well drained sandy loams and loams, on which fairly rapid growth occurs.

Catalpa is especially valuable for fence posts because of the natural durbility of the wood. The tree does not attain large size and it is therefore inferior for lumber. Its blossoms supply much honey.

American Elm (*Ulmus americana*)

American elm can be grown successfully in any part of the State on the moister sites. This species is best adapted to sandy loam and loam soils which have slow drainage. It is one of the most rapid growing hardwoods, height growth of one foot to two feet per year often beginning within a year after planting. Diameter growth is also rapid.

American elm will yield lumber, fuelwood, and fence posts. The lumber is vastly inferior to that of many of the hardwoods and is therefore not in such great demand. In sections where American elm is used by the basket industry, there is a good demand for this species. Because it will grow close to streams this species is satisfactory for planting along game fish streams for shade to moderate water temperature.

Eastern Cottonwood (*Populus deltoides*)

Eastern cottonwood is adapted to a variety of sites in the lower peninsula, but makes its best growth on soils that are well supplied with moisture. Soils with slow drainage are ideal for cottonwood. It will succeed on sandy soils but growth will be slow and it will mature early. On favorable sites, where it can be grown readily from cuttings, the growth is very rapid, a height growth of two to three feet annually being common.

Cottonwood has a limited market. In some sections, it is in demand for excelsior or pulpwood. It can be used for lumber but the product is of inferior grade. Pulpwood is produced in about 30 years. Because of its prodigious sprouting capacity, cottonwood withstands browsing remarkably well. It is also a favorite food for beaver.

Balm of Gilead (*Populus balsamifera*)

This species is similar to cottonwood and is recommended for planting in the northern part of the State rather than cottonwood. It does not grow as large but will reach a diameter of three feet on moist sites.

Black Cherry (*Prunus serotina*)

Black cherry is adapted to well drained sandy loams and loams throughout the lower peninsula. Although occurring naturally in the upper peninsula, the tree does not develop such large size and good form and is therefore not recommended for commercial forest planting there, except where food production for birds is a primary object of the planting.

Black cherry is a rapid growing tree when not crowded. Diameter growth of one and one-half inches per decade and height growth of two feet annually are characteristic.

This species is valuable for wood production, particularly for furniture stock, fuelwood, and fence posts. Trees of good sawlog size can be grown in 60 to 80 years.

The fruit of black cherry is a favorite food of birds. Its use as an associate species for bird production is recommended.

Miscellaneous Species of Trees and Shrubs

Several species of trees and numerous shrubs have special value for aesthetic purposes and for game management, but are inferior for the production of wood, although some of them are used for rough lumber and firewood. These species will be discussed briefly in the subsequent paragraphs.

Beech (*Fagus grandifolia*) and the several species of hickory (*Hicoria sp.*) are especially valuable as a source of food in the form of nuts for squirrels. Beech nuts are also consumed by pheasants. Beech will grow in any part of the State on sandy loams. The wood is hard and heavy and is commonly used for rough lumber and fuel. The hickories must be confined to the southern half of the lower peninsula on sandy loams, loams, or sandy clays. Its wood is commonly used for handle stock.

Eastern red cedar (*Juniperus virginiana*), hackberry (*Celtis occidentalis*), sassafras (*Sassafras variifolium*), red mulberry (*Morus rubra*), hawthorn (*Crataegus spp.*), serviceberry (*Amelanchier canadensis*), and dogwood (*Cornus florida*), all produce some browse and small fruit which is eaten by both small animals and a variety of birds. Dogwood, serviceberry, hawthorn, and eastern red cedar add special variety to the landscape and therefore have high aesthetic value. Any of these species can be grown on average

Table 1. Trees for forest planting in Michigan.

Name	Wood				Birds						Deer												
					Food				Cover		Food				Cover								
	Lumber	Ties	Posts	Pulp	Spring	Summer	Fall	Winter	Summer	Winter	Spring	Summer	Fall	Winter	Summer	Winter	Beaver	Rabbit	Squirrel	Fish	Pheasant	Honey	Erosion
White pine	x						x		x	x				x	x	x			x				
Norway pine	x						x		x	x				x	x	x			x				
Jack pine	x			x		x	x		x	x				x	x	x			x				x
Scotch pine	x			x		x	x		x	x				x	x	x			x				x
Western yellow pine	x						x		x	x					x	x			x				x
Balsam fir	x			x			x		x	x					x	x							
White spruce	x			x			x	x	x	x					x	x			x		x		
Norway spruce	x			x			x	x	x	x					x	x		x	x		x		
Black spruce				x			x	x	x	x					x	x							
White cedar		x	x				x	x	x	x				x	x	x		x		x	x		
Hemlock	x						x		x	x				x	x	x				x	x		
European larch	x	x	x				x		x		x			x	x								
Black locust	x	x	x		x		x	x	x	x	x				x			x			x	x	x
Basswood	x						x	x	x		x	x		x	x						x	x	
Red oak	x	x	x				x		x				x		x				x		x		
White ash	x		x				x				x			x	x				x			x	
Black ash	x		x				x		x		x			x	x				x	x			
Yellow poplar	x						x	x						x								x	
Sugar maple	x						x		x			x		x	x				x			x	
Black walnut	x														x				x				
Catalpa			x		x				x						x							x	
American elm	x		x		x				x	x				x	x			x		x			x
Cottonwood	x							x	x	x				x	x		x						x
Aspen								x	x	x				x	x		x						x
Black cherry	x					x	x		x					x	x				x		x		
Pin cherry						x	x		x		x			x	x						x		x
Beech	x						x	x	x				x	x	x			x	x		x		
Hickory	x						x		x						x				x				
Red cedar	x	x	x				x	x	x	x					x	x		x					x
Hackberry	x						x		x						x				x				x
Sassafras	x					x			x			x		x	x				x				x
Mulberry						x			x					x	x			x	x		x		x
Hawthorne							x	x	x						x				x		x	x	x
Serviceberry						x			x		x	x		x	x						x	x	x
Dogwood						x			x			x		x	x				x			x	x
Red maple	x								x		x	x		x	x				x	x		x	x
Silver maple	x								x		x	x		x	x				x	x		x	x
Box elder									x		x	x		x	x							x	
Yellow birch	x							x	x		x	x		x	x								
White birch	x							x	x		x	x		x	x								
Grey birch								x	x		x	x		x	x					x			x
Alder									x						x								
Willow					x				x		x	x		x	x					x	x		x
Witchhazel									x			x		x	x					x			x

Table 2. A partial list of shrubs and vines of value for food and shelter for birds and cottontail.

(Suggested by P. F. English, State Conservation Department)

	Bob White	Pheasant	Ruffed Grouse and Partridge	Hungarian Partridge	Cottontail
Arrowwood, toothed, *Viburnum dentatum*	x		x		
Ash, mountain, *Sorbus decora* or *Aucuparia*	x				
Bayberry, small, *Myrica caroliniensis*	x		x		
Barberry, Japanese, *Berberis thunbergii*	x	x	x		x
Beech, blue, *Carpinus caroliniana*			x		
Bittersweet, *Celastrus scandens*	x	x	x		x
Blackberry, high, *Rubus alleghenienses*	x		x		x
Blueberries, *Vaccinium spp.* (several species)	x	x	x		x
Buckthorn, *Rhamnus spp.* (several species)			x		
Cherry, sand, *Prunus pumila*			x		
Chokeberry, black, *Aronia melanocarpa*	x	x	x		
Chokeberry, red, *Aronia arbutifolia*	x				
Coral-berry, *Symphoricarpos vulgaris*			x		
Cranberry, *Oxycoccus spp.*			x		
Cranberry, highbush, *Viburnum opulus*	x	x	x		
Deerberry, *Vaccinium stamineum*	x				
Dewberries, *Rubus procumbus* or *hispidus*	x	x	x		
Dogwood, blue, *Cornus alternifolia*	x	x	x		
Dogwood, panicled, *Cornus paniculata*	x	x	x		x
Dogwood, red-osier, *Cornus stolonifera*	x	x	x		x
Dogwood, silky, *Cornus amomum*	x		x		
Elderberry, common, *Sambucus canadensis*	x	x	x		
Elderberry, red, *Sambucus racemosa*	x		x		
Grapes, *Vitis spp.* (several wild species)	x	x	x		x
Haw, black, *Viburnum prunifolium*	x		x		
Hawthorn, *Crataegus spp.* (many species)	x	x	x	x	x
Hobblebush, *Viburnum alnifolium*	x		x		
Holly, mountain, *Nemopanthus mucronata*	x		x		
Honeysuckle, Japanese, *Lonicera Japonica*	x	x	x		
Honeysuckle, smoothleaf, *Lonicera dioeca*			x		
Honeysuckle, tartarian, *Lonicera tatarica*		x	x		
Honeysuckle, trumpet, *Lonicera sempervirens*			x		
Huckleberry, *Gaylussacia baccata*	x	x	x		
Ivy, poison, *Rhus toxicodendron*			x		
Juniper, *Juniperus communis*	x	x		x	
Matrimony vine, *Lycium halimifolium*	x				
Plum, beach, *Prunus maritima*			x		
Raspberry, black, *Rubus strigosus*	x	x	x		x
Raspberry, rose-flowered, *Rubus odoratus*	x		x		
Roses, *Rosa spp.* (many species)	x	x	x		x
Sheepberry, *Viburnum lentago*	x		x		
Smilax, *Smilax spp.* (several species)	x		x		x
Snowberry, *Symphoricarpos racemosus*	x	x	x		
Spicebush, *Benzoin aestivale*	x		x		
Sumac, mountain, *Rhus copallina*	x		x		
Sumac, smooth, *Rhus glabra*	x		x		x
Sumac, staghorn, *Rhus typhina*	x	x	x		
Viburnum, maple-leaf, *Viburnum acerifolium*	x		x		
Virginia creeper, *Psedera quinquefolia*	x	x	x		
Wahoo, *Euonymus atropurpureus*	x	x	x		
Winterberry, *Ilex verticillata*	x	x	x		
Wintergreen, creeping, *Gaultheria procumbens*	x		x		

well drained soils in the southern part of the State, although serviceberry is adapted to the entire State.

