NOTES ON THE RAISING OF FOREST TREES IN THE NURSERY

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Why a Nursery ?

In countries with large areas of established forest the replacement of felled, blown or dead trees is, in most cases, done by nature. In such countries artificial regeneration is employed only in patches where, for some reason, natural reproduction fails or in cases where, for financial, silvicultural or other reasons, the introduction of one or more new species or a different strain of the existing species is considered desirable.

Except for a few isolated examples of the application of such a system in this country the task confronting our foresters at the moment is the stocking of areas which do not carry even the remnants of a tree crop. The soil, vegetation and climatic conditions obtaining on these planting sites are very seldom suitable for the direct sowing of seed of the commercially valuable species, hence the necessity for the forest tree nursery where plants of suitable species, size and vigour are produced.

Nursery Site

The selecting of ground for a large permanent nursery is a highly important task and needs careful consideration. An unsuitable site may have disastrous results owing to the production of substandard stock and high operational costs. Expenditure on nursery work must be charged to the plantations from the start at compound interest so it is important to keep it as low as possible consistent with the production of high quality stock. More serious still is the question of the plantation which, owing to the use of low-grade plants in its formation, struggles on through a full rotation, producing a poor annual yield, ravaged by insects and fungi, and serving as a breeding ground for these pests which then attack nearby plantations.

In selecting a nursery site the following main points should be given careful consideration.

Soil. Broadly speaking, the soil demands of forest trees are similar to those of farm crops. Most conifers, however, prefer an acid medium (between pH5 and 6) and have a distinct dislike for limestone soils. These latter should be avoided for raising conifers

but they are quite suitable for the growing of most hard woods. Clayey soils are difficult to work, are generally very weedy, and seedlings on them nearly always suffer severely from frost lift. They are inclined to cake and crack in dry weather and young trees, on being lifted from them, suffer considerable loss of their fibrous roots. The nurseryman would be well advised to avoid such soils.

Fertile sandy loams are the best for general nursery purposes. Excess of stones in the upper twelve-inch layer is a disadvantage as such material makes cultivation difficult with a consequent increase in production costs.

The soil depth necessary for raising tree plants need not be great; the average depth of root penetration is about eight inches. Good drainage is an important factor. This is influenced by the depth of soil and the amount of organic matter present in it, the nature of the subsoil and the slope of the ground. A study of the drainage is desirable in winter and in summer as areas seen in the summer only may sometimes be misleading in this respect.

Old forest land is often suitable but the cost of clearing the ground may be a deterrent.

Topography and Aspect. Narrow valley bottoms are undesirable sites owing to danger from frost and excess moisture. Steep slopes are difficult to work and with constant cultivation suffer considerable downhill movement of the soil resulting in an exposed subsoil on the higher reaches. Gently sloping areas have the advantage of good surface drainage and are the most suitable. Generally speaking, the most suitable aspects in this country are northern and eastern. In hilly country many southern and south-western slopes tend to stimulate early growth and are dangerous owing to liability to possible damage from late spring frosts. They may also suffer from drought. Areas liable to floods should, of course, be avoided. A certain amount of shelter from harsh drying winds by belts and clumps of trees is often beneficial, but it is not desirable to have the ground so completely enclosed as to produce a near-green-house atmosphere—healthy, hardy plants is the aim. If the area is very exposed, however, hedges of a species such as Lawson's Cypress can be planted along the windward boundary and through the site at right-angles to the prevailing wind.

Shape and Size. As a fair degree of accuracy in the measurement of ground is necessary in most nursery operations and as short ground and lines of varying length are a nuisance from the working point of view, it is desirable that the nursery be approximately rectangular in shape. The question of shape, however, should not be brought to bear too heavily if the ground is suitable in other respects.

In determining the area required consideration must be given to the ground necessary to produce the number of fit transplants required each year for first planting and for replacing failures, the ground that must be devoted to seed-beds and manure crops, the

ground to be given over to paths and roads and the ground that, for some reason, may have to lie fallow. Experience has shown that, having regard to these points, the area of the nursery should be approximately 3 % of the annual planting acreage.

General. The best time to take over an area is immediately following an oat crop or a root crop such as turnips. Where the area is under grass and is urgently needed for nursery purposes a deep (nine inches) ploughing in October followed by cultivation with disc harrow and/or rotovator in spring will produce a tilth suitable for the lining out of seedlings.

