Issued November 15, 1909.

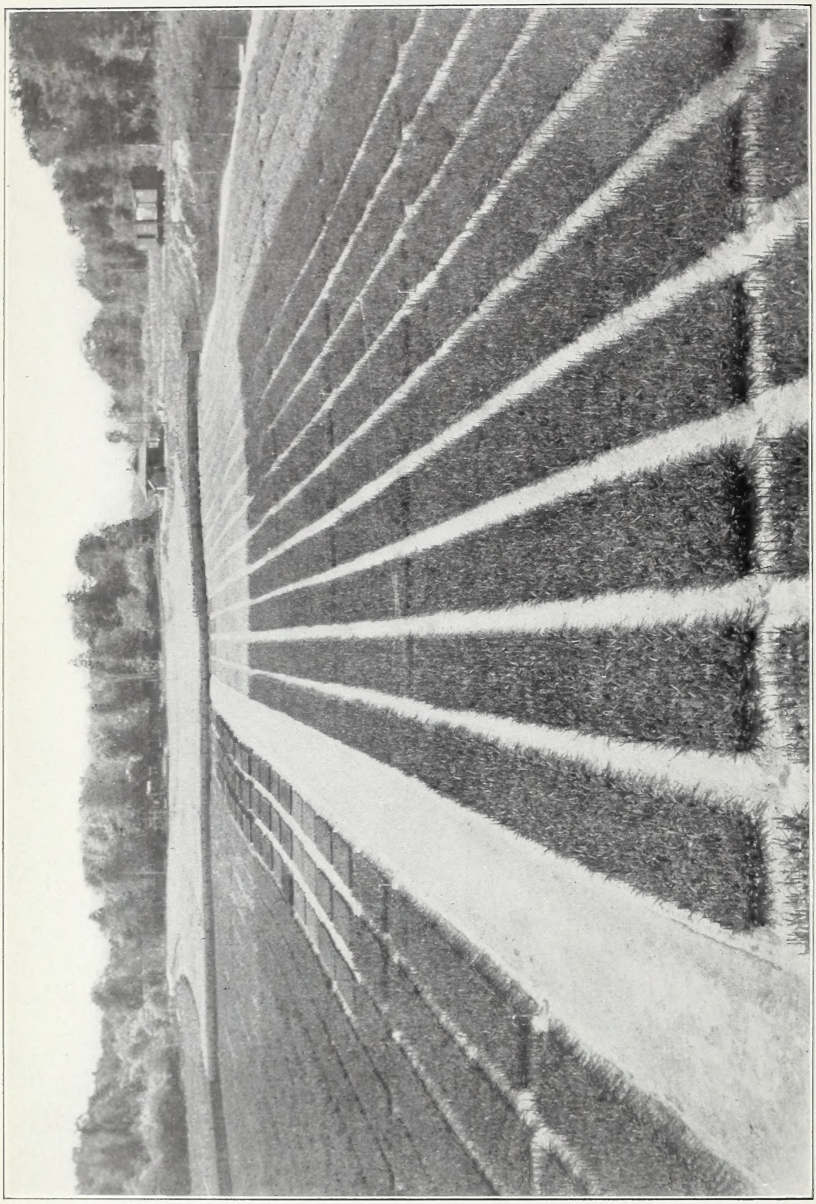
U. S. DEPARTMENT OF AGRICULTURE,
FOREST SERVICE—BULLETIN 76.
GIFFORD PINCHOT, Forester.

HOW TO GROW AND PLANT CONIFERS IN THE NORTHEASTERN STATES.

BY

C. R. PETTIS,
EXPERT IN PLANTING.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.



AN IDEAL NURSERY, SHOWING GROUND PLAN AND ARRANGEMENT OF BEDS.

Issued November 15, 1909.

U. S. DEPARTMENT OF AGRICULTURE,
FOREST SERVICE—BULLETIN 76.
GIFFORD PINCHOT, Forester.

HOW TO GROW AND PLANT CONIFERS IN THE NORTHEASTERN STATES.

BY

C. R. PETTIS,
EXPERT IN PLANTING.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Forest Service,
Washington, D. C., July 9, 1909.

Sir: I have the honor to transmit herewith a manuscript entitled "How to Grow and Plant Conifers in the Northeastern States," by C. R. Pettis, Forest Expert, and to recommend its publication as Bulletin 76 of the Forest Service. The five plates and four diagrams accompanying the manuscript are necessary for its proper illustration.

Respectfully,

Gifford Pinchot,
Forester.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

ILLUSTRATIONS.

PLATES.

DIAGRAMS.

HOW TO GROW AND PLANT CONIFERS IN THE NORTHEASTERN STATES.

INTRODUCTION.

During the past ten years there has been a growing interest in forest planting in the northeastern United States and an increasing realization of the need of reforesting waste lands whose greatest value lies in the production of timber. A greater amount of forest planting is being done each year, and there is a demand for more specific information about the growing and planting of conifers, and particularly of white pine.

The information in this bulletin is derived from seven years of nursery and planting operations at the New York state nurseries in the Adirondacks and from studies of planting in New England. With slight modification these results may be applied to nursery practice and planting in New England, New York, the Lake States, and the mountainous portion of Pennsylvania.

PROCURING THE SEED.

The seeds of coniferous trees are contained in a cone, sometimes called a "burr" or a "bud," which varies in size and other characteristics according to species. This cone is composed of scales arranged spirally around a central axis, and the seeds are located at the base of the scales on the upper side, usually two to a scale. When the cones are green the scales are closed tightly, but on maturing they usually open and liberate the seeds. Seed may be procured by purchase or by collecting the cones and extracting the seed. Too much emphasis can not be laid on the importance of securing seeds of the highest quality, because no matter how painstaking all other parts of nursery practice may be, if poor seeds are used good results can not be secured.

PURCHASE.

Most persons who plan to raise conifers will purchase seed. Care should be taken to buy from reliable dealers. Unfortunately, seed is usually bought and sold without any guaranty as to quality or purity, though it is generally true to name. The forest-tree seed business in the United States is somewhat new, but is rapidly growing. Dealers generally do not gather seed, but buy it from collectors. Some

companies have their own collectors in many parts of the world, and thus are able to offer a very wide range of kinds from which seeds may be selected. A collector handles seed that grows only in his particular locality; he generally sells it at a reasonably low price, and usually may be depended upon to have a fresh supply.

In buying seed it is an excellent plan to ask for a sample and to request the dealer to guarantee the seed he sells to be equal to sample. A quick and fairly satisfactory test of samples can be made as follows: Count out 100 or 200 seeds, cut them open with a sharp knife, count the empty seed shells, note whether the seeds are well filled and contain embryo, and see if they yield much or little oil when crushed. Plumpness and a large amount of oil in the seeds are indications of good quality. The number of good seeds per hundred will be a guide as to the quality of the seed, though the actual germination per cent will be lower than that shown by the cutting test.

Purchase is advised for those who need only a small quantity of seed or for those who are not near a region where seed may be collected; or perhaps the desired seed can not be collected in the home district in a particular year. Orders for seed should always be placed early, so that the desired quantity may be secured, since seed crops often are light and many buyers are likely to be disappointed.

Seed prices vary according to the size of the year's crop. In general, when prices are below the average, seed is plentiful and usually of good quality; but when seed is scarce and prices are above the average the quality is likely to be poor.

The locality where the seed has been collected should be ascertained and an endeavor made to secure seed grown in a climate similar to that of the region where the trees are to be planted. Seed from the South planted in a northern region are likely to produce seedlings that are not hardy, but northern seeds can be used in the South with good results. Seed selection is important, and seed from vigorous trees is better than that from scrubby specimens. These points are hard to determine by the purchaser, but if information is insisted upon it is likely that the seed trade will soon adopt the highest standards, and that reliable collectors and dealers who do their best to supply perfect seed will have the most remunerative trade, and others will therefore find it to their advantage to adopt the same high standard.

COLLECTION.

Granted ample opportunities, facilities, and time, tree-seed collecting may be satisfactory and profitable, but unless the work receives the most careful attention no decided advantage will be gained. Many persons may desire to collect seed for their own use, and, if the

work is properly done, better seed can be collected than bought. Yet there are many elements affecting the quality of seed, and these should be thoroughly understood before collecting is undertaken.

SECURING CONES.

While it is most important to gather cones at the proper time, no specific rule can be given nor definite time stated, because there is such wide variation. Drought in August will delay the maturing of white pine several weeks, while a warm, wet August hastens the ripening of seed and shortens the period of collecting. If cones are collected before the seeds are fully developed there will be a low germination per cent and weak seedlings; yet if collecting is delayed too long the cone scales open and part or all of the seeds escape. Before collecting begins the cones should be examined to see whether the seeds have commenced to harden. The best method is to open a number of cones and to examine the seeds carefully. A brownish color of the cones is a good indication of ripening; yet many cones which are green have ripe seeds, because only those directly exposed to the sun's rays become brown in the fall. Cones produced on trees in the open mature earlier than those in dense woods, and on a south exposure earlier than on a north slope.

The method described below has been used for several years in collecting large quantities of the seed of conifers, such as white pine, pitch pine, red or Norway pine, jack pine, red or Adirondack spruce, white spruce, hemlock, balsam, and arbor vitæ or white cedar.

To get good cones it is necessary to climb the trees and pick before the scales open, or to gather fresh cones that the squirrels have bitten off. Squirrels' hoards sometimes contain as much as several bushels, and the seed is usually good. Trees that grow in the open produce more cones than those in dense woods. Moreover, trees in the open have branches near the ground, which facilitates climbing. Cones can be gathered cheaply from trees felled in lumbering.