The three maples, red maple (*Acer rubrum*), boxelder (*Acer negundo*), and silver maple (*Acer saccharinum*), are especially valuable for deer browse and cover for birds. They are aggressive species which withstand mistreatment remarkably well and with prodigious sprouting ability are particularly valuable for continuous browsing. The birches, yellow birch (*Betula lutea*) and white birch (*Betula papyrifera*), supply both cover and food to animals and upland birds and are valuable for lumber. Then such species as alder,

willow, witchhazel, and shrub species of dogwood are of particular value for use along streams for shading purposes, and all except alder are browsed by deer. Tables 1 and 2 list the commoner trees, shrubs and vines, with their principal uses, that will grow in Michigan.

PURE VERSUS MIXED STANDS

Although it is usually easier and frequently advantageous financially to establish plantations of a single species, there are certain advantages in using more than one species. The advantages of a mixed plantation are largely biological. They are less susceptible to various destructive agencies and they more successfully satisfy the food and shelter requirements of animals and birds. It is generally recognized that a mixture of species will make better utilization of the site, conserve the quality of the site to better advantage, and avoid or minimize certain insect and disease difficulties to better advantage than will a plantation of a single species. It has also been found in some cases that the timber quality is improved by using the correct species combination.

An excellent example of reducing insect damage by mixed planting is found in the case of the white pine, which when grown in pure stands is much more susceptible to white pine weevil attack than when developed as a mixed stand, using either other conifers or hardwoods in mixture. Similar experiences have been encountered with the black locust which is attacked by the locust borer, and the balsam fir which is attacked by the spruce budworm. There is always a greater tendency for any insect or disease to become more serious when a stand consists entirely of one species, the host tree. Obviously, if more than one species is growing in a plantation and only one species is destroyed by disease or insects, the timber stand will not be completely destroyed. Fortunately, none of the diseases or insects attacking forest trees recommended for planting in Michigan are so damaging that there is any prospect that a plantation of a single species might be wiped out, but it is well to recognize that an insect and disease menace is ever present and that any precautions that can be taken to discourage their development are well worth while.

Since our knowledge of growing two or more species together in a plantation is incomplete, it is best to keep mixtures rather simple and to use combinations that from experience have demonstrated their value. Complex mixtures should be avoided. It is safest to limit the number of forest trees to be grown together for wood production to two or three. From the standpoint of improving timber quality by hastening natural pruning of the trunk of conifers, it is best to grow together a slow growing shade enduring species with a rapid growing light demanding species. Such a combination also results in more complete utilization of the site because the stand can be kept denser.

With some species, particularly those about which our knowledge is fragmentary, it is not practicable to grow two species in direct mixture with each other. In that case, some of the advantages of a mixture can be secured by planting each species in separate groups or strips. For example, in using the strip method of mixture, a strip of three or four rows of one species would be alternated with strips of three or four rows of the second species.

Group mixtures are well adapted to areas having considerable variation in soil and drainage. By using this method, it is possible to use the species best adapted to each site. For example, on an area where the topography is rough and broken, if white pine and red pine were to be planted in group mixture the white pine could be used on north aspects, on the flats where soil moisture is favorable, and on the better soils, while red pine could be used on south aspects, on ridges, and where the soil is of poor quality.

Mixtures of forest trees which have proved successful include: (1) White pine and Norway spruce, (2) white pine and red pine in strip mixtures, (3) red oak and white pine, and (4) Scotch pine and white pine. Other mixtures which give promise of success are white spruce and balsam fir, black locust and other hardwoods such as red oak, sugar maple, and white ash, red pine and Norway spruce, and jack pine and red pine. When any of the hardwoods are planted in mixture with white pine, it has been found that a group mixture is best because it prevents mechanical injury to the pine terminals by whipping of the hardwood tops.

Where wild life management is an important, or the principal consideration, plantations should be planned to produce food and shelter during the different periods of the year. This inevitably results in mixed stands in which cellulose production will be subordinated to wild life. Timber species under such circumstances should be mingled with trees and shrubs designed to furnish the greatest possible attraction and protection to the desired birds or animals or both. Often, with that in mind, open areas within or adjacent to the forest must be retained for the production of herbaceous and annual seed producing plants.

CHOICE OF PLANTING STOCK

In forest planting, two classes of planting stock are commonly used, seedlings and transplants. Seedlings are trees one to three years of age, grown from seed in a seed bed. Coniferous seedlings two years old usually average two to six inches in height and three-year-old seedlings from three to ten inches in height. Hardwood seedlings grow much more rapidly, some species reaching heights of one foot to two feet the first year. Because seedlings grow a long straggling root system they must be planted in the field within the first two or three years, or reset in single rows in the nursery.

When reset in the nursery, they are then known as transplants and for forest planting purposes remain from one to three years. Since transplanted seedlings are spaced two to four inches between plants, with rows from six to 20 inches apart, they develop a compact bushy root system which gives transplants a size and quality advantage over seedling stock of the same age. The transplant stock sold from most forest tree nurseries is once transplanted stock from three to five years of age, averaging from six to 15 inches in height. Differences in the character of the site largely determine whether seedling or transplant stock should be used.

Small seedlings cannot survive as much competition from vegetation as transplants, therefore, on sites bearing heavy sod, tall weeds, or brush, the latter class of stock is a better choice. Grass or weeds compete for soil moisture and light in summer, as well as forming a smothering mulch in winter. For these reasons, small seedlings should not be used on such sites

unless this competing vegetation is removed as described under the section "Site Preparation" on page 26.

Normally, denser vegetation is found on heavy soils, so that seedlings stand a better chance on lighter soils considering vegetative competition only. However, such light soil, especially if there is no heavier subsoil present may also require transplant stock because of the lack of moisture. Neither seedlings nor transplants will thrive under the cover of older trees or tall brush. If a wooded area is to be planted, the openings only should be filled in.

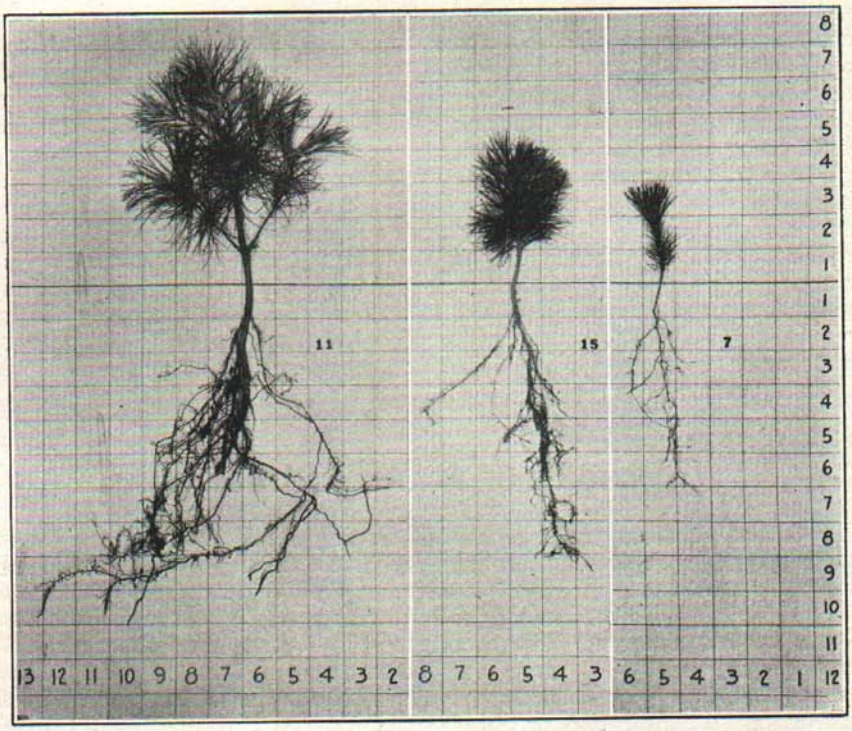

Fig. 5. White Pine Seedlings. Left to right—2-1 stock, i. e., stock 2 yrs. in seed bed followed by 1 yr. in transplant rows; 2-0 stock—2 yrs. in seed bed; 1-0 stock—1 yr. in seed bed. Numerals bordering the figure represent inches. 2-0 or 2-1 stock as shown, or 3-0 and 2-2 stock (not figured) are common ages for forest planting.

In the average rotation of 40 to 80 years with planted forests, a difference of one to two years in the age of the original stock is negligible and so the only essential limitation is whether or not the smaller stock will survive, as it can be purchased for less and requires a smaller planting hole, reducing planting costs. In addition, small trees suffer less shock and disturbance both during digging from nursery beds and during resetting in the field. They are, therefore, in better condition to become established and begin growth. As a general rule, the size of the tops must be at least large enough so that the trees will compete successfully with the natural

vegetation. The minimum root length must be greater than the depth to which the soil dries out in summer. Ten inches may be considered sufficient root length for seedlings since holes are seldom opened lower than this in ordinary field planting.