Seed Supply. Seeds of most species can be bought from seed merchants or, in many cases, particularly hard woods, can be collected by the nurseryman himself. This collection by the grower is a commendable practice as the resulting stocks will be better suited to prevailing local conditions. It is very important, though, that the parent trees be really fine examples of their species. Heredity operates in trees as in other living things and consideration should be given to such factors as straightness of trunk, lightness of branches and rapidity of growth in the parents. Most of the common tree species ripen their seeds in October. Exceptions are Aspen, which comes early in May, Elm early in June, and Birch early in September. Seeds of broad-leaved species such as Oak, Beech, Chestnuts and Sycamore fall to the ground when ripe and can be picked or swept up. It may be necessary to pick seed of Ash from the tree as they are inclined to hang on, sometimes into the following spring.

Trees of *Cupressus macrocarpa*, Lawson's Cypress, and *Thuya plicata* growing on the margins of belts or as isolated specimens produce seed in abundance and at a height which makes collection possible without climbing. Gathering of conelets of the two last-mentioned species should not be delayed beyond ripening in October as they shed their seeds freely. The same applies to Silver Fir cones which, on ripening, disintegrate on the tree-top. Japanese Larch and Sitka Spruce, during bursts of hot sun, may also shed their seeds in October and therefore collection should not be delayed.

More difficult problems are presented by many species of Pines, common Spruce, Douglas Fir and European Larch. The cones of these, which may be gathered any time from October to March, are generally borne on the topmost branches and in the case of pines and larches may persist on the trees for several years. Collection from standing trees is expensive, as climbing is necessary but if fellings of these species are contemplated it may be possible to arrange that the work be carried out within the period suitable for collection.

Before any collection is made it is wise to ascertain whether the seed in the cones is sound by splitting a few with a sharp knife.

Drying of the cones by artificial heat in order to open them is necessary; the temperature in such operations should not exceed 130° F. Rather elaborate cone-drying kilns and other equipment are necessary for the extraction of seeds on a commercial scale but the

amateur or enthusiast should be quite successful with a simple home-made kiln and drum of fine mesh netting wire.

Aspen and Elm seeds should be sown immediately they are collected. Seeds of other broad-leaved species may be sown when collected or stored until spring. Conifer seeds should be stored in a dry cool place (optimum temperature is 32°-34° F.) perferably in air-tight containers; a petrol tin with an efficient screwcap is suitable.

It should not be forgotten that seeds of most tree species are very attractive to rats and mice.

Pre-sowing Treatment of Seeds

Seeds of Ash, Lime, Hornbeam, Rowan, Whitebeam, Holly and Hawthorn seldom germinate until the second year after ripening. During this period of dormancy it is the practice to store them mixed with equal parts of sand in a two-foot deep pit on a well-drained site. It is advisable to have a layer of stones or gravel at the bottom of the pit and to line and cover it with fine mesh wire netting against rats and mice. In March of the second year the seed and sand are sown together. Sowing rates in Table 1, however, are for clean seeds.

Conifer seeds may germinate more rapidly if soaked in water for certain periods. The usual soaking periods are five days for Sitka Spruce and one day for all the others. Attacks by mice and birds have to be guarded against and to this end the seed is dressed with red lead. This dressing has no adverse effects on germination. One pound of red lead should be sufficient for seven to eight pounds of seed.

The ground selected for seed beds should be fertile, friable and as clean as possible. In bringing the soil to a suitable tilth size of seed is the guiding factor. In the case of Oak and Chestnuts a tilth suitable for most farm crops is sufficient but it will have to be made increasingly fine as the size of the seed to be sown decreases until, in the case of small seeds such as those of Alder, Birch, Sitka Spruce, *Pinus contorta* and *Tsuga*, a top layer of at least two inches of soil as fine as meal is required. The achievement of this is a slow and laborious process if done by hand and entails considerable working of the soil. This has been the method employed for centuries but in recent times the rototiller and rotovator have considerably lightened the task.

In considering seed-sowing one may choose from three well-known methods, viz., (1) Broadcast in beds; (2) Band sowing; (3) Drill sowing.