It is slow work to pick cones of hemlock and white cedar, because they are very small. An instrument used in picking blueberries is very useful with these two species. It is a small hand-shaped tool with finger-like teeth, which allow the branches to slip through, but tear off the cones. Red spruce cones usually can be collected from felled trees on a lumber job. A rapid way to collect cones from felled trees is to hold a pail between the knees and pull the cones off into it. Cones of spruce, hemlock, and white cedar should be free from leaves and dirt. Scotch pine and Norway spruce can not be collected in quantity in this country, since they are not native, and only isolated specimens, here and there, are old enough to bear seed.

EXTRACTING THE SEED.

Cones must be dried, either naturally or artificially, to open the scales so that the seeds may be extracted. In large operations it is not practical to spread cones in the sun to dry, because rain is likely to offset all the advantages gained by previous drying.

If, for a special purpose, a large quantity of seed is required, a temporary structure will suffice for a drying shed; but if an annual supply is assured a permanent building is desirable. Two rooms are needed, one a curing room, where the cones can be stored and allowed to dry slowly, and the other a drying room, where they can be subjected to artificial heat to release all the seeds. Both rooms should have tight floors to prevent loss of seed. It will also be advisable, in large operations, to have a third room for thrashing and sorting the cones.

CURING ROOM.

The curing process, preliminary to final drying, is essential, because it permits the inclosed seeds to ripen, just as in the gradual process of nature. It prevents molding and makes for great economy in the final application of artificial heat. The curing room should be constructed to allow the free circulation of air, and doors and windows should be screened to keep out birds and rodents that would eat much of the seed. Racks for drying the cones should be 4 feet square and made of lath, the laths to be placed about one-half inch apart and fastened at each end by nailing a lath flatwise above and below. Each of these frames will hold 2½ bushels of cones, but the cones will dry more quickly if the space in the building will allow a smaller quantity to be spread on each frame. The frames, or racks, rest like shelves, 18 inches apart, one above another, on upright notched boards fastened to floor and ceiling. Aisles should be left between the stacks wide enough to allow the unobstructed carrying of a bushel basket. To facilitate drying, the cones should be stirred often, and, in connection with this, a careful watch should be kept for wormy cones, which must be sorted out and discarded. These infested cones, particularly of white pine, are readily disinguishable by their brown color and shrunken, wilted appearance. These are cones that have dropped off before developing and should never be collected from the tree. Their seeds usually are valueless. In curing, the cones will snap and pop as they open, which indicates progress in drying. When enough are partly open, they should be sorted out to be artificially heated in the drying room, where they will open fully, so that all the seeds may be extracted. (See Pl. I.)

DRYING ROOM.

The drying room should be reasonably tight, to keep in the heat. The heating stove may best be set up in a corner, so that by the use

CURING ROOM, WITH WHITE PINE CONES.

[This shows the arrangement of racks on which cones dry gradually before being subjected to artificial heat.]

of a double elbow the stovepipe may be extended across the room on a level with the top of the stove in two parallel horizontal lines about 2 feet apart. The two pipes may be reconnected and led out as a single pipe. The object is, of course, to furnish the maximum heating surface with an economy of fuel. By thus extending the stovepipe across the room at a low level the heat will rise through a large series of trays placed over the pipes and will penetrate underneath them, as well as around the upper part of the room. Trays of cones may be transferred progressively from the less to the more heated parts of the room. The trays in the drying room are frames of wood fitted with bottoms of wire mosquito netting. The cones should be screened before they are put into the trays, in order that all loose seed may be separated and not subjected to heat. The room can be kept at a temperature of about 100° F. without injury to the seed.

When the cones are nearly all open, they should be taken out to be thrashed. There should be a thrashing room, if possible, to adjoin the drying room. The cones that are fully open can be thrown on the floor for thrashing, while those that are not may be taken back for further drying. The cones are thrashed with a flail and then screened. To avoid loss of seed, the floor should be swept frequently and the seed taken up. A convenient work-table for sorting and sifting cones consists of a screen with a one-half inch mesh in a frame 3 feet wide and about 6 feet long, set at a convenient height for use. It will also be useful for screening the cones before they are placed in the trays. The operations of drying and thrashing should be continuous for all the cones of any one species, in order that the seed of different conifers may not be mixed.

The material which falls through the screen contains the seeds. For further separation this material should be rubbed through finer screens that have a mesh about the size of the seed that is being sorted. This rubbing will break off all the seed wings and remove the larger particles of dirt and pitch. The mesh sizes for various seeds are as follows:

Species.	Wires to an inch.	Size of mesh.	Species.	Wires to an inch.	Size of mesh.
		Inch.			*Inch.*
White pine	6	$\frac{1}{8}$	Arborvitæ	10	$\frac{1}{10}$
Balsam	6	$\frac{1}{8}$	Hemlock	10	$\frac{1}{10}$
Norway spruce	6	$\frac{1}{8}$	Red spruce	12	$\frac{1}{12}$
Red pine	8	$\frac{1}{8}$	White spruce	12	$\frac{1}{12}$
Pitch pine	8	$\frac{1}{8}$			

The material from the last screening is ready to be run through a fanning mill, by which the hollow or "blind" seeds will be blown away with the wings and dirt, and the rest will be clean seed ready for sowing or storing.

TREATMENT BY SPECIES.

While general methods of seed extracting are similar, there must be modifications for different species.

WHITE PINE.

The seed of white pine is the easiest to collect, and the methods already described are the results of long experience with this species. The cones usually should be collected between September 1 and 15, but the time for collecting may vary over a period of six weeks.

BALSAM.

The time for gathering balsam seed is also during the first two weeks in September. When fully ripe the cones of this species fall to pieces, and therefore must be gathered before maturity. They may be spread on the floor of the curing room to ripen, when they will fall to pieces and be ready for cleaning. They are cleaned and fanned like white-pine seeds, with the same sized screen mesh.

NORWAY SPRUCE.

Norway spruce has been introduced from Europe for ornamental purposes and for forest planting. The cones should generally be collected during the first two weeks in September, and when fresh cones are obtainable they may be collected and cured in the same manner as white pine.

RED PINE.

It is most difficult to cure the cones and extract the seed of red pine. The cones should ordinarily be collected between September 1 and 20, yet the cones on the south side of the tree will open early and lose their seed, while those on the north side may remain closed all winter. It takes about two weeks in the drying room to open them, while white pine opens in about six hours. The drying trays should be fitted with a covering of cheese cloth over the wire bottom, because the seeds are so small they will fall through the wire mosquito netting. If there are only a few bushels of cones of this species it is best to place them in trays in the upper part of the drying room and leave them there for several weeks while drying other cones, though if there are enough to warrant it they should be dried separately. It will be impossible to extract all the seeds, but those which are retained at the butt and tip of a cone are usually not fertile.

PITCH PINE.

The cones of pitch pine may be collected during the months of September and October. When the cones remain on the tree they may hold the seed for years, but they open readily in a drying room. There

is no pitch, the seeds come out easily, and the yield is large. The only difficult part of the process is the removal of the seed wings, and the best way is to rub the seeds on an ordinary washboard before fanning.

ARBORVITÆ.

The cones of arborvitæ should be collected from about September 5 to 20, and should be spread out on the curing-room floor to dry, since after they are cured the seeds can be pounded out of the cones without heating. If the cones are free from leaves the result will be clean seed. The wings can not readily be separated from the seed.

HEMLOCK.

Hemlock cones are small and hard to collect and the seeds are not easily cleaned. They may be collected from about September 5 to 20. They can be cured and dried easily enough, because the thin cone scales soon lose their moisture; but unless all dirt is removed before the cones open it will be almost impossible to separate it from the tiny seeds afterwards. The cones need to be cured for some time and then will open after a few hours in the drying room, when they will be ready for thrashing. As in the case of red pine, the bottom of the drying-room trays should be covered with cloth, and since the cones are small they may be spread on the floor of the curing room instead of on racks.

RED SPRUCE.

Cones of red spruce should be gathered from about September 5 to 25. They are very pitchy and require careful treatment, such as a frequent stirring in the curing room to break up the pitchy film about each cone, which keeps them from drying and tends to stick them together in large masses. As soon as they dry so that they will not stick together, all dirt should be removed. This is to obtain clean seeds, because it is very hard to separate the dirt from the seed after the cones open; screening will not altogether remove the particles of dirt of the same size as the seed, and fanning will not separate particles of the same weight.[a] The pitch makes thrashing very irksome.

WHITE SPRUCE.

The cones of white spruce should be collected between September 1 and 20. The treatment is the same as for red spruce.

STORING SEEDS.

Seeds of all conifers should be stored in a cold room over winter. Cellars or stables are not good storage places, because in the former

[a] A detailed description of collecting seeds of this species is contained in the Eighth Annual Report of the Forest, Fish, and Game Commission of the State of New York, 1902–3.

the air is moist and there is no free circulation, and in the latter ammonia fumes will injure the seed. They may be inclosed in a bag, and to be safe from mice should be suspended from the ceiling. Or they may be layered in boxes with moist sand and left in a place cold enough to keep them from germinating before spring. The sand can be sifted from the seed, which must be sown as soon as they are separated; otherwise they will dry out and deteriorate rapidly. This method of layering is called ripening by some commercial nurserymen, although there is no actual ripening. Still another and a successful method for winter storage of seed, especially for large quantities, is by the use of tight tin cans, each having a capacity of 50 pounds, placed in an unheated building.

ESTABLISHING A FOREST BY PLANTING TREES.