Seedling trees two or three years of age are most commonly used in forest planting. Three-year-old seedlings are slightly more expensive than

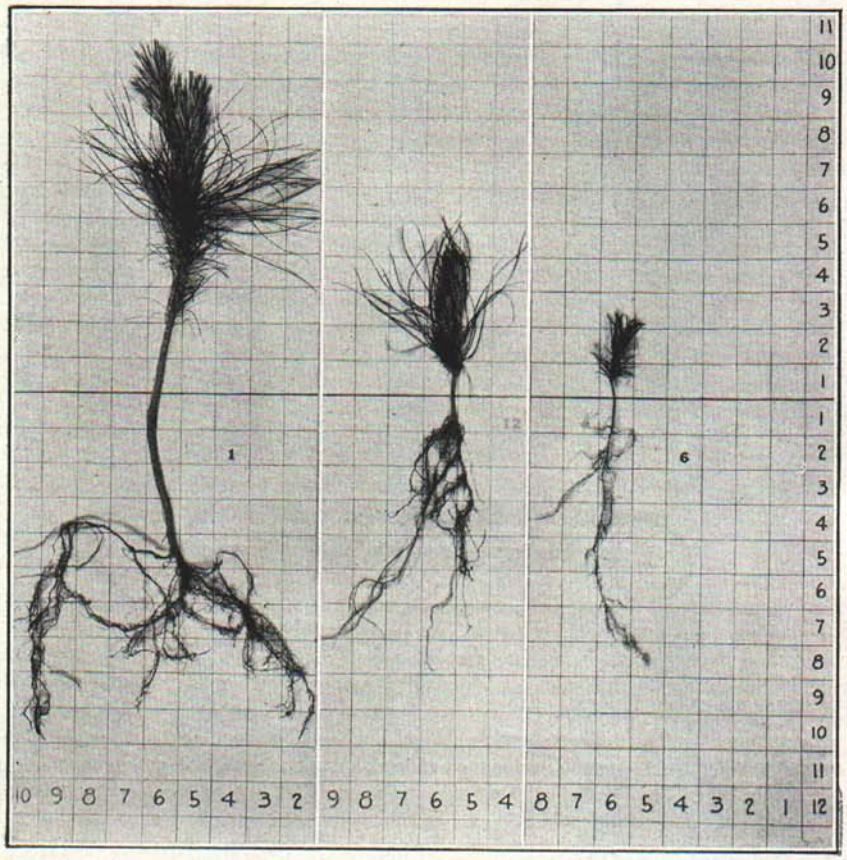

Fig. 6. Red Pine Seedlings. Left to right. 2-1 stock, i. e. stock 2 yrs. in seed bed followed by 1 yr. in transplant rows; 2-0 stock—2 yrs. in seed bed; 1-0 stock—1 yr. in seed bed. Numerals bordering the figure represent inches. 2-0 or 2-1 stock as shown, or 3-0 and 2-2 stock (not figured) are common ages for forest planting.

two-year-old plants but have better tops. This increased top growth gives an advantage to the seedlings in competition with weeds and grass, both in the growing season and in winter when dead grass may bury the smaller trees, causing extensive losses. Transplant coniferous stock may be used on heavy sod or on shifting sand as well as on areas where a deeper and larger root system is required to reach a constant and adequate moisture supply.

Hardwood stock for reforestation purposes is seldom grown to transplant

size because seedling stock is usually large enough to survive even on adverse sites. This greater size factor helps overcome quite adverse site conditions in planting. Transplants, though costing more than seedlings, are sometimes a better investment on difficult planting sites in terms of the number of trees that actually live. Some loss will usually take place. An 85 per cent seedling and a 95 per cent transplant survival is considered a highly successful planting.

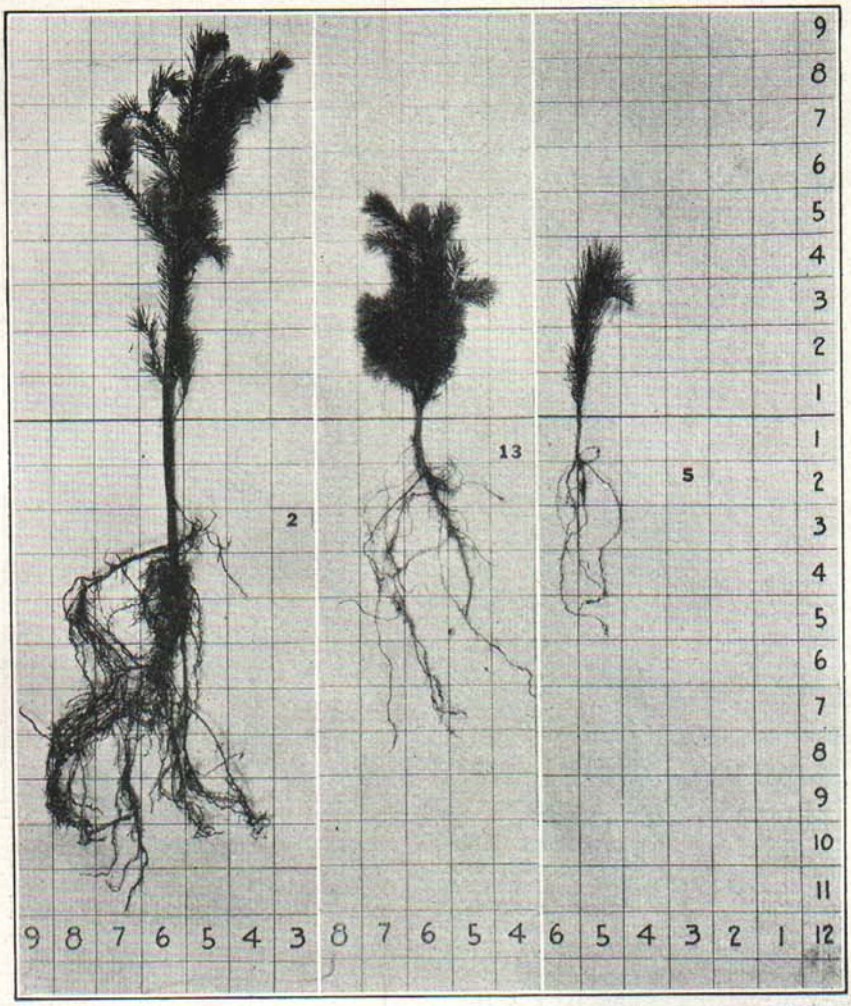

Fig. 7. Norway Spruce Seedlings. Left to right. 2-1 stock, i. e. stock 2 yrs. in seed bed, followed by 1 yr. in transplant rows; 2-0 stock—2 yrs. in seed bed; 1-0 stock—1 yr. in seed bed. Numerals bordering the figure represent inches. 2-0 or 2-1 stock as shown, or 3-0 and 2-2 stock (not figured) are common ages for forest planting.

WHERE TO SECURE PLANTING STOCK

For a small project, enough wild seedlings may be dug from the woods nearby, especially if these plants have been growing in the open. However, there are several disadvantages in the use of wild forest stock. First, a state law requires a permit for the transportation of trees or shrubs beyond the land on which they are growing. Permits are given by the State Department of Agriculture after inspection of the stock has indicated that the plants are free from noxious insects and disease. This limits the source of wild stock to trees grown on the owner's land or that of a licensed dealer. Secondly, without nursery care most wild trees have developed straggling root systems, which are difficult to transplant successfully. The tops are often spindly from excessive shade under older trees and the sudden exposure to sun and wind after transplanting may cause the death of many such trees. Finally, wild stock also lacks the uniformity of age and size possessed by nursery trees. Many of them are much older than they appear and have been suppressed in growth so long that it may be several years before they resume normal growth. In view of these factors, nursery stock is generally used on reforestation projects.

The planting stock should be purchased as near home as possible so that the stage of growth of trees in the nursery will be as nearly as possible similar to the vegetative development in the planting area. Trees in a nursery too far north may be still frozen in the ground during the early weeks of the planting season farther south, thus making it impossible to set the trees during the most favorable part of the season. Trees from a nursery too far south will have buds open, with resultant danger of drying out by the time northerly planting sites are fit for planting. Stock from a nearby nursery should also be received in better condition because it is not so long in transit. Transportation costs, of course, are also less when stock is purchased as close to the planting site as possible.

A number of nurseries regularly carry forest planting stock of desirable species. Trees for forest planting are sold at cost of production by two state departments: One, the Forestry Division of the State Conservation Department at Lansing and the other, the Forestry Department of Michigan State College at East Lansing. The conifer nursery of the former is at Higgins Lake and the hardwood nursery is at Wolverine. The forest nurseries of the Michigan State College, Forestry Department, are located at East Lansing and Sault Ste. Marie. For unusual species not handled by these nurseries, inquiry can be made to the Forestry Department of the College or to the Secretary of the State Nurserymen's Association. The State Department of Agriculture also publishes a list of all the licensed nurseries in the State and the type of stock sold by each.

Planting stock for any project should be ordered several months in advance of the proposed planting date if possible, especially where it is particularly desired to secure a definite species. Price lists from most nurseries are prepared in midsummer describing the stock available for shipment that fall and next spring. Because of the large unpredictable demand the practice of getting orders in early often means the difference between receiving the type of stock desired or accepting substitutes.

Forest planting stock costs usually range from $2.00 per thousand trees for small seedlings to $16.00 per thousand for large transplants. In addition

to the cost of trees at the nursery, forest planting stock is shipped at the applicant's expense. A few private nurseries make an additional charge for packing or crating trees, but this is a minor item. Shipments by express or parcel post are preferable to freight in order to avoid delay in transit. First class express is charged on coniferous shipments because the tops must be left uncovered to prevent molding in the heat of express cars and offices, but hardwood stock is often shipped second class express since these plants may be completely wrapped.

SEASON OF PLANTING

In southern Michigan, better survival is normally secured with trees set out in spring than at any other season of the year. Spring planting should be done as soon as possible after the frost leaves the ground which occurs about April 1 in southern Michigan and from three weeks to a month later in more northerly portions of the state. By planting as early as possible, the seedlings are able to produce new roots and will become well established before the summer drought. If planting is delayed, the tender new growth may be injured by drying out during and after planting and before the roots have established contact with soil moisture. The season of planting in the spring for conifers may be described as from the time the frost leaves the ground until the buds begin to break, but the hardwood season is a little shorter, since planting should not be attempted after bud growth begins.

Certain species such as European larch begin growth very early in the spring and, for that reason, may be set out in the autumn of the year. Among the hardwoods, there is a great difference in the season of the year at which bud growth may start. Black cherry for example will start bud growth early in the season whereas the oaks and catalpa will be somewhat later. Where a large range of hardwood trees and shrubs is being planted, it might be well to consult the Forestry Department of the Michigan State College for advice as to the order of planting to use with different species of hardwood.

Fall planting always exposes the newly set trees to injury, either from winter "burning", frost heaving, or both. Frost heaving, a term applied to the alternate freezing and thawing of the soil which may force the plants entirely out of the ground by spring, is worse on heavy soils than on light soils. Winter "burning" occurs when the roots are frozen in the ground and cannot receive sufficient water from the soil to offset the constant loss of moisture by the tops. This may cause enough injury to set the trees back very considerably in growth the next year or to cause their death.