1. The width of the bed may be three feet six inches to four feet but the 4 ft. bed is now generally accepted as standard.

Between each bed and the next is a path or alley usually fifteen inches wide to enable the worker to move freely in carrying out the necessary seed-bed operations. Beds may be used for all species and broadcast sowing in beds is the system most generally used in this country.

2. Bands are shallow trenches about seven inches wide separated by alleys of the same width but having a fifteen-inch alley at intervals of every four bands. They are used mostly for hard woods and are especially suited for Oak where it is the practice to undercut and wrench the roots in September with a view to producing a better rooted seedling.

3. Shallow drills may be drawn on seed beds by various methods but usually are made by pressing two-inch wide laths on the prepared seed bed. The depressions, in which the seeds are sown, are usually four to six inches apart and may run transversely or longitudinally on the bed. This method is used mainly for conifers and certain advantages are claimed for it, particularly in weedy nurseries where, by its use, weed growth may be more cheaply controlled.

Weed Control

Conifer Seed Beds. Normally many weeds appear before the conifer seeds germinate. These may be dealt with by spraying with vaporizing oil. Except where weeds have reached a height of 1½ to 2 inches it is as well to delay spraying until there are signs of germination of the tree seeds and then all the weeds that have come through can be killed in one spraying. After the seedlings appear weeding of seed beds has to be done by hand and by hoe.

Lining Out

The principal points to be watched in lining out in the nursery are:

(*a*) That the trench opened to receive the young trees should have a firm perpendicular back against which the trees are set, and be deep enough to allow of the roots being extended vertically downwards to their full length.

(*b*) That the young trees should be set at the same depth in the soil as they were in their previous situation, the soil mark on the stem being used as a guide.

(*c*) That fine soil should be placed against the roots and the trees well firmed by packing the soil with the foot.

(*d*) That the roots should not be allowed to dry out during the operation.

The spacings for the various species in the transplant lines shown on Table 2 have been found to be satisfactory. Wider spacings do not conduce to the production of any better plants and by adopting the spacings given the area to be weeded is kept at a minimum.

Season for Lining Out. Larch should be lined out not later than the end of February and it has been found that the best time for lining out Beech is October, and for Corsican Pine and *Pinus radiata*, February. Most species are generally too advanced in growth for handling after the end of April and all lining out should be completed by then.

Weeding Lines. Hoeing should be carried out as necessary during spells of dry weather. The " Planet Junior " wheel hoe has been found a most useful implement in this work. In addition to hoeing a few hand weedings between the plants in the lines is generally necessary during the growing season. Weeds should be killed when small as if allowed to grow they rob the trees of much moisture and nutrients as well as being more costly to control.

Soil Fertility

Owing to the intensive stocking of nursery ground and the fact that evergreen conifers return nothing to the soil in the way of leaf fall, the drain on fertility is severe.

Most agricultural soils, when first broken in, are capable of growing young trees for two or three years without the addition of manures. A close watch should be kept, however, for signs of decreasing fertility such as poor growth and discolouration of the foliage. If the fertility is allowed to run too low the cost of restoring it may be disproportionately high.

The application of artificial manures direct to young trees often has harmful and sometimes apparently negative results; their use in that manner therefore is not recommended. Other means of manuring are the growing of crops such as potatoes or turnips manured with farmyard manure, the application of compost or broad-leaved conifer leaf-mould and the use of green manuring. The last-mentioned is the most widely practised as the other materials are seldom available in the quantities required.

Artificial manuring may be used in green cropping and a normal dressing per acre would be:

4 cwt. Superphosphate	35 %
2 cwt. Muriate of Potash	50 %
1 cwt. Sulphate of Ammonia	20 %

A good supply of humus in nursery soils is very necessary and even regular green manuring is not always capable of maintaining the supply at a suitable level. If signs of lack of humus such as caking of the soil or the appearance of grasses in abnormal quantities are noticeable a dressing of farmyard manure at the rate of fifteen to twenty tons to the acre is desirable, applied, of course, to a green crop, not direct to the young trees.

Fungal Diseases

Damping Off. On heavy soils containing excess moisture or in densely-stocked seed beds conifer seedlings under one year old are sometimes attacked by " damping off " fungi. These fungi can be controlled by:

(1) Burning the infected seedlings and opening shallow isolation trenches around the infected patches.