The right choice of species in making a forest plantation of conifers is of prime importance. This choice can be made only after full investigation of all conditions, and before starting a nursery or beginning forest planting it is exceedingly desirable that the owner seek expert advice from the State or the Federal Government, or from private foresters. If only a small plantation is to be made, or if a nursery is impracticable, the owner should purchase the trees from a reliable nurseryman. If extensive areas are to be planted, a forest nursery should be established.

NURSERY PRACTICE.

LOCATION OF NURSERY.

The nursery should be conveniently located, either for conditions of labor and supervision or for nearness to the land to be planted, or for both, if possible. If the planting operations are to be extensive and suitable conditions can be found at a central point where facilities for labor and transportation are good, a permanent nursery should be established. But if the planting is on a small scale, and the cost of shipping the seedlings to the planting site is low, it will be advisable to establish the nursery convenient to supervision and labor. The initial cost of the nursery will, of course, be determined largely by the quantity of planting stock required and the number of years the nursery will be in use. (See Frontispiece.)

SOIL.

A good soil is prerequisite to success, and even though an unfavorable one can be artificially improved, great care should be used in its selection. A rich sandy loam soil is best. It should be further enriched with fertilizer in an available form to be taken up easily by

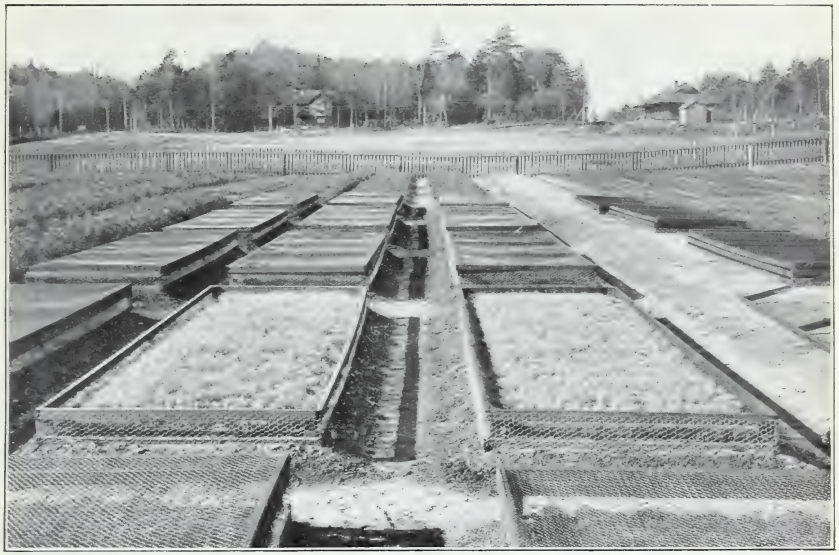


FIG. 1.—SEED BEDS OF 1-YEAR-OLD WHITE PINE.

[Two of the beds uncovered to show the density of the seedlings.]

FIG. 2.—SEED BEDS OF RED PINE, 2 YEARS OLD.

[These beds contain 12,000 to 15,000 trees in a 4 by 12 foot bed.]

the young plants. Seed beds, particularly, must be heavily fertilized. Expenditure for this is economy in the end, especially in producing large numbers of trees. Experiments with commercial fertilizers have not been carried far enough to determine the best for use on seed beds. It is known, however, that ground-bone meal, as a top dressing, has severely injured 1-year-old spruce seedlings. Well-rotted barn manures probably are best if they do not contain live weed seeds. A compost heap should be made each year and allowed to rot three years before it is used. This can be arranged by having three piles, so that when one pile is used another one is made. All fertilizers will probably be improved by the addition of unleached hardwood ashes. The ground should lie so that water will not stand on it in winter and spring, but on the other hand should not slope so that the beds and paths will be washed or gullied. A northern exposure has an advantage over others in that the frost does not go out of the ground so early in the spring that it will freeze later and thaw again, and so heave the plants out of the ground. This heaving out results in loss unless the seedlings are promptly reset before the roots dry out from exposure to sun and wind. The nursery might be placed to decided advantage in a sheltered spot so that the ground will be protected from drying winds in hot weather, and from winter winds that would blow the snow away when it is needed as a protective covering.

Water for irrigation or sprinkling is at times a necessity, and if it can be had at a small outlay the cost of raising the young trees will be lessened and the assurance of success greatly increased. If care is taken to select a place not overgrown with weeds it will save much money and labor in future cultivation. Weed seeds may be killed by burning brush on the site. The ground should be turned in the fall preceding the first spring planting, or better still, might be used in growing potatoes the first year in order that the soil may be thoroughly worked up.

Wherever the nursery is located, it should be well fenced. Woven-wire field fence is best, because with it snow will tend to lie on the level rather than to drift, as it does with a picket or board fence.

AREA OF NURSERY.

An area of approximately 1¼ acres will annually produce 75,000 4-year-old transplants,[a] yet if it is possible to secure, at a reasonable cost, half as much more land, or nearly 2 acres, this will permit a rotation of crop every two years with the same annual output. In other words, two-thirds of the nursery will be in trees, while a soiling

[a] For further discussion see Tables I to V, inclusive, in the Appendix.

crop is grown on the other one-third. Every year a different division of the nursery will be sown to some other crop to improve the soil, so that every third year the rotation will be complete and the soil crop be repeated in each division, as shown in diagram 1.

Both seedlings and transplants may be raised in forest nurseries, but transplants are generally the more desirable for forest planting. The object of transplanting is to develop a stronger and more compact

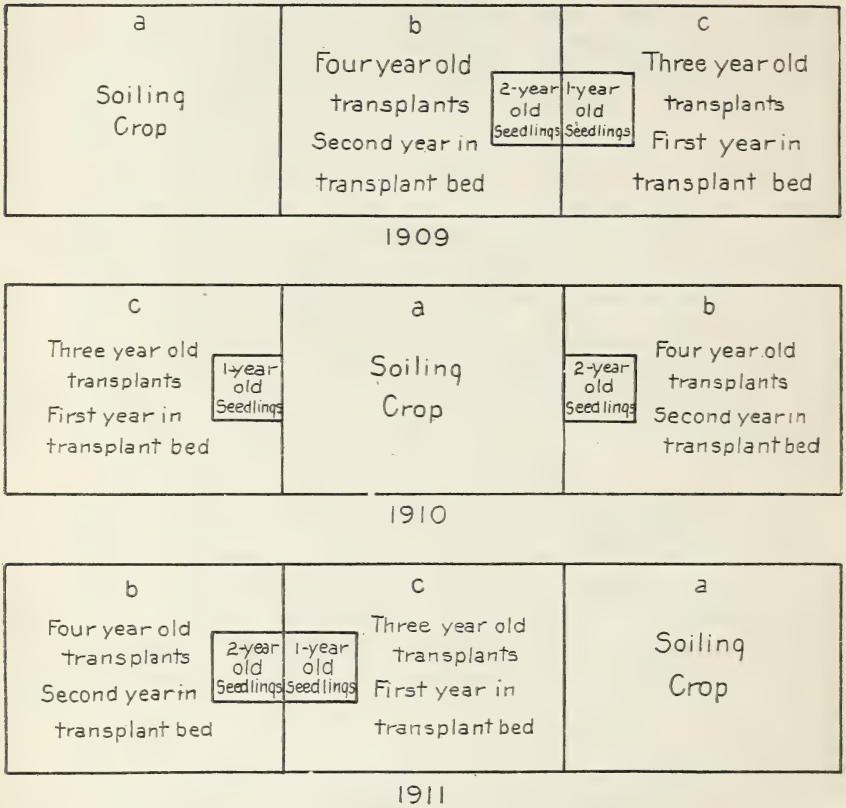


DIAGRAM 1.—Plan of nursery to provide rotation for a soiling crop.

root system. One transplanting is ordinarily sufficient to produce sturdy stock for use on sites requiring stronger plants than seedlings. In this bulletin 2-year-old seedlings are untransplanted trees 2 years old, and 4-year-old transplants are 4-year-old trees once transplanted.

GROUND PLAN.

After the site and extent of the nursery have been decided, beds should be laid out and paths and roads located. Should the nursery work be limited to a few beds, the best and most convenient place

for them would be in one corner of a garden. But a large nursery should be laid out in the shape of a long rectangle with a road lengthwise through the middle.

A definite plan should be charted before work begins, in which seed beds and transplant beds are arranged most effectively for systematic work and convenience, for beds can not be shifted until the trees in them are ready for removal.

If it is decided to raise 4-year-old transplants, which are to be in seed beds two years, the nursery should have two distinct parts equal in size, each to contain both seed beds and transplant ground. The seed beds in one division should be large enough to supply seedlings for the transplant area in that division. After the nursery becomes fully established, there will be first-year seed beds in one division and transplants in their third year; in the other division second-year seed beds and transplant beds with trees transplanted the year before and now in their fourth year. Hence, when the transplants in one division of the nursery are 4 years old and ready for forest planting, the seed beds in that division will furnish 2-year-old seedlings for transplanting to that portion of the nursery from which the 4-year-old stock is sent to the field. Thus, all the new work each year is confined to one division. In a nursery where 3-year-old stock is raised, it will not be possible to divide the nursery equally in this way and there may be other differences, since 1-year-old seedlings may be transplanted and grown two years as transplants, or seedlings transplanted at two years and held one year as transplants, before they are set out in the permanent plantation.

SEED BEDS.

After the ground for the seed beds has been properly enriched it should be spaded thoroughly and cleaned of all débris such as sods, roots, sticks, and stones, and the earth pulverized. The seed beds should have their longest direction nearly east and west; this will secure a moving shade from lath frames which are placed over the seed beds. The beds should all be of like size, and preferably 4 feet wide and either 6 or 12 feet long. If the nursery is small and is to be cared for by one person, 6-foot-long beds are best, because one person can, without assistance, remove and replace the lath shade-frames, but 12-foot beds are better and more economical for large nurseries where there will be two men at hand to move the frames.

