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GLENTRESS.

Silviculture.

Introd:- Forestry is a combination of different branches of science dealing with physical and biological conditions. If the object of growth is to grow trees in their natural form, eg. in a park or policies for ornament, this is Arboriculture. If trees are grown for commercial returns this is called Silviculture.

Locality

The soil assisted by the sub-soil provides the plant with the means of stability and nourishment. The atmosphere overlying the soil furnishes certain substances and conditions necessary for tree growth and life, eg. temperature, light and moisture. Hence the soil including the sub-soil and the atmosphere are the media which act upon forest vegetation. They are separately called, Factors of Locality and together, Locality.

It is variations in any one or all of those factors which cause variations in the growth of trees. The active factors of locality depend on the nature of the soil and on the climate the latter being governed by the geographical situation.

Climate.

The geographical distribution of the forest trees throughout Europe is partly due to climatic causes and partly to variations in the physical conditions of soil and situation.
No kind of tree will thrive except, where it can have sufficient summer warmth and a long enough

period of vegetation to enable it to carry out, in a satisfactory way, the process of assimilation and of forming lignous tissue.

For the least exacting of our forest trees a period of four months vital activity (May - August) and a mean summer temperature of 54°F are requisite although a very low temperature during winter may also fix their limits as in Arctic Russia and parts of Scandinavia which are destitute of woodlands. The Northern limits of some of our common trees are as follows

Scots Pine	-	68-70° Lat.
Spruce	-	67-71° L.
Oak	-	63° L.
Beech	-	60° L.
Silver Fir	-	48°-52° L.

In the same way, the higher the situation above sea level the lower the temperature of the air and soil, and this causes an irregular distribution of trees throughout Vertical zones in mountainous tracts. This climatic influence is increased by the fact that evergreen conifers, like Scots Pine and Spruce, are limited in their distribution Northwards and Vertically upwards by Transpiration being induced on bright sunny days in winter when the frost-bound soil can supply no moisture to replace that evaporated.

The Southern limits of our European forest trees are mainly determined by the quantity and the regularity of the summer rainfall. In the hot, dry climate of Europe it has been found that when rain does not on the average

fall once every six to eight days throughout the summer months the woodland crops are in danger of succumbing to drought owing to their being unable to obtain the requisite supplies of moisture for the maintenance of transpiration.
As far as the temperature and rainfall are concerned the climate of Gt Britain is well suited to many forest tree species. We find the Broad-leaved trees in the great Central, Eastern and S.W. plains of England and in parts of Yorkshire and Cheshire. The N., N.W. of England and Scotland are more suited to all coniferous trees.
So far as damage from cold is concerned some species suffer more damage from frost than others. The winter cold is not however so injurious as late frost occuring in the Spring when young leaves and shoots are tender, or as in early frost in Autumn before the last shoots have become hard enough to endure the cold. Danger from frost is greater on plains than on hilly tracts; greater on S. and S.E. exposures than on N. and Western; greater in valleys and basins than on ridges and shoulders; greater in a dry state of the atmosphere than in a moist; greater on fresh soil than on dry; greater on loose sandy soil than on a stiffer loam.
The liability to suffer depends however, less on the kind of tree than on the stage of growth to which the young shoots have advanced. It is greater in weaker than in healthy and vigorous plants. It is greater too, in plants suddenly exposed after having had the shelter of nurse trees than in

those that have been gradually accustomed to the loss of shelter.

Frost hardy species include:- Alder, Aspen, Birch, Elm, Hornbeam, H/Chestnut, Poplars, Willows, Scots Corsican, Austrian & Weymouth Pines, N/Spruce, Wellingtonia.

Moderately Hardy:- S/Chestnut, Lime, Oak, Cedars, Sycamore, Douglas Fir, Japanese and European Larch.

Frost Tender:- Ash, Beech, Plane, Walnut, Silver Fir and Sitka Spruce.

Soil and Situation.

What has been said about local temperature and humidity in the Br. Isles applies also to situation because, in the Br. Isles climatic differences are mainly due to local physical conditions and their influence. The aspect or exposure of any hillside exerts an influence somewhat similar to vertical elevation because, the mean temperature of S., S.E. and S.W. slopes is higher than that of N., N.E. and N.W. aspects and this naturally affects the growth of woodland crops. With regard to the soil the particular characteristics of each of our forest tree species vary greatly according to the shape of its root system and the depth to which it goes. Even shallow rooting trees however grow best on deep soil because of the greater facility for obtaining their food supplies and because of greater anchorage. Most trees form either a strong tap root or else a deep heart shaped root system with side roots, eg. Oak, Larch, Elm, S/Chestnut, Pines, Silver Fir, Maple, Sycamore

and Red. Others have no well developed tap root but throw out strong side roots penetrating fairly deep into the soil, e.g. Beech, Hornbeam, and Aspen. Others again like Alder throw out strong side roots with strands going down into the soil while some have only a shallow root system like, Spruce, Birch, Willow and Poplar.
Spruce, Aspen, Birch and Mountain Pine can accommodate themselves to the least depth of soil about 1 ft., whilst Oak and Larch require the greatest, 3-4 ft. Of the other trees, Scots Pine, Silver and Douglas Fir need deeper soil than Austrian and Weymouth Pine. Beech, Hornbeam and Alder though not shallow rooted can thrive with less depth than Elm, Maple, Sycamore and Ash. Depth of soil favours the formation of a long straight bole, whereas, a short and narrow stem generally indicates that the root system is cramped and unable to develope freely.
It is a fact that, evergreen conifers make more moderate demands for soil moisture and for mineral food than broadleaved trees. The powers of tree species to accommodate themselves to a certain site varies considerably. Those where the accommodative power is strong include;- Scots, Weymouth Pine, Aspen, Birch. Less strong in Oak, Beech, Spruce and Silver Fir; least strong in Elm, Maple, Sycamore and Red.
The total influence of all the factors comprised in soil and situation show their results in the quantity and quality of timber produced.
Depth of soil regulates the rate of rise of temperature in Spring. Shallow soils heat up more rapidly

than in deep soils. Uncovered soils (bare of vegetation) heat up more rapidly than soils covered with vegetations.

Light and Shade.

Trees require a certain amount and intensity of light to carry on the process of assimilation of the carbonic acid withdrawn from the air Unless, such due intensity of light were necessary there is no reason why foliage within the crown of a tree should not be as dense as around its Periphery. Although excess in light may in some cases paralize the action of Chlorophyll; this never happens to our forest trees in Britain and the more light they receive the better they will grow. Beech leaves, eg. growing in full sunlight are about three times as thick as those growing in heavy shade.

But the various kinds of trees exibit very marked differences as to the maximum amount of direct light they need in order to thrive or in other words, capable of enduring. Some kinds are so little tolerant of shade as to be only classifiable as light demanding while others are shade enduring or shade bearing; and others again occupy an intermediate position; there never can be any hard and fast classification of this sort because even light demanding trees show themselves more tolerant of shade on fresh soil and in a favourable situation than on dry, average or inferior soil and vice versa. Shade enduring trees are less tolerant of shade on poor dry soil and on hot exposure than on

good deep fresh soil (land). Isolated trees in full light develope a more branching crown than those in shade. The formation of flowers and seeds is fuller and more abundant of trees grown in the open or on margins of woods than in shade. Absence of light delays the tendency to produce seed. As regards light trees can be divided into three classes:-

Light Demanding.	Moderate	Shade Bearers.
Larches,	Weymouth Pine.	Beech,
Pines, Scots,	Douglas Fir,	Hornbeam,
Austrian	Sitka Spruce,	Silver Fir,
Corsican	Maple,	Hemlock Fir,
Oak, Ash, Elm.	Alder	N/Spruce,
S/Chestnut (after 20 yrs).	Sycamore	Cypress
Poplars, Willows,	Lime.	Yew,
Plane, Birch, H/Chestnut.		Red Cedar.
Cedars, Wellingtonia, Robinia.		

The capacity for enduring shade on any given soil & situation is shown by the thickness, density, colour and persistence of the foliage and by the length of time over shadowed twigs retain life. Little is known as to the absolute quantity of light required for the assimilative process of any tree.

Shape of Root System.

Trees with very branching roots need most growing space and are best able to accommodate themselves to rather any soil, eg., Willows, while shallow rooting trees of course do better on thin soil than deep rooting kinds. Trees with a pronounced tap root system offer greatest resistence to storm,

eg Oak and Larch. Oak, Elm, Ash, Lime, Maple Sycamore, Chestnut, Larch, Silver and Douglas Firs and Pines have the deepest root system, while Oak and Chestnut retain their tap root longest. Beech, Hornbeam and Alder occupy an intermediate position and Spruce, Birch, Acacia, Poplar and Willow are usually shallow rooted. But again, the root system is always better developed on good fresh porous soil than on stiff tenacious land.

Shape of Stem and Crown.

The woodland or close grown form of a tree is always different from a natural or openly grown form which a tree assumes when it has full freedom of growth above and below the ground. The more shade bearing a tree the greater is the difference. All our woodland Coniferes have a natural tendency to forming a good ascending axis or bole though this tendency is distinctly stronger in Douglas Fir, Larch, Spruce, Silver Fir and Weymouth Pine, than in Scots, Austrian and Corsican Pine. It is also stronger in Poplar, Sessile Oak, Ash, Elm, Sycamore, Maple, Alder, Acacia and Birch than in Pedunculate Oak, Beech, Willow, Hornbeam, Lime and Chestnut. In all trees, the leading shoot of the central axis develops more vigorously than the side shoots and especially, while the trees are young, while in some the side shoots soon begin to compete with the axial shoot so that the stem is short and the crown low and wide spreading. But when each tree is forced to accommodate

itself to a limited growing space such natural tendency is checked and competition takes place for light and air, so that the main vital energy is transformed into upward growth. The more light demanding the tree, the greater is this upward impulse necessary.
Age has an effect on the form of stem of some trees but generally, Larch, Spruce, Douglas fir and Silver Fir retain the conical shape to old age, others become more oval or rounded with age.
Soil and situation affect the shape of trees because of the relation between food supplies and vegetative energy. Good fresh loam generally encourages a full crown of foliage and a large girth of stem, but it does not favour a good length of bole. Deep, fresh, light, sandy soil favours length of stem but the girth is usually smaller as there is a slower branch development and less foliage. Shallow and rocky soil causes branching and stunted growth because the roots have to spread far in search of food. High elevation and cold windy situations also cause poor, stunted growth.

Rate of Growth.

The rate of growth of different trees in height and girth and therefore in cubic contents is an important characteristic because the possibility of growing mixed crops of any two or more trees depends essentially on their rate of growth in height and their demand for light or capacity for bearing shade. Growth in height varies not only with every

different kind of tree but also according to its age, the soil and situation and the way the woods have been formed and tended. The upward impulse is strongest in Douglas Fir, Spruce, Silver Fir, Larch, Scots and Weymouth Pines which can often be made to attain a total height of 100-120' in good woodlands in close canopy. Elm, Oak, Red, Beech, Maple and Sycamore can on good deep soil reach a height of about 100' while Poplar, Birch, Hornbeam, Alder and Willow can reach 80'.

Growth in girth begins early in most of our light demanding trees, is usually most vigorous from about 20-35 years of age, then continues active till about the 50th or 60th year when it gradually declines. Wild Oaks and other shade bearing species growth in girth is usually somewhat later in beginning but is often well maintained till between the 70th & 90th year. When woods are crowded growth in height is forced on at the expense of growth in girth and whenever they are kept somewhat open growth in girth is favoured at the expense of growth in height. When plantations are heavily thinned after growing in close canopy, the trees left standing rapidly thicken in girth as the result of greater exposure of the crowns for the expansion of the crown and of the root system. Among the broad-leaved trees the largest girths are attained by Oak, Elm, Sweet Chestnut, Lime, Beech and Black Poplar. Among conifers, by Silver, Douglas Firs, Spruces and Pines. Growth in cubic contents or total increment is the combined effect attained by the growth in height and girth.

As the number of individual stems per acre has to be sooner decreased to provide the necessary growing space, light demanding trees culminate in increment and become less energetic sooner than shade bearing trees though ofcourse, here again, much depends on soil and situation. The productive energy of a crop of woodland trees is quite a different thing from the productive energy of an individual tree, but so far as whole crops are concerned Br. woodlands maybe roughly classified as follows with regard to total energy in total increment.

Conifers	Broadleaved.
Sitka Spruce,	Beech, Oak, Ash,
Douglas, Silver Fir	Elm, Sycamore, Maple,
Pinus Corsican	Sweet Chestnut,
Weymouth,	Willow } light or
Jap. & European Larch	Poplar } moist sites.
Scots Pine.	

Reproductive and Regenerative Power.

Trees may either regenerate themselves by producing seed or by throwing up suckers from the roots [root-suckers]; and if they are cut off near to the ground certain species will reproduce themselves by sending up stool-shoots. Other species are best reproduced by Layering, budding, grafting or by cuttings which will be dealt with later under Nursery work.

The ability to form seed depends on the amount of starchy and nitrogenous reserves secreted in the tree and this ofcourse varies according to its age, the soil and situation and the amount of

light and heat that the tree has. The most prolific period of seed production is when the trees have completed their main growth in height and have begun to expand their crown because that is the time when their vital energy is greatest. Good soil, warm situation and a free growing space of course favour the production of seed. In the forest generally the flowering and production of fertile seed should start:-

15-20 yrs old – Pines, Larches, Birch and alder.
20-25 " " Douglas Fir.
25-30 " " Sitka Spruce.
30-40 " " N/Spruce, Hol, Elm, Maple, Sycamore
40-50 " " Beech + Oak.
50-60 " " Silver Fir.

The times will vary according to locality, species and density of crop. Certain trees have qualities inherited from the parents and one of the qualities may be seed production.

It is a fact that if a tree is checked by any cause it will tend to produce more seed when checked and again when reaching maturity. Seed years or mast years are years in which trees produce a rich harvest of seed periodically eg. Oak and Beech.

In the case of Beech a full mast year occurs generally every ten years with a partial mast year every three to five years. In Oak a full mast year occurs every five to six years with a partial mast year every two to three years.

This is due to the fact that the formation of fruit exhausts the reserve materials and only when the storage cells in root and stem have been replenished is the full formation of fruit

again possible.

The formation of stool shoots after felling is merely an evidence of the strong recuperative powers. Broad-leaved trees owing to their larger store of reserve nutrients and because of the position of dormant buds, possess this power to a very much greater extent than conifers among which, with the exception of some Larch and some of the three needled pines, it is practically non-existent.

The power of quickly replacing sufficient foliage to carry on the work of transpiration and assimilation is strongest during the younger stages of growth but it is always more or less dependant on the soil and the amount of light. Sweet Chestnut, Oak and Elm retain such recuperative powers longer [to about 85 yrs); though Alder, Sal, Hazel, Maple and Sycamore coppice well, while stools of Beech and Birch lose their reproductive vigour after being coppiced [cut over] several times.

The formation of root suckers seems to be the only means by which certain trees, English Elm, Lime, Sweet Chestnut and most Poplars and Willows can utilise their surplus starchy reserves as they do not produce seed in this country with a good germinative capacity.