(2) Treating with fungicides such as (*a*) Cheshunt compound at a strength of one ounce to two gallons of water applied with a water-

ing can at the rate of one gallon per square yard, or (*b*) *potassium permanganate* at a strength of one ounce to one gallon of water, also applied at the rate of one gallon per square yard at ten-day intervals. These measures need not be adopted unless " damping off " appears but prompt action is necessary immediately it is noticed.

Leaf Cast in Larch. This is a widespread and serious disease of European Larch from which, however, Japanese Larch is normally immune. It can first be detected by the appearance of brown patches on the leaves of the lower part of the plant. In due course the affected leaves become completely brown and fall. It differs from frost damage, with which it may be confused, in that the browning of the leaves is gradual and that the tips of the shoots are seldom affected. Larch on ground of low fertility suffers much more than that on good ground. Sulphur sprays are used to prevent and control the disease, winter and summer strengths of these sprays being used. The most suitable sprays are of Lime Sulphur and Liver of Sulphur. The winter strength spray is applied once in January or February before the buds burst. Lining out of the young trees is usually done at this time and instead of spraying the shoots can be dipped in the liquid. Summer sprays are applied at fortnightly intervals from early April to the end of September. Spraying should not be carried out in strong sunshine, dull calm weather being the most suitable.

The following are the sprays:

Lime Sulphur : Winter Strength: 1 part in 30 parts water.
Summer Strength: 1 part in 40 parts water.
50 gallons of spray to 1,000 square yards.

Liver of Sulphur : Winter Strength: 14 lbs. to 100 gallons water
Summer Strength: 7 lbs. to 100 gallons water.
50 gallons of spray to 1,000 square yards.

Leaf Shedding Diseases in Pines. If disease appears spraying with a 1 % Bordeaux mixture should be carried out in the month of April. The mixture is as follows:

4 lbs. Copper Sulphate.
4 lbs. Lime.
40 gallons Water.

Oak Mildew. This is caused by the fungus *Microsphaera quercina* which can be controlled by spraying with a solution of 2 lbs. of Flowers of Sulphur to 50 gallons of water, giving special attention to the undersides of the leaves.

INSECT PESTS

Cockchafer Larvae. These are whitish grubs with brown heads and three pairs of legs. They cause considerable damage in the nursery by eating the fine roots of young trees and girdling the stronger roots. The most widely applied control measure consists of the fallowing of the affected ground and the hand-picking of the grubs, combined with cultivation during the month of July.

Green Spruce Aphis. These may be controlled by spraying with either nicotine or paraffin emulsions. The latter is the more widely used and the ingredients and methods of preparation are as follows:

Paraffin, 2 pints.
Soft Soap, 1 lb.
Water, 10 gallons.

The soft soap is dissolved in one gallon of boiling water and while the solution is still hot the paraffin is added. The mixture is churned well and nine gallons of cold soft water are then added. After being thoroughly mixed the emulsion is ready for use. In spraying special attention should be given the undersides of the leaves.

Frost Damage

Two common types of frost damage are recognized. They are (1) Damage to the leaves and shoots, and (2) Frost lift.

Damage to Leaves and Shoots. This type of damage usually takes place in May and early June when newly-flushed growth may be killed resulting in crooked plants, double leaders and otherwise undesirable shoots.

Protective Measures. Protection of transplants in lines is seldom economical owing to thin stocking of the ground and protective measures are usually confined to seedlings in beds. Screens made from laths 4 ft. x $2\frac{1}{2}$ inches x $\frac{1}{4}$ inch, which are nailed $\frac{3}{4}$ inch apart to " runners " 6 to 9 ft. in length are standard for seed bed protection. These screens are supported on wires which run one foot above the ground on each side of the bed.

Branches of Laurel, Broom, Birch, etc., stuck in the ground so as to form a canopy may be used instead of laths.

Generally there is little danger after the end of May or first week of June and the protection might then be removed.

Frost Lift. Losses from frost lift, which is a mechanical damage, are generally confined to one-year conifer seedlings; hard woods are usually sufficiently deeply rooted not to be seriously affected. Sitka Spruce is the most susceptible but small one-year seedlings of other conifers such as *Tsuga*, *Thuja* and Lawson's Cypress may also suffer.