The seed beds must be in the best drained part of the nursery to prevent "damping off," a fungous disease that attacks the young seedlings when moisture is excessive. The bed should be raised about 4 inches above the path and its surface rounded off slightly, so that the center will be about 1 inch higher than the outer edges.

FRAME COVERS.

A framework covered with ¾-inch wire netting should be built to fit around the bed and placed in position before the seeds are sown. This frame and net inclosure should be sunk in the soil so that the top of the bottom sill will be even with the surface of the bed. This framework, or seed-bed box, protects the seeds and seedlings from birds and rodents. It is completed by a cover which fits over the

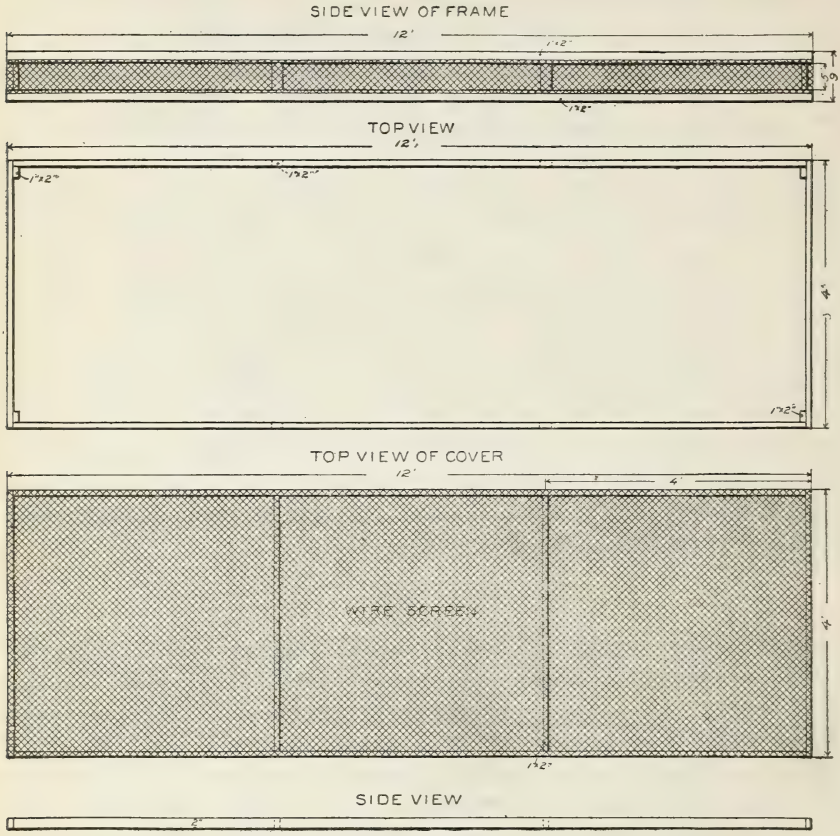


DIAGRAM 2.—Protective wire frame for seed bed, showing construction.

frame. The cover should be separate to provide for weeding. The seed box and cover should be constructed according to diagram 2.

The ¾-inch wire netting is not ordinarily carried by hardware dealers, but can be ordered through them, and when purchased in full rolls of 150 feet a discount may be had from the retail price per foot. A full roll of the 4-foot width will furnish wire for 12 of the 12-foot or 25 of the 6-foot covers. For the sides the 1-foot width should be purchased and afterward split lengthwise through the

middle in order to get the 6-inch width required, but which can not be purchased. One roll of the 1-foot width will make sides for nine 12-foot or fifteen 6-foot boxes. If the ¾-inch "poultry" or "rabbit" wire can not be obtained "sand screen" may be substituted, or

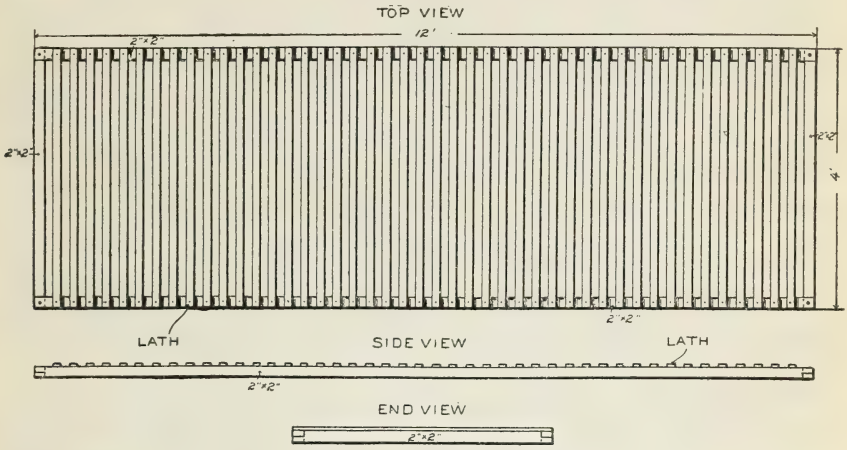


DIAGRAM 3.—Shade frame for seed bed, showing construction.

½-inch mesh screen, though the ¾-inch netting is by far the best and every effort should be made to secure it when a permanent nursery is to be established.

In addition to the netting covers, there must also be provided a shade frame of lath that will protect the seedlings from the direct

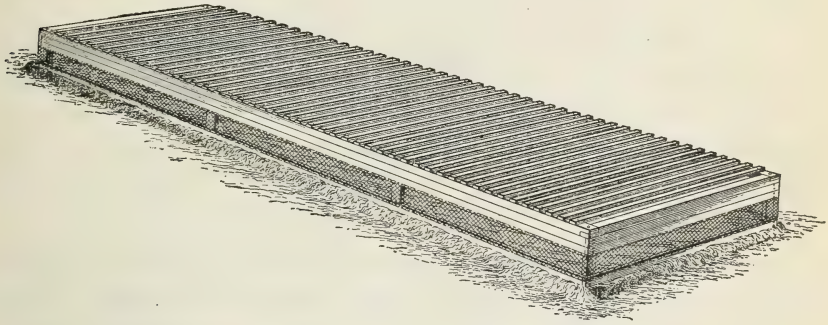


DIAGRAM 4.—Protective screen and lath shade frame in position.

rays of the sun, by reproducing in part the play of light and shade of the natural forest. This shade frame should be made according to diagrams 3 and 4. A complete outfit of wire box, cover, and shade frame, based on constructing 100 of them, will cost $3.08 for each bed of the 12-foot size.

PLANTING SEEDS.

After the box is placed in position the soil must be thoroughly moistened to a depth of at least 6 inches. The seed beds should then be shaped, packed, and smoothed and the seeds then sown broadcast by hand as evenly as possible over the bed. The top soil should then be firmed and the seeds pressed into it by the use of a clean hoe or other tool with a smooth, flat surface. Care must be taken to see that the seeds do not adhere to the tool. The quantity of seed of various species for a bed is given in Table VII, appendix. After the seed has been pressed into the soil, a layer of fine soil not more than one-eighth of an inch deep should be sifted over the seeds. For this, a sieve with a mesh of about ¼-inch, or one used for screening coal ashes, will do. After sifting the dirt, the wire-screen cover should be set in place on the seed-bed box and the lath shade frame laid on top of the cover. The soil should be kept damp by sprinkling with water until the seeds have germinated.

The seed beds are thus prepared for the germination period by entirely inclosing them. All open spaces in the lath shade should be filled by loose laths, and the open sides and ends of the screen box closed by tacking some tight covering like building paper around them, and earth should be banked around the bottom of the paper. The germination period will vary according to weather conditions and the quality and kind of seed. The approximate lengths of time in which seeds of certain species will germinate is here given:

Species.	Approximate time of germination.	Species.	Approximate time of germination.
	Days.		*Days.*
White pine	21	Scotch pine	14
Hemlock	21	Red pine	14
European larch	18	Norway spruce	14
Western yellow pine	16	Red spruce	12

Seed should not be sown until some time after the frost is out of the ground and all danger of freezing weather has passed. If the seeds are sown too early they will rot, but if the sowing is delayed until too late the tender seedlings will succumb to heat. It is better, however, to sow late than too early.

After sowing, the covers of the beds must be raised frequently and the progress of germination observed. If good seed has been used and these directions have been carefully followed a full, even germination will result and the seedlings will all break ground practically at the same time. When enough seeds have germinated to make a thick stand, the loose laths on the top and the paper at the sides must be

removed at once. This will admit light, dry out the soil, and keep the little trees from making a spindling growth. If the cover remains on too long, the trees grow tall and spindling for lack of light, they have thin tissues, are very weak, and should "damping off" start in all would be likely to succumb. Even if the stand is scattering and thin the loose laths and paper must be removed within a few days after the seedlings break ground. In extremely damp weather all coverings, including shade frames, should be removed, leaving only seed-bed boxes, without covers, in position. Should the beds be damp and yet the plants apparently wilting, the lath shade should be removed at once, and an effort made to dry the beds out, because this condition indicates "damping off." Investigation will show that the stems of the young plants are shriveled at the surface of the ground and the little plants will topple over and lie flat. Any sign of damping off is most noticeable in the morning. The fungus which causes this develops most rapidly under humid conditions in shady places, on wet soil. Thorough ventilation and drying out are good preventives. In fact, the chief care during the first season will be to prevent "damping off," and measures of control must be taken at once when needed.[a]

At this time in the life of the little trees there is also danger of their being destroyed by birds. As the young plant comes up the seed coat is pushed out of the ground and remains on the tip until the needles develop and push it off. Sometimes birds will pick off this seed coat and with it the tip of the plant, which is thus killed. This explains the necessity for the screened, inclosed seed bed, from which the protective covering should not be removed during the first summer, excepting to prevent excessive moisture.

