Cosens, Gordon G.
The cultivation of nursery
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THE CULTIVATION OF NURSERY STOCK

FOR

PULPWOOD PLANTING

Gordon G. Cosens, Forester.

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UNIVERSITY OF TORONTO

(Circa: late 1920's)

The Cultivation of Nursery Stock
for Pulpwood Planting

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The continuously increasing cost of suitable pulpwood cordage at the point of manufacture has given rise to considerable discussion as to the advisability of reforesting with suitable species devastated areas in close proximity to the mills. Such planting would not be an effort to relieve the dependence of the manufacturers on the future yield of cut-over lands, but would assure a basic material of sufficiently high grade to allow of adulteration by the addition of what are as yet considered inferior species.

The investment involved in such a forestry practice would not deduct from the amount that should be re-invested in the limits in scientific management, but would serve to assure the future and the continuity of "Canada's largest single industry". Take for example an imaginary paper concern with a total wood consumption of seventy-five thousand cords each year. Allowing the mill sufficient land for a continuous cropping on a sustained yield basis, if the executives were determined on a planting programme of five hundred acres annually devoted to the pro-

 

duction of spruce, either pure or in a suitable mixture, the yield at the end of fifty years would be in excess of twenty thousand cords exclusive of thinnings. This investment would serve as timber insurance against accidents such as fire, insect depredation, and other destructive agents, in fact as a safe guard for the economic future of the company. If the lands devoted to natural regeneration maintained their yield, which of course is highly probable, any surplus cordage would be readily disposed of at that time. To facilitate administration and management, concentration of forest growth is only a question of time, if the histories of European countries is to be taken as exemplary.

Even when regeneration is natural, nursery stock used to fill in the blanks in the reproduction would shorten the rotation, and increase the yield by making all the forest property productive. That is, whether the young plants are being grown to establish artificial stands or simply to fill in fall places in the natural reproduction is immaterial; the greatest single factor in the success or failure of a plantation is the production of the most suitable plant possible for the purpose.

The choice of species is restricted to some tree of general adaptability to planting sites, and at the same time yielding a product of the highest order. Thus, in

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the East, the selection would seem to fall on White Spruce, *Picea canadensis*. The wood is considered very highly by the manufacturers; while due to its extreme tolerance, planting under hardwoods coppice such as will be encountered in practically any reforestation project is possible. It has, however, the weakness common to the three native spruces of being rather difficult to cultivate artificially. Only with considerable care and judgment can it be grown to furnish stock suitable for planting at a reasonable cost per thousand. In plantations established practice requires a mixed stand as a protective measure against inroads from biological causes, and also the largest yields are from mixtures. Such other species as are considered suitable may be selected to form the minority in the spruce mixture, but in this particular treatise consideration will be given mainly to the nursery cultivation of White Spruce.

Seed Collection and Care.

To what extent eccentricities in the character of individual forest trees are inherited or acquired has not so far been determined satisfactorily, although certain research along these lines has been carried on in Europe. So at this period of insufficient scientific knowledge, it seems

[illegible]

1. The first of these is the fact that the Commission has not yet received any information from the Government of the United States regarding the activities of the Committee for the Liberation of the People of the East (CLPE) in the United States.

better to err on the side of the assumption that most dominating characteristics of the parent tree are passed along, than to come to grief by assuming it to be a fact that certain eccentricities of growth and form are acquired. Resultantly, the seed collected must be restricted to trees of development approaching an ideal - a tree of rapid growth rate, healthy aspect, and good form. Maximum differences of site are highly undesirable. The restriction of cone areas to those in close proximity to the planting grounds eliminates dangerous differences in site factors. Such a restriction is purely relative, and to be determined by a personal estimate of conditions.

Cone years commonly occur every other year as half or third crops, with "full" or abnormal seasons at from four to six year intervals. In a period of normal fruiting, a tree growing in the open of over forty feet in height and a proper crown development will yield upwards of two bushels of closed cones.