North of a line from Bay City to Ludington, fall planting is possible, especially on light soil. This region usually has a continuous winter snow cover, which acts as a protective cover for the tops of the trees and reduces frost heaving to a minimum. Planting should not be attempted while the ground is frozen because it is almost impossible to pack frozen ground firmly about the roots of trees to prevent air spaces; if planting is attempted during freezing weather, the roots will freeze very quickly and this is almost as detrimental to the roots as the drying weather of late summer.

The type of weather encountered during the planting season has a great effect on the success or failure of the plantation. Planting usually is not advisable after more than a week of dry weather during the planting season. Even if only the surface soil has dried out, it is difficult to plant without

having surface dust fall into the planting hole around the fine roots of the seedling. Sufficient dry, warm surface earth may sift in around the roots to dry them out seriously, giving the tree small chance of survival. Planting in moist soil during cool or rainy weather always increases the possibility of survival.

SPACING

The amount of stock required is readily determined when the acreage is known. The only variable factor is the spacing to be used in setting out the trees. Recommendation for spacing in various plantations varies somewhat with the species, their rate of growth, and space requirements. For conifers a spacing of about six by seven feet is recommended as a general rule. However, European larch which will not stand crowding requires a spacing as wide as 10 by 10 feet. Hardwoods are usually planted at a spacing of eight by eight feet, or 10 by 10 feet. Mixed plantations of hardwoods and conifers are usually planted about eight by eight feet.

In some cases a spacing of eight by eight feet is used for the main crop trees, with a temporary crop of trees interspaced at four by four foot intervals. White or Norway pines may be planted at the eight by eight feet intervals with Norway spruce, white spruce, Douglas fir or some other (Christmas) tree species at the four by four foot intervals. The Christmas trees are removed after six to ten years of growth, leaving the permanent plantation or crop trees at the eight by eight foot spacing. By this means an early cash return is secured from the plantation and, in addition, the ground is shaded by a closed canopy within a few years after establishment. For pulpwood plantations a spacing of five by five feet or five by six feet is recommended.

The tabulation which follows gives the number of trees required per acre at various spacings; the numbers for other distances may be calculated without special difficulty:

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

The spacing adopted in a plantation is important for a number of reasons. It affects both the original cost of the plantation and the returns to be expected, as well as the quality and the amount of timber. It is necessary to plant more trees than will be left in the mature stand for only by early closing of the tops or crowns may the trees be forced to grow tall and straight as is desirable. The loss of the side branches tends to produce clear lumber which in turn improves the quality of the product. Close spacing also reduces the period during which the small trees are in competition with weed growth, and the site is exposed to the drying and baking effect of direct sunlight. Spacing is governed by the requirements of the tree species involved, as well as by the purpose for which the plantation is made. Slow growing trees and those of slender form should use close spacing. Christmas trees, can be closely spaced (4 x 4 feet) because the trees will be harvested in about 10

years. Some plantations of jack pine for pulpwood are planted as close as five by five feet because the trees will be taken out at a comparatively early age. Plantations made for watershed cover and for game production will often use close spacing, four by four feet to six by six feet. Occasionally, on sites of very low fertility, wider spacings than normal for the species will be adopted.

The spacing used determines the dates at which thinnings must be made and this is important, since the cost of the operation and the value of the products removed affect the investment, and the final return. Thus, a four by four feet spacing for white pine is no longer recommended even though it does shade the site quickly and leads to the early pruning of side branches because a thinning would be necessary at such an early age that the value of the trees cut out would not offset the cost of the thinning nor the cost of planting these trees a few years before. Where there is a market or use for small poles close spacing followed by early thinnings may be justified. Spacing also affects replanting, since it is estimated that a planting at six by six feet may suffer even a 15 per cent loss and still not require replanting if the loss is more or less evenly distributed over the plantation.

SITE PREPARATION

If the area to be planted is fairly free from stones, moderately level, and of sufficient size, it may be possible to plow shallow furrows at regular intervals in which the trees will be set. This is the most economical way of preparing an area for planting, but is not always feasible. Furrows should be spaced the distance apart it is planned to have the tree rows, although it is not desirable from an aesthetic standpoint to keep the rows entirely straight.

Where the planting is so located that it forms a part of a naturalistic scenic view, or where an extensive planting is otherwise conspicuously located such as along a state highway it is often desirable to make a special effort to plant the trees in irregular pattern. However, such irregular planting may increase the cost of the planting somewhat since either furrows or other methods of spacing can be expedited by a degree of regularity. In the case of sloping ground, the furrows should be plowed along the contours to avoid soil washing.

The furrow width should be from 12 to 14 inches and the depth as shallow as possible; just sufficient to turn over the sod. A depth of two or three inches is sufficient. Plowing a 12-inch furrow makes a space approximately two feet wide in which there is little competition from weeds for the next two or three years and, in addition, the furrow makes an ideal place in which to do the planting. This work of soil preparation should be done if possible a considerable time before planting occurs, the previous autumn for spring planting. This advance preparation helps kill the grass in heavy sod areas and also permits the soil to slump down into the furrow and become settled in sandy areas. In addition, with fall plowing, the furrows thaw out earlier than the undisturbed sod and allow earlier spring planting.

When the area to be planted is too small or too rough for plowing or the soil is too stony, spot planting is necessary. Spots one foot or more in diameter may be prepared either some time in advance of planting or at the

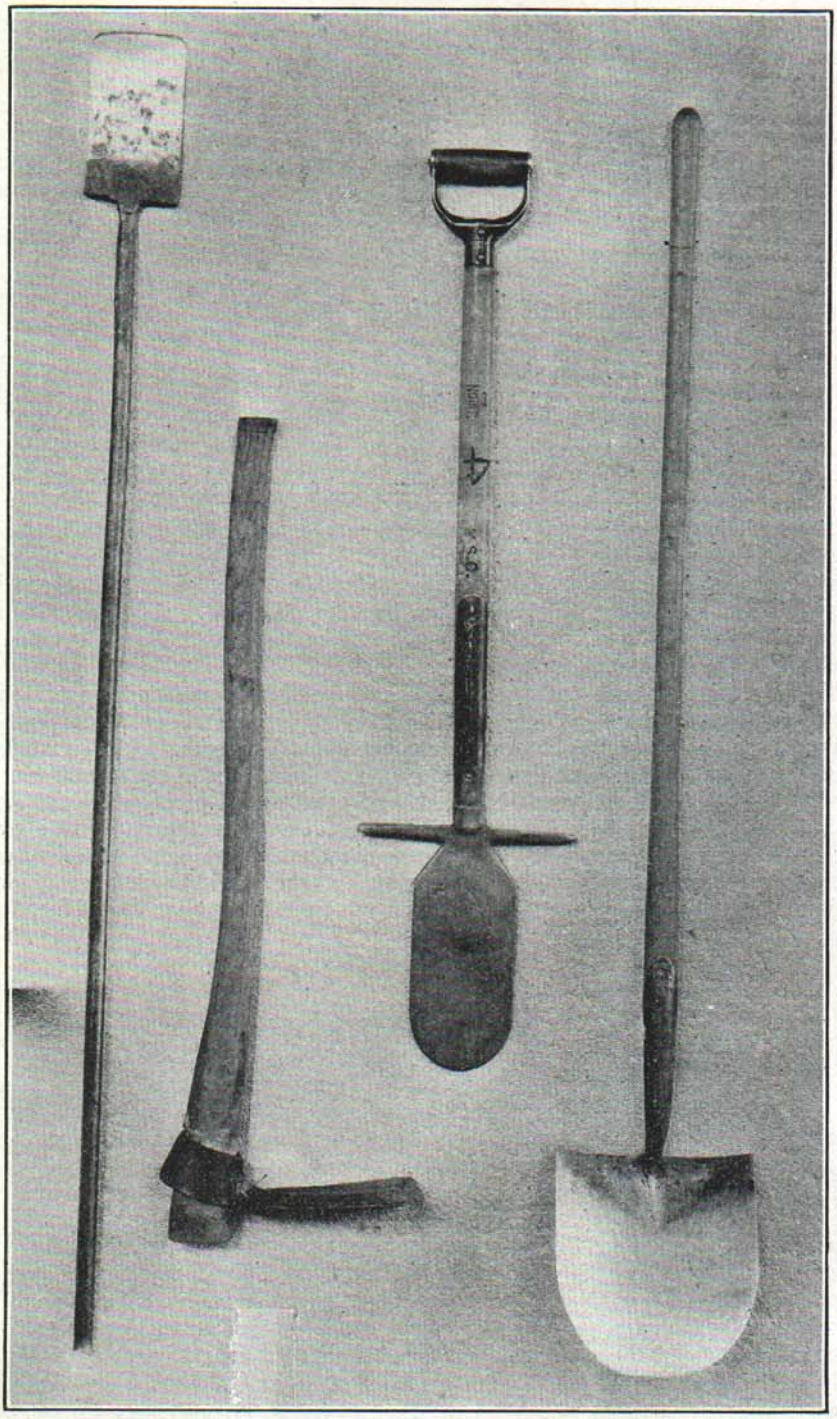

Fig. 8. Planting Tools. Left to Right—Michigan planting bar (inverted in photograph) Grub Hoe—Howard Planting tool—Shovel, common round pointed long handled style.

time planting is done. A fairly large spot should be "scalped" for each tree, taking off a thin layer just sufficient to remove the sod or other vegetation. This helps reduce weed competition for a season or two.

Complete plowing of the proposed planting area is not advised for several reasons. Usually, forest planting land is unsuitable for complete cultivation and the cost is excessive. Plowed land may produce a crop of weeds which is worse than the vegetation plowed under. Except in very unusual situations furrow plowing or spot "scalping" is sufficient soil preparation.

CARE OF TREES ON ARRIVAL

If trees are received one or two days after leaving the nursery, the bales or crates should have moisture enough in the packing material to keep the tree roots in good condition for at least 48 hours. However, the bales, if unopened, should be placed in a cool basement or shed and kept moist. A better plan, if there is any danger of the roots drying out, is to open the bales and "heel in" the stock in a shaded place.

To "heel in" trees, a trench should be dug about one foot wide and one foot deep. Slope one side at an angle of 45° towards the south and cut this slope smoothly. The bales should then be opened and the different species sorted in separate lots. The individual bundles of trees should then be cut open and spread in a thin layer upon the sloping side of the trench with the tops of the trees above ground.