Should the weather be dry, the beds may be watered lightly with a sprinkling pot or hose, about sunset. Weeds must be kept out, but if the seeds are good and a full germination is secured this will be an insignificant part of the work.

The lath shade frames should be used during the summer, when necessary, to protect the plants in hot, dry weather. The shade is at the proper height above the beds as it rests upon the wire covering. The shade should be removed after heavy rains until the beds are fairly well dried out.

After the season's growth is over, and other vegetation has been checked by frost, the shade frames, if still in use, should be kept off in order that the little seedlings may harden up for the coming winter, and later in the fall the wire boxes and covers should be removed from the seed beds and placed in a storehouse. Early in the winter, and preferably after a light fall of snow, one thickness of burlap

[a] Circular 4, Bureau of Plant Industry. The Treatment of Damping off in Coniferous Seedlings. By Dr. Perley Spaulding, scientific assistant.

should be fastened in place directly on top of the seedlings. This will prevent heaving of the soil during the ensuing spring. Burlap is cheaper than leaves, and much better. In the spring, after all danger of frost is over and the burlaps are removed, the seedlings ought to be found in the same condition as when covered.

During the second summer the seed beds will require no shading and but little attention, except for weeding. The roots are sufficiently deep in the soil, and the dense growth of the tops shades the ground so that watering is rarely, if ever, necessary, provided none of the trees have been removed and transplanted at the age of one year. Nor will they need a covering the second winter, since the roots are then deep enough in the soil to prevent heaving.

Seedlings should not be kept in the seed bed more than two years. They are then ready to be taken up and transplanted, or even may be sent to the field if it is deemed advisable to use trees this small for field planting. It is a common practice in growing white pine in southern New England to soak down the first-year seed beds and prick out the seedlings, leaving from 50 to 75 per square foot. Those pricked out are set in transplant beds for one year and those that remain, having plenty of room for development, are planted at the end of the second year as seedlings.

The plants must be taken up carefully. A spade should be forced deep enough into the ground next to the plants to get to the bottom of the roots, and a piece of the bed thrown up as a sod. This sod should be shaken until it falls to pieces, so that none of the small roots may be broken off or the stems of the plants split. They should either be transplanted or "heeled in" at once, since the plants will be killed by an exposure of the roots to sun and wind for even a short time.

TRANSPLANT BEDS.

Transplanting is necessary if strong, well-rooted trees are desired for forest planting. The work should begin in the spring, as soon as possible after the frost leaves the ground, and should be complete before the new leaders begin to form. Since European larch begins to grow before the frost is out of the ground, an exception must be made in its case and it should be transplanted in the fall, both in the nursery and to the field.

Transplant beds should be approximately 4 feet wide, since this is the most convenient width for work. The paths at the sides of the bed need not be over 2 feet wide, but those at the ends should be 2½ feet, to permit the use of a wheelbarrow. Transplant beds may be any length, but 40 feet is a convenient one, and a bed this size will hold approximately 1,000 transplants with rows 6 inches apart and plants 4 inches apart in a row, 13 plants in a row, and 81

rows. Making allowance for losses, each bed ought to furnish 750 young trees for planting. If the transplants are to remain in the bed only one year they may be spaced closer, or in rows 6 inches apart and the plants 2 inches apart in the row. A bed 40 feet long with plants set at this spacing may contain 2,000 trees or, with a proportionate allowance for loss, should produce 1,500 young trees.

The transplant beds should be well prepared and, if on a moderately good soil, should be raised about 4 inches higher than the path. Paths serve to conduct away the surface waters during a rain storm and to prevent soil washing and the burying of plants. The beds should be 4 feet 6 inches wide (including slope of edge) in order that the planted row of trees may be exactly 4 feet long. This leaves 3 inches on each side of the slope of the edge, and will allow for a certain amount of washing away of the edges of the beds without exposing the plant roots. The paths may be laid out to facilitate drainage, but in any case it will add greatly to the appearance of the nursery if all the work is neatly done, and exact. A system of stakes and cords may be used, and results with these ought to be thoroughly satisfactory, though in a large nursery it may be advisable to have some of the main lines surveyed and staked off as bases for all the beds.

All of the beds need not be complete before transplanting begins. If the soil is too dry the bed should be thoroughly moistened to facilitate planting. The seedlings should be carried in a pail in which there is sufficient water to cover the roots. A transplanting board will aid the work, since by its use the seedlings can be placed regularly and with little trouble. This board should be 4 feet 3 inches long and 5½ inches wide, with notches cut on both edges of the top side, either 2 or 4 inches apart, according to the required distance between plants in the row, but the first notch should be 3 inches from one end and the notches exactly opposite on both sides of the board. The board is held in place by two sharpened pins set in the board and projecting from the under side. The planting board is laid crosswise of the bed, so that the first row of trees will be set on the line marking the end of the bed, and one end of the board will be against the string that marks the side of the bed. After this first row is planted, the board is moved back, or toward the planters, and the far side of the board placed against the row of seedlings already planted and one end against the string as before. One plant is set at each notch, and the work proceeds in this manner until the bed is filled. If care is taken to keep the end of the board even with the string along the side of the bed, the plants in each bed will be in straight rows both ways. It costs no more to have this uniform arrangement and is an advantage in every way, especially

since it aids cultivation and gives each tree equal advantage. (See Pl. III, fig. 1.)

Two men to a transplant board, one at each end, can work to best advantage and, doing the work thoroughly, should set out 500 plants per hour. A long, narrow trowel is the best tool to use, and care should be taken to make the hole sufficiently deep for the root system. Care must also be taken to put the roots into the hole in proper position and to see that the plants are set in the ground at the same depth they were in the seed bed. The earth should be thoroughly packed around the roots. The foreman can easily see whether the laborer has planted the seedlings at the proper depth and, by pulling, can find out whether they are set firmly and are tight in the ground. It requires constant supervision to see that the soil around the roots has been packed properly. As soon as the planting is completed the paths should be leveled and the nursery cleaned up.

During the summer the beds should be kept free from weeds and the soil between the rows lightly cultivated, though the trees must not be loosened or injured. If there is hot, dry weather soon after planting the trees should be watered, or shaded temporarily with lath covers. The paths also should be kept free from weeds, and all the collected weeds removed from the nursery in order that no seeds may be left. The weeds in the bed must always be pulled up, never broken off; therefore it is best to weed after a rain when the ground is soft. The first two weedings of the season are the heaviest and the most expensive, but if they are well done subsequent weeding will be comparatively easy and much less expensive. All trees that die should be removed and a record should be kept of their numbers.

The transplant beds need no covering in winter. The following spring these transplants are 3 years old and, under certain conditions (see p. 23), are suitable for forest planting. Should large-size material be desired, the transplants should remain in the same place another year. Practically the only additional cost of 4-year-old over 3-year-old transplants is in the expense of weeding during the second summer in the transplant bed. They are more bulky to transport to the planting sites, and they need larger holes when planted in the field; but they are stronger and more likely to succeed, especially under unfavorable conditions of competition with weeds, brakes, or brush cover.

PACKING FOR TRANSPORTATION.

In packing for transportation the distance and the time in transit must be considered. If the distance is short, they may be packed in a large wagon box or in good-sized packing boxes lined on the inside with burlaps that have been soaked with water and rubbed in

earth to make them air-tight. If the distance or time of transit is long or the weather very dry, wet sphagnum moss should be placed around the roots. The trees should not have the tops and roots mingled; if they are kept separate the time and trouble of sorting will be saved. Seedlings should be bundled in lots of from 50 to 100 trees, but larger trees need not be bundled. The tops should be exposed, so that the air may circulate through them; otherwise they will heat and the plants will be ruined by being scalded. Care must always be taken that the roots do not become dry at any time, because if they dry out thoroughly the plant will die.

When stock arrives at the place where it is to be used, the plants should at once be heeled in. Before the boxes are opened they should be distributed over the planting site, in order to save the expense of carrying them some distance to the planters.

MAKING A FOREST PLANTATION.

AGE CLASSES OF TREES.

In the nursery practice just described it has been assumed that the trees were grown two years in the seed bed, then transplanted and kept two years before they were set out in permanent plantations. But on cut-over lands with a thin ground cover, or on old fields covered by a light growth, such large, strong trees are not required in forest planting; 2 or 3 year old trees once transplanted or strong 2-year-old seedlings have proved sufficiently sturdy to meet such conditions. Perhaps some pines may be best transplanted at the end of one year and held in transplant beds two years before setting out.

If the ground cover is dense, it is false economy to use small untransplanted trees, and this is especially true in the Adirondack region of New York. Yet in New England most of the land to be planted will need only the 2 or 3 year old transplants or even 2-year-old seedlings, provided the plants are stocky and have good root systems.

When healthy wild seedlings are obtainable these may be used in forest planting. As a rule, however, their root systems are straggling and they lack decidedly the characteristics that are essential for success. A modified use of wild stock consists of setting the wild seedlings in transplant beds in the nursery for a year prior to planting. This will, however, cost as much as, or more than, the raising of trees from seed, and should only be practiced when conditions are unusually favorable for the economic gathering and care of such stock.

SEASON FOR PLANTING.

Planting should be commenced as soon as the frost is out of the ground in the spring. Spring planting before the buds begin to grow

is better than planting in the fall after the trees have completed their season's growth. As between planting and sowing the seed beds in the spring, the former should always take precedence in point of time. The length of the planting season varies from four to six weeks.