Oak, Beech, Elm, Sal, Maple, Sycamore, Lime, Sweet Chestnut, Hornbeam, Alder, Great Willow (Sallow) and Birch produce more stool shoots than suckers, while the latter, are more frequently produced than stool shoots from Aspen, Acacia [Robinia] Mountain Ash, non-indigenous Willows and Poplars and White Alder. But Sweet Chestnut

English Elm, Lime and Maple at the same time throw out a very fair proportion of suckers which may be severed and transplanted like seedlings. Among coppice shoots, Hazel produces stool shoots chiefly, and Blackthorn mostly suckers while Field Maple throws up both.

Maturity and Longevity.

Great differences exist as to the age to which several kinds of trees can continue growing in a healthy condition before showing signs of decay from old age. Though many historical trees are known to be much older the ordinary limits of healthy tree life may be put at about 400-500 yrs. for Oaks, about 200-300 yrs. for English Elm, Silver Fir and Beech and about 150-200 yrs. for Ash, Maple, Sycamore Spruce, Larch, Scots Pine and Lombardy whilst Aspen, Birch, Alder and Willow seldom attain over 100 yrs; but the above ages are more than twice or three times the period of rotation that could possibly be economic in woodlands.

When grown as timber crops, the different kinds of trees in Britain appear to reach their greatest market value at about the following ages. So much depends on climate, soil and situation that this estimate can only be taken as a rough classification:

Species	On good soil	On Inferior S.
Larch, S/Pine, Spruces.	60-80	50-70.
D/F, S/Fir, &c.	70-90	60-80.
Willow, Birch, Poplars.	50-60	40-50.
Ash, Elm, Maple, Sycamore	60-70	50-60
Beech.	90-120	80-100.
Oak.	120-150	90-120.

Stages in the life of a tree.

Tree may be propogated by seed or vegetatively by layering, budding, grafting, stool shoots, root suckers or cuttings.
The essential point in grafting or budding is that the cambiums are placed together and secured firmly.
In order to successfully germinate seed sufficient air, moisture, temperature and soil conditions are required. Root growth precedes shoot activity. Growth is confined to the tips of the roots and shoots and to the cambium. To start off, growth is slow then after the trees become established in the soil there is a period of rapid growth. Height growth ceases long before girth growth. To begin with all trees have more or less symmetrical shape, later each tree assumes the form characteristic of the genus or species and one can identify trees at a distance from this form in later life.
In the early stages of the life of a tree the bark is smooth, later it becomes ridged and grooved in most species. The flowering stage should begin about the time rapid height growth is finished. This is affected by soil and density of crop. In all trees a time comes when the main seeding stage ceases; the tree goes on living and declining. The first symptoms of old age appear in the crown. Twigs may dry up and die and the tree becomes stag-headed. This is due to the roots being no longer able to force water to the top of the tree. Before actually dying a tree may produce a large quantity of fruits most of which are infertile.

that generally trees develope irregularly and we are able to classify the stems found in a wood viz:-
1. Wolves - large, coarse branching trees.
2. Whips - lanky, slender and upstraun trees.
3. Dominants - Average, good types with crowns free may be sub-divided into:
a) Co-dominants.
b) Sub-dominants.
4. Dominated - slightly below class 3 b.
5. Suppressed - Hopelessly outclassed and under the dominated [trees.
6. Dead, dying and diseased.

The forest is maintained in a fairly close canopy stage for a few years for several reasons. By keeping trees sufficiently close they form long clear stems; the size of branches are controlled and thus the size of knots; seed formation with its utilisation of much food is delayed. Density prolongs vegetative growth and delays the flowering stage; the crown usually should occupy about a third of the stem. In the forest where the crowns inter-lace to form a canopy there is a better proportion of spring and summer wood formed and thus better timber. The annual rings are more nearly equal if the density of canopy is regulated more or less evenly thus giving better timber. In a close-canopied tree there is reduced transpiration which causes less demand on water and therefore less cells in the spring wood, thus better timber. In close grown woods the stems are more cylindrical because of the distribution of growth near the top. As the growth is made from the crown the stem is more cylindrical. In isolated trees roots spread further, green branches persist lower down thus stem growth is greater lower down

and we get a more conical shape with a buttressed base. The buttressed base is also caused by a mechanical reaction on the part of the tree to resist the swaying movement caused by wind. In close canopy the temperature of air owing to the heat of the sun causes the upper part to start growth before the lower part. The upper part is able to obtain more food material and therefore it maintains a cylindrical form.

The forest is maintained fairly close to obtain good height growth and balance of crown to total height but is gradually thinned or opened out to allow the trees to develope so that they will put on a regular and economic layer of wood each year. The flowering and seeding stage of the forest is now reached the trees reaching maturity. The decision must now be made as to how the forest is regenerated.
a) by natural seeding or natural regeneration from the parent trees or b) by clear felling and planting (artificial regeneration) thus we complete one generation of the forest and are ready to start a new generation.

Nurseries:

Nurseries may be either permanent or temporary. Temporary nurseries are formed as near as possible to the intended planting ground and may only be used for transplanting and not for seed beds.

Advantages of a T. nursery:-
1. The plants are in the immediate vicinity of the planting area which avoids cost of transport, [cheaper to transport seedlings to nursery than to transport large transplants to the area] danger of

drying up of the roots and more soil can remain on the roots.
2. Young trees are accustomed to conditions similar to those in which they are to grow.
3. Fencing is unnecessary as the nursery area is already enclosed by the plantation fence.
4. Grubs, wireworms etc. have not had time to become serious pests.
Advan. of a Permanent Nursery:-
1. A skilled regular nursery staff can be employed.
2. Generally yields better plants.
3. Cost of preparation of nursery ground only incurred once.
4. Roads, water supply etc. are all made available.
Selection of Site:-
In the T.P. this is normally done by the D.O. but on private estates it may be done by the forester. The success of a plantation mainly depends on the quality of the transplants used. The position of the nursery is important. The soil conditions can often be improved by drainage, manuring, etc.
Site:- Near a foresters house for supervision. Near a good permanent road and water supply.
Aspect:- Aspect is of great importance as regards extreme heat and cold. S. and W. aspects should be avoided. Choose by preference a N.E. or N.W. aspect. If the nursery is on the E. coast a N.E. aspect should only be chosen if there is sufficient shelter with that exception. N. is preferable to S. On N. aspects vegetation awakens later on in the spring, this is a safeguard against late frosts and gives a longer lining out or planting

season. A plant may be frozen but if thawed out slowly it may recover without permanent injury. On N. aspects thawing is slower therefore less damage is done. Frost hollows and narrow valleys must be avoided

Soils:- There must be sufficient strength, but the physical properties, depth, porosity and moisture are even of more importance. The more important plant foods are calcium, nitrogen, phosphorous, and potassium. In order to maintain fertility in a soil, additions of one or more of these may have to be made from time to time. The mere presence of food substances in the soil is not enough; they must be present in a form in which plants can assimilate them. A plant raised on poor soil has a poor root system with very little fibre and has little chance of collecting nourishment when put into a forest soil; well nourished but not soft plants suffer less from injurious climatic and organic enemies than ill-nourished plants. As regards tenacity of soil a sandy loam is preferable. The clay soils should be avoided because, 1. it is difficult to work in the spring 2. It is useless for seed beds as frost lift causes heavy losses in seedlings.

3. In summer it becomes dry and cakes on the surface. Avoid too light a soil as sandy soils are apt to become dry and cause plants to develope a long tap root searching for moisture. The depth of soil depends greatly on the species of tree to be raised eg. Oak deep, Spruce shallow. Shallow soils should as a rule be avoided. They are easily dried up and poor in nutrient.

Medium depth for a nursery is 18 to 24!
Pan or impermiable sub-soil should be avoided.
Slope:- Choose a level site but a slight slope is not a disadvantage because it allows a good drainage. Also, if the slope is towards the north the plants are protected from the early morning sun which does much damage when it strikes the frost covered plants in the morning. Steep slopes must be avoided because they are subject to rain washing.
Shape:- The best shape is rectangular for general ease of working.
Size:- This depends on a) species to be raised
b) age at which the plants are to be put out into the forest and if trees are to be raised from seed or seedlings, bought in for lining out
c) The area for annual planting programme.

New Nurseries Chap. 1.

Plans:-

For records and control a plan on a scale of 1 inch to 1 chain is required and such a plan should be made as soon as possible. A scheme of operations should next be drawn up. It is unlikely that the whole area will be required for development immediately and arrangements should be made for ground not required at once to be utilised in some manner which will be most beneficial to its ultimate use as a nursery, eg. a crop of potatoes might be raised in order to ensure that the ground is thoroughly well worked.
Certain portions of the nursery site may be potentially more suitable for raising seedlings than are others. So far as possible they should be allocated to that purpose. Points to look out for are frost hollows, areas of poor drainage and

patches of infirst soil. Make a thorough examination of the ground, digging soil and subsoil pits at intervals particularly where changes are expected. The easiest worked ground should be reserved for seedbeds, in so far as rational cropping permits.

Fencing:- Rabbit proof fencing is needed at practically every nursery [see Sec. I chap. III T. notes] This should be laid out on the most economical plan; it is usually cheaper to enclose the whole area at the outset rather than to deal with it 'piece-meal'. Gates or the hanging posts for them should be erected wherever required by the general road system. They should be wide enough to allow of the passage of machinery and lorries that is, at least 12' wide and must be rabbit proof.

Drainage:- Thorough drainage is essential for efficient nursery work. If drains are required lay them out on a plan that will not conflict with the haulage roads, or with the use of mechanical equipment. Remember that pipe or tile drains [which are unsuitable for forest use] may give good results in a nursery; their extra cost may sometimes be justified there. In large nurseries attention must be paid to the drainage of the road system, all surface water being carried well clear of the road bed.

Layout of Roads and Paths:-

Careful thought should be given at the outset to the layout of roads, paths, beds and hedges as it will be difficult or impossible to alter them later on. On most sites a rectangular lay-out is much the best, avoiding waste ground and 'slot work' by mechanical plant.

A convenient distance between main roads is 315' in one direction x 410' in the other, such a space will contain six sections each 150'x200', divided by 5' paths after allowing for a 2½' working space adjacent to each road. Each section contains 20,000 sq. ft, 2,222 sq. yds., or approx ½ acre. Each rectangle of roads therefore encloses three acres of workable ground whilst no point in it is further than 160' from a road. The actual distance between the main roads will in practice be varied with the site. Remember that too wide an espacement will result in an undue length of haulage over soft ground; too close an espacement will hinder the efficient working of mechanical plant.
If every working section is of approx. the same size, the planning of every operation is simplified and supervision, costing and stock-taking are easier and therefore cheaper. Dimensions should preferably be in multiples of 10', the length of the standard lining out board. Where the outline of the nursery is irregular as many standard sections as possible should be laid out and the oddly shaped areas remaining should be used for such purposes as compost heaps, tool sheds etc.
Hedges. The first point to note is that any existing shelter such as hedges or rows of trees should be retained. New hedges should then be laid out if required on lines chosen with ref. to wind direction, slope of land and general exposure. It is important that such hedges should not interfere with the free movement of mech. plant and therefore the best positions will usually be along the outside boundaries of the

nursery or along the main metalled roads. The distance apart of such hedges will naturally vary with the degree of exposure but a spacing of 410' x 315' has been found adequate on a moderately exposed site. No hedge should be established across the slope at the foot of the nursery in such a way that it will check the downward flow of cold air on frosty nights; a hedge so placed would probably create a 'frost hollow'. The best species for general use is Beech which retains its foliage into the winter and is unlikely to harbour pests attacking coniferous trees. Five transplants are required for every running yard of hedge set about seven inches apart in a single line; one + two or 2+2 transplants 15"-18" high are suitable. A height of 6' when full grown with a thickness of 2' is ample. Annual trimming is necessary and in order to preserve a full hedge lower down and avoid damage by wet snow in winter the upper portion should be trimmed to a knife-edged top. Time will be saved if the trimmer stands on a box. Beech takes time to form an effective hedge and in the early years additional protection may be provided by an artificial shelter of hurdles or a temporary hedge of broom. On very exposed sites an admixture of Hawthorn with the Beech has been found beneficial.

Artificial Shelter:- Woven hazel hurdles, cleft chestnut fencing and similar artificial shelter may often serve a useful purpose where a permanent hedge cannot be established. Their advantages are that the shelter is established

immediately it is required whilst it can just as quickly be removed when it interferes with large scale mechanical cultivation.

Construction of Rds:- Sound roads that will take lorry traffic under all weather conditions are essential for efficient nursery management. Plan them so that they serve the maximum area for the minimum length. Metalling of the whole surface or of the wheel-ruts is necessary and good size drainage and camber are required. Turning points of ample width should be provided wherever necessary.

Buildings:- The sites of the main nursery should be chosen where they will most conveniently serve the nursery as a whole when it is fully developed. In addition, subsidiary shelter should be present at every large nursery as otherwise a great deal of time may be lost by workers walking to and from the main shelter during showery weather. If possible shelters should be within 100 x of every working point; they need not be elaborate but should be large enough for use as grading sheds in wet weather. Latrines should be distributed over the area in the same way to avoid loss of working time.

Cultivation:- A full season's cultivation is normally necessary to render pasture or rough grazing ground fit for lining out transplants and a further year [under transplants] is required before seedbeds can be safely made. Attempts to work faster than this have often brought difficulties in their train. This preliminary cultivation has three main objects.

1. The breaking down of turf or other surface vegetation that may impede the working of tools.

2. Germination of any weed seeds that may be present.
3. Creation of a satisfactory tilth.

The following methods have proved satisfactory in converting rough pasture to nursery use though it should not be assumed that this particular procedure is the best for every site.

Work was begun in the autumn by cutting and burning all woody growth of gorse and brambles etc. together with patches of bracken. Larger trees were uprooted with a tractor and hauled out of the way. The next step was to skim-plough to a shallow depth, turning the turf over to lie as flat as possible close to the surface. The ground was then rolled with a heavy, smooth roller and left throughout the winter to give the inverted turf time to decay. In the following spring the land was again ploughed, this time to a depth of nine inches working across the previous furrows so as to cut up the turf and bury it, narrow furrows are best for getting full depth. During the ensuing summer the land was bare fallowed being worked in dry weather with spring tine cultivators, disc harrows and spike harrows. This periodic cultivation destroyed weed seedlings and brought any incompletely buried turf to the surface where it dried by becoming dried out. This ground was fit for lining out a year after treatment began.

New nursery land is seldom in good heart and it is advisable to test the soil for mineral deficiences before cropping is begun. In view of the particular requirements of forest trees an analysis of the soil should be obtained with particular reference to

its P.H. status and its contents of Potash, Phosphorus and Nitrogen. P.H. being the chemist's term for expressing small differences in the acidity or alkalinity of the soil.

Coniferous transplants should usually be chosen as the first crop as in this way the new ground is inoculated with the mycorhiza forming fungi that are essential for the growth of conifer seedlings.

Heathland Nurseries.

Nurseries established on heathland by the research branch have given very good results in raising conifer seedlings, particularly those of Pine and Spruce and this method has now been extended to general conservancy practice.

Selection of site:- The site selected should be at as low an elevation as possible and in the most sheltered situation available. Avoid elevations above 800'. Very poor gravelly ~~podsols~~ should be avoided. Select if possible a sandy heath having some admixture of grass and bracken in the surface vegetation. The site should be near a road for ease of access and preferably near a stream for water supply.