The heeling-in trench usually holds about two hundred seedlings per foot of length and correspondingly smaller lots of larger trees. Moist soil is spaded back to fill the trench and cover the roots. The soil should be worked in well among the roots and then tramped thoroughly in order to compact it around the roots of the trees. The entire lot of heeled-in trees should now be watered to pack the soil and to add the necessary moisture. Shade over the heeling-in bed, protection from strong winds, and frequent watering will render this stock safe for several weeks, but the plants will start growth if planting is delayed too long. For convenience, heeling-in should be done close to the planting area, if possible.

PLANTING METHODS

As soon as the trees are taken from the bales or from the heeling-in bed, they should be placed in containers and the roots then covered with water, wet moss, or burlap. Since the roots must be kept moist at all times pails or boxes are used to carry the trees while planting.

Elaborate methods to secure the exact spacing determined upon are not recommended, not only because such efforts to keep trees in straight lines and equidistant from each other are time consuming and expensive, but also because such precision is generally considered unaesthetic by nature lovers. Rows can be lined in by eye with pole flags at either end of the row or in furrowing by keeping the approximate distance from the easily visible last furrow. Where a large crew is planting without furrows, the first planter may be lined in by flags, the others keeping their distance from the man next to them. This method tends to bring about a uniform rate of planting

since no one can work ahead of the man upon whom they depend for their distance. Spacing the trees within the row is approximated by pacing.

Trees are set in the ground either in a slit opening or in a larger hole, the former method being used with small seedling stock and the latter on stony ground or with large trees. Where tree planting is done by the slit method, the operation is usually a one-man procedure whereas in hole planting it is customary to use two men.

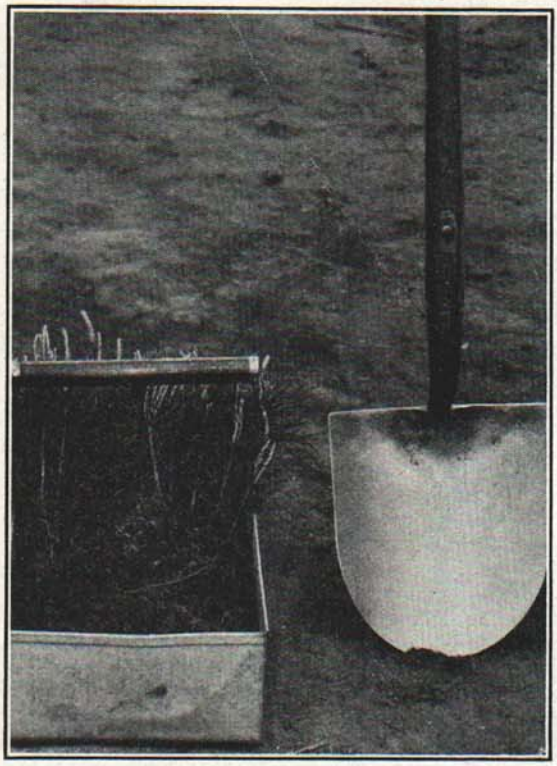

Fig. 9. Planting Equipment. Left — Erhart planting tray, with roots of seedlings covered by moist sphagnum moss. Right—Common round pointed shovel, often used in forest planting.

SLIT PLANTING

In opening a slit in which to insert the trees, the ideal method is to make a rectangular opening rather than a narrow slit. With a little care, this may be done except in very hard soil. Using either the shovel or planting bar, the tool is first driven straight down into the ground to the required depth for the roots. The handle is then shoved forward the length of the arm, so that it makes a 45° angle with the surface of the ground. The tool is now pushed an inch or so deeper at this position, to secure a new grip with the

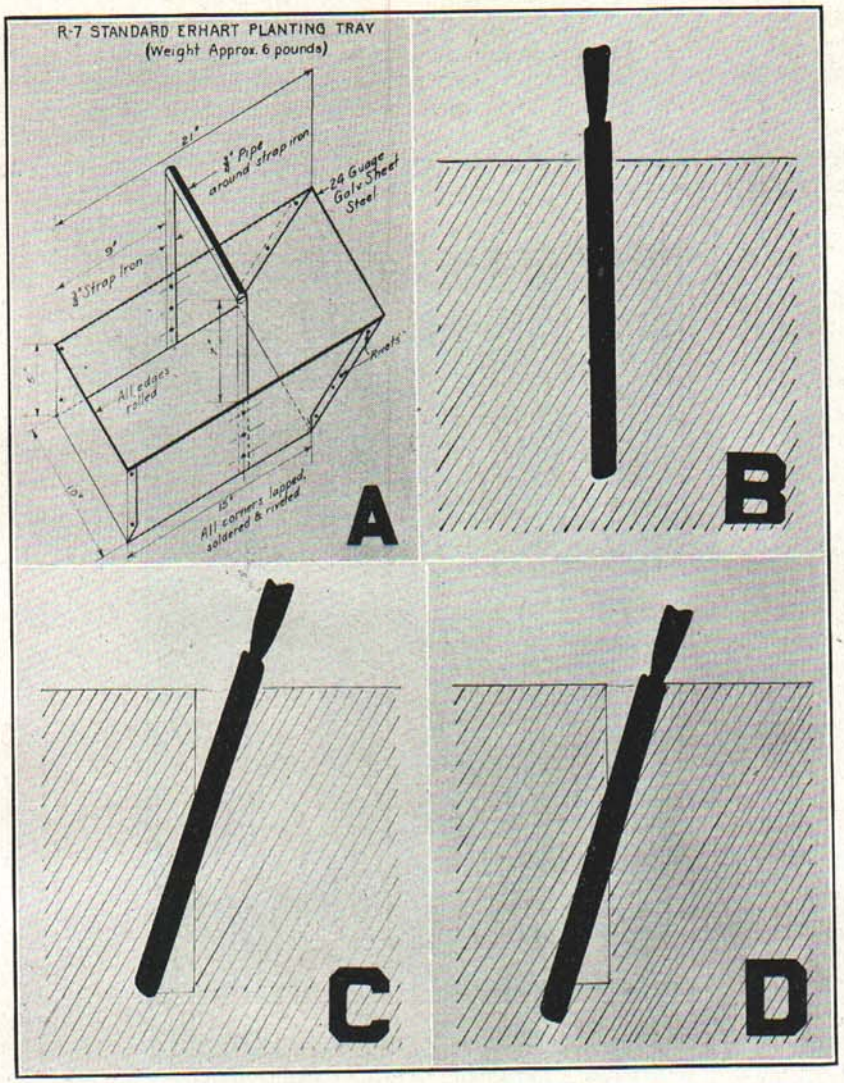

Fig. 10 A.* Working diagram of standard Erhart Planting Tray, approximate weight six pounds. B-D: Procedure in planting by the Slit method. B—Tool driven straight down into the soil. C—Tool pushed forward to the extent of the arm. D—Tool pushed deeper into the soil, for new leverage.

point of the tool in the soil, and is then pulled back with the new leverage to open a hole wider than a slit, Figures 10 and 11. The action as illustrated avoids the X-shaped hole made by "pumping" the tool back and forth. It is very difficult to fill an X-shaped hole completely with soil, yet if it is not filled the air space left around the roots permits them to dry out. A further disadvantage of the X-shaped opening with an unfilled space at the bottom is

*Fig. 10 A. By courtesy R-7. U. S. F. S.

the settling of the soil after the first rain with resultant exposure of the upper roots.

When a proper slit opening has been made, a single seedling is taken from the pail and held between the fingers at the depth in the planting hole that it grew in the nursery. The roots must be made to drop full length into the planting hole and should not be permitted to curl upward. If any difficulty is encountered by the roots catching on the sides of the slit opening, a half turn of the tree will often free them, or it may sometimes be necessary to push the roots down straight with the fingers. The roots should extend freely

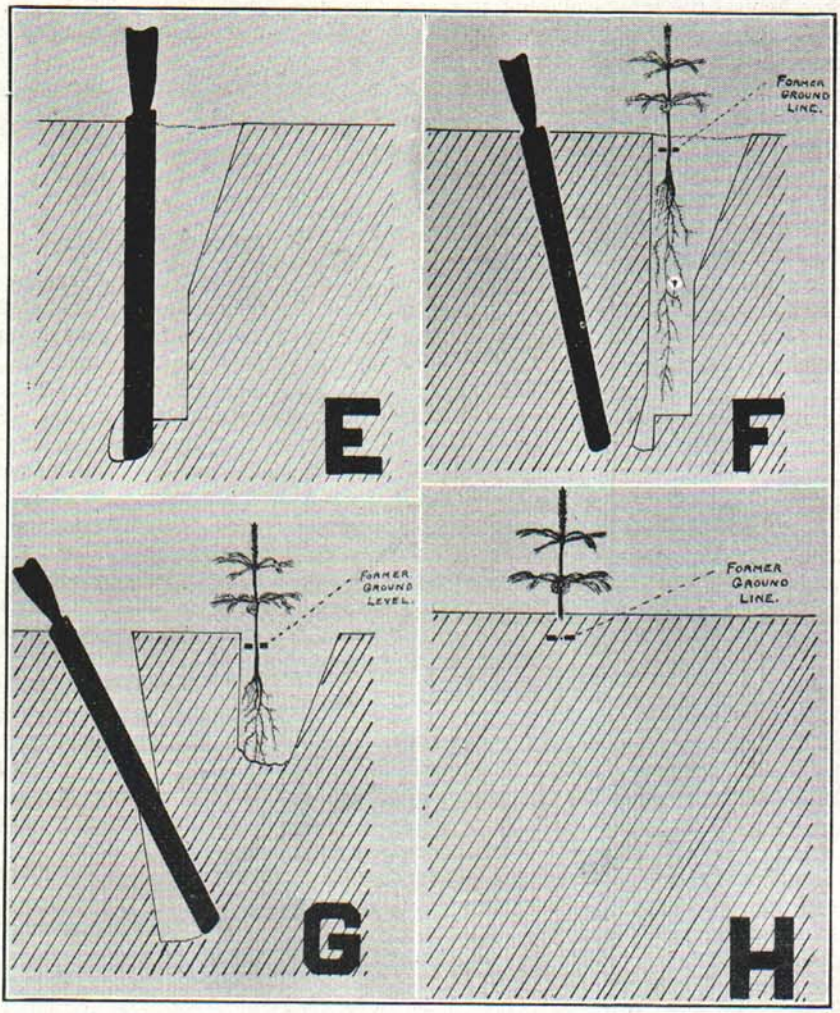

Fig. 11. E-H—Continuation of procedure in Slit planting. E—Tool pulled back to vertical position to open a rectangular hole. F—Seedling tree placed in hole with roots well extended. Tool driven into soil behind newly placed tree. G—Tool pulled back **toward** planter to close **base** of planting hole. H—Remainder of hole closed and soil well firmed by planters heel.

to their full depth, and spread out sideways as much as possible. Doubling back of the main roots is harmful to the tree, checking the natural growth toward moist soil and robbing the tree of full root length for which it was carefully cultured in the nursery. Failure to take full advantage of the depth of the roots may result in loss of the plant during the first dry spell or so weaken it that later insect or other injury may cause death. The opening of the hole for the plant and the careful placing of the root system are stressed because of their prime importance.