While the seed yield from a standard amount of cones fluctuates with the seasons, due to insect attacks such as *Dioryctria reniculella*, and to the prevalence of aborted kernels resultant from early frosts, incomplete fertilization and other factors, a bushel of cones will extract slightly better than a pound of cleaned seed. Due to the uncertainty of seed years, it is well to carry at least three years' supply

of seed well stored, to be used in case of a contingency arising. This supply, of course, would be continually utilised and renewed, thus never permitting seed to accumulate for more than three seasons as it depreciates rapidly. For an annual output of one million four-year-old transplants, a collection of ninety to a hundred bushels of cones will provide sufficient seed for one year's sowing under normal conditions.

On approaching maturity, rapid changes take place in the cones. The seeds ripen from a creamy-white soft mass into a grain with a pure white oily albumen and a dark-coloured, hardish, crisp testa in a period under two weeks; and at the same time the cone changes from a light green to a yellowish brown. The opening of the cones is practically co-incident with the change in colour. Therefore the period of collection is very restricted, unless retarded by damp cloudy weather. As the larger seeds and those of greatest fertility are on the central scales of the cones, and consequently are first lost when the scales open, it is well to commence collection while the seed is still slightly undermature.

To all practical purposes, the ideal for cone collection is a young tree, under fifty years of age, and branched almost to the ground. Such are found scattered or clumped throughout the St. Lawrence flood plain as volunteer

growth, on pasture lands, along fences, and frequently in the farmers' coniferous wood reserves. The cones are hand-picked, and if careful supervision is maintained the work is readily adaptable to "jobbing", at a set price per standard measure. The practice of branching with an axe is very destructive, as it takes upwards of seven years for a tree to recover sufficiently to warrant picking again. In contract collecting, care must be taken to forbid the practice of following loggers. Cones are often picked from trees cut in the summer for pulpwood purposes. Such cones are frequently very much under-mature, but have an appearance almost identical with that of mature cones, except that on close examination the seed will be found to be of a light brown, while the grain is shrivelled or completely hollow.

Considerable discussion has arisen as to the age or as to a more definite determination of the tree height at which cones may be collected without a serious falling-off in the germination percentage. Experiments carried on have proved conclusively that any tree of vigorous growth, and free from mechanical injury, may be picked when there are sufficient cones to warrant the labour. Thus a tree bearing cones which is

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over twenty feet in height can be picked without danger of the seed being seriously aborted or below the standard in any respect. In fact, the reverse is often true, the cones are larger and the seed heavier and healthier than that collected from a more mature tree.

Unopened, freshly-gathered spruce cones have a high moisture content, and heat readily if stored either loose or in bags in quantity. As the seed-coat has not yet attained its final imperviousness, and consequently is very susceptible if subjected to a warm humid condition, such as is caused by heating, a preliminary drying is imperative immediately following collection. The cones are spread uniformly, not in excess of two inches in depth, and are constantly turned over.

Curing may be carried on in almost any covered building, but it is greatly facilitated if the structure selected is such that a free circulation of air may be maintained throughout. The cones are laid out on racks or long stretches set horizontally in tiers, each layer being superimposed almost a foot above the lower one with alleys left between the tiers to permit of ready access. In case of unfavourable weather, the sides or doors may be closed down and the humidity regulated by ventilation.

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Cones can be opened by employing any one of several methods, as for example:

- (a). By sunlight - the cones being spread out on ground cloths.
- (b). In drying shed- using no artificial heat, but depending entirely on air circulation and frost.
- (c). Preliminary curing and later a short period of moderately high temperature.

In Eastern Canada fall sunshine, accompanied by showers and high winds, as it frequently is, does not open cones sufficiently, and thus deducts seriously from the quantity and probably the quality of the seed yield. Gusty weather carries the lightly-weighted winged seed out of the cone and off the drying area. When exposed to free air circulation and winter temperature, the objection is similar. The forces brought into play are not sufficiently severe to diverge the scales adequately, with the result that much seed is retained in the cones. If the cones are subjected to a constant temperature of 40°C for eight hours in the tumbling barrels, after a preliminary drying period of upwards of three weeks, the seed extraction is complete, and vitality is not imperilled.