Preparation of site:- If a bulldozer is used to remove the heathery covering this should be done with great care so as to remove as little of the peaty humus as possible. Never pare off all the peaty humus down to the mineral soil. Where the peat is tough intensive disc harrowing is needed to break up the peaty layer and incorporate it thoroughly with the mineral soil. Plough as shallow as possible to keep the surface peat in

in the top 6" of the soil.
Manuring:- One of the great advantages of heathland nurseries is the saving of weeding costs, at any rate, during the first few years. Therefore every effort must be made to avoid bringing in stable manure, pig manure or incompletely composted straw; all of which are liable to bring in weedseeds. The initial fertility of heathland areas is naturally low and fertilizers are required at the following rates.
a) Where hop-waste is applied — 750 lb of fresh raw hop waste per 100 sq. yds of nursery bed. 16 ton-acre.
Nitrogen:- 13½ lb of crushed hoof per 100 sq. x. 6 cwts to acre.
Phosphate:- 4 lb of Gafsa mineral phosphate per 100 sq. yds. Afford. 3 cwts. to acre.
Potash:- 4¾ lb of muriate of Potash per 100 sq. x. 2 cwts to acre.
b Where no hop waste is applied.
Nitrogen:- 13½ lb of crushed hoof per 100 sq. x
Phosphate:- 14 lb of Gafsa mineral phosphate per 100 sq. x.
Potash:- 4¾ lb. of muriate of Potash per 100 sq. x.
all applications of fertilizers should preferably be made about three weeks before the beds are sown, though there is no harm in doing it somewhat earlier. They should be forked, cultivated or disced into the top 4" of the soil
Maintenance of fertility:-
Soil Reaction:- Recent research has shown that the successful growth of forest tree seedlings is closely dependant on the PH reaction of the soil, ie on whether it is acidic or basic. Under the methods of cultivation practised in the past there has been a tendency for nursery soils to become too basic for satisfactory growth. In future it is essential to ensure

that no fertilizers that tend to make the soil more alkaline, shall be used in forest nurseries. In soils the usual range of ph values is from ph 3·5 to ph. 8. The following are some arbitrarily selected points on the scale:-
ph 3·5 extremely acid, ph 4·5 very acid,
ph. 5·6 moderately acid, ph 6·5 slightly acid
ph 7·2 neutral, and ph 8 - alkaline.
Seedlings of spruce and pine have been found to require for satisfactory growth a relatively acid soil, ph 5·6 or below. They grow poorly on soils of neutral or alkaline reaction. Larches appear to be more tolerant of basic conditions. Chestnut and beech and probably Oak and Birch also appear to prefer acid conditions. Ash and Sycamore on the other hand, can be safely sown on soils round about the neutral point. Methods of correcting the conditions resulting from a basic action are still in the experimental stage. In the meantime, the sowing of spruces, pines and beech must be restricted to those areas known to have an acid soil.
Determination of soil Acidity:- Take out at intervals of 50'-100' depending on the size of the area, but at not less than a dozen points, a thin slice of soil to a depth of 4" and put it in a bucket. Mix the soil samples thoroughly and take from it a smaller sample of about 1lb. in wt. Put in a wooden box or tin lined with grease-proof paper or cellophane together with a label giving, Name of nursery, No. of section and name and address of forester. The same information should be given on the back of the postal label. If the proposed seed bed areas in different parts of the same nursery or if there is reason to think that soil conditions in the same section vary, separate bulk samples should be taken

and labelled appropriately, viz:-
England & Wales:- Officer i/c soil Testing,
Rothamstead Experimental Stn. Harpenden, Herts.
Macaulay Institute for soil Research,
Craigiebuckler, Aberdeen.
When the results of the tests are received they should be recorded for future reference. Remember however, that the soil reaction may change under subsequent cultivation necessitating re-testing.
Prohibition of Liming:- The following practices which would tend to make nursery areas more basic are specifically prohibited by Silvicultural circular No. 21. a) The use of lime or basic slag for application to the nursery soil whether seedbeds, lines or green crops.
b). the spreading of any existing weed heaps which lime has been added to.
c) The covering of seed with limestone chips or with any gravel containing free lime.
To test presence of lime, test with vinegar or hydrochloric acid in the chips etc. If effervescence occurs, lime is present.
Manuring:- Although forest tree seedlings and transplants remove appreciable quantities of mineral nutriments from the soil, they appear to take these most readily from manures that release them slowly. There are also indications that young forest trees thrive best in soils that are rich in humus. The elements essential for tree growth should therefore be supplied as far as is practicable in the form of organic manures such as leaf-waste, farmyard manure and composts. Inorganic manures or chemical fertilizers may be essential in order to supply seedlings with their

requirements of Potash and phosphates and also for the raising of greens crops.

Farmyard Manure:- Well rotted farmyard manure has proved highly satisfactory in maintaining nursery fertility. It supplies all the essential elements and is a valuable source of humus. Dressings should be adequate from 20-30 tons per acre worked well into the ground by thorough cultivation. It varies widely both in quality and price. It should have been stacked for at least one year prior to use in order to ensure thorough composting of any raw vegetable matter. If stacking sites are required at the nursery they should have a concrete base and if possible an overhead cover of corrugated metal sheeting. The great drawback of farmyard manure is its tendency, even when thoroughly rotted, to introduce weed-seeds. For this reason it should not be applied to land that is to be used during the next season for seed beds. The best practice is to apply it to areas due for greens cropping so that if weeds arise they can be controlled without undue expense or difficulty.

Hop Waste:- This is relatively cheap and can often be obtained from breweries for little more than the cost of cartage. Supplies are apt to limited however. Comparative trials with raw hop waste and hop waste after composting have shown that little or no benefit arises from the composting and the material should therefore be applied fresh. Hop waste however, should never be left stacked in large heaps as these are liable to heat up, dry out and lose most of their manurial value. If it has to be kept for some time, stack in small heaps of not more than a ton and turn these at intervals if they

tend to clog up. A great advantage is its freedom from weed seeds. Rate of application from 15-20 tons per acre.

Leaf-mould:- Where available leaf mould from broadleaved trees particularly Beech is an effective fertilizer when applied at the rate of 30-40 tons per acre. It should be only taken from woods where its removal will not adversely affect the growth of timber crops.

Peat:- Molinia peat has sometimes proved effective as a means of increasing the humus content of nursery soils; but as little is known regarding the properties of this and other forms of peat their use should be restricted to an experimental scale.

Crushed hoof:- This is a form of nitrogenous manure which has been found to give good results on seed beds probably because it releases its nitrogen slowly. The recommended rate of application is 6 cwts per acre [14lb per 100 sq. yds].

Shoddy:- is the waste from wool and woollen mills. It may be used in place of crushed hoof, but it is necessary to get a high grade with a guaranteed nitrogen content. With a nitrogen content of 14% the rate of application should be 6 cwts per acre [14 lb to 100 sq. yds] Slower acting than hoof.

Other Organic Manures:- Certain organic manures such as poultry manure and sewage sludge may be used locally but their application should be restricted to an experimental scale until their effects on nursery soil are known.

Inorganic Manures.

Phosphates:-

The form of phosphates now favoured for nursery

seed beds is basic mineral phosphates applied at the rate of 6 cwts to acre. The use of basic slag is prohibited since it tends to make the soil alkaline.
Potash:- This is usually applied in the form of muriate of potash. For seed beds the rate of application should be 2 cwts per acre, ie 4¾ lb per 100 sq. yds.
Nitrogen:- Forest trees whether seedlings or transplants show little effective response to manuring with nitrogenous fertilizers. Such manures should in general be confined to areas intended for green-cropping where they may serve a most useful purpose by ensuring growths dense enough to smother weeds. The usual inorganic sources of nitrogen are sulphate of ammonia and nitrate of soda. A normal rate of application of either for green crops is 1 cwt per acre.
Blends:- is a mixture of inorganic manures giving 7% nitrogen, 7% phosphate, 7% potash mixed in a base of granulated peat. Quantities not yet definitely fixed.
Soil Testing:- The rates of application stated above are those for seed beds & green crop areas in nurseries having a normal degree of fertility. Where any extensive scheme of manuring is intended for the restoration of fertility to impoverished nurseries, expert advice should be sought and soil samples submitted to testing stations for a report on their deficiences in each particular chemical element. A definite programme of manuring should then be laid down with the object of restoring fertility over a series of years and thereafter maintaining it at a satisfactory level. Isolated applications in single seasons have little permanent value. It is likewise essential to treat the whole area, which is not always feasable in

any one year.

Purchase, Storage and application of manures.

Inorganic fertilizers are usually purchased under arrangements centrally but the officer responsible for applying them to the ground should obtain a statement of their chemical analysis so that he can satisfy himself that the rate of application is adequate. This is particularly necessary in the case of phosphates, crushed bone, dried blood and shoddy in which wide variations may occur in the quantities of essential elements present. All manures should be carefully stored under cover and kept quite dry until required. Where it is required to apply two or more kinds of fertilizer it is usually advisable to obtain them ready mixed by suppliers who have the necessary plant and can do the work more thoroughly and cleanly than is possible by hand. Wherever possible the fertilizers should be applied to the land by mechanical manure distributors which will spread them more easily, quickly and cleanly than is possible with hand labour.

Composts.

Although encouraging results have been obtained by the research branch with composts obtained by treating hop-waste straw, bracken and similar material with dried blood and other composting agents under controlled conditions no technique has yet been devised that can be regarded as economically successful for large-scale nursery practice.

Where however, composting is decided upon, it should be remembered that the turning and watering

of the heaps must be given systematic attention and the temperature of the heaps should be tested regularly with a hot-bed thermometer. The heaps should be formed near a hard road preferably under cover and should not exceed a size of 5' high x 4' wide x 8' long. On no account should nursery weeds be added to the heaps as in practice their seeds are seldom destroyed by composting. The main objection to composts at the present time is their cost which should be carefully checked and compared with that of alternative manures.

Treatment of Nursery Weeds:- There has been a tendency in the past to regard nursery weeds as a rich store of plant nutrients that ~~nursery weeds~~ must on no account be lost and which must at all costs be returned as early as possible to the land. Consequently, a great deal of effort has been expended on composting them, but in practice this has seldom resulted in the destruction of all weedseeds included in the compost heaps and has tended to raise subsequent weeding costs. The seeds of many common weeds can lie dormant for years until suitable conditions for their germination arise. All weed material that includes stems or roots of perennial weeds particularly docks and couch grass should first be stacked in small heaps to dry out and then burned in an incinerator. The same method may be usefully followed in the disposal of annual weeds. The incinerator ash should be spread on areas about to be green cropped and not on those due for seed beds as it is unlikely that it will be entirely free from live roots or weed seeds. Where annual weeds are destroyed by rotting in heaps, at least four years should elapse before the

leafs are returned to the nursery. Even so, they are only to be spread on areas due for immediate green cropping so that the green crop will smother the weed seedlings that will probably arise. The addition of lime to the leafs serves no useful purpose and is expressly forbidden.

Although the burning of nursery weeds destroys a certain amount of humus that might be retained if they were allowed to rot in leafs, it may as well to face this loss rather than to risk the continued propogation of weeds in the nursery with resulting high costs of weeding and removal.

The humus content of the nursery soil can be kept up just as effectively by applying weed free humus such as spent hops or leaf mould which bring no weeding problems in their train.

Green crops.

The objects of green cropping are to ensure thorough cultivation of the soil, the suppression of weeds and the addition of humus. A green crop that fails to develope satisfactorily may permit weeds to grow up and seed besides adding insufficient humus forming material to the land, therefore, the crop must be well chosen and tended and adequately manured.

As a general rule crops for harvesting should not be grown since their removal lessens the supply of nutrients to the ground but a crop of potatoes may be advisable where deep and thorough cultivation is required.

The choice of green crops is limited to those that will tolerate moderately acid soil conditions. Crops that need an alkaline soil and which cannot be grown well without the addition of

lime are unsuitable for forest nursery use. This includes most of the cruciferae including, mustard, rape, turnip, swedes and cabbages of all kinds as well as most clovers and vetches. No green crop should be selected which requires a great deal of labour at any stage of its growth whether for planting, weeding, tending or harvesting. In practice the choice of most nurseries is limited to Lupins, Rye, Oats, Buckwheat and potatoes; but in areas of exceptional climate such as the West of Scotland, other crops may have to be considered.

Preparation of Ground:- This should be just as thorough and systematic as for a crop of trees. The main operations are:- 1. Apply farmyard manure if required and plough up as soon as the ground is fit in winter
2. Cultivate with spring-tine cultivators and harrows and allow to lie for two or three weeks.
3. Plough again to bury germinating weeds.
4. Level the surface with light harrows.
5. Apply any inorganic fertilizers that may be required with a manure distributor.
6. Sow seed with mechanical drill or fiddle sower.
7. Cover seed with light harrows.
8. Roll seed bed.

Lupins:- Blue or yellow annual lupins are sown with or without crimson clover at any time from March to August. From 1-2 cwt lupin seed is required per acre. Plough the crop in as soon as it flowers before any seeds are formed or the stems become woody, from two or three months after sowing. A dense crop is best rolled before ploughing in; the plough should then follow the roller not run across its tracks or in the opposite direction. The ground should then be harrowed down in readiness for use under forest trees or for a second green crop. Two crops of lupins can be secured in a

favourable season.

Rye and Oats:- Either of these cereals may be raised as a greencrop by drilling seed from March to July at the rate of 1 cwt per acre. The variety known as the 'Potato' oat is favoured in Scotland. Where the soil is suitable vetches or field peas may be mixed with the cereal crop at the rate of 56 lb of seed per acre. The crop is ploughed before the grain ripens.

Buck Wheat:- This crop has given good results on poor, light, acid, sandy soils in the S. of England but is of little use in the North. It is sown at the rate of 50 lb per acre in late spring and is ploughed in at the flowering stage.

Potatoes:- These are occasionally used as a cleaning crop to secure deep cultivation of the soil or to aid in the removal of cock-chafer grubs. They should not be grown on ground required for seed beds in the following season as sprouts from small tubers add to weeding difficulties. If it is decided to grow potatoes it should be borne in mind that the high cost in labour, cultivation and manuring associated with this crop can only be recovered if it is handled on the lines followed by commercial growers. The variety must be one that is known to suit local soils and markets, only new or once-grown 'seed' should be used. Manuring must be adequate. The following is a usual dressing per acre.

Farmyard Manure — 20 tons applied separately.
Super-phosphate — 6 cwts.
Muriate of Potash — 2 cwts.
Sulphate of Ammonia — 2 cwts.

Equipment designed for the job should be used for

sowing seed, ridging up the plants, spraying and above all, for lifting the crop, makeshifts are certain to prove costly. A serious drawback to potato-growing in nurseries is that the crop must be harvested in autumn when all hands are normally required for the main business of lifting or lining out the trees. It is therefore inadvisable to clamp or pit the potatoes, they should be sold as soon as lifted.

West of Scotland System of Green cropping.

The following system has proved suitable under the difficult conditions arising from high rainfall in the West of Scotland.

In March:- Prepare the ground and add
20 tons of farmyard manure or else
12 tons of above plus 5 cwts of lime-free compound fertiliser viz. Nitrogen, Phosphate + Potash.

In April:- Sow the following mixture.
Potato Oats — 4 Buckets per acre.
Scots Grown Swedish Turnips - 1 Bucket per acre.