Care in closing the hole in order to pack moist soil against the roots is equally important. In slit planting, the tool is driven into the ground a few inches behind the newly planted tree and then the handle pulled back toward the planter to close the bottom of the slit. The top of the hole is filled by pressing soil in with the planter's heel and enough soil is then scraped in with the foot to fill the second hole. The soil around the base of the planted tree must be well firmed with the feet to prevent air spaces.

HOLE PLANTING

Hole planting consists of digging, with a shovel or mattock, a hole large enough to accommodate in its natural position the entire root system of the tree. The tree is held at the proper height in the middle of the opening with one hand while the other is used to scoop in the soil. When the hole is about half filled, the earth should be worked down among the roots and well firmed. The remainder of the soil should now be scooped in and packed firmly. The tree must not be allowed to slump down during planting, but must be held in position, keeping it at the same level in the hole as it grew in the nursery. Planting one-half inch or so lower than it stood in the nursery is not harmful, but planting too deeply, especially on wet soils, smothers surface roots. This forces the plant to send out a new fan of fibrous roots just below soil level. The hole method is superior to the slit method, especially on stoney or wet sites, but is slower and therefore more costly than the latter. However, no matter what method is used, success depends primarily on the care devoted to the planting operation. Hasty work is never profitable in terms of tree survival.

With fairly large stock, where the hole goes below top soil, the subsoil and the top soil may be kept in separate piles. When planting the tree, the good soil should be packed in around the roots and the subsoil used for surface filling. On grassy planting sites, the soil from the hole should be placed on a cleared spot because it is easily lost and not enough may remain to fill the planting hole unless earth is dug from an entirely new spot.

It is important that the bark of the tree be left uninjured while firming the earth around the tree with the feet. In planting conifers, no pruning is necessary either of the roots or tops unless some especially long and straggling side roots interfere with planting operations. It is advantageous to leave a loose mulch on the surface of the soil around the planted tree. This may either be loose earth, dead leaves or other duff useful in keeping moisture in the soil.

On slopes, the trees should be set perpendicularly rather than at right angles to the slope, since the tree will naturally seek an erect position when growth begins. Also, upon slopes, no deep pockets should be left

around the tree for the soil from above may wash in and smother it. It is well to test the quality of the work being done by the tree planters by pulling on the top of an occasional planted tree to discover whether or not it is firmly set in the soil. Trees which pull out too easily have not been set well and the planter must be corrected in his technique.

Fig. 12. Hole Planting. A 2-2 Norway Spruce transplant being supported at the proper depth for planting, while earth is scooped in, and tramped firmly about the roots.

COST OF PLANTING

The cost of tree planting varies with a number of factors, including the size of stock being set, the cost of the labor, the amount of tree planting experience the laborers have had, the number of trees being set per acre, and the soil and cover conditions. When planting prepared furrows by the slit method with small seedling stock, between two and three thousand trees per man day have been set by experienced crews. This rate of planting should not be used as a standard, however, since it may result in inferior work. While it is possible for an experienced man to plant at a high rate and to have a high percentage of survival, speed is not recommended as the goal

for the average planter. The quality of the work is much more important. Fifteen hundred per day per man is a satisfactory total by the slit method.

The number which may be planted by the hole method is considerably less, usually closer to six hundred trees per day on very heavy or stony soil. Planting cost will vary with each operation but on an average may run from three to six dollars per acre.

REPLANTING

The amount of replanting necessary depends on whether or not the number of trees surviving per acre is sufficient to produce a good stand. Generally a 10 to 15 per cent loss does not justify replanting. If losses are heavier so that the remaining trees are too few in number, it is necessary to replace all or a portion of the losses. If possible, replanting should be done the first or second year after the plantation is established. It is most readily accomplished where furrows were used in the original planting because the failures may easily be discovered and those spots reset with trees. However, even on a spot planting operation, it may be possible the next year after planting to go back over the area and find most of the spots, especially if this be done in early spring. However, if it is too difficult to find the blanks it may be necessary to delay the replanting until the tops of the surviving trees show above the surrounding vegetation. This will require usually only two or three years and the slight difference in age of the replanted trees as compared with the original stand will have little effect on their chances of competing successfully with the rest of the plantation.

The amount of replanting necessary depends primarily upon the care used in planting and on the season which follows the planting operation. In years of excessively dry weather, abnormal losses may occur, requiring much replanting. Over a period of years, however, the normal loss in carefully set plantations should average between 10 and 15 per cent and sometimes runs considerably less. If given average conditions, the percentage of survival will depend primarily on the quality of the work done in planting the trees, on the quality of the tree stock itself, the care the stock receives, and finally, the competition the trees have with grass and other vegetation. The aim in any planting operation should be to plant the best type of stock possible with insistence on careful planting technique. Establishment of a plantation in one operation is much more satisfactory and considerably cheaper than when one or more replanting operations must follow the original.

CARE OF THE PLANTATION

Although a forest plantation requires less attention than other farm crops, a certain amount of care is necessary if the maximum of good quality wood products is to be produced. Some plantations require more attention than others while they are young. This is particularly true if the species is susceptible to disease or insects. As the plantation becomes older, thinning and pruning are often advisable in order to maintain a satisfactory growth rate and to improve the timber quality.

Cultivation has only limited application because of its impracticability on many areas and because its value is not in proportion to the cost. Trees are usually planted on areas supporting fairly heavy vegetation which has been broken only by the furrows or by the small spots where the sod has been scalped. Usually it is not convenient to cultivate such areas even though the topography is relatively flat. Where the surface slopes, cultivation is usually undesirable because it is likely to start erosion.

Cultivation is advantageous, if costs are disregarded, where it can be done conveniently and where it will not cause erosion. This is particularly true during dry seasons because at such times, the vegetation competes seriously for moisture with the trees. Cultivation will reduce tree losses and will increase height growth. Obviously where vegetation is sparse, there is little advantage in cultivation. It is only temporarily beneficial on any area, and, as a matter of act, the trees are likely to be damaged by injury to the roots and trunks if cultivation is continued for more than two or three years. By that time, the trees will have become well estiblished and can withstand the competition from the grass and other vegetation.

Where trees are planted on an area that supports a fairly heavy stand of grass, the question often arises as to whether livestock should be allowed to utilize the forage, thereby giving the owner some return from the land for several years. Although grazing in a young plantation is not usually recommended, this is not a hard and fast rule. If there is plenty of palatable forage and the livestock are carefully handled, conifer plantations can sometimes be grazed without damage. Cattle are more likely to graze without browsing on the seedlings than are sheep. If damage is to be avoided, no more animals should be allowed in the area than the forage will support. The animals sometimes develop the habit of congregating at certain times of the day in favored parts of the plantation. This is likely to cause damage to the seedlings by trampling. If this develops, it is wise to remove the livestock from the area. If an attempt is made to graze sheep in a plantation, they should be watched closely from the start, in order that any damage that they do may be detected immediately and the animals removed. It is seldom good policy to allow livestock of any kind to graze in hardwood plantations since the foliage of broadleaved trees is fairly palatable and is commonly browsed by any class of livestock.

The chief advantages in grazing the plantation *if it can be done without damage to the trees* are: (1) It provides for utilizing the forage on the area, thereby deriving an income from the area for five to 10 years; (2) it may increase tree survival by reducing the competition from the grass; (3) it helps to reduce the fire hazard.

A large proportion of the forest plantations on farms are situated where the fire danger is not great. Under such circumstances, special precautions against fire are unnecessary. Wherever trees are planted in a grassy area that has adjacent to it areas of inflammable material such as grass, ripe grain, or old stubble, it may be a good precaution to keep a plowed strip clean of vegetation between the plantation and the adjacent field. This also applies to plantations adjacent to railroads since such locations are especially hazardous. A strip 10 to 15 feet wide will sometimes prevent a fire from an adjacent field crossing into the plantation or at least slow its progress enough to lessen its damaging effects. Every precaution should be taken to keep fire out because serious damage will occur to the trees at any time during their lives. When the trees are only a few years old, they are easily killed. At that time there

is usually enough vegetation on the site to allow a fire to spread rapidly. Later when the tree crowns come in contact with one another to form a closed canopy, fire readily gets into the tops. A crown fire spreads rapidly and is likely to wipe out the entire plantation.

DISEASE AND INSECT CONTROL MEASURES

Very few of the species recommended for planting in Michigan are susceptible to serious disease infection, and, if given proper care while immature, they are not likely to become infected with disease before they are harvested. Aside from the white pine blister rust and the western gall rust, most diseases such as trunk rots and cankers gain entrance into a tree only through bark or root abrasions. Consequently, if the trees are protected against fire and mechancal injury, disease infection to a large extent takes care of itself. Small abrasions usually heal over before infection sets in. Some unavoidable mechanical damage may occur as a result of wind or sleet storms, and against such catastrophes there is no practicable protection.

Wherever northern white pine is planted, a thorough survey of the surrounding country within 900 feet should be made for presence of native currant and gooseberry bushes. All such bushes should be destroyed by pulling, taking care to remove all the roots. A single eradication of currant and gooseberry bushes may not be adequate. New bushes may become established or some of the old ones may sprout from the roots if they are not carefully and thoroughly destroyed. After several years, it is a good policy to resurvey the surrounding country and to destroy any bushes which have developed since the previous eradication.