The drums are enclosed in a chamber, the heating of which is regulated by a controlled influx of hot air, and a series of small ventilators, usually along the ceiling, insuring a constant draft. Columnar structures posed

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horizontally, of a diameter approximating three feet, and meshed with one-quarter-inch wire, form the drums. These are arranged in rows, and turn on an axis, the end of which protrudes from out the kiln, and some method of rotation, either by hand or by power is installed. The number of drums depends on the seed requirements, each having a capacity of from three to six bushels, governed by the weight of the cones. These are introduced by openings either in the face or side of the machine, and are emptied by lifting the same covers, the discarded cones being discharged down the seed-hopper. Seed is more readily damaged by high temperature if the air is humid, therefore it is essential to maintain a complete air circulation. During the drying period, the drums are rotated every hour, thus tumbling the seed as soon as it is released, and insuring uniform heating. Too-frequent turnings increase the foreign debris in the seed by grating the cone scales.

Undoubtedly thoroughly cleaned seed retains its germination power better than does untreated seed, but for ordinary general purposes it is questionable if the expense is justifiable once a definite ratio has been established to make allowance for foreign matter in apportioning the quantities for seeding. The wings are removed by sprinkling and rapid drying, or by passing the seed in a fine wire cylinder, the inner surface of which is rubbed by rotating brushes.

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Damping the seed, later followed by a brief period over the inlet pipe of the extraction chamber, shrinks the wings. The separation is much more thorough than by the former method, which breaks loose the wing, leaving the lower portion of the base still firmly cohering to the seed. After the wings are loosened, the seed is passed through a modified fanning-mill. A conveyor carries the material forward, dropping it before a rapidly rotating fan. In this manner, the heaviest particles - the seeds - are deposited near the fan while the lighter portions are carried into more remote chambers. As the fertility of seed varies directly with the weight, that of greatest germination power is in the first pocket with practically no debris. The foreign matter increases, and the proportional amount of seed decreases, as does also the germination percentage, in each succeeding pocket. The first pouch will test over seventy-five percent in a thirty-day laboratory proof.

Cleaned or uncleaned seed is stored after a similar manner, in hermetically sealed containers, - a capacity of forty pounds making a good unit. These are stored in some location of uniform temperature approximating 4°C. The seed must be absolutely dry when sealed, and a certain air space should be left in the can to permit of such respiration as may be carried on through the epidermis.

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1. The first step is to identify the problem. This involves understanding the situation and the goals that need to be achieved. It is important to gather all relevant information and to consider the perspectives of all stakeholders involved.

The Nursery Location and Site.

The selection of a nursery site is a factor requiring some exercise of judgment, as the initial investment in construction is final, and mistakes are expensive to rectify. On these grounds, the many varied influences must be carefully balanced, in order that the final location may be favourable.

The requirements for a spruce nursery may well be divided under two main headings - direct agents of site, and other requirements with only an indirect bearing. The enumeration of the site qualities of direct importance is as follows:

I. The nursery area must be sufficiently large to grow the amount of stock required with adequate allowance for resting areas, and thought must be given to future policy if an increased production is anticipated.

II. The land must be as nearly level as possible, with a decided slope down which drainage may be directed to carry off flood water from heavy rain storms and snow.

III. As growth in the nursery due to lack of any ground cover is always in advance of field and bush conditions, marked southern and eastern slopes are to be avoided. After the ground is thoroughly thawed in the field, considerable

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time must elapse in order that planting may be carried on before growth starts in the nursery. Therefore, a northern slope sufficient to retard growth slightly is a desirable feature in a location. Frosty or low lands are dangerous, as winter heaving and early and late frosts are two evils that are prevalent in our climate.

IV. A soil of a loamy nature fine enough to retain moisture and yet not be wind-carried is necessary. Clayey soils are difficult to work, cold, and excessively heavy. The post-glacial marine deposits along the St. Lawrence and other lake and river valleys are especially suited to nursery requirements.

V. A dependable water supply nearby to furnish a natural reservoir is required. As water must be delivered throughout the nursery with tap pressure, the tank is placed on a natural or artificial eminence of at least forty feet in height.