In June or July:- Plough the first crop in and re-sow with the following mixture:

Perennial rye-grass	—	20lb per acre.
Italian Rye-grass	—	10lb per acre.
Broad leaved clover	—	2½lb per acre.
Late-flowering Red clover	—	2½lb per acre.

The resulting crop is ploughed in during winter or spring immediately before lining out. It enables the lining-out gang to work on ground that would otherwise be too sodden and in practice the green material causes little interference with the spade work. Alternatively, the crop may be grazed off by cattle before ploughing in.

Bare-Fallowing:- The use of bare fallows is not

normal practice in forest nurseries as unstocked ground can usually be put to better use under green crops, exceptionally bare-fallowing may be needed to eradicate weeds such as bent grass. If so, constant cultivation must be the rule. Fallow land must never be allowed to become a source of weed seeds.

Seed Collection and Storage:-

Forecasting seed crops:- Foresters should observe and record the flowering and fruiting of the main tree species in their districts each season and be prepared to estimate the probable abundance of the seed crops. Such estimates enable deficiencies in one part of the country to be made good elsewhere.

Annual collection programme:- This is laid down from year to year and the range of permissable costs for each kind is indicated. The programme is based on advance estimates of crops and costs. When employing collectors on piece-work rates it is advisable to give each his quota which must not be exceeded. Control of quantities is essential as money must not be paid out for seed not actually required. Employ the most reliable collectors available. The children often do the work cheaply but should not be relied upon too much. — Inspect — then pay.

Identity Numbers:- A record is kept of the source of each stock of seed which is given its own identity number, therefore, keep stocks separate throughout collection, cleaning, storage or despatch. Separate identity numbers are usually laid down for each species and for each forest or estate.

Seed required for experimental work must be

identified more closely according to the actual wood or plantation from which it is gathered and this practice is to be recommended where practicable for more general collections.

Stratifying Pits:- Pits are required at most nurseries for stratifying the seeds of certain species. Select the site with care, it must be well drained. A depth of 3' is normally sufficient; the bottom 6" should be filled with rubble to ensure good drainage, whilst the top 6" is required for the top covering of pure sand. A width of 3' is normally ample. The pits may be as long as required, any position not in use or required for another species may be divided off with a wooden partition. Pits wider or deeper than specified are unsuitable for small quantities of seed. The sides and ends of the pit should be lined with boards and as these are continually exposed to conditions favourable for decay, they should be creosoted before use. Boards at the top and bottom are desirable but not essential. Where mice or squirrels are troublesome the pits must be lined with fine wire netting not larger than 3/8" mesh. Small quantities of seeds are best stratified in large flower pots which may be plunged in the sand of an ordinary pit.

Mixing with Sand:- As it is seldom possible or desirable to separate the seed from the sand before sowing, the sand selected should be clean, sharp and free from silt or any tendency to cake. Enough should be used to keep the seeds apart from one another. Sand varies in weight for a given volume according to its moisture content. A careful record of the weight of the seed used in

in each portion of the pit should therefore be kept in order to estimate the quantities at sowing time.

Conifers:- Cones should preferably be collected from fellings of good mature trees. Exceptionally a collection from immature plantations may be necessary, but in such cases one must make sure that the trees are of a good strain or type, and that the cones actually contain enough sound seed to justify collection. The season for collecting the commoner varieties extends from October to March but varies with species, season & locality. Begin collecting in autumn when cones show signs of ripening eg. by turning grey or brown. Stop collecting in spring when a substantial proportion of seed is escaping owing to the opening of the cone scales. These remarks apply particularly to the Pines, Larches, N. Spruce and Douglas fir. Where the time of collection can be chosen it is best left until late in the season so that fully ripened seed may be secured. With the Silver firs, Tsuga, Thuya, cypresses and Sitka spruce the interval between ripening and seed fall may be very short, lasting for two or three weeks only. Close observation and prompt and speedy action are therefore needed to gather good seed before it is dispersed. Before collecting, examine a sample of the cones, but through specimens to see what amount of seed is present. Each cut should reveal three or four seeds. Apply a further cut-test to a sample of seed, cutting each grain across to see whether it contains a firm white embryo. Cones smaller than the average for their species seldom give a useful proportion of sound seeds. Once paid for store them in

a cool dry place protected from rats or squirrels. As soon as sufficient quantity is available despatch to the appropriate extraction station. Complete and accurate labelling is important; a second label should be inserted in each sack as well as that on the outside. Details are to be given of quantity species and sources. Do not delay despatches until your whole collection is complete. The extraction stations require a steady flow of supplies in order to get through their work. The months for collecting each species stated below are those that normally give best results.

Scots Pine:- Home collection is the principle source of Scots Pine seed. Select well grown stands of good form and height growth. Avoid stunted and much branched forms and scrub-pines generally. If it is necessary to collect from young plantations select if possible those known to be grown from seed of an approved origin. Scottish strains are usually preferable to those of continental origin, and seed from the W. of Scotland should be reserved as far as possible for use in that area. Collect from January to March.

Corsican Pine:- Seed is normally imported. When home collection is required select good stands of true type. Avoid all Austrian, Calabrian or Maritime forms, distinguished by their shorter, straighter, harder and sharp-pointed needles and much branched habit of growth. Collect from mid Dec-March.

European Larch:- Home grown seed is usually preferred to that of continental origin. It is only worth while to collect well filled cones as otherwise the percentage of good seed is too low. The usual cut tests should be made. Husking machinery is

normally required for large scale extraction. Collect from Oct. – Jan.

Japanese Larch:- Seed is usually imported. No special types are recognised amongst home grown stocks. Collections can be made from Oct. – Jan.

Hybrid Larch:- Demand for seed of the Dunkeld Hybrid larch exceeds the supply and all useful cones should be collected. Collect from Oct – Jan.

Douglas Fir:- Seed usually imported but home collection is occasionally possible. Young plantations sometimes produce well filled cones. Avoid Blue or grey forms. Reject seeds damaged by DF seed fly, viz, (Megastigmus spermatrophus). Its presence is shown by exit holes in the empty husks. Stratify for light to ten weeks prior to sowing, normally from Jan – April. Collect from Oct – Feb.

N. Spruce:- Home collection is important although a proportion is imported. No types are generally distinguished as yet. Examine cones carefully for damage by seed-eating grubs viz. megastigmus (Spermatrophus) and reject any so damaged. Collect from Oct – Dec.

Silver Firs (Abies species) Collection must be carried out in early autumn before the cones break up. Seed is normally imported and fellings rarely occur. Young plantations occasionally bear accessible cones. Cones ripen in the year of their formation except those of European Silver Fir (A. Alba) which require 18 months to ripen.

Cypress + Thuya:- Fertile cones may frequently be obtained from young open grown specimen trees. Collect as soon as ripe in September or shortly

after. Nootka cypress requires stratification for one year prior to sowing.
Cedars:- Cones ripen in their second year and may be stored dry.
Tsuga:- Young plantations may yield fertile cones. Only Tsuga Heterophylla is normally required. Collect as soon as ripe in September & shortly after. Dry storage is satisfactory for most species.
Pinus Pulke needs stratifying for one year
Pinus Contorta normally imported, requires stratifying for eight weeks prior to sowing, i.e., from Feb - April.
Methods of Storage:- Conifer seeds are generally kept at a central seed store in glass carboys sealed with wax. Red lead is added to the wax to discourage rats and mice. To avoid extremes of temperature the carboys should be kept on the lower floors of a stone-built barn or similar building. During the time between the arrival of the seed at the nursery and its actual sowing stratification, care should be taken to protect it from rodents, damp and extremes of heat and cold. Nearly all supplies of hardwood seed from home sources. Each of the main kinds requires its own method of collection and treatment as detailed below.
Oak:-
Types:- It is seldom possible to secure pure seed of either Pedunculate or Sessile species owing to the amount of hybridisation and mixed planting which occurs. The sessile type is preferable and seed from such stands should be kept distinct. Acorns of sessile oak taper towards the point and have unstalked cups. Avoid Turkey oak which

has hairy acorn cups. Oak is so variable in form that the selection of good type is a matter of difficulty. Seed from good open grown trees is acceptable, but scrub-oaks should be avoided.
Mast years:- are variable, good crops usually occur at intervals of three or four years.
Season & Method of Collection:- Collect from the ground beneath the trees from Oct - end of Dec
Storage:- Acorns must not be kept in sacks or large heaps or they will heat up and decay; spread them out on a stone or earth floor not more than 1' deep. Turn daily for about a fortnight until heating ceases, then leave them under cool moist conditions until required for sowing in Spring. A barn, shed or dairy cellar is suitable or a specially constructed pit.
After collection a certain amount of pre-germinat and outgrowth of tap root may occur. This seldom causes permanent damage provided it is checked by turning and partial drying off before growth has proceeded too far.
Beech:-
Types:- Collect from best type available, avoiding much forked trees and those with fluted stems.
Mast Years:- Variable and irregular, about every third or fourth year. Good years are so infrequent that collection is usually intensified when they occur
Season & Method of Collection:- Oct - Dec. Two main metho a) Hand-picking, price varies greatly with abundan of seed from a few pence to a shilling or more per lb. Insist on clean seed free from husks, empty seeds, stones, etc.. b) Sweeping and cleaning. Sweep up the seed where it lies plentifully on the clean

floor of the beech wood - some leaves, earth etc., is swept up at the same time but this cannot be avoided. Occasionally it is possible to clean the forest floor before the seed falls.

To clean:- Run the seed etc. through a winnowing machine as used by farmers. Adjust the screens so that the seed is extracted free from leaves and soil. The small amount of sticks, husks etc., which come through with the seeds may be removed by floating off i.e., put the mixture in a bath of water and the dross floats off. The good seed which sinks can then be recovered and dried.

Storage:- The best method is probably to store dry until Jan., then stratify until just before the seed begins to germinate usually, in March. Avoid very dry storage. Stratification with a moderate amount of sharp sand, dry or slightly moist is effective, but really damp conditions should be avoided. Protect against birds and rodents.

Oak:-

Types:- None recognised but much forked trees should be avoided. Mast years frequent.

Season + Method of collection:- Seldom collected green. Collection normally postponed until the seed is fully ripe in mid-autumn. May be gathered from the standing tree or picked up beneath it. Usually gathered as peace work.

Storage:- Stratify in clean sharp sand for 18 months before sowing.

Birch:-

Types:- Important to select seed from well grown specimens free from fluting. The Verrucosa type with many

twigs is preferred for dry conditions.
Mast Years:- Fertile seed is normally available every season.
Season & Method of Collection:- Catkins ripen rapidly usually about September but varying with season and locality. It is essential to gather them before they break up and seeds disperse. Picking catkins is a tedious process and time may be saved by putting fertile branches in a sack which is hung up to dry. The seeds then fall away. Quantities required are usually so small that 'piece work' is unnecessary. Do not pack closely or the seed may heat up.
Storage:- It is seldom worth while to clean the scales from the seeds which may be stored dry or stratified in moist sand until spring; best plan is probably to store dry until early January and then to stratify until germination begins about March. Daily sowings are advisable as the seed is apt to lose its germinative power.
Sycamore & Maple (Norway).
Types:- None recognised, but trees of good form should be selected.
Mast years - fertile seed is normally produced every season.
Season & Method of Collection:- Collect the winged seeds from the ground when they fall in autumn.
Storage:- Either dry or stratified in moist sand until the following spring.
Other Hardwoods. Sweet Chestnut - no types are recognised fertile seeds ripens in most seasons in the S. of Eng. and may be picked by hand from beneath the trees in Nov & Dec. May be stored dry or stratified

until spring. Requires careful handling to avoid heating or decay.
Alder:- The fake cones are gathered from the trees in Nov + Dec. drying in gentle heat releases the seeds which may be stratified or stored dry. Early sowings are advisable.
Wild cherry:- The fruits ripen about July and are gathered from the tree. The flesh should be removed from the stones which are stratified for sowing in the following (season) spring, alternatively, direct sowing may be practised.
Rowan, Whitebeam + Crab apple (Pirus). Gather the fruit when they ripen about Oct, extract the seed and stratify in sand for six months. Alternatively, the seed may be left in the fruit and stratify for 18 months.
Aspen:- Seeds are gathered from the tree as they ripen in early Summer and are sown immediately.
Elms:- Gather the seed in summer as soon as it begins to be blown by the wind and to lose its green colour. Sow at once, cover with sand and water frequently. The seed from the Wych or Scots elm usually gives satisfactory results but that from other species is uncertain.
Lime:- requires stratification for 18 months prior to sowing.
Walnut:- Stratify for six months.

Cuttings.

Poplars for forest planting are normally raised from cuttings. It is important to cut take from trees of a known strain, preferably grown in a stool bed where all stocks are identified and labelled. Avoid random cutting and the use of material of unknown or doubtful identity. The

same remarks apply to willows. Particular care is required to identify the true cricket-bat (willow) strain (Salix Alba caerulea.

Conifer Seed Beds:-

Attention to the details of proved successful technique is essential for the economical production of high quality conifer seedlings. Extra care in the seed bed stage is amply repaid by higher yields of useful plants.

Ground:-

Choice of Same: Normally, each portion of the nursery will be used in rotation but any areas subject to frost, poor drainage, extreme exposure to high winds or damage by summer storm water should be avoided. The site selected must have carried coniferous transplants at some previous period. Seedbeds are apt to fail on new ground, probably because mycorhyza forming fungi are absent; Fertility is of the first importance, it is a waste of time and money to attempt to raise seedlings on poor soil except in the case of wasteland nurseries to which special manurial treatments have been applied. A high humus content is very desirable. It may be secured by dressing with organic manures well in advance and by frequent green cropping.

Preparation of Ground:- The ground should preferably lie fallow for a few months prior to use. Cultivate it thoroughly during this period to destroy germinating weed seeds and secure a good tilth whilst at the same time working in any composts or manures that are to be used. A rotary hoe or similar mechanical tool as

particularly effective in securing a fine tilth during the final stages of cultivation. It also ensures the thorough mixing of soil, compost and fertilizers in the top 3 or 4" of the soil. Seed beds should be thrown up a few days before they are required for sowing.

Width of Beds:- 3'6" is standard; this gives 3' of clear surface allowing for width lost and left unsown at the edges.

Height of Beds:- This varies with soil and rainfall. 3" above alley-ways is ample in most districts. In high rainfall areas as much as 6" may be needed to secure drainage and surface wash. Allowance must be made for the natural settlement of the soil after throwing it up in beds.

Length of Beds:- As long as convenient 100' or more.

Relation of Beds to slope of ground:- Where, as is normally the case, the nursery lies on gently sloping ground the beds should be so arranged that they run along rather than up and down the slope if practicable. This lessens the risk of erosion during summer storms particularly along the edges of the beds. It also ensures that any wheeled equipment used can move on the level rather than up or down.

Width of alley-ways:- Min 1'6", at least 2' should be left where mechanical cultivators are used to weed the alleys as otherwise machinery will strike the stakes used to support the seed bed shelters. Mechanical weeding of alley-ways is much cheaper than hand work. Secure the finest possible surface tilth before sowing. The tools used for this purpose will vary with soil and weather. On light soils consolidation by rolling or stamping

may be desirable; the following method has been successfully used.

1. Plough as soon as possible, preferably before frost, leaving the ground ridged up in the rough.
2. Lay out main paths.
3. Cultivate with rotary hoe.
4. Mark out actual seed beds.
5. Throw up beds using top soil only.
6. Rake surface to a fine tilth with 12 tine steel rake forming a slight camber.