The State Department of Agriculture in Lansing in cooperation with the Federal government is engaged in a campaign to eliminate currants and gooseberries from white pine sites. At this time, 1935, that organization will upon request, prepare plans and furnish the supervision but not the labor necessary to eradicate these plants from private lands.

Some insects cannot be suppressed satisfactorily by the present known methods of control that are practicable in forest plantations. In such cases, it is best not to plant the species involved. Methods of insect control which can be applied effectively to individual ornamental trees are not practicable in plantations because of the high cost per tree. Therefore certain species can be grown for ornamental purposes because they can be protected from insects even when it is not wise to grow them in plantations. Several insects which may cause trouble and which can be controlled at a reasonable cost are discussed in the following paragraphs.

Control of the white pine weevil should begin with measures which will prevent serious infestation. This can be accomplished by correct spacing and composition. Close spacing, six by six feet or less, and the growing of hardwoods or other conifers in mixture with white pine are usually effective in reducing greatly the number of trees that are attacked.

When using a mixture, at least 50 per cent of the trees should be associated species. Even though these precautions are taken some trees will be attacked by the weevil. It is necessary to resort to a definite scheme of handling the infested trees in order that the infestation can be held in check. This can be done most effectively by cutting the infested leaders and all but one of the

top whorl of branches. This one branch will eventually become the terminal leader and a forked trunk will be avoided. The infested leader is then either destroyed by burning or placed in a screen cage of a mesh sufficiently small to prevent the weevils from escaping. Parasites which attack the white pine weevil will then have an opportunity to destroy the larvae and at the same time have a chance to multiply. The parasites being smaller escape through the screens but the weevils do not. The theory of this type of treatment is that by allowing the parasite to increase, a certain degree of natural control will ultimately develop. This practice is usually more expensive than the burning method, consequently the latter method will be preferred.

Persons experienced with the nature of white pine weevil damage can often secure effective results by a single examination of the plantation at just the right time of the summer. They find that by waiting to remove the weeviled tips until they begin to wither and turn brown, a second examination is unnecessary. Less experienced persons prefer to make two examinations in order to make certain that leaders which showed no damage in the early part of the season but show damage later, will not escape treatment. If control measures are to be effective in reducing subsequent damage, examination and cutting of the infested terminals must be followed annually until the trees become so tall that the work can no longer be done effectively. By that time, the canopy of the plantation will be fairly well closed and weevil damage will automatically be less serious.

Locust borer damage can be minimized by planting black locust only on sites where this species will make rapid vigorous growth. The site requirements of black locust are discussed in the section "Recommended species". To prevent injury to slow-growing stands that are not yet attacked, it may be advisable to cut the trees off near the ground to allow sprouts to develop. Severely damaged stands can probably best be clear cut to allow sprouts to develop. Serious damage in moderately injured stands can probably be avoided by thinning out the weaker trees. This should result in improved vigor and growth of the remaining trees.

The June-beetle can be suppressed most effectively by keeping the fields adjacent to a plantation cultivated. This appears to be the only practicable method of controlling this insect in plantations.

Damage by the European pine-shoot moth is of such recent origin that sufficient time has not elapsed to develop methods of control upon which complete dependence can be placed. It is believed, however, that cutting off the infested shoots and burning them should prove effective in most cases. This may be done any time between the middle of August and the first of the following June. Effective control can be accomplished only by annual operations until the trees attain a height of seven or eight feet.

When the spruce bud-worm becomes epidemic, there is no economically feasible method of control that will save the infested tree. Therefore, the logical procedure is to cut the tree and utilize the wood before it dies. Light attacks by the spruce bud-worm which continue for only a few years will not seriously injure the tree although it will cause reduced growth and lowered vitality. If there is a likelihood that it will recuperate, an infested tree need not be cut.

THINNING

There comes a time in the life of a forest plantation when the trees begin to crowd one another and compete more and more for space. A certain amount of crowding is desirable in that it induces the trees to grow tall and straight and tends to clear the trunk of branches, thereby improving the quality of the timber. If the trees are crowded too much, there will be a material loss of diameter growth and some of them will die sooner or later. It is therefore advisable to reduce the number of trees per acre by thinning the plantation in order that the better trees may have an opportunity to make normal growth. The age at which thinning is advisable depends primarily on the original spacing of the trees and their rate of growth. The first thinning usually should be made between the fifteenth and twentieth years.

The best practice in thinning is to remove the less desirable trees, that is, the smallest ones, those that are not vigorous, and have the smaller crowns and those that are of poor form or seriously damaged. The trees that are removed in the first cutting are of small size, and will have little value other than for fuelwood. The first thinning should not be too heavy because the stand should be kept sufficiently dense in youth to maintain rapid height growth and to discourage the development of abnormally large limbs and crowns. Each tree remaining should have only about six inches to a foot all around for the expansion of its crown. By removing the smaller trees, a relatively large proportion of the trees can be removed but these will represent a much smaller portion of the stand volume. From 25 to 40 per cent of the trees, representing from 15 to 30 per cent of the cubic foot volume can be removed to advantage. If a thinning of this character is applied in the first operation, a second thinning will probably have to be made eight to 10 years later. As the stand becomes older and has attained most of its height growth, the cutting can be heavier giving the crown of each tree remaining one to two feet on all sides for crown expansion. The heavier thinning which will give more space to the individual trees will stimulate diameter growth, which, in later life, is the desired goal.

PRUNING

So long as the limbs remain attached to the trunk, the tree can produce only knotty lumber. However, when the trunk is free of limbs, each year's growth adds to the volume of clear timber. Consequently, when trees are grown chiefly for lumber, it is advantageous to secure a clear trunk as early as possible in order that a maximum quantity of high quality lumber may be produced. Since the limbs of conifers are slow to drop off naturally it is often advisable to remove the limbs by pruning. Some pruning can be done immediately following a thinning. The two operations cannot be done advantageously at the same time because special saws must be used for the pruning.

It is not advisable to prune every tree because many trees will be removed in thinnings before they attain sawlog size. Consequently, any money spent on trees taken out several years later would be wasted. The object should be to select for pruning, 100 to 200 of the best trees on an acre, which will

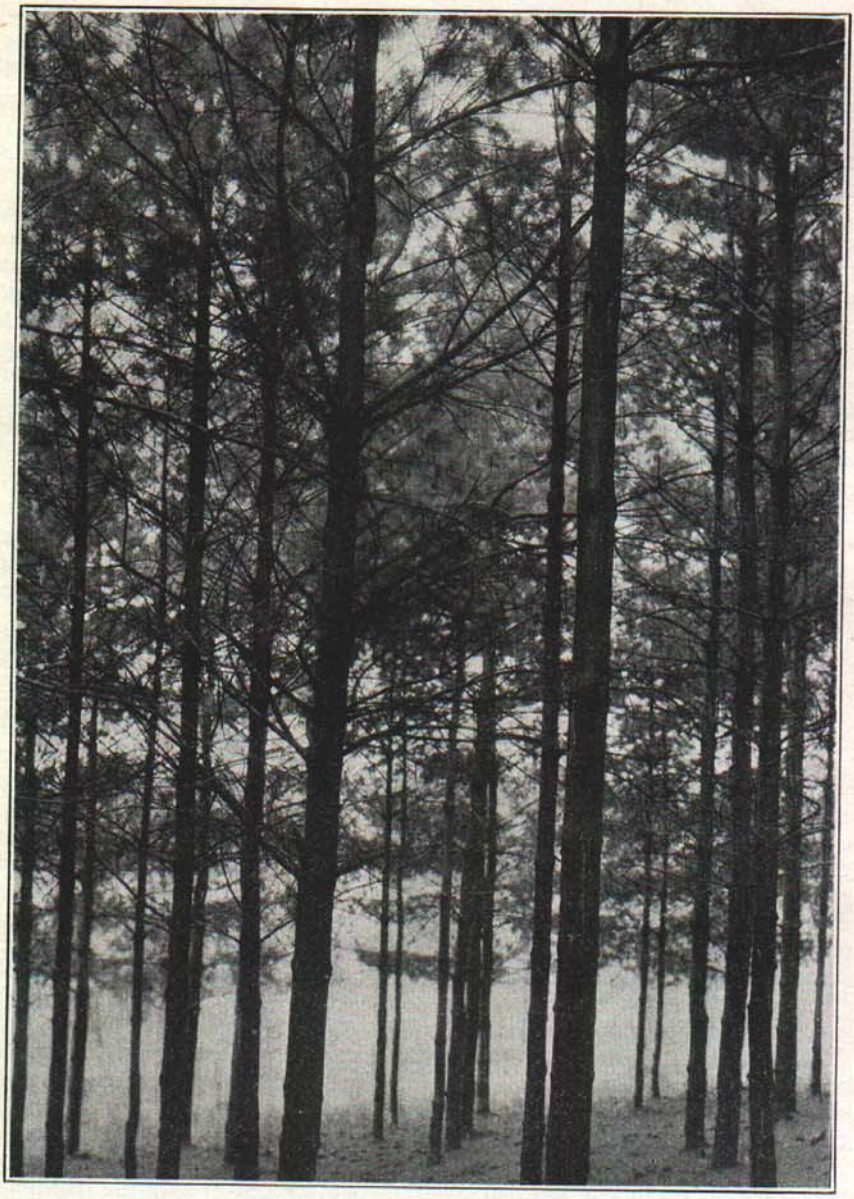

Fig. 13. Pruning of 100 to 200 crop trees when they are two to four inches in diameter is a good investment because of the large increase in clear lumber produced.

constitute the final crop. Only straight thrifty trees should be treated. Trees in the outside rows should not be pruned because they provide wind protection and nesting sites and food for birds and their quality is usually poor because of the large size of the limbs. To secure the maximum advantage from pruning and thinning, a special effort should be made in future thinnings to favor particularly the pruned trees by releasing them as much as is feasible in each thinning operation.