VI. If the nursery is not partially sheltered in periods of drought, the mortality is seriously increased by wind. In the spring, especially in the newly-transplanted trees and in the seed-beds, this is dangerous, as the young growth is very tender. If natural wind-breaks are not available, artificial shelters of rapidly-growing

18. The first of these is the fact that the majority of the population of the United States is now living in urban areas. This is a result of the process of urbanization, which has been going on since the beginning of the 20th century. The second factor is the fact that the majority of the population of the United States is now living in the South and West. This is a result of the process of migration, which has been going on since the beginning of the 20th century. The third factor is the fact that the majority of the population of the United States is now living in the South and West. This is a result of the process of migration, which has been going on since the beginning of the 20th century.

7. *Aspergillus* will grow only in
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growth of *Aspergillus* in media of natural
composition is dependent on the presence of
certain factors in the media.

species should be planted at once. Protection by ridges decreases the wind damage, but frequently increases frosting by creating a low pocket.

VII. The relative location of planting areas to the nursery is important as latitude or altitude differences incline to accentuate the lateness of the commencement of the growing season in the bush.

Indirect factors are essentially problems of labour and transportation. An abundance of labour is required for about five months, with a slack period for the remainder of the year. Bush labour is the most satisfactory, taking all factors into account, as in the spring and summer men and boys are available at reasonable rates.

The hauling cost of organic fertilizer is a large item, as this necessarily, with few possible exceptions, comes by rail and the distance of the nursery from the point of discharge increases very materially an item that is already too high. Trees may or may not be shipped; nevertheless, other commodities are continually arriving and leaving, so that an ideal situation is one where a siding actually enters the nursery or is very close.

Nursery Compartmenting.

The subdivision of the nursery into compartments is dependent on the class of plant grown. White Spruce

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adapts itself best under average conditions to a "two and two" rotation, (two years in seed-beds and two years in nursery lines). However, such an age classification need not necessarily be adhered to, as either two-year-old seedlings, three-year-old seedlings, or "two and one" stock may be planted with varying success.

The two-year-old seedling is satisfactory under limited conditions. It is cheap and easy to plant, but is practically restricted for successful use to cleared cultivated land. Three-year-old seedlings may be planted, but with indifferent success due to a surprising lack of root development. The "two and one"-year-old tree is frequently planted, but as the difference in cost between it and a "two and two" is small, there seems little justification for its use. Thus in general for planting purposes the two ages only are at all suited, - that is, the two-year-old seedling and the "two and two" transplant. The latter is suited to practically all planting conditions. Its root system is ideal and the tree itself is large enough to withstand reasonable competition from hardwoods.

On these grounds, the nursery is subdivided largely into transplant areas. The first acreage, however, for

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selection is the seed-bed compartments. Such land must be a fine rich sandy loam exceedingly well sheltered either by natural or artificial wind-breaks. The water supply should be placed with reference to the seed-beds in such a manner that a maximum pressure may be obtained at all times. The best soil and situation should then be laid out as a permanent bed area.

The compartments will rotate naturally around three sub-divisions, - one-year-old seedlings, two-year-old seedlings and resting, - the basis being that an acre in beds will grow between four and five million seedlings, broadcast-sown. As seedlings are delicate and very sensitive to early and late frosts, and to heaving from excessive soil moisture freezing, the area must be high and well-drained even at the expense of additional exposure which can be rectified artificially by planting. If a uniform slope is obtained by grading to permit the rapid departure of flood water, although care must be taken not to surface underlying coarse or inferior textured soil, the value of the site is greatly enhanced. It is immaterial if the seed-bed areas should be slightly remote from the transplant grounds, as transportation costs of seedlings are almost negligible.

Transplant areas, like seed-bed sections, return to resting for a year after being cropped. Therefore,

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1. The first step is to identify the problem or question that needs to be answered. This involves understanding the context and the specific requirements of the task.

the total acreage must be three times the requirements for one year, or, including road allowance, eighteen acres per million trees delivered to the plantations.