The Seed:-

Treatment of seed:- Most conifer seeds is stored dry and requires soaking before sowing. Stratification in moist sand for 12 weeks prior to sowing is recommended for D. Fir and Pinus contortal. Stratified seed needs no further soaking; if it begins to germinate in the pit it must be sown at once. It is usually pitted in early January for use at the end of March.

Soaking:- Dry stored seed should normally be sodked in water for at least 24 hrs. prior to sowing. One day is long enough for Larix, but with other conifers the period may usefully extend up to seven days, the water being changed daily. If for any reason it is found necessary to sow during a period of drought soaking is best omitted so that germination may be delayed until adequate soil moisture is available.

Red Leading:- Treat all conifer seeds with red lead whilst they are still moist before sowing. This discourages mice and stops the seeds sticking together whilst they are being sown. 1LB Red lead — 10 lb seed normally.

Weighing:- Before stratification, soaking or red leading seed should be made up into parcels of a known weight, eg., linen bags holding one or two lb. It is impossible to weigh seed accurately after such treatment.
Sowing Methods:- Both the drill and broadcast methods give good results in skilled hands and either may be adopted where it is found to succeed. There is some evidence that broadcast sowing gives the better results with Pinus and Larix which produce relatively large seedlings able to compete with small weed growth during their first year; on the other hand, drill sowing is preferable for spruces and other conifers whose small seedlings need intensive weeding in the early stages, and it also enables small hoes to be used for weeding the beds. With either method, avoid sowing to the edge of the bed, allow a clearance of 3" on either side to prevent wastage of seed.
Drill Sowing (Hand) The right equipment is essential for economical working and should be got ready in good time. The slatted roller is the best tool for forming cross drills. It bears slats 3-4" apart, 1-2" wide and 1/4-3/4" deep, the edges of these slats should be slightly levelled. A seed box slightly longer than the bed is wide should be used for holding the seed which is transferred to the drill with a grooved lath. A set of laths with grooves of different sizes is needed to allow for different sowing densities and sizes of seeds. Covering material is best applied with a grit box and grit lath. The usual dimensions of drill sowing equipment are, viz:-

Seed Box:- 4' long, 6" wide at top 3" deep
Seed Lath:- 3' 6" do. 2" wide, thickness, depth of groove, are variable.
Grit Box:- 5' do. 1' wide at top 1' deep.
Grit lath:- 3' 6" do. 3" wide, thickness & depth variable
Machine Drilling:- A method recently adopted with some success makes use of a 'Planet' or similar vegetable seed drill. To sow conifer seeds in rows running length wise up the beds it is essential to adjust the machine correctly and to employ an operator who understands the job. Under such conditions the work is done both cheaply and quickly. A similar tool equipped with a grit-box may be used for covering the seed.
Broadcast sowing:- Skilled workmanship is essential for proper distribution. The old fashioned cuffing board is a difficult tool to handle effectively and now that sand or grit is used for seed bed covering should seldom be required.
Time of Sowing. The best time to sow each species varies with locality and weather conditions; avoid droughts and sow frost tender species later than the hardier kinds. Otherwise, the earlier the seed is sown the better. Normal times in an average season and situation are early March D. Fir, late march Pines, Spruces. early april, all other conifers. Most conifer seeds germinate within twenty days of sowing. Sitka and Douglas may take up to forty days. Germination may be delayed by dry weather; all conifer seed should be sown by the end of April, none may be sown later than 31st May

in any year except with the director's consent.

Sowing Density:- The standard densities laid down for sowing seed of normal germinative capacity are given below.

Table of standard densities for sowing conifer seeds.

Species	Sq. yds per lb of seed average Quality DRILLS	BROADCAST	Normal % Germination Lab. Test	Depth to cover	average number seeds per lb
Pinus Sylvestris	75	55	90%	1/4"	75,000.
P. Laricio	50	35	55%	3/8"	32,000.
Larix Europaea	65	55	50%.	1/8"	70,000.
L. Leptolepis	80	60	50%	1/8"	100,000.
Pseudotsuga Douglasii	60	45	80%	1/4"	40,000.
Picea Excelsa	60	45	85%	1/4"	64,000.
P. Sitchensis	115	85	90%	1/8"	190,000.
Chamaecyparis Law.	55	40	45%	1/8"	180,000.
Cupressus Macrocarpa	40	25	35%	1/4"	73,000.
Tsuga Heterophylla	90	60	60%	1/8"	300,000.
Pinus Austriaca	50	35	65%	3/8"	25,000.
Pinus Contorta	90	75	90%	1/4"	140,000
P. Pinaster	30	25	80%.	3/8"	11,000.
Sequoias	20	15	15%.	1/8"	100,000.
Abies Pectinata.	40	30	50%	3/8"	10,000.
A. Grandis.	30	25	35%	3/8"	10,000.
A. Nobilis.	30	25	35%	3/8	15,000.
Picea Omorika	60	45	90%	1/4"	100,000.
Thuya Plicata	60	45	65%	1/8"	340,000.

Poorer seed must be sown more densely. The ground it requires may be calculated from the formula:-

Area for 1 lb of Sample A = Area for 1 lb of Normal seed X

$$\times \frac{\text{\% Germination of A.}}{\text{\% normal Germination.}}$$

The figures for normal seed may be taken from the table; the % germination of each lot of seed is obtained from the advice note which is sent with it. Advice notes usually give three figures; one refers to purity but this varies so little with coniferous seeds that it may generally be ignored. The other two give the germination and the first of these representing actual germination on test is the best guide to the probable germination of the sample. The second figure represents the proportion of sound seed which did not actually germinate on test. As conditions in the nursery are seldom more favourable than those at the testing station it is safest to ignore this second figure when calculating sowing areas eg., To find the best sowing density for Pinus Sylvestris seed with the following test figures.

Germination 70% + 5%.
Purity 98%. (true to species).

Ignore the purity figure which is too near 100% to make an effective difference. Ignore 5% and take 70% as the operative amount. From the table take the area for 1 lb. of normal seed which is 55 sq. yds b/cast × 70% given above ÷ 90 average lab. germination % stated in the table. Then $\frac{55 \times 70}{90}$ = 43 sq. yds for 1 lb of seed for this sample.

Avoid over crowding seedlings. Sowing too densely may result in a high proportion of plants being rejected as 'culls'. Such plants contribute nothing to the net out turn and raising them is a waste of seed and effort.

Covering Materials:- The choice of the right

material for covering conifer seeds has a very important influence on the yield per lb. Owing to transport difficulties, covering material is not supplied from any one, single source and those in charge of nurseries must make their own selection from local supplies. Cost is a minor consideration as the extra expense in getting the right stuff may be repaid many times over by a higher yield of seedlings.
Obtain supplies well ahead of sowing time. Usual sources are gravel pits, river beds, quarries and the sea shore. Sea salt does not harm but grit from old lead workings may be toxic.
It is essential to get sand or grit free from fine silt. This means it must be washed either naturally or artificially. Avoid any material that cakes and never use ordinary earth for covering. The best material for most nurseries is clean, sharp, silver sand such as Leighton Buzzard sand no. 2+.
Where high winds are liable to blow this away use fine grit with particles up to 1/8" dia. All covering materials must be free from lime; if any doubt exists they should be tested by putting a handful in a jar of pure vinegar when effervescence will show the presence of lime in a harmful form.
Seed of Sitka spruce and other small seeded species including N/Spruce, Hemlock, Thuya, Lawson cypress etc are not to be covered with local nursery soil except with the written authority of the director.
Method of covering:- A grit distributor i.e. a hopper on wheels with an agitator results and effects a big saving in costs of covering broadcast beds in a big nursery. Alternatively, the covering material may be applied with sieves which spread it better than

does the unaided hand though care is required to avoid covering the smaller seeds of certain species too deeply since the grit is apt to fall too quickly in patches.
In dry weather, a light rolling with a smooth roller has been found to aid germination.
Weeding:- Is a major item of expense in the production of seedlings. Aim to keep its cost down by using the right methods applied at the right time. Half the battle may be won before the seed is sown by proper cultivation and the avoidance of manures or composts containing live weed seeds. In practice it is difficult to avoid a crop of annual or ephemeral weeds on the seedbeds. Tackle these as early as possible. Frequent light weedings pay best in the long run and give the seedling trees the best chance of growth. Large weeds are difficult to root out without damage to the seedlings. Always hoe the weeds before they flower and seed.
The early and thorough weeding of first year seed beds is of the greatest importance in securing a high yield of plants for every pound of seed sown. There is always a tendency to leave it too late but the aim should be to get the weeds up before they have begun to check the tree seedlings. Ample labour should always be available and this calls for planning in advance.
The best type of tool to use should be determined by local experience. Narrow bladed hoes are often effective for working between drills; for drills from 3" to 4" apart a two inch blade is suitable.
Blow lamp Treatment:- The use of blow lamps for scorching weed seedlings before the conifer seedlings

appear is a standard practice for which equipment should be kept available at every large nursery. The blow lamps should be used before the main germination occurs and the loss of a few early germinating seedlings is not a serious matter. It is essential to keep the flame in constant motion destroying the green weed seedlings by scorching without burning the tree seeds. A safe flame is one that does not discolour a piece of cigarette paper buried ¼" under the soil.

Shelter:- Overhead shelter serves two purposes. It protects tender seedlings from frost damage and [though it is not fully effective against frost lift] and also sun scorch. Most kinds of conifers benefit from shelter when the shade temperature falls below 32° or rises above 70° F. a few are completely hardy whilst others such as Tsuga require continual shelter during their first season.

Practice varies in different districts owing to variations in climate but it is most unwise to take risks and the following general rules should always be observed:

Always Shelter, Spruces, Larches, Tsuga, Silver firs
Shelter whenever there is a risk of frost or sun scorch
Douglas, Thuya, Lowsican, Lawson Cypress, miscellaneous conifers.
Shelter unnecessary Scots Pine.

When to shelter:- Seedlings pass through their most tender stage when they germinate. A few hours of hot sun or sharp frost may kill millions in the delicate cotyledon stage. Make sure therefore that shelter is ready when germination is due ie early in April.

Later on sheltering may be restricted to the hotter hours of the day but in practice it is rarely possible to remove and replace all the shelters at a large nursery. Once the hardier species are well established shelters may be removed <u>provided</u> weather conditions are normal.

Types of shelter:- The lath shelter is the most satisfactory and economical under most conditions but in the W. of Scotland where the rainfall exceeds 60" per annum, it causes difficulties due to drip. Under such conditions a tent-like framework of spruce branches stuck in the ground and arched over to meet above the bed is satisfactory.

Wherever frost damage to small seedlings is anticipated in the autumn, winter and spring following sowing the overhead shelter should be restored before the first ground frosts occur.

Where a nursery lies on sloping ground serious harm may result from cold air moving over the beds on still frosty nights. This can be checked by placing a row of fascines down the pathways between every third bed so obliging the air to move over the shelter instead of beneath it.

Where the beds happen to run up and down the slope fascines placed across the ends of the beds in a continuous row will have the same effect.

If lath shelters are found to be insufficient by themselves they may be augmented with branches etc.

Standard size of lath shelter:- Rolls 30' long x 4' wide. Laths 4' long x 1" wide x 1/4" thick. Space between laths 3/4" No. of wires per shelter six each 34' long. Total length of wires per shelter 204'

Supporting wires No. 8 guage [546 yds per cwt.]

Staples 1½" [59 weigh 1 lb]. Pickets wood 3 to 4' dia., 18" long spaced 16" apart [< iron pickets are satisfactory and take up less ground; a notch must be cut in them to carry the wires].
Lath shelters are best made where a proper machine is available but repair work can be done at any nursery preferably under cover as a wet weather job. The quantities of shelter required at a large nursery are enormous but it is false economy to try to manage with a small supply. A sudden drought allows no time for improvisation. Estimate requirements well ahead and have the full quantity of shelters, wires and pickets ready at the start of the season.
Watering Seed Beds: Watering is normally limited to periods of exceptional drought. Once begun it must be continued till the weather breaks. Thorough soaking repeated at intervals of two or three days is most effective. Light waterings even if frequently repeated are of little avail.
When seeds that have previously been well soaked are sown reasonably early in soil that is already moist subsequent watering is seldom required. But if a spring drought follows the sowing watering is advisable in order to lessen losses arising from a check in germination. Provision for watering should therefore be made in advance of seed sowing as it is impossible to forecast such droughts. It is preferable to water late in the afternoon and when the sky is overcast though in practice, it may be difficult to limit operations to such periods.
Shallow rooted species such as Spruces benefit most

Pines, Larches and Douglas have deeper roots and only require watering in the most extreme drought conditions.

Equipment:- Watering by hand is uneconomic and seldom possible for any large scale.

Mechanised fire-fighting equipment is suitable and where water mains are available their use should be considered as the expense of using a metered supply may be more than justified if valuable plant stocks are safeguarded thereby. Sprinkler nozzles are essential; the revolving type used by green keepers is effective where large areas have to be watered. Methods are now under investigation and further information will be issued when the best technique has been determined.

Protecting seed beds See also Sec. 4 Chap 2 insect pests & Chap 3 II Fungal diseases.

Frost lift:- This may do severe and large scale damage to spruce and other shallow-rooted species during their first winter after sowing. It may occur at any time from Nov – April and is usually most serious in the spring. It is apt to be worst on heavy soils; damage may be minimised by a) early sowing.

b) securing vigorous growth the first year so obtaining sturdy, deep-rooted seedlings.

c) efficient draining of seed beds,

d) Maintaining a high humus content in the soil.

e) Overhead shelter.

f) Where serious damage is anticipated covering the beds with straw or leaf-mould.

g) never forming conifer seedbeds on any portion of the nursery which is known to be particularly

susceptible to frost lift, eg. because of water-logging in winter or local concentration of frame frost. Attempts to rescue frost lifted seedlings by lining out have seldom justified the cost and trouble involved. All too often the frost has damaged the roots and rendered recovery impossible. Prevention is therefore far better than cure.

Rain storms: Summer storms may wash out portions of seedbeds. The risk is naturally greatest on sloping ground and although it can be lessened to some extent by terracing the beds along the slope, local peculiarities in the ground formation may make other precautions advisable. The nursery drainage system should be planned with this risk in mind and in some units it may be necessary to dig open drains round or through large areas of seed beds; such drains may be permanent or temporary but, in either case, they should be so sited as to interfere as little as possible with mechanical equipment. Beds should be raised an ample distance above ground level at all known or suspected danger points. Storm-boards 9" wide and of any convenient length may prove effective in controlling the flow of storm water into channels where it will do little or no damage.

Wind Storms:- On nurseries with light soils in exposed situations high winds may remove both the seed and its covering material from the beds. Preventive methods include
a) Provision of hedges and shelter belts
b) use of large grit as covering medium.
c) covering the beds directly after sowing with seed bed shelters either on wires or laid as a temporary measure flat on the ground.
d) erection of wind boards about 9" high along the

windward side of seedbeds.

Birds:- Damage to conifer seed beds by birds is only occasional and local but when it occurs, it may prove very serious as the birds become persistent in their attacks. This damage takes one or more of three forms a) the seeds themselves are eaten before germination b) the tender cotyledons are eaten as soon as they appear above ground c) the seed bed is disturbed by the birds making dust-baths on its surface.