ORGANIZATION OF PLANTING WORK.

The different parts of the work require no little special skill, and men should be selected for their special fitness. When the work is on a small scale it consists simply in two operations, digging holes and setting the trees, and one man is needed for each operation. This pair of men working together may be considered as a labor unit in all planting operations. Several pairs of men will be required for planting on a large scale and there will then have to be a definite system of supervision. One foreman can superintend the work of six or eight pairs of men, who will form a working crew. While it is of course true that the more extensive the operations the more crews will be required, the number can not be increased indefinitely; and more than 100 men can not be controlled economically under several foremen and one superintendent. Some help is required to supply the planting crews with trees and to set flags for the guidance of the diggers, and one person to supply laborers with water.

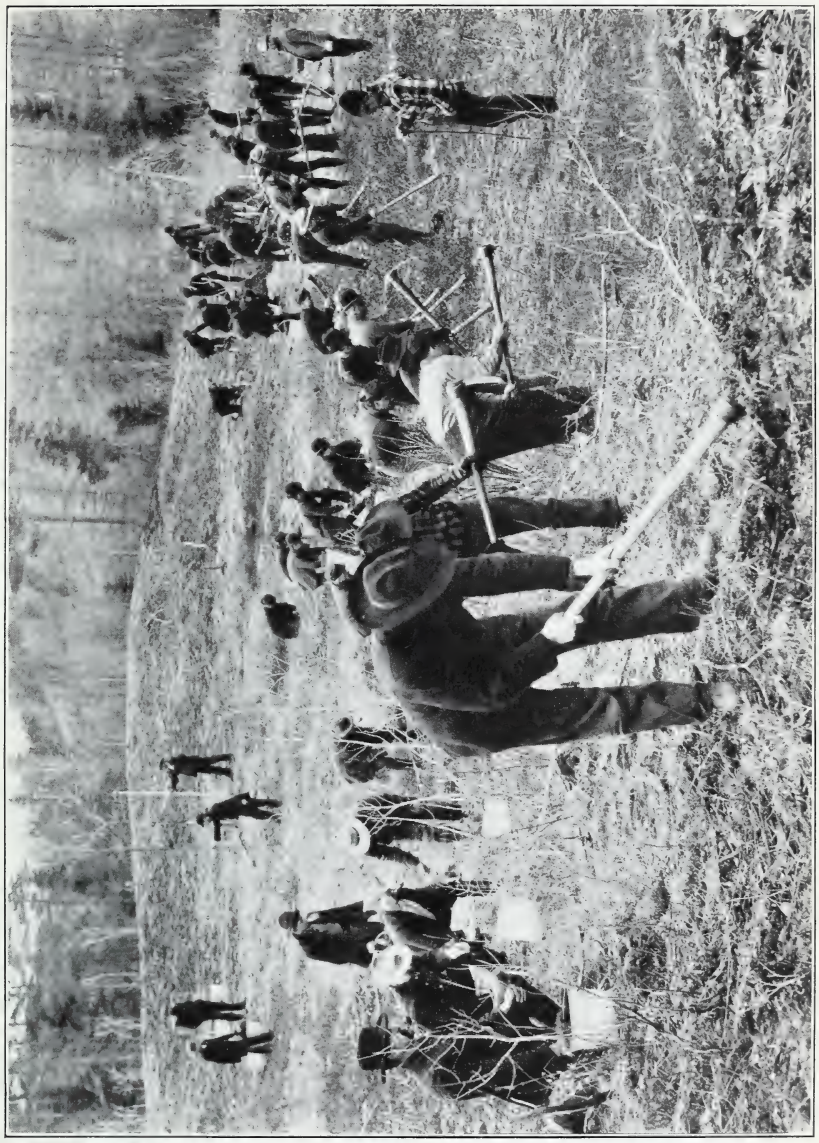
PLANTING.

One man in each pair should be provided with a grubbing hoe or a mattock for digging the holes; the other should follow with a pail of trees and set one in each hole. Besides the hoes and pails there will be need for flags for lining up the men, shovels for heeling in, and baskets for carrying the trees from the place of heeling in to the planters' pails. The trees should be set at regular intervals in rows, to utilize the ground to the best advantage and to produce the best forest stand. When the pairs of workmen are lined up to begin planting, two or more sets of flags should be set ahead to guide the first pair of men, who set the first row of trees across the field. This first pair keep in line with the flags, and set the plants in the row according to the prescribed spacing. The second pair start another row opposite the first plant set by the first pair and keep along parallel, according to the spacing desired; the third pair similarly, and so on. If the diggers and planters exchange labor after crossing a large area the work will be less tedious, but this changing requires much sharper supervision to insure good planting. (See Pl. IV.)

In making a hole it is well to cut off and remove a thin slice of sod, to give the plant a better opportunity to grow with the competition of the grass removed. The hole should be large enough to give room for the roots without crowding, and the tree should usually be

FIG. 1.—TRANSPLANTING. SHOWING USE OF THE TRANSPLANTING BOARD.

FIG. 2.—TRANSPLANT BEDS OF WHITE PINE 4 YEARS OLD. TRANSPLANTED WHEN 2 YEARS OLD.



MAKING A PINE PLANTATION.

placed in the ground, especially on light soils, slightly deeper than it was in the nursery. The earth should be packed about the roots thoroughly, so that open air spaces will not be left and the plant will be able to get the moisture from the surrounding soil. Just as in transplanting, great care should be taken to get the roots in as nearly a normal position as possible. Two men, after they have had a little experience, should set out 1,000 of the medium-size trees per day and 1,200 of the smaller ones.

Attention must be given to the plants that are heeled in, and if they so remain for some time before they are planted they must be watered and covered with wet burlaps during hot, dry days. This cover will prevent the buds from developing too rapidly and permit of planting over a longer period of time during the spring. Baskets are most convenient for carrying the plants from the place where they are heeled in to the planter's pail.

PROTECTION.

After the plantation has been made it should be protected from fire. This may mean merely the annual clearing of fire lanes around the plantation, supplemented by bare strips of land dividing the plantation into blocks, or, in extensive reforestation, the maintenance of a patrol in season of danger.

OPERATION AND COSTS.

OPERATION.

Field planting is carried on mainly in the spring, within a short space of time, while nursery work is continuous from the time the frost leaves the ground in the spring until it freezes again in the fall. These two branches of the work, therefore, may be considered separately, and, in fact, the two are distinct in organization and supervision.

NURSERY WORK.

No matter how large or how small any nursery may be, there should always be some one at hand with sufficient authority and experience to control all work efficiently. If the nursery is large, this person should act as a foreman only; but if the work is conducted on a small scale, he can guide the work and also perform some of it. If a foreman is in charge he should be shown proper consideration and be given necessary authority to discharge men and issue orders. Any superintendent over him should give orders to the foreman and have him execute them. This gives the foreman standing with the men under him and avoids the confusion which often

results when more than one person is giving orders. The accompanying outline shows the usual lines of nursery work in their chronological order. It is of course apparent that seed collecting and curing done in the fall has but little part in the routine management of a forest nursery, where most of the activity is in the spring months. For this reason no account is taken of collecting and storing in the synopsis of spring nursery work.

- Nursery foreman
  - Taking up trees for field planting or shipment.
    - Loosening.
    - Pulling.
    - Heeling in.
  - Shipping
    - Packing.
    - Carting.
    - Shipping.
  - Preparing soil
    - Plowing.
    - Fertilizing.
    - Harrowing.
    - Cleaning soil.
    - Removing stones, sods, etc., from nursery.
  - Making beds
    - Staking out and lining.
    - Spading.
    - Leveling.
    - Rolling.
  - Sowing and transplanting
    - Taking up seedlings.
    - Distributing seedlings.
    - Transplanting seedlings.
    - Sowing seedbeds.
    - Inspecting work.
  - Time and cost keeping [a]
    - Keeping time.
    - Paying men.
    - Keeping costs.

Work during the first year, while a nursery is being started, will be confined to cleaning ground and preparing and caring for seed beds. The balance of the nursery area may be sown with a leguminous or other crop. Transplanting enters into the work of the second or third year, according to the system decided upon. Then when the transplants have reached the required age for planting, all lines of work will be in operation.

FORMATION OF PLANTATIONS.

The field work should be organized and conducted so that it can be carried on in direct relation to the nursery work. They are interdependent, and the field work should be organized to take the planting stock and plant it as fast as necessary to remove it from the nursery. Enough help should be employed to make sure that the

[a] The foreman, if time permits, may look after these matters.

planting will all be done before the buds have started too vigorously. In some cases it may be necessary to establish quarters and board the men while the field planting is in progress. Board should be of good quality and liberal in quantity. Men are more likely to quit as the result of poor board than because of low wages.

The following outline shows work in connection with planting, arranged in chronological order:

Planting superintendent.	Stock	Ordering shipments from nursery. Distributing loads of trees over planting site. Keeping planters' pails supplied with trees. Caring for trees heeled in.
	Lineman	Setting flags to guide planting crews.
	Planting crews (under foreman).	Digging holes and planting by as many crews as necessary. (Unit of labor—one laborer digging holes, one planting trees; one crew of 5 or 6 pairs under one foreman.)
	Time and cost keeping.[a]	Keeping time. Keeping costs. Paying laborers.
	Camp	Supplies. Cook.

COSTS.

Every one who contemplates reforesting will naturally want to know the expense. It is not possible to prepare estimates which will apply to all cases, but some idea of costs may be gained from an exact statement of the cost of raising 250,000 three-year-old white pine transplants, and making a plantation of approximately 200 acres, per annum.