Grading of transplant beds is a matter that varies under different climatic and miniature topographic conditions. If the region is northerly and subjected to heavy snowfall with a rapid run-off, or liable to violent summer storms, a uniform slope in the lines prevents excessive washing and allows a freer escape of water. In the spring as the snow is leaving, the upper two or three inches of soil form a paste which freezes again with disastrous results, as the tree roots are still firmly imbedded in the lower frozen layers. Grading, then, is a decided preventative of this, as surplus water escapes much more rapidly. If the surface irregularities are levelled, it accelerates the speed of transplanting, and later saves in the cultivation costs.

An area of three acres or about half a million trees makes a good compartment unit. A main road should either bisect or bound the area on one side, while at right angles a generous path aids in the removal of herbaceous accumulations and increases the accessibility.

These compartments may or may not be separated by wind-breaks as the situation demands. A panoramic view of the nursery should give an impression of a large

squared chequer-board, with the buildings centrally located. Each block is more or less definitely defined by the tree-breaks at right angles to the prevailing winds.

Fertilizers and Soiling Crop.

The preliminary preparation or inter-crop resting season of seed-beds and nursery lines is similar. If possible, the land should be broken in July two years before, harrowed, and sown to a soiling crop or left fallow. Early the following spring, a uniform coating of well-rotted manure, between twelve and fifteen tons to the acre, is ploughed under. However, if the land is new or rich, this amount must be reduced accordingly. For seed-bed areas it is absolutely necessary that the fertilizer be well-rotted, as otherwise the weed crop is very difficult to eradicate. The quantity should be greater than in the case of transplant compartments, but not exceeding twenty tons.

The selection of a soiling crop is largely dependent on local conditions, especially as many of the Leguminosae are easily frosted. Any plant used must be heavily foliated to choke out weeds, and to produce an abundance of organic matter when turned under in the early fall. If the grain lies dormant for a year, or ploughing

is not done before its seed matures, volunteer growth will prove troublesome amongst the young trees of the next year. Any of the legumes, rye, or buckwheat, may be used, but due to the rapid growth and heavy foliage of buckwheat when sown about two bushels to the acre after fertilizing, it is probably the most satisfactory, especially if rolled before being ploughed. A deficiency in nitrogen, however, must be supplied through other agents.

Seed Beds and Seedlings.

Seed-beds should run east and west in order that the shadows thrown by the screening progress run equally along the bed without unduly exposing any portion. It is well if the drainage is in the same direction, but this is not, however, an absolute requisite as by the construction of adequate ditches at right angles to the ends of the beds flooding can be prevented.

Beds, broadcast-sown, are usually about four feet in width to allow of weeding; in drill sowing if the interval between the rows is sufficiently large there is no restriction as to size. The length of the beds is immaterial unless special framing is necessary to protect against birds. If the slope direction permits, one hundred feet is a good unit; however, when the beds are at right angles to

the grade this length must of necessity be reduced to permit more perfect drainage.

The beds are abutted against the side of the compartment, and lined in by staking. Paths eighteen inches or two feet in width separate each, the soil removed being thrown on the beds to crest them. This curvature increases the soil evaporation, but decreases the action of other damaging agents such as heaving. If the area is well-ditched and the grade upward of two per cent, in ordinary porous soil, the maximum convexing need not exceed three inches above the path level.

After a thorough raking, the desired contour having been obtained, the soil is packed by rolling with a concaved roller the same width as the bed. When an ordinary garden tool is used, only one half of the bed surface is rolled at a time, thus maintaining the curve. Seeding, which follows, may be either broadcast or drill. In spruce beds, however, due to the delicate nature of the individual seedlings, the loss is likely to be heavy if the seed is drilled; however, in broadcasting the seedlings are mutually supported. Damping-off does not patch as it does in pine, but kills singly or in small clumps; thus it is not necessary to isolate by rows to prevent fungal diseases from spreading. As the lateral development of spruce is much less than that of pine due to the shortness of

the needles, an equally well-developed plant may be produced in a broadcast-sown bed. Labour and material costs are increased due to the additional area required, thus it would seem that unless especially large well-developed seedlings are required, that broadcasting is better suited to ordinary purposes.