The birds mainly responsible are chaffinches, green finches and sparrows. On a large scale, scaring from dawn to dusk is the only remedy. Small areas of beds may be enclosed with wire netting; the cost of these measures is justified provided they are only taken when really necessary. Very often attacks are limited to short spells of dry weather and once the seedlings become well established the birds ignore them. Attacks at the cotyledon stage are often confined to one species - eg. Austrian Pine may be wiped out whilst Scots in neighbouring beds remains untouched. The use of protective netting may therefore be restricted to one or two species. At other times of the year the finches and sparrows are beneficial to forest industries as their diet includes insects and weed seeds. Insect eating-birds such as fly-catchers and warblers are still more useful and should be encouraged to nest in hedges or nest boxes.

Mice:- Mice may attack seed despite red-leading. The only remedies are trapping, protection netting and the encouragement of hawks etc.

Moles:- moles may ruin seed beds by burrowing through them. Trap them with spring traps. A poison

called "molrat" may also be applied externally to worms which are placed in the runs and subsequently eaten by the moles.

Deer, Hares and other livestock:- In districts where occasional deer or hares occur it may be necessary to extend the nursery fences above the normal height of height 3 ft. Every precaution must of course be taken against trespass by rabbits and livestock by sound fencing and attention to gates.

ages for lifting seedlings:- Questions of supply and demand usually determine at what age seedlings stocks are to be lifted. as a general rule the following species are normally grown to a useable size in fertile nursery soil in a single season:- Scots, Corsican pine, Larches and Douglas. The pines are also satisfactory at the 2nd year stage but too large for use if left to stand for three years. In the richer nurseries however, the larches and Douglas tend to grow too large if left for a second season and therefore should be lifted after one year's growth, while other conifers such as the spruces have to be left for a 2nd year, modern technique aims at lifting all plants after one year's growth.

Lifting & Handling:- Every care should be taken in lifting seedling conifers. The ground should be thoroughly loosened with a fork before the plants are raised. Culling is best done after grading but any obvious culls are best rejected at the lifting stage; it is not worth while to count such culls. Culls will include plants with severely forked stems, those lacking any definite leading shoot and undersized specimens generally. Ploughing out seedbeds in order to lift the plants with a minimum expense has proved satisfactory in some nurseries. The mould board

should be removed from the plough and the share set at the right depth to avoid damage to the roots.

Boxes for seedbeds:- Seedlings should not be bundled until after grading and the handiest way to transport them is in wooden boxes 2'6" long × 1'6" wide × 7" deep with holes in the ends to serve as handles. These boxes are easily carried by hand or on barrows or lorries. They keep roots moist, protect seedlings from damage and save the expense of 'heeling' them in for short periods.

Grading:- Unless a stock of seedlings is exceptionally even, it is worth while to grade them. Grading is work that may be well done on wet days under cover and adequate shed-room with trestle-tables provided to allow workers do it efficiently. In the absence of any special instructions for a particular batch of plants, two grades of useful plants should be formed ie.

Grade 1. Over half the maximum size.
" 2. Under " " " "

All culls should be rejected at grading, they may be destroyed without formality. When seedlings are to be sent from one nursery to another grading is normally done at the despatch centre but the receiving nurseryman may specify any particular sizes preferred.

Chapter V.

Hardwood Seedbeds:- The different kinds of hardwoods require varied treatment in their seedling stage and it is essential to study and apply the methods appropriate to each. With most species the aim should be to raise a seedling fit for transplanting

after one season's growth. Fertile soil is therefore a first essential and composting of the beds prior to sowing may be well worth while. Sowing Methods:-
Broadcasting in Beds:- This is the most useful method for most species. The beds are prepared precisely as for conifers (see Chap. 4). Small seeds may be covered with sand or grit in the same way as conifers but an earth covering is essential for large seeds such as acorns.
B/casting in Bands:- Bands are narrow beds about 6" wide with 6" alleys between them. This method requires a good deal of ground and should only be adopted under special circumstances. Its chief merit is that the tap-rooted seedlings such as oak are readily undercut if they have to stand over for another season, but if attention is paid to nursery fertility it should be possible to lift such seedlings after the first year.
Drill Sowing:- This is not a normal procedure for hardwoods and should only be adopted in special cases as with the smaller seeds and seedlings.
Dates of sowing:- As much as possible of the hardwood seed be in before the end of March. No hardwood seed should be sown later than April 30th in any year except with written consent of the director concerned.
Sowing densities:- The following table summarizes recommended densities expressed in running yards of beds or bands per lb of seed, for the principal species, depth of cover is also given.
P. In practice it is difficult to cover seed uniformly to a depth of 1/2". Satisfactory results have been secured by pressing the seed into the surface of the bed and then watering and shading until germination occurs.

Species	lb of seed to yards of 3' band (sq yds)	6" Band	Depth of cover (inches)
Oak	1	2½	1
S/Chestnut	1	2½	1
Beech	4	16	¾
Red	12	30	½
Sycamore	10	25	½
Norway maple	10	25	½
Birch	30		⅛ P.
Alder	30		⅛ P.
Aspen	25		Nil.
Walnut	4		1½
Elm	6		⅛ P.
Wild Cherry	5		½
Rowan	22		¼
White Beam	8		¼
Crab Apple	8		¼
Mixed fagus.	22		¼

Shelter:- although it is possible during normal seasons and in most situations to raise satisfactory crops of hardwood seedlings without overhead shelter the need of this precaution should never be overlooked. a combination of early sowings and late frosts may prove disastrous. Light shelters used for ~~[illegible]~~ conifers are effective and a sufficient quantity should be secured in advance wherever frost is likely. Beech suffers more than any other hard wood from frost damage in the seed bed particularly in the cotyledon stage and sheltering must be regarded as a routine measure. Oak, Red and other hardwoods are susceptible to hard frost while even Birch may be destroyed at its cotyledon stage.
Watering:- This is an exceptional procedure for broadleaved seedlings but may be required to help

the smaller sorts such as Birch and Alder during periods of drought.

Treatment of Individual Species:-

Seed Oak:- Acorns are normally stored under moist conditions and such seed may be sown straight from the store. The presence of pre-germinated tap roots is not a serious defect of the seed is otherwise sound as side shoots are readily formed. Dry stored acorns should normally be soaked in water for 24 hrs before sowing. Acorns are sometimes treated with paraffin and red lead prior to sowing to discourage birds and mice but this is not an absolute safeguard.

Sowing:- March is the best month. Beds should be prepared by drawing back the soil with the spade replacing the earth after sowing. Leaf mould may be added if desired. It is worth while to place the acorns individually at about 1½" apart. Reject all unsound seed.

Protection:- Acorns may be eaten by pheasants, wood pigeons, voles, mice, rats and squirrels. Trapping & scaring are the best remedies. Mouse netting 2' wide ⅞ mesh, 25 guage with the bottom sunk 6" in the ground and the top turned over. Is useful for small areas but too expensive to adopt on a large scale. Spraying to prevent oak mildew is a normal practice in most summers (see sec. 4. Protection fig 3.2.

Lifting:- The spade is the best tool for lifting and then any deep going tap roots are then cut cleanly through and the plants are raised without damage. Under cutting is advisable when ever seedlings have to be carried forward to a second season.

Sweet Chestnut:- The seed is difficult to store and is apt to lose germinative power if kept too dry. Careful stratification of selected

seed is probably the best method. Sowing etc. same as for Beech: Seed: Seed stored under moist conditions is much to be preferred. Dry stored seed has poor germinative power and may even lie dormant for 2 months. If any seed is received it should be stratified in sand frost for mat. failing that, be soaked for 24 hrs. prior to sowing.
Sowing:- Beech responds well to a soil with a high humus content. Seeds are too small for individual sowing and careful broadcasting is essential for even distribution. Early april is the best time for sowing, but if overhead shelter cannot be provided sowing should be postponed till the end of the month.
Protection:- Lath screens are used against frost from sowing to the end of may. Against animals and birds treat as for Oak. Damping off may occur in the cotyledon stage. (Sec 4 3 11)
Lifting:- Seedlings may be large enough to lift at one year under optimum conditions.
Ash:- Is best sown as taken from the stratifying pits after 18 months storage. It is not necessary to remove the sand.
Sowing:- Fertile soil is essential and land that has been dressed with farmyard manure during the previous season is to be preferred. It is useless to try to raise Ash on poor soil. Protection from frost advisable if sown before end of April.
Lifting:- Useful ash seedlings may sometimes be obtained at the one year stage but two years is the normal seed bed period.
Sycamore + Norway Maple:- Stratification for six weeks before sowing has given good results. Dry stored seed should be soaked for 24 hrs. previous to sowing. The subsequent treatment of both species should follow that of Ash. Both species respond well to fertile soil.
Birch:- Should be stored dry until January then stratified

in moist sand until April.
Sowing:- A fine seed bed is very important. Broadcast the seed thinly over raised beds and cover very lightly with fine sand. Earth is definitely unsuitable. Overhead protection from frost is advisable at the cotyledon stage but unnecessary thereafter. Dry weather may delay germination which can be hastened by thorough watering. Frequent waterings encourage growth throughout the season.
Lifting:- Two years in seed bed normally necessary exceptionally, seedlings large enough for transplanting may be raised in one year.
Alder Seed:- Soak dry-stored seed for 24 hrs prior to sowing - Stratification has been found beneficial in some instances but the results are uncertain.
Sowing:- The general treatment should follow that of birch unless the ground has previously been used for alder. It is probably advisable to add a small quantity of soil from a stand of alder trees. Sowing in March appears advisable as the seed loses germinative power if stored for too long. Beds sunk below the general level of the ground have given good results.
Aspen:- Must be gathered as soon as it is ripe it may dried under cover and shaken out from the catkins.
Sowing:- The seedbeds should be prepared as for birch. Sowing must be done as soon as the seed is ready. The seed is pressed into the soil but not covered in any way. Watering and close shading are essential in the early stages. Seedlings are usually large enough to lift after one year.
Walnut:- Seed should be stratified from Autumn until early April and removed from the pits when on the point of germinating.
Sowing:- Ground should be liberally treated with farmyard manure at the rate of 30 tons to the acre. The seeds are

sown individually with dibble 1½" deep, spaced 6" apart x 12" between rows. The seedlings remain undisturbed for two seasons.

Elm :- Only the Scots or Wych elm is usually grown from seed. This is best sown as it ripens, failing that, it may be stored until the following March; thereafter, it loses its germinative power.

Wild Cherry :- Best method is still to be determined but satisfactory results have been obtained by rasping off the pulp and stratifying seed for six months. Alternately, direct sowing may be practised.

Rowan, Whitebeam & Crab apple :-

Either extract the seed by pulping and sieving and stratify them for six months or else leave the fruits in tact and stratify for 18 months.

Mostly Pages :- Seed should be stratified, general treatment may follow that of Beech.

Lime :- Seed should be stratified for 18 months.

Other Hardwoods :- Special instructions should be sought in each particular case. The research branch has had wide experience in raising the less usual species.

Poplars & Willows.

Cuttings :- The following methods have been found most satisfactory. Cuttings are taken in autumn or winter from stool beds or standing trees. One suitable source of material known as top consists of branches removed during pruning or after felling; it may safely be sent to a distant nursery if despatched in the full length.

Cuttings should be prepared just before they are required by cutting out lengths 1' long and about ¼" dia. at the base preferably, of the current years growth. Each cutting should end at a bud and the thin tips of twigs should be discarded. The cuttings are struck in rows 12" apart

with 9" between each being set deeply so as to leave only one bud showing above ground. If more than one bud develops the others should be pruned off.
After one growing season, the rooted cuttings are lifted and stumped by cutting back to within a few inches of ground level. They are next lined out in good ground spaced at 3' x 2', only one shoot is allowed to develope from each and after two years this should be 8-10' high. The lower side branches should be removed by disbudding or pruning, and the upper ones shortened before transplanting. Particular care is needed when removing large trees with their extensive roots which require protection with straw or bracken in transit. Pit planting is essential and additional soil should be mounded round the stems.
Other species:- Certain ornamental and large shrubs such as Lonicera nitida and cotoneaster simonsii are readily increased by cuttings struck during the winter months. These should be lined out for one season before being used in their final position.

Transplant Lines.

Lining out on a large scale is a highly technical operation calling for careful organisation and attention to detail. The work must be done thoroughly to secure a high percentage of useful surviving plants but low costs are likewise important. The true cost is proportionate to the percentage of good plants that result, 80% is a reasonable figure. Fast work if well done and supervised favours success besides reducing costs.
Experiments in mechanisation may shortly lead to changes in customary procedure particularly at the larger nurseries. Further notes will be prepared when such methods become standardised
Ground for lining out:- Ground for transplant lines

must be freed from weeds and well cultivated to obtain the tilth aeration necessary for the formation of fibrous roots. Fertile soil is essential for the production of sturdy transplants. A high humus content makes for easy working under difficult weather conditions and promotes the desired type of growth. Cultivate the ground well shortly before work begins, hard compacted ground leads to slow and costly work. a good depth of well cultivated soil is the first essential.

Seedlings for lining out:- Grading is essential for normal stocks. It facilitates handling, produces more even grades of transplants and reduces the time taken in stocktaking. Two grades are the rule as under

Grade 1. Plants above have maximum size.
Grade 2. " below " " "

All culls being puny, undersized, stunted, malformed or badly forked specimens should be eliminated. Exceptionally even lots of seedlings may be lined out ungraded.

Grading is best done under cover providing suitable work for wet weather. Under such circumstances some form of heating is frequently essential to enable the workers to carry on with reasonable efficiency and comfort; but the roots of the seedlings should never be allowed to dry. When once they are graded return them to a cool moist place, well away from hot stoves. Undue insistence on precise sizes when demanding seedlings may result in high grading costs as well as the rejection of good plants that happen to lie just outside the set grades. Remember that grading is a means to an end and never an end in itself.

Occasionally a stock of plants that appears unsuitable for lining out may arrive from a distant nursery. They may be over or undersized, contain a high proportion of culls, show evidence of disease or have suffered from frosting or heating

in transit. You should at once report the arrival of plants which you consider unfit for lining out and you should ask for instructions as to their disposal.
The handling of stocks from the time of lifting until lining out is actually done requires careful attention. Roots must be protected throughout from frost and drying winds either by heeling in or by keeping in boxes.
Root pruning is sometimes desirable before lining out but it should be regarded as an exceptional operation needing close supervision.
Season for lining out:- The lining out season now extends from the end of September until the end of April.
The best times cannot be laid down by hard and fast rules owing to local variations in climate and weather. On the whole, the earlier the work is done the better. Avoid late lining out particularly in districts where spring droughts are frequent. In high rainfall areas [W. of Scotland] early spring is probably the most suitable season.
In some districts and on certain soils small seedlings are liable to frost lift if lined out in autumn. Damage may also be done by heavy snow which can flatten small plants until their roots become exposed. Where such damage is anticipated autumn lining out should be restricted to the larger seedlings ie. the first and second grades of good growth. Lots which are small throughout or include a high proportion of second grade seedlings should be stand over until the spring. The following species require special attention:- Beech, early lining out is recommended begin in Oct. as soon as the leaves start to turn brown.
Scots Pine:- is apt to flush early in the S.W. line out before April. Corsican:- Line out before the end of February preferably in showery weather and on the same day as the seedlings are lifted. Larches:- Line out before the needles

flush. This occurs in late February in the S.W. and early in March further north.