The initial investment for permanent improvements and equipment may be from $400 to $1,000, and will depend upon local conditions, such as the price of land, cost of a water system, price of labor, and cost of materials. The annual expenditures, in addition to the permanent improvements, may be more definitely stated, as follows:

Annual expenditure to raise 250,000 3-year-old white pine transplants annually and set them 6 feet by 6 feet apart in plantation.

Expenditures on—	First year.	Second year.	Third year.	Fourth year.
1-year-old stock	$235.00	$235.00	$235.00	$235.00
2-year-old stock	.....	87.50	87.50	87.50
3-year-old stock	.....	.....	475.00	475.00
Planting	.....	.....	.....	975.00
Total annual expenditure	235.00	322.50	797.50	1,772.50

[a] If time permits, planting foreman may attend to these matters.

As soon as the first lot of transplants is ready for field planting, the annual expenditure reaches $1,772.50 and thereafter should remain relatively constant.

Many and careful computations have been made of the cost of growing seedlings and of making plantations with various aged classes of stock and for different spacings. The results are given in the appendix, in Tables X and XI, based on experience in large reforesting operations conducted by the State of New York in the Adirondacks, but low costs can not often be secured on small operations or without experience.

No allowance has been made for the technical advice or supervision of a consulting forester, but all cost of foreman and superintendence, not technical, is included. Labor cost, 22 cents per hour; lumber, $25 per thousand feet (board measure); lath, $4 per thousand pieces. No allowance was made for soil rental or interest on the money invested. Ten per cent of the cost of equipment, buildings, waterworks, tools, tool houses, fences, etc., is taken for fixed charges.

Miscellaneous current expenses include charges which can not readily be apportioned under the headings given, such as general care of nursery, watering, spraying, work on paths, walks, ditches, and other miscellaneous items.

The following statements show the charges included in securing the final figures shown in Table X in the appendix:

Cost per thousand of producing 2-year-old white pine seedlings (column 1):	
Use of seed-bed boxes and lath shade	$0.08
Labor putting in seed beds	.12
Care during first summer	.20
Care during second summer	.10
Covering with burlap first winter and removing it	.05
Fixed charges first year	.10
Fixed charges second year	.10
Miscellaneous current expenses first year	.10
Miscellaneous current expenses second year	.10
Allowance for loss of seedlings	.15
Average cost of producing all species (except cost of seed) [a]	1.10
Average cost of white pine seeds	.19
Cost of 2-year-old white pine seedlings in seed bed	1.29
Cost per thousand of 3-year-old white pine transplants (column 2):	
Cost of 2-year-old white pine seedlings (as above)	1.29
Cost of taking up seedlings	.10

[a] The price of seeds per thousand is computed by taking average cost of seed as found in Table IX, column 1, and reducing cost to price per ounce; then multiply by number of ounces needed to sow a seed bed (see Table VII). This gives cost per bed for seed, and this amount divided by 7½ (the average number of thousand trees in a seed bed) gives the price of seed per thousand trees. This cost, added to cost of production, $1.10, gives cost per thousand for various species.

Cost per thousand of 3-year-old white pine transplants (column 2)—Continued.

Cost of transplanting	$1.40
Cost of weeding third year (trees spaced 2 by 6 inches in transplant bed)	.25
Cost of fixed charges third year	.05
Cost of miscellaneous current expenses third year	.10
Cost of 3-year-old white pine transplants in beds	3.19

Cost per thousand of 4-year-old white pine transplants (column 3):

Cost of 2-year-old white pine transplants (as above)	1.29
Cost of taking up seedlings	.10
Cost of transplanting	1.40
Cost of weeding third year (trees spaced 4 by 6 inches in bed)	.40
Cost of weeding fourth year (trees spaced 4 by 6 inches in bed)	.20
Cost of fixed charges third and fourth years	.10
Cost of miscellaneous current expenses third and fourth years	.20
Cost of 4-year-old white pine transplants	3.69

The following statements show the way figures in Table XI were obtained:

First division, when 2-year-old seedlings are used:

Cost per thousand of 2-year-old seedlings in bed	$1.29
Cost per thousand of taking up seedlings	.10
Cost per thousand of planting in the field (two men, 1,200 per day)	2.90
Cost per thousand of growing and planting 2-year-old white pine seedlings	4.29

When a 6 by 6 foot spacing is used 1,210 trees per acre will be required. (See Table VI.)

Number of thousand trees per acre	1.210
Cost per thousand	$4.29
Cost of 1 acre of plantation	5.19

Second division, when 3-year-old transplants are used:

Cost per thousand of 3-year-old transplants in beds	3.19
Cost per thousand of taking up transplants	.40
Cost per thousand of planting in the field (2 men, 1,000 per day)	3.50
Cost per thousand of growing and planting 3-year-old white pine transplants in the field	7.09

When 6 by 6 foot spacing is used 1,210 trees per acre will be required; hence—

Number of thousand trees per acre	1.210
Cost per thousand	$7.09
Cost of 1 acre of plantation	8.58

Third division, when 4-year-old transplants are used:

Cost per thousand of 4-year-old white pine transplants in bed	$3.69
Cost per thousand of taking them up	.60
Cost per thousand of planting them in the field	4.00
Cost per thousand of growing and planting 4-year-old white pine transplants grown and set in the field	8.29

When a 6 by 6 foot spacing is used 1,210 trees are used per acre.

Number of thousand trees per acre	1.210
Cost per thousand	$8.29
Cost of 1 acre of plantation	10.03
Miscellaneous costs per thousand, all species:	
Care of seed beds first year	$0.20
Care of seed beds second year	.10
Cost of taking up seedlings	.10
Cost of taking up, bunching, and packing seedlings	.40
Cost of transplanting seedlings in nursery	1.40
Cost of planting 2-year-old seedlings in field	2.90
Cost of planting 3-year-old transplants in field	3.50
Cost of planting 4-year-old transplants in field	4.00
Cost of taking up 3-year-old transplants in nursery	.40
Cost of taking up 4-year-old transplants in nursery	.60
Cost of weeding 3-year-old transplants	.25
Cost of weeding 4-year-old transplants third year	.40
Cost of weeding 4-year-old transplants fourth year	.20
Cost of miscellaneous current expenses seed beds per year	.10
Cost of miscellaneous current expenses transplants per year	.10

LABOR REQUIRED.

Full explanation has already been given as to the capacity of laborers, and certain units of labor have been described. The value or capacity of this labor so varies with its class and experience that it is impossible to state definitely that to operate a specific nursery area it will require the employment of an exact number of men. Even on such an apparently trivial item as weeding during the summer there will be much variation, because some pieces of ground seem to have an unlimited capacity for growing weeds while others do not. These practical limitations make it inadvisable to try to state in detail the number of laborers needed. It may be said, in general, however, that two men under average conditions will care for a nursery of two acres during the summer, and look after transplants and seedbeds and have some time for work on permanent improvements.

ESTABLISHING A FOREST BY SEEDING WHERE THE FOREST IS TO GROW.

The simplest, though not always the most certain or the cheapest, method of reforesting land is by sowing seed in the place where the future forest is to be. The advantages of sowing are these: It is nearest to the method of nature; transplanting, no matter how carefully done, involves, as a rule, injury to the roots, which may start decay; a forest from seed is dense and produces timber free of branches; on stony soil planting is expensive, and sowing is the more desirable method of establishing a forest. Moreover, sowing is very simple,

and where planting stock will be prohibitive in price, or where there is no expert labor for planting, the method can be used to advantage. On the whole, however, sowing can not be considered under some conditions as the most advantageous method of establishing a forest. On wet or dry soils, or soils subject to freezing or covered with a dense mat of weeds, the conditions are less favorable for sowing than for planting. Sowing can not be recommended in cases where seed must lie over in the ground a whole year (basswood), or if the seed is very small (aspen, willow), or is very expensive (white pine). It will take not less than 4 quarts of white-pine seed to sow an acre with white pine, and many advocate more, or not less than 5 pounds. It is evident that seed sowing in such quantity will pay only when the seed is very cheap. Otherwise the average cost of white pine seed, $2.25 per pound, will make the cost of the seed over $11 per acre, and will justify this method only in extreme cases, when planting for some reason is impossible.

The seed may be sown over the whole area broadcast or in regular strips, or only in spots.

BROADCAST SOWING.

It is generally necessary to prepare the ground for establishing a forest by seeding, for without such preparation the possibilities of failure are great. Only under especially favorable conditions has the sowing of seed without previous preparation of the ground any chance to produce good results with eastern conifers, as in cases where there have been recent fires which have burnt off the grass and loosened up the soil. Even then, however, the seed should be raked or brushed into the soil. Broadcast sowing may be often very cheeply done when combined with crop raising. After two or even three years of such grains as rye, wheat, oats, and especially of corn, and crops of potatoes, the soil will be in excellent shape for forest seeding. The cost of cultivating the ground in such cases is fully paid by the crop. Before the seed is sown it is often advisable to coat it with thick paste made of red lead and water, or to soak it in a solution of blue vitriol and then dry it, to lessen the danger of having it eaten by birds.

PARTIAL SEEDING.

STRIP METHOD.

Sowing seed by the strip method reduces the amount of seed required for the whole area. Instead of sowing all the land the tract is gridironed by strips on which seed has been sown broadcast. The sown strips may be 6 to 8 feet wide and separated by unsown strips of the same width.

SEED SPOTS.