Removal of the lower limbs should start while the tree still has a small diameter, (two to four inches) in order that clear lumber may be produced for the maximum period. The pruning should remove all dead limbs and possibly a few of the live ones. Care should be used in removing live branches because their removal in large numbers will result in reduced growth for a few years at least. Subsequent pruning will be necessary, the objective being to produce a bole that is free of limbs to a height of 17 feet. This will yield one clear 16-foot sawlog. It is not practicable to go beyond this height because of the increased cost, and the fact that the upper logs will be much smaller than the butt log when the tree is harvested and will yield correspondingly less clear lumber.

Almost any type of small hand saw can be used effectively for pruning limbs to a height of six or seven feet. At a greater height, a long handled saw, preferably with the blade set at an angle, should be used. The branches should be cut close to the trunk using care to sever them completely and smoothly.

FINANCIAL ASPECTS

The profit that can be reasonably expected from growing timber is subject to considerable variation. The original cost of establishing the plantation, the intrinsic value of the species grown, intermediate returns from thinnings, the quality of the site, the care given the plantation to maintain optimum growth, and the local market will all influence to some extent the profit that the plantation will yield.

It is, of course, important that enough money be spent in the initial establishment of the plantation to secure a fully stocked stand. Anything less than full stocking leaves parts of the soil unutilized, consequently, full yields cannot be expected. Furthermore, understocking is likely to result in the development of inferior knotty timber.

There is considerable difference in the intrinsic value of various species. Their stumpage value varies correspondingly. The average stumpage values for sawlogs of the majority of the species recommended for planting is between $8.00 and $15.00 per thousand board feet. The value of some species will not exceed $3.00 per thousand board feet while that of certain hardwoods, notably white ash and black walnut, will exceed greatly the maximum figure quoted. Theoretically, it would be good policy to plant only species of high value, but in practice it is not applicable because all sites are not adapted to highly valued species. Consequently, it is necessary to raise what the land will produce. Many species attain their highest value in the form of sawlogs, consequently, in those cases, it is most profitable to allow the trees to reach sawlog size, rather than to cut them for cross ties, fuelwood, and other inferior products. Generally speaking, these latter products can be secured as by-products. Some species do not yield high quality sawlogs, but they do

yield good crops of pulpwood, fence posts, or other timber products in a relatively short time. Such crops may sometimes be as profitable as sawlog crops because they can be grown in a short time.

Profits from thinnings while the stand is still developing are dependent on a nearby market for small products. The material taken out in the first thinning is usually so small that it has very little value. In some cases it may be used for fuelwood. Not often will the trees taken out in the first thinning yield a profit; the owner should be satisfied if the value of the material removed is equal to the labor cost involved in removing it, in other words, to break even. Later thinnings will often yield a small profit, thereby liquidating a part of the investment.

The quality of the site will have a definite bearing on the profits that can be realized. A first quality site may yield twice as much timber as a third quality site in a specific period. The costs of establishment and care of the plantations on the two sites will probably differ very little, consequently, the profit will be more or less in proportion to the yield.

The care given a plantation will materially affect the income from it. Optimum growth, secured through the maintenance of proper stand density, will contribute much toward enhanced profits. Expenditures for controlling such hazards as fire, insects, and disease add to the costs of timber growing, but sometimes this cannot be avoided. Either the expenditure must be made or the value of the crop will be greatly lowered. Tree crops of high value justify a greater expenditure of funds for care than do low value tree crops.

The favorableness of the local market may sometimes determine whether tree crops can be grown at a profit. This is particularly true in dealing with low valued species or with sites of low productive capacity. Sometimes the general market for a certain species is poor or very limited, consequently the production of such a species would generally yield a low profit, but if there is excellent local market for such a species, its production may prove very profitable to the owner.

Obviously, so many factors influence the returns from the timber grown in a plantation that each case must really be analyzed separately. Table 3 indicates the yield in sawlogs that may be expected on a site of average quality from a few of the species for which data are available, the average

Table 3. The yield of selected species on average sites.

Species	Age			Stumpage value	Total value per acre		
	40 years	60 years	80 years				
	Volume—board feet per acre			Per M.	40 years	60 years	80 years
White pine	4000	20,500	40,900	$9.00	$36.00	$184.50	$368.10
Jack pine	1000	7,500	12,000	4.00	4.00	30.00	48.00
White spruce	1720	14,300	22,200	5.00	8.60	71.50	111.00
Balsam fir	2430	12,900	20,000	2.50	6.07	32.25	50.00
Basswood	.....	12,400	.....	10.00	.....	124.00	.....
Red oak	1550	7,070	12,645	13.00	20.15	91.91	177.32

Table 4. The yield of pulpwood species on average sites.

Species	Age			Stumpage value	Total value per acre		
	40 years	60 years	80 years				
	Volume—cords per acre			Per M.	40 years	60 years	80 years
Jack pine.....	27	36	40	$1.00	$27.00	$36.00	$40.00
White spruce.....	29	58	69	2.00	58.00	116.00	138.00
Balsam fir.....	32	59	69	1.00	32.00	59.00	69.00

value per thousand board feet of the standing timber, and the total value per acre.

Table 4 shows the returns that may be expected from the three pulpwood species listed in Table 1 when cut as cordwood rather than for saw timber.

The figures in Table 4 give some suggestion of the great variation in the yield and value of different tree crops. Some stands will, of course, yield less and others more than the figures shown in the foregoing tables. Some idea of what other species will yield can be obtained by comparing their growth and value with that of the species given. Red pine will yield less than white pine and its stumpage value is somewhat lower; Scotch pine will yield about the same quantity as red pine, but its stumpage value is less; Norway spruce will exceed white spruce in yield and its stumpage will be approximately the same; European larch will compare favorably with white pine in yield, but its stumpage value will be less. Among the hardwoods, American elm, yellow poplar, and white ash will compare favorably with basswood in yield. Yellow poplar and white ash will exceed basswood in stumpage value while American elm will usually have a much lower value. Sugar maple usually will yield less than the foregoing hardwoods, but its stumpage value is about the same as that of basswood. The yield of black locust and catalpa cannot be estimated very easily because they are usually utilized for fence posts.

In order to illustrate the possible returns that may be expected from plantations, two concrete cases are presented, one in which physical and market conditions are very favorable and the other in which conditions are less favorable.

The following costs and returns are estimated for the case where planting conditions are especially favorable, consequently necessitating no replanting, and where no expenditure need be made for disease and insect control. Furthermore, markets are sufficiently favorable to make a profit on material removed in thinnings after the twentieth year.

The plantations are assumed to be under the Michigan Woodlot Tax Law, whereby the property is assessed at $1.00 per acre. If the timber is sold, the owner must pay a 5 per cent yield tax at the time of cutting. If the timber is used by the owner, he is exempt from the yield tax, and the interest on the investment would be slightly higher than in the cases presented.

Cost Per Acre

Nursery stock and planting	$7.15
Taxes, $0.015 per acre annually (based on a 15 mill tax on a land value of $1)	
Land value	$1.00

Returns Per Acre

Thinning at 20 years (material removed just pays for labor of cutting)	$0.00	
Thinning at 30 years	5.00—5% yield tax—	$4.75
Thinning at 45 years	15.00—5% yield tax—	14.25
Thinning at 60 years	40.00—5% yield tax—	38.00
Final crop at 80 years, 40,900 board feet per acre valued at $9.00 per M board feet	368.10—5% yield tax—	349.70

The foregoing costs and returns are taken into account in the following formula, which shows the compound interest rate which this investment will return.

$$8.15\,(1.ox)^{80} + \frac{.015(1.ox^{80}-1)}{.ox} = 4.75\,(1.ox)^{50} + 14.25(1.ox)^{35} + 38.00\,(1.ox)^{20} + 349.70 + 1.00$$

Land Value and Planting Cost	Taxes		Value—1st Thinning	Value—2nd Thinning
$8.15\,(1.ox)^{80}$	$+ \frac{.015(1.ox^{80}-1)}{.ox}$	$=$	$4.75\,(1.ox)^{50}$	$+ 14.25(1.ox)^{35} +$

Value—3rd Thinning		Value—Final Crop		Land Value
$38.00\,(1.ox)^{20}$	$+$	349.70	$+$	1.00

By assuming various values for .ox (the compound interest rate) the foregoing equation is worked out by the trial and error method until the assumed value for .ox is the same as the computed value. At this point, it means that all the investments made in the plantation will yield a compound interest rate of this percentage over a period of 80 years. In this case, the calculation yields a figure of 5.5 per cent.

In the second case, planting conditions are assumed less favorable, the yield lower, and the market for the products less favorable. The following costs and returns are assumed.

Cost Per Acre

Nursery stock and planting	$8.15
Replanting—2 yrs. after original	3.00
Disease control $0.50 when plantation is established, and $0.50 10 years later	
Insect control, $0.60 annually between 5th and 12 years	
Thinning at 20 years	$5.00
Taxes, $0.015 per acre annually (based on a 15 mill tax on a land value of $1.00)	
Land value	$1.00

Returns Per Acre

Thinning at 30 years	$0.00	-	
Thinning at 45 years	5.00	—5% yield tax—	$4.75
Thinning at 60 years	20.00	—5% yield tax—	19.00
Final crop at 80 years, 30,000 board feet per acre valued at $9.00 per M board feet	270.00	—5% yield tax—	256.50

By using the same formula as in the preceding case, the set-up is as follows:

Land Value, Planting and 1st Disease Control | Replanting | 2nd Disease Control | 1st Thinning

$$(1.00 + 8.15 + .50)(1.0x)^{80} + 3.00(1.0x)^{78} + .50(1.0x)^{70} + 5.00(1.0x)^{60} +$$

Insect Control

$$\frac{.60(1.0x^{8}-1)\ (1.0x)^{68}}{.0x} + \frac{.015(1.0x^{80}-1)}{.0x} =$$

Value—2nd Thinning | Value—3rd Thinning | Value—Final Crop | Land Value

$$4.75\ (1.0x)^{35} + 19.00\ (1.0x)^{20} + \$256.50 + \$1.00$$

By the same procedure as in the previous example, the value of x is found to be 3.6 per cent. In other words, the investment will yield a compound interest rate of 3.6 per cent over the 80 year period.

The foregoing gives some conception of the returns that may be expected under two widely different conditions. Many cases will fall somewhere between these figures while others will fall above or below.