Seed is either spring or fall sown. Here again there is a marked preference in our latitudes. Seed sown in October, and given the same treatment, germinates more evenly and earlier than does spring sowing. Also, the seasonal division of his duties aids the forester, who can give the seeding more attention in the fall as the pressure of work is not as great as in May. The early germination lengthens the growing season, and allows the cotyledons to lose their seed caps before the return of the sparrows, finches and other migratory seed-eaters, all sworn enemies of the forest nursery. As the soil is not disturbed, the moisture from snow and early spring rains is retained in the ground much better than in the case of spring sowing, thus decreasing the watering charges.

Before sowing, beds are thoroughly damped with a minimum penetration of five inches. The seed is then hand-broadcasted in the ratio of three-quarters of a pound of cleaned seed to one hundred square feet. Such a

quantity is not inflexible, and should be regulated by the germination power and age of the seed. Sub-surface soil is sifted over the beds in sufficient quantity to conceal the grains completely, and the whole bed re-rolled. In order that an even distribution may be had, it is better to sow in the early morning or the evening, as a slight breeze will roll the seed into the paths to quite an appreciable extent.

Prior to germination, covering may be done with many different materials such as straw, leaves, canvas and others. These all have serious faults, however,- the litter of straw or leaves is inclined to induce various fungal diseases, more especially early spring molds or snow fungi, and later damping-off. Canvas or burlap permits of an extreme surface evaporation, but lifts off clean, and does not mold to any extent. Spagnum moss collected in peat bogs which are found scattered at random has many fine qualities. The moss allows the penetration of surface water, and retains the frost in the spring, thus preventing the too early germination of the seed. Such a covering is to a certain extent sterile if fresh and mulches so that little soil moisture escapes. A continuously uniform coat about an inch thick is covered

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again by the lath screens which protect the beds from being wind-whipped.

If the seed is spring-sown, about eighteen days after seeding the moss should be lifted in spots to observe how germination is progressing. In case of fall sowing, such a scrutinization should take place shortly after growth starts. When the testa splits and the plumule begins to protrude, the lath screens should be erected. This lathing gives half shade, and is constructed after the fashion of the old picket fences, the individual members joined by three wire strands, the interval between units being equal to one lath width. Small rails are set up on pickets bordering the edge of the bed in such a manner that the screens may be rolled out at will. The cover is removed by hand as soon as the seedlings have taken root and begin to raise the moss. Care must be exercised not to leave the covering too long, as the young plants may be broken in its removal, if the seed cap penetrates the moss. After the removal of the germination blanket, the screens should be rolled over the beds at once.

In the early summer, periods of heat are often broken by heavy thunder storms and wind. The dashing of the rain on the beds during the first month after germination exacts a heavy toll among the young seedlings unless they are protected. Heavy canvas rolls

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that run out over the screens and fasten down by wires or some other means break the force of the wind and rain. They may also be used to protect against sun scalding in case of extreme heat.

The watering can be done either by overhead sprinkling or by garden hose. Pipe lines are laid so that the whole area is reached with good pressure as the spray must be very fine, and used only during periods of slight sunshine or at nights. As damping-off and other fungal and bacterial conditions increase rapidly in a warm humid condition, watering should be done only moderately. During light rain, or cloudy weather the screens are better rolled back, exposing the trees.

In the summer the beds are kept moist, the trees being gradually strengthened by rolling the screens back for longer periods each day. About the middle of August, screens are lifted completely, and at the same time the watering is gradually decreased even in time of drought to assure that the trees become hardy, and form buds before the first cold weather.

As a protection against heaving, the trees should be lightly covered with moss. In the spring, the frost is held late and the damage caused by alternate thawing and freezing is diminished appreciably. Serious losses may

10. The Commission has also received information from the Government of the United States of America that the United States has been providing military assistance to the Government of the United States of America.