Layout & spacing:-

For large-scale work, particularly where machinery is employed, economies are secured by long lines. The breaking up of lines by frequent paths wastes ground & causes delays, but paths 100' apart may be needed to facilitate extraction of weeds. The space left between the lines is governed by the method of lining out especially, where machinery is used and by the tools used for weeding. Normal distance is 9" to 10"; 2' apart should be regarded as the standard distance in the lines with 1½" as the absolute minimum. Closer spacing only results in a larger proportion of culls. Large plants such as re-lifted transplants of well grown seedlings of Oak etc. should be spaced 3' or even 4' apart. Cuttings are normally spaced at 6".

Max. no. of plants lined out at various spacings at 10" between lines.

"apart in lines	Plants per sq yd.	Plants per acre.	sq. yds required per 1000 plants.
1½	86	387,000.	12.
2	65	314,000.	15
3	43	193,000.	24.
4	32	157,000.	30
6	21.	96,000	48.

Lining out methods:- The open trench method or one of its variations is generally employed. Lining out in slits or dibbling in has usually proved less satisfactory. Plants may be set in the open trench by hand or by the use of boards

Lining out boards:- length should not exceed 10' where possible, the length of the line should be a multiple of 10' so that shorter boards are unnecessary. Material for

boards should be well seasoned deal ½" thick. Designs have not been standardised but the usual type requires three pieces of board. The main board is 4" wide and the closing board 3" wide is attached to it by hinged iron rods and fastened with a moveable iron ring on a chain. The spacing board should be 2" wide and secured to the main board by screws. It is the most readily damaged part so should be easily replaceable, notches should be 2" apart, centre to centre on one side, and 1½" apart on the other. By unscrewing and reversing, it may then be used for any of the four spacings, 1½" 2", 3" or 4". Ash wood has been found very satisfactory for spacing boards; rubber draft tubing of ⅞" dia. with a canvas flange may be tacked to the closing board which protects the plants from injury.

Trestles and Shelters:-

Ample trestle supports for holding the boards during filling and shelter screens for protecting them from drying winds must be provided. They should be of substantial materials so that they can be used for several seasons.

Trestles 30" high, shelters 7' high x 12' long with two side wings, each 6' long; upright members are 1¼", steel tubes with a 9" dia. base-plate below which two steel prongs descend into the soil to hold the structure firmly. Horizontal members are wooden bars 3" x 1¼" secured to the uprights by eye bolts. Hessian, replaceable is tacked to the wooden bars. Duckboards are necessary to prevent compacting of the soil where the boards are filled.

Protection of Roots:-

It is essential to keep the roots moist throughout the whole process of lining out. Keep the plants 'heeled' in conveniently close to the work. In dry weather, it may be worth while to stand them in a bucket of water and earth puddle whilst the filling of the boards

are in progress. Troughs may be used to moisten the roots after the plants have been inserted in the boards. Quick work lessens the period between lifting and covering over and reduces drying out.
Organisation:- See that the right proportions are maintained as between diggers and board fillers. On long lines sometime of the whole gang is lost if the lining out is always begun from the same end of the bed. By lining out on two parallel lines a short distance apart the work can proceed from both ends; no time being lost in walking back to the starting point for the process is continuous in a rotary fashion
Common faults:- a) trenches too shallow. Make sure that the trench is always cut to the right depth and avoid any bunching or bending of roots.
b) trees set slanting, this arises from shallow or carelessly cut trenches. Although the shoots may straighten up, the tree retains a permanent bend at ground level. a straight back to the trench is essential
c) Incorrect depth due to careless filling of boards, small plants tend to be set too deeply.
d) not firm enough, test by pulling sample plants.
Mechanisation:- a horse drawn plough can be used to throw up a portion of the earth against the plants but hand labour is still required for firming it up and cutting down the next trench.
Weeding lines:- a wheeled hoe of the 'Planet' type is a useful labour-saving tool. It can be adapted in various ways to suit the type of crop and is most effective for frequent light weedings.
Weed early and often, never let weed growth reach the stage where expensive handwork is necessary to eradicate large weeds. Early, clean and

thorough weeding is always the cheapest. It enables one worker to cover a wide area quickly, prevents the weeds from seeding and avoids the expense of carting away and destroying a big bulk of weed growth and the removal of fertile top soil. Constant hoeing and cultivation is a safe-guard against drought. The number of weedings required each season varies with soil and weather, three or more weedings are usual.

Spraying:- In moist summers the spraying of transplants is sometimes required in the following cases:-
European larch for Mesia and Oak for Mildew.

Ages for lifting:- In a fertile nursery pines, larches and Douglas fir are normally lifted after one year in the lines; pines should seldom be retained for a second year. Spruce often require two years in the transplant lines but it is undesirable for them to remain three years. Aim to grow good +1 transplants as these are produced more cheaply and quickly than slower grown +2 stocks.

Lifting transplants:- Either spades or forks may be used but it is essential to dig deeply; avoid damage to the roots, especially in the case of Corsican or Scots Pine which strip their roots very easily. If the transplants cannot be graded and bundled at once, heel in without tying up. Always ensure that roots have adequate protection against drying out.

Grading:- The sizes to which transplants are graded are usually determined by the requirements of the receiving forest. It is wasteful to spend further time on plants which cannot be used for forest work.

Holding plants over:- Stocks which cannot be used when they reach plantable size may be held over if desired by various methods. 1. Undercutting – for Oak and other tap-rooted species, the main roots are undercut with a sharp spade during the winter months.

Wrenching :- The plants are heaved up with a fork or spade to loosen the hold of the roots and then firmed up again. This should be done before spring growth commences. It should be done down both sides of the row unless the weather is very dry.
Cutting Back :- Exceptionally broadleaved trees, Douglas fir or even Japanese larch are clipped back to reduce shoot growth, this may be combined with wrenching.
Re-transplanting :- This is the best but most expensive method; it requires a great deal of ground and the check to root development may be greater than with wrenching.
Destruction of plants :- bulbs may be destroyed without special instructions; plantable stocks which cannot be used, sold or held over may have to be destroyed but precise instructions must be obtained.
Management, Records and despatch of Plants :-
Labels should have the following details :-
1. Nursery section number.
2. Species of tree
3. Identity number.
4. Either, age when lined out (transplants) or seed (seedlings).
5. Either No. in 1,000" (T) or wt. in lb (seedlings).
6. Year when sown or lined out.
7. Area occupied in sq. yds.

Despatch of plants :- Although economy is desirable in packing and transport of plants, due regard must be paid to their relatively high value and to the fact that in many cases they cannot be replaced if damaged. The best method therefore is not always the cheapest but the one that will ensure the plants arriving without loss of time or condition.
Essential conditions for the safe transit of plants are

1. Dryness of foliage, packing material & containers.
2. Avoidance of dryness at roots.
3. Adequate packing.
4. Ample ventilation secured by a) adequate packing as above b) avoidance of overcrowding.
5. Protection from rain, frost and snow.
The gravest risks are frost at the roots and heating.

Land Available for Planting.

The following types of land are generally those available for planting:-
1. Rough moorland pasture.
2. Moorland with good quality peat.
3. Old, felled, woodland areas.
4. Low lying, marshy or boggy land.
5. Sandy tracts near the coast.

There can be profitable afforestation and re-afforestation in numbers one, two and three above.
No. four is often productive after drainage and no. 5 can produce good results after the sand has been fixed.
The better classes of wasteland are often covered with broom, whin and bracken or scrub birch, pine, oak or mountain ash. Moorland in exposed uplands is often covered with heather, bent grass (molinia) mat and deer grass. Near peat bogs we find bell heather and cotton grass. If shelter and drainage are good, trees are likely to succeed.
In afforestation of wasteland, the plantations should be large as the cost per acre is less for fencing and management. Trees grow better in large areas because of shelter and because soil moisture conditions are improved. Planting around water catchment areas

eg. Liverpool corporation Vyrnwy gives a more regular flow, a cleaner flow because grazing animals are excluded, but it does not necessarily increase the rainfall.

Having acquired a new area to plant, the first thing to do is to get a 6" map of the area with contours on it if possible [contours being lines passing through points whose heights are the same above sea-level]. Mark the boundary of the area acquired with a yellow line. Go over the whole area and make notes as to the form of the boundary eg, walls, fences, ditches, streams or watersheds.

Find out which sections of the boundary are maintained mutually with the neighbouring estates. The position of the roads through the forest area should be marked out on the ground bearing in mind the possible method of extraction of timber, gradients and the type of ground over which extraction must take place. These roads are not made at first except to enable the forester to get plants on to the area. The main purpose of laying out the roads at this early stage is:-

1. To fix position of gates in fences [rights of way particularly]
2. To fix the layout of the drainage system.
3. In past years the layout of roads has always been neglected until crops become too high to see over and made layout far more difficult.

It may pay on large areas to make at least one road through the forest area at an early stage for fire control purposes and to get plants cheaply and ~~back~~ quickly nearer to the planting area. In other areas a track for a horse to take the plants on to the hill may be quite sufficient

read [T.N. Sec. 1 pp 13-15.]

The area should now be divided into compartments or at least, the planting area for two years ahead. This must be done on the ground using the map and not done in the office and then transferred to the ground as was done in some cases in the past. We divide an area into compartments for three main reasons:-

1. For ease of extraction.
2. For fire fighting.
3. For administrative purposes.

A compartment need not necessarily be made to include land which will require different species for planting. On fairly flat, rectangular or undulating ground the compartments can be more or less rectangular based on the extraction roads. On sloping ground the compartments are based on the extraction roads which have already been laid out on the ground. Triangular compartments provide the shelter band by bore or other means for the extraction of thinnings and if we have extraction roads running more or less at 45° across the slope of the hill. Triangular compartments can easily be laid out This is suitable for long even-sloped hillsides. Firebreaks or fire rides between compartments should run up and down the slope and they should use streams and rock out crops to make suitable points for stopping a fire or for starting to back fire. Firebreaks should be situated close to possible sources of outbreak. No definite size for compartments is laid down but fifteen to forty acres are suitable sizes. The main rides should run very nearly parallel to the prevailing wind; rides running uphill should not be straight for the sake of amenity and also for extraction purposes.

Fencing.

See pp 20-24 sec I T.N., pp 33-35 Forestry practice.

There are one or two points to be borne in mind when laying out a fence line.

1. If the boundary is a dry stone dyke keep the fence line back about 3' on the inside of the wall. The dyke being the actual boundary must be kept in good repair.
2. The same applies to a mound or bank of earth thrown up from boundary ditches, such mounds are certain to contain rabbits and are difficult to clean out.
3. Avoid as far as possible putting a fence across the face of a steep slope as this requires a higher fence to prevent vermin jumping it.
4. Avoid places such as hollows where the fence may be covered with snow in winter.
5. Where a fence crosses a stream find out the flood level and keep the strainer posts well back from such level.

There are many specifications for fences. Suitable specifications are given in the official publications and quantities required should be learned so that orders can be drawn up for any length of fence.

Deer Fences:-

A good specification for a wooden fence is as follows:-

Stobs – 8' or 8'6" x3"x3" at nine yd intervals.
Stobs – 5'6" x3x3 at 9' intervals.
Droppers – 3'6" x1¼" x1¼" at 3' intervals.
Plain wire 8 guage at 3", 4" 5" and 6" from the ground and each other.
Barbed wires at 6" & 7" above plain wires.
Plain wires at 9" & 11" above the barbed.
Barbed wire at 15" above plain.

If the fence is to be covered with rabbit netting at

the bottom and by sheep netting at the top, then the number of wires can be reduced and placed wider apart. It is often essential to erect a fence of iron material in exposed places where the soil is shallow and rocky, the following is a good specification for iron material required:-

Iron deer fence:-

Strainers type 1. wrought iron or mild steel tapered square sec. 1¾" x 1¾", total length 6'5", bored for wires at distances of 1½, 14½, 25½, 33½, 40½, 46½, 52½ 57½, 62½ and 67½ inches from the top. Lower 4½" prepared for batting in stone.

Strainers will be punched front and side for reception of ½" dia. stay-bolt at 18" and 21½" from the top.

Strainer type 2. Same material as 1 but not bored, but 4½" lower and 18" + 21½" from the top. This type of strainer will be fitted with slip on winder brackets.

Gate Pillars No. 1. Wrought iron as before, wire + stay holes as for strainer type 1 and fitted with crooks to carry the gate.

Gate Pillar No. 2. as for No. 1., no crooks. In this case the pillar will have a 3" slot bored for the reception of the gate slip bolt.

Stays for standards:-

Same material 1¾" x 1¾" x total length of 4'6". Lower 3" will be bent down to an angle of 45° and prepared for batting in stone. Head of stay will be flattened, rounded off and punched for reception of ⅜" stay bolt. Price to include stay bolt ½" x ⅜" for each stay ~~bolt~~.

Iron gate:- Same material. Size, 6' high x 5' wide with hinges to suit crooks on gate pillar No. 1 and slip bolt

to suit slot in gate pillar No. 2.
Strainer, winder brackets:- Same material to slip on strainer type 2. Square section 1¼"x1¾", double full. Price should include bracket wedge and winder stop pins. Double full – straight, double full – right angles.
Stays for strainers:-

Same material by total length of 6'4". Lower 3" will be bent down at angle of 45° and prepared for batting in stone. Top end bored for reception of ½" dia. stay bolt and flattened to fit front of strainer. Each stay should be provided with stay bolt 3¼"x½".
Standards:-

Same material, 'T' section, size 1½"x 1½"x¼" by total length of 6'4". Lower 3½" prepared for batting in stone. Leg of 'T' will be bored for reception of no 8 guage wire spaced from top at distances of 1½, 14½, 25½", 33½ 40½, 46½, 53½, 57½ 62½ and 64½ inches. Leg of 'T' will be bored for ⅞" dia. stay bolt at 35" from the top.

Starting from the top opposite the first, fourth and fifth wire holes, two holes will be bored on the flange for reception of No. 8x1½" fencing staple.
Erection of fence:-

Having chosen and cleared the fence line, the next job is to select the position of the straining posts which should not be too far apart.

The holes should be well dug and when the strainers are put in, the base should be packed with stones on the side opposite to the strain and at the top, a large stone sometimes called a 'Breast

stay should be put in on the side of the strain to prevent the strainer being pulled into the soft surface soil and out of the plumb. If necessary, especially at corners, wooden stays can be put in to support the strainer. The stay should be put in on the middle of the angle made by the two fences. Instead of this, a tie back of wire fixed to a short stob can be fixed on the outside of the corner. It is generally considered that a lot of stays are a sign of poor workmanship.
Having got the strainers in, the next job is to fix and tighten bottom wire. The only problems to be faced here are the crossing of ridges and hollows. In crossing hollows use longer stobs and allow the bottom wire to be pulled straight. Short stretches of extra fencing can be put in below the main fence. On ridges, the wire should be kept at the same level above ground all the way.
If the fence has to be covered with rabbit netting the track for the netting should now be cut and opened before any more wires are added to get in the way of the worker. Erect the remaining wires, lay out the netting, hang it to the top wire and staple it to the stobs then bury the bottom six inches of netting and cover it. The top barbed wire can then be strained and fixed to the stobs. In fencing an area for planting it is essential to enclose as large an area for planting as to reduce costs. It may be necessary because of lack of supplies or lack of time, to erect a permanent fence on 3 sides and a temporary one on the fourth side which will allow for the extension of the permanent fence at a later date. Field gate, water gate, stile for deer fence – see illustrations.