Sowing in seed spots consists of removing the sod or other cover and loosening up the soil in spots about 15 inches in diameter, and as far apart each way as it is desired to space the future trees. Owing to the tenderness of young conifer seedlings during the first two years, there is always a high percentage of deaths among the seedlings in seed spots. The directions given for lining up men in making a plantation may be followed in this work. It requires nearly as much work to prepare the ground for the seed spot as to dig the hole for planting a tree. From 5 to 30 seeds should be planted in a spot, depending upon the species. The seeds should be coated or treated the same as for broadcast sowing. A few years later this field should be gone over, and wherever several plants are in a spot part should be removed and only the most promising one left. Those removed should be used to fill the spots where the seeds failed to grow. Three men, 2 of them making spots and 1 putting in the seeds, will plant 3 acres per day. Allowing $1.75 per day for labor and $2.25 per pound for seeds, the initial cost of this work is $4 per acre, plus the labor needed in going over the field a second time, as described above. This makes the cost per acre by the seed-spot method nearly equal to planting transplants from a nursery.

There are two modifications of the seed-spot method, as described above. The first consists of roughly breaking the surface of the soil where the seeds are to be sown, dropping a few seeds on the spot, and pressing them in with the foot. This differs from the regular method only in the fact that each spot is not carefully prepared, and hence the cost of the work is less. The second variation consists in dropping a few seeds on unprepared ground and then covering them with a handful of soil. For convenience the soil may be carried in a bucket, and replenished from time to time.

APPENDIX.

TABLE I.—*Nursery area required to produce 15,000 trees of various ages.*

Age of trees.	Area, in square feet, required for—	
	One crop only.	Continuous annual supply.
1-year-old seedlings[a]	168	168
2-year-old seedlings	168	336
3-year-old transplants[b]	1,913	2,249
4-year-old transplants	3,825	7,986

[a] One foot all around a 4′ x 12′ seed bed is allowed for path for each bed, making 36 square feet per seed bed in addition to its area.

[b] The unit of area for transplant beds is a rectangle 6′ x 42½′=255 square feet. This figure is used in computing transplant area. It is a 4′ x 40′ transplant bed with allowance in addition for one-half the width of paths, 1¼ feet on the ends, 1 foot on the sides.

TABLE II.—*Nursery area necessary each year while a nursery is being started to produce 15,000 three or four year old transplants annually.*

Year.	Square feet of nursery required annually to produce—	
	3-year-old transplants. 2-1.[a]	4-year-old transplants. 2-2.[a]
First	168	168
Second	336	336
Third	2,249	4,161
Fourth	.....	7,986

[a] The first figure indicates years in seed bed; the second figure, years in transplant bed.

TABLE III.—*Number of trees of various ages that can be produced annually in a given sized nursery.*[a]

Age of trees.	Number of trees annually produced in nursery.			
	Area, one-eighth acre.	Area, one-fourth acre.	Area, one-half acre.	Area, 1 acre.
2-year-old seedlings	240,000	480,000	960,000	.....
3-year-old transplants	35,000	70,000	145,000	290,000
4-year-old transplants	9,000	20,000	40,000	80,000

[a] No allowance made for a main road in the nursery.

TABLE IV.—*Nursery area needed to produce different classes of trees sufficient to plant 10 acres annually at various spacings.*

Spacing in plantation (feet).	Number of trees per acre.	Nursery area, in square feet, required to produce trees for planting 10 acres annually.		
		2-year-old seedlings.	3-year-old transplants. 2–1.[a]	4-year-old transplants. 2–2.[a]
4 by 4	2,722	672	4,242	14,952
5 by 5	1,742	454	2,749	9,634
6 by 6	1,210	336	2,121	6,966

[a] The first figure indicates years in seed bed; the second figure, years in transplant bed.

TABLE V.—*Number of acres of plantation that can be made annually with different classes of trees produced in a nursery of one-half acre, when the trees are set at various spacings.*

Classes of trees.	Number of trees that can be raised.	Area of plantation when trees are spaced—		
		4 by 4 feet (2,722 per acre).	5 by 5 feet (1,742 per acre).	6 by 6 feet (1,210 per acre).
		Acres.	*Acres.*	*Acres.*
2-year-old seedlings	960,000	352	551	793
3-year old transplants	145,000	53	83	119
4-year-old transplants	40,000	14	22	33

TABLE VI.—*Number of trees required to plant 1 acre using rectangular method of spacing.*

Distance between the rows.	Number of trees when distance apart in the row is—				
	4 feet.	5 feet.	6 feet.	7 feet.	8 feet.
Feet.					
4	2,722				
5	2,178	1,742			
6	1,815	1,452	1,210		
7	1,556	1,244	1,037	888	
8	1,361	1,089	907	777	680

TABLE VII.—*Amount of seed of various kinds required to sow one seed bed (48 square feet to produce 7,500 seedlings) and the amount to collect or purchase in order to raise a given number of seedlings.*[a]

Species.	Amount of seed to raise—		
	7,500 trees.	37,500 trees.	75,000 trees.
	Ozs.	*Lbs.*	*Lbs.*
White pine	10	3¼	6½
Red pine	6	2	3¾
Scotch pine	8	2½	5
Pitch pine	10	3½	6½
Jack pine	6	2	3¾
Norway spruce	8	2½	5
Red spruce	6	2	3¾
White spruce	8	2½	5
European larch	16	5	10
Balsam	12	4	8
Arborvitæ	6	2	2¾
Hemlock	8	2½	5

[a] These figures are for good seed. If the seed has poor germination per cent, a greater quantity to a bed must be sown, according to the percentage of bad seed.

TABLE VIII.—*Number of seeds per pound and average germination per cent of fresh seed.*

Species.	Average number of seeds (medium weight) per pound.[a]	Average germination (per cent).
White pine	30,000	60 to 70
Red pine	80,000	70 to 80
Scotch pine	70,000	60 to 80
Jack pine	90,000	60 to 80
Pitch pine	50,000	65 to 85
Norway spruce	65,000	60 to 70
Red spruce	120,000	65 to 80
White spruce	100,000	60 to 70
European larch	75,000	50 to 60
Balsam	50,000	35 to 60
Hemlock	80,000	35 to 65
Arborvitæ	175,000	60 to 70

[a] The number of seeds per pound will vary with the crop. This can be readily understood since a bushel of white pine seeds will vary in weight from only 30 pounds when seeds are poor to as high as 40 pounds when seeds are very good.

TABLE IX.—*Market price of seeds and local cost of collecting in quantity, not including permanent equipment.*

Species.	Average market price per pound.	Range of market price per pound.	Cost of collecting.
White pine	$2.25	$1.40 to $4.00	$0.60 to $2.50
Red pine	7.00	6.00 to 7.50	2.40 to 6.20
Pitch pine	2.50	1.20 to 3.00	1.10 to 1.65
Jack pine	3.30	1.25 to 5.00	.....
Scotch pine	1.90	1.50 to 2.50	.....
Red spruce	4.50	3.00 to 7.00	.90 to 1.50
White spruce	3.50	1.20 to 4.50	1.45 to 2.20
Norway spruce	.85	.60 to 1.20	.....
Balsam	1.45	1.00 to 2.25	.90 to 1.50
Arborvitæ	2.05	1.50 to 3.00	.90 to 1.80
Hemlock	3.75	2.75 to 4.50	2.00 to 3.20
European larch	1.20	.85 to 1.50	.....

TABLE X.—*Cost of raising nursery stock in quantity for forest planting (based on growing 500,000 trees annually).*[a]

Species.	Cost per 1,000 to raise—		
	2-year-old seedlings.	3-year-old transplants.	4-year-old transplants.
White pine	$1.29	$3.19	$3.69
Red pine	1.45	3.35	3.85
Scotch pine	1.23	3.13	3.63
Pitch pine	1.30	3.20	3.70
Jack pine	1.27	3.17	3.67
Norway spruce	1.16	3.06	3.56
Red spruce	1.33	3.23	3.73
White spruce	1.34	3.24	3.74
European larch	1.26	3.16	3.66
Arborvitæ	1.21	3.11	3.61
Balsam	1.25	3.15	3.65

[a] These figures are for transplants and seedlings in the nursery and do not include cost of taking them up.

TABLE XI.—*Cost per acre of making plantations with various-aged nursery-grown trees when they are set at various spacings.*[a]

Species.	Total average cost[a] per acre of raising and planting—								
	2-year-old seedlings spaced—			3-year-old transplants spaced—			4-year-old transplants spaced—		
	4 by 4 feet.	5 by 5 feet.	6 by 6 feet.	4 by 4 feet.	5 by 5 feet.	6 by 6 feet.	4 by 4 feet.	5 by 5 feet.	6 by 6 feet.
White pine	$11.68	$7.47	$5.19	$19.30	$12.35	$8.58	$22.57	$14.44	$10.03
Red pine	12.11	7.75	5.38	19.74	12.63	8.77	23.00	14.72	10.22
Scotch pine	11.51	7.37	5.12	19.14	12.25	8.51	22.40	14.34	9.96
Pitch pine	11.70	7.49	5.20	19.33	12.37	8.59	22.59	14.46	10.04
Jack pine	11.62	7.44	5.17	19.24	12.32	8.55	22.51	14.41	10.01
Norway spruce	11.32	7.25	5.03	18.95	12.12	8.42	22.21	14.21	9.87
Red spruce	11.79	7.54	5.24	19.41	12.42	8.63	22.67	14.51	10.08
White spruce	11.81	7.56	5.25	19.43	12.44	8.64	22.70	14.53	10.09
European larch	11.60	7.42	5.16	19.22	12.30	8.54	22.48	14.39	9.99
Arborvitæ	11.46	7.33	5.09	19.08	12.21	8.48	22.35	14.30	9.93
Balsam	11.57	7.40	5.14	19.20	12.28	8.53	22.46	14.37	9.98

[a] No allowance is made for the cost of transportation of trees from nursery to planting site, because this is too variable a charge to figure.

O