It is a very good idea to have a copy of this letter in your file. It is a very good idea to have a copy of this letter in your file.

arise from snow fungi, due to the retention of an ice-coating over the beds, causing a chamber to form roofed by the ice and grounded by the seed-bed. Little is known about the classification and control of such fungi, but certainly if the large snow accumulations are broken by shovelling or by sprinkling black soil on the snow surface, the melting is hastened, and the foliage allowed to dry up before any serious damage is accomplished.

During the second summer the care is limited, the beds are watered in time of drought, and kept free of weeds. Lifting the following spring for transplanting is done with a wide-toothed fork, four-pronged. A forkful is seized, split, and the clinging dirt removed by knocking the two handfuls together. The trees are either packed in boxes with damp moss or transported in pails one-quarter full of water to the transplant compartments.

Transplanting and Transplants.

Transplanting increases the crown and root development of the plants. If they were to continue in the seed-beds, even if in rows, the root lengthens extremely with three or four main branches and a very slight growth of rootlets. The crown is more or less spindly, without the marked lateral shoots of the transplant. In lifting seedlings, the roots are broken to some extent, and thus, when transplanted,

develop laterally in the trench with many minor divisions, resulting in a plant which has a much larger and more compact root system.

Long lines are set out running east and west, each plant being two or three inches from its neighbour and the rows separated by eight or ten inches. All nursery transplanting must be done in the spring, before the season's growth commences, as otherwise unless the soil continues very moist or the compartments are watered artificially the mortality is high. Fall ^{trans/}planting is very expensive and unsatisfactory as, unless heavily mulched, the frosts re-open the planting trench and throw the trees completely out of the ground.

Transplanting may be done by many different methods, but gang planting with the Yale board is most generally used. If the work is well supervised, the cost is not excessive and the mortality is low. The trenching is usually done by a gang of three spade men who use a plank slightly narrower than the inter-row spacing to keep true. Each gang is supported by four transplant cabins. These are canvas structures set up to shelter the roots of the trees from the sun and wind, and may be moved at will. A shelf projects across the cabin from side to side about three feet from the ground on which is rested the "machine" when it is being threaded; while a crew of three, two threaders and a

carrier, accompany each cabin.

The board consists of two six-foot strips about five inches wide and half an inch thick, usually of pine. The lower edge of the underpiece is faced with strips equal to the tree interval in length, separated by a square notch of about three-eighths of an inch in width. Two handles are fastened on each board, and hinged in such a manner that the upper board fits down on the lower piece just above the notches, thus grasping the two firmly. The trees are threaded in the cabins and the board carried to the trench, where it is placed resting on the inner edge in such a manner that the roots hang down against the square cut face of the ditch. The earth is filled by two rakers and soundly packed by a third man. A fourth member of the racking crew follows behind the gang filling fall places and tramping the tree lines to insure each tree being soundly planted.

The care the following two summers is similar. The compartments are kept free of weeds and cultivated, as a dry soil surface much greatly aids in the retention of moisture. Before the freeze-up in the fall, it is again well to cultivate, as the upper layers are loosened and mulch reduces the damage from heaving. This mulching can be done with a hoe, or more economically with one of the many hand-pushed cultivators in the agricultural implement market. Local difficulties such

as cut-worms, grasshoppers, and other troubles, must be dealt with as they occur.

Often nursery sites are acid and the transplants as a result are yellowish. Such a condition can be rectified by the addition of slacked lime or powdered marble with the organic fertilizer, but not in excess of one thousand pounds to the acre in any one application.

The lifting and shipment to the plantations is really a plantation charge, as the tree costs are calculated usually before leaving the compartments. Packing must be done thoroughly, and discarded moss from the seed-beds makes an economical litter. Fork-men loosen the trees, while lifters follow behind; care being taken to drive the forks deep enough to release all the roots.

In general the success or failure of a nursery is dependent on the personal element to quite an extent. The rules are simple, and the solutions of problems that arise can usually be arrived at by a careful summary of the data. That is, the difficulties are not as a rule from deep underlying causes, but can be overcome by a close study of primary conditions, and the showing of some initiative by the nursery forester.

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