Protective measures: As the amount of water in the soil is one of the most important factors relative to frost lift, efficient drainage in the beds is important. This may be facilitated by deepening of alleys and by leaving the soil in the alleys loose just before winter sets in.

One-year seed beds of susceptible species should be protected from October onwards in the same manner as described for protection against frost damage to leaves and shoots.

TABLE I

SEED SOWING

Species	*Yds. of 4′ bed to 1 lb.*	*Sq. yds. to 1 lb. (incl. alleys)*	*Yds. run of band to 1 lb.*	*Depth of cover (inches)*	*Season to sow*
(1)	(2)	(3)	(4)	(5)	(6)
Scots Pine	45	80	—	¼	April, May
Corsican Pine	17	30	—	⅜	do.
Pinus Contorta	45	80	—	⅛	do.
Mountain Pine	40	70	—	¼	do.
Pinus insignis	12	21	—	⅜	do.
European Larch	20	35	—	⅛	do.
Japanese Larch	25	44	—	⅛	do.
Douglas Fir	16	28	—	¼	do.
Sitka Spruce	45	80	—	⅛	do.
Norway Spruce	24	42	—	¼	do.
Abies Pectinata	8	14	—	⅜	do.
Abies Nobilis	8	14	—	⅜	do.
Abies grandis	8	14	—	⅜	do.
Cup. macrocarpa	16	28	—	¼	do.
Tsuga het.	45	80	—	⅛	do.
Cup Lawsoniana	16	28	—	⅛	do.
Thuya plicata	16	28	—	⅛	do.
Oak	½	¾	4	2	Nov. or Mar.
Beech	2¼	4	18	½	April
Sycamore	9	16	72	½	Feb. or Mar.
Ash	9	16	72	½	Aug. or Apr.
Spanish Chestnut	½	¾	4	2	Nov. or Mar.
Horse Chestnut	⅓	½	2½	2	do.
Alder	19	33¼	—	lightest possible	April
Birch	19	33¼	—	do.	April, May
Elm	11¼	20	90	do.	May, June
Pine	1½	2⅔	12	½	April
Hornbeam	5¼	9	42	½	do.
Whitebeam	3¼	1¼	6	½	do.

TABLE II

LINING OUT

Species	*Age*	*Spacing*	*No. per sq. yard*
Scots Pine	1 year	8″ x 1″	220
Scots Pine	2 year	9″ x 1½″	96
Corsican Pine	1 year	6″ x 1″	220
Corsican Pine	2 year	9″ x 1½″	96
Pinus contorta	1 year	6″ x 1″	220
Pinus contorta	2 year	9″ x 1½″	96
Mountain Pine	1 year	6″ x 1″	220
Mountain Pine	2 year	9″ x 1½″	96
European Larch	1 year	6″ x 1″	220
European Larch	2 year	9″ x 1½″	96
Japanese Larch	1 year	do.	96
Japanese Larch	2 year	9″ x 2″	72
Sitka Spruce	2 year	10″ x 3″	43
Norway Spruce	2 year	10″ x 2″	65
Abies pectinata	2 year	do.	65
Abies grandis	2 year	do.	65
Abies nobilis	2 year	do.	65
Cupressus macrocarpa	1 year	9″ x 1½″	96
Cupressus Lawsoniana	2 year	10″ x 2″	65
Tsuga heterophylla	2 year	do.	65
Thuya plicata	1 year	do.	65
Douglas Fir	2 year	do.	65
Pinus insignis	1 year	9″ x 2″	72
Oak	1 year	do.	72
Beech	1 year	do.	72
Sycamore	1 year	do.	72
Ash	1 year	do.	72
Spanish Chestnut	1 year	do.	72
Horse Chestnut	1 year	do.	72
Alder	1 year	do.	72
Birch	2 year	do.	72
Elm	2 year	do.	72
Lime	2 year	do.	72
Hornbeam	2 year	do.	72
Whitebeam	2 year	do.	72
Rowan	2 year	do.	72
Holly	2 year	9″ x 3″	48
Hawthorn	2 year	do.	48
Aspen	1 year	12″ x 4″	27
Poplar	cuttings	12″ x 6″	18