Preparation of the Ground.

Heather :- If heather is very rank it may, with the O.C's permission, be burned at least two years in advance. But the risk of such fire getting beyond control should not be taken if any young plantations are near at hand. Heather burning is also likely to cause the surface to become compact and deteriorate. This is avoided if the area is ploughed after burning and this is about the only time that heather burning would be allowed. Shelter from heather is beneficial to young plants if growth is not too strong.

Bracken:-

Some estates cut the young bracken fronds for two years in advance of planting and this greatly reduces the vigour of the bracken and reduces weeding costs after planting. Cutting or switching when the fronds are fresh, up to three weeks old has proved to be the most economical as far as labour costs are concerned. Often on West coast, rank grass growth follows bracken cutting and this must be considered before under-taking advance cutting on a large scale.

Broom & Whin :-

These should be cut in advance of planting and must be kept under control after planting.

Scrub :-

This generally consists of Oak, birch, hazel etc If the trees are scattered and straight they can be left on the ground and planted round. If they are short and scrubby they should be felled and the produce can be cut down so that trees can be planted through.

With fairly dense scrub we usually find that gaps or openings appear in it and these should be enlarged

with strips of good straight stems left as shelter. The strips can be about three to ten yards wide. The openings can be planted with the most suitable species which of necessity may be a shade bearer eg. Tsuga, Douglas fir or Monday spruce. In dense and younger scrub complete strips at least one chain wide, should be clear felled and leave strips of about five yard width for shelter. The material removed if in a fairly accessable spot may be sold as firewood. Care must be taken when planting not allow the young trees to be planted within a foot of old stumps, as the young trees will be smothered by coppice shoots. Paths should be made from one group to another so that no groups are overlooked in weeding ops.
If possible try to avoid 'girdling' or 'ringing' of trees, ie. the complete removal of a band of bark all round the stem and the killing of the cambium or growing layer. Trees which die as a result of this present an ugly blot on the landscape and it is preferable to fell the tree. If girdling must be done then the job should be done at the time when the sap is flowing and the bark easily peeled off and in a dry spell when it will dry off more quickly. In girdling oak it must be cut right through the sap wood. In clearing scrub areas one must strike a balance between the amount of felling required to give light to the future crop. The cost of the operation and the prevention of other herbaceous weeds from getting a hold on the bared ground before the planted trees get away.
Re-planting felled Woodlands:-
The first problem is to get the ground fit for planting as soon as possible with the min. expense and labour. Do not waste effort in striving for a perfectly clean forest floor as light debris does more good than harm.
Brush Wood:- clear this into gaps between the planting

rows if possible and do not burn it unless unavoidable. Burning is costly and is often overdone by the workers. Remember however, that where rabbits or weeds such as brambles or bracken are likely to prove troublesome, a reasonable degree of cleaning at the outside may prove best and cheapest in the long run.

Felled Timber:-

One often finds odd lengths of timber left lying after a wood has been felled. Spend no money on removing unsaleable material. It is better to plant a tree a few feet out of line than to spend several shillings on shifting useless material out of the way.

Derelict Woodland:-

The war time fellings have left some areas in a derelict condition with small poles or rough old trees scattered about. It is very seldom desirable to retain any of these old relics of the former crop. Oak and birch may be dealt with by girdling but beech and ash are best felled. Useless conifers should be felled and disposed of. If the logs cannot be economically removed, they should be rendered unfit for the pine beetle to breed in, by barking. The risk of damage by the pine weevil will however remain.

Prep. of Soil for planting.

Shifting sands or coastal areas:-

The surface movement of sand by wind, must first be stopped by forming a covering of turf, branches, heather or by planting sand grasses (Bent and marram). It has been proved that the best and most economical method is by covering the surface with brushwood. The old systems of sowing whins and broom has largely disappeared.

Wet Soils:-

Drainage is required on such soils. Trees vary

greatly in their demand for water. Some will stand a wide range of moisture although none will stand too much. The water in all cases must be fresh and not stagnant. On wet ground the failure of trees is due to

1. Want of air in the soil, roots unable to breath.
2. Bog or marsh means a low soil temperature
3. Incomplete decomposition of humus makes the soil acid-sour.
4. Frost lift is worst on wet soils.
5. Red rot is liable to occur because the root is apt to decay and this is most liable to occur where thin gravelly soil overlies clay soil, ie. gravel over a tenacious sub-soil.
6. Windfall often happens where excessive water is present due to an impervious layer in the soil through which the root cannot penetrate

Why we drain:-

In practically all soil, except in completely waterlogged soil, water will penetrate from the surface downwards to a certain depth. The depth at which a soil can receive no more water and becomes waterlogged is known as the 'Water table'. The plant roots are unable to penetrate below the level of this water table as there is no air in the soil. The benefits derived from drainage depends upon the depth to which this water table is lowered so that instead of constantly stagnant water a movement of both water and air is established in the soil around the drain.

Previously, only the portion not waterlogged was available for root growth but now a portion is available to a greater depth. Oxygen from the soil atmosphere is essential for the growth of plant roots so that in a waterlogged soil the roots are confined to a top layer only but after draining the roots can penetrate as far as the air extends.

In an undrained soil, the roots are confined to a shallow

layer which in dry weather is soon deprived of the water available for the plant so that, the plant may suffer greatly from drought. In a drained soil however, the roots are able to penetrate deeper thus more water is available for the plant and it will be in a better position to withstand a period of surface drought. This is probably the main reason why spruces are more suited for planting in wet places as they are shallow or surface rooters.

We drain also to make the soil permeable to heavy rains in order to prevent the soil becoming waterlogged. Wind throw occurs most often when gales follow heavy rains. If the soil is made permeable by drainage then there is less chance of wind throw.

The soil is composed of a very large number of very minute mineral particles in addition to larger pebbles and stones. These mineral particles may be of regular or irregular shape; between these particles in a well drained soil there should be air spaces and a film of moisture round the soil particles. In a water-logged soil there are no air spaces but the spaces between the soil particles are entirely filled with water.

We therefore drain soils on dry east coast areas not so much to get rid of the water as to break up the surface soil and aerate it. Some of our glacial deposits of boulder clay are so compact and hard that they must be broken up to allow tree roots to penetrate. In many such soils at varying depths below the surface we find a layer of soil which is bound together in a very hard and compact layer by an iron deposit. This is called pan or 'iron pan'. In draining such ground it is essential to penetrate this pan and when this is done there is a free movement of water both upwards and downwards by

capillary attraction and thus the soil is better aerated for tree root growth.

In order to improve wet areas we must first find the cause of wetness. If this is due to spring water it may be possible to catch the water where it rises and lead it off into a ditch to prevent it from spreading and thereby rendering an area too wet for planting.

The layout of the drains cannot be planned in the office because each individual area has its own problems of peat, slope, type of soil (sub) etc. Drains should be made atleast one year in advance if possible in order to allow the soil to settle before planting time. Start draining at the lower level and work up to a higher level and avoid working in water by maintaining a run away. The whole drainage work including bottoming should be completed before planting starts. A drainage system of leader and feeder drains should be built up. The distance apart will depend on the amount of water to be taken away on the slope and on the porosity of the soil. Feeder drains should not be too far apart, on non peat areas from one to two chains apart on a fairly steep slope. The depths of drains will depend on the nature of the soil. In light land drains should be ⅔ wider at the top than the depth of the drain. In stiff soil the top width can be ¾ of the depth.

Feeder drains on peat 26'x24'x 14".
Leader drains on peat 36'x30'x 20'
Feeder drains on hard ground 20'x not less than 9"x 12".
Leader " " " " 32x30 x15".

Bear in mind, that water will always flow in the direction of the steepest slope and the best way to prevent this flow of water is to cut across the slope with as slow a fall as possible. Such drainage is called contour

drainage as the drains follow very closely to the contours. These contour drains are feeder drains running into a main drain or small stream. The feeders should enter the main drain at an angle of about 45°. We therefore have the following types of drains:-

1. Leader or main drains
2. Feeder or side drains which may be contour drains.
3. Trap or catch drains which run along the bottom of a slope and check the flow of water to the area below, like the eaves of a roof.

Wet soils with deep peat:-

Drainage of such soils is absolutely essential; the principle of drainage of such soils, which are usually found on the flat basins or on undulating ground in high rainfall areas, is the layout of a system of parallel drains of such dimensions and spaced at such distances apart that the turf from the drains provides a site for the plants at the desired planting distances. These drains must all open into a main leader and if possible should be dug through the peat and into the mineral soil for about 3'. In very deep peat this is not however, always possible.

These parallel drains are sometimes referred to as turf drains, because the surface is used for planting eg. if planting distance is 5'x5' as with the spruces, the drains will be spaced at 25' apart, centre to centre. Turf drains are then laid out at this spacing and the sides cut 18" wide with a cutter spade. The turf is then cut across the drain with a cross-cut spade to give turfs of approx. 18" squares. When cross cutting the turfs press down the handle of the spade so as to lift the turf out. The turfs are then dragged out by a pistol-grip handled drag into five rows and turned upside down on the ground vegetation. This gives five rows of turfs at 5' spacing

between the turfs and 2½' between the centre of the out side turf and the outside of the drain. Some foresters use four lines of turfs between drains which are 21' apart. It is principally in the earliest stages of growth that trees derive benefit from drainage. It causes them to form a good root system and get an early start with growth after the upheaval caused by the transfer of the young tree from the nursery to the planting area. All deep-rooted trees derive greater benefit and stability from drained soils. It is most important that all drains are regularly cleaned out to prevent the soil from again becoming waterlogged. Read forestry practice ff 35-37.

Drainage on felled Woodlands:-

On many w/lands felled during the war years, the satisfactory growth of the future crop was only made possible by a system of artificial draining. Even where such a systems was maintained in good order up to the time of felling, it is certain to have been damage in the subsequent extraction of the timber. Old drainage systems should therefore be cleaned out thoroughly before replanting begins, provided that they are properly sited. Particular attention should be paid to the downstream outlets which may have silted up during the course of years.

Planting:-

As many of our woodlands have been felled, there is little opportunity for natural regeneration left. By natural regeneration we mean the opening out of the old wood to allow the seeds to fall + germinate naturally, thus giving a new crop without having to plant. Read E.P. chap V + T.N. Sec 1 chap 5 ff 35-39.

Advantages of planting over natural regeneration:-

1. It is more or less independant of seed years
2. Time is saved in establishing a crop as good seed years

occur at intervals for natural regeneration.
3. Soil cover is established more quickly.
4. In planting there is less difference in age of plants.
5. It is easier to replace failures.
6. Large areas of wastelands not near to existing woods can be afforested.
7. New species can be introduced. In natural regeneration only the existing species on the ground can be regenerated.

General control of planting:-

Whatever method of planting is used the following rules of planting are of general application.

1. If your plants are received from an outside nursery the bundles must be opened and the plants sleughed in at once to prevent drying out. In frosty weather the packages should be opened and the roots covered with straw or bracken to avoid damage from frost.
2. Trees which come into leaf early or trees which start growth early should be planted first, deciduous trees before conifers. Conifers should never be planted after buds have started growth. Warmer exposures eg. S. should be planted before colder ones. On the whole, spring planting is more favourable for evergreens as they will transpire on sunny days in winter and the ground may be frozen round the roots so that they are unable to take in any water. Roots of deciduous trees may go on vegetating late but roots of conifers usually come to a complete rest at the beginning of winter. Planting of wet or exposed sites should always be left until spring.
3. Efficient organisation of planting squad and for supplies of plants is essential. The sleughs should be near the planting area and the planters should never be short of plants.
4. The plants must be kept in planting bags, only one plant removed at a time and plants sleughed in if the

men stop fork for more than half an hour.
5. Start the squad off under a leader in echelon formation at the right spacing between rows.
6. Keep lines straight and correct spacing between plants in the line.
7. Planting should be done carefully & quickly.
8. Tools must be of good quality and suitable for the type of ground and method of planting.
9 Notches or holes for roots must be deep enough and wide enough to allow ~~for~~ roots to be spread out and not bunched up. In turf planting the roots must be spread out under the turf.
10. Ground must be firmed carefully by the heel and make sure that the plants are not skinned in the firming process.
11. Plant trees vertically and to correct depth, depth to which trees were in nursery. Good planting can be tested by trying to pull out newly planted trees. If there is no movement then planting is satisfactory.

There are two main methods of planting trees:
1. Ball planting, where a ball of nursery soil is attached to the tree roots. This method can be used with success if carefully done at almost any season of the year. Mostly used for arboriculture and fit planting.
2. Tree-root planting is the common method used for large scale work and is confined to certain seasons of the year, winter and spring.

Advan. of Spring planting:-
1. The period of rest between the time of planting and the restart of growth is less than in winter or autumn planting, less chance for
2. The danger of frost lift, esp. on turf and ploughed land planting is reduced and generally obviated.
3. In spring planting, plants are not so long exposed to winds, blow them about, loosen roots & expose them to drought before root growth begins as they are in winter planting.

4. Some species transpire throughout the winter and should be planted in the spring when there is plenty of moisture in the soil.

Advan. of Autumn + Winter planting:-

1. Labour is sometimes more easy to obtain. Agric. & fishing work in spring. Forest workers holdings - time off in peak period.

2. Trees and some of may grow on later in autumn and establish themselves before winter.

3. When there is a large planting programme, it is necessary to start planting early to ensure completion.

4. Often in Spring after planting drought spells occur - so trees planted in autumn may be more able to survive.

5. Trees which flush early eg. Larches, pines should be planted early.

6. Weather in autumn or early winter more free from frost, and snow + more beneficial to establishment of young trees.

Individual Methods of planting:-

1. Notch - includes mattock planting

2. Turf. 3. Pit planting. 4. Mound planting, 5. Dibbling.

3, 4 + 5 are seldom used now.

Notch:-

Spades used are Macefield, Norfolk, Sellick or ordinary garden spades and the planting mattock. Using the Macefield or Sellick spade a notch is made by driving the spade vertically into the ground. The plant is inserted in the notch, the spade is then driven in alongside the first notch + pulled over to close the notch and press the soil round the tree roots.

Using Norfolk or garden spades, two or three notches are made in the shape of an 'L' 'T' or 'I'.

Points to note are:-

1. Notches must be vertical.

2. Deep enough to allow trees to hang full length w/out the roots being bent over.

3. Care must be taken not to damage the plant when firming the soil.

This is one of the commonest methods of planting and is used for pines,

larches, Sw. spruces on good soft ground etc. Compression by the spade hardens the soil in stiff soils and deaths may be expected. The notch may open in dry weather and the roots dry - tree dies.

Mattock planting:-

Mattock is used on very hard ground which is too steep or uneven to be ploughed and where there are too many stones for spade notching. Soil is first broken up by the pick end and then a hole made with the mattock end. The tree is inserted, the roots spread out and soil pushed back and firmed against the tree.

Turf planting:-

The upturned turfs have been spread out in advance when the drainage was done. By planting time the two layers of vegetation are beginning to decay. Turf is slit vertically from one outside to centre which is usually made on West side for two reasons
1. Prevailing winds tend to blow tree against the solid part of turf if cut from E. side, winds would tend to blow plants loose in notch.
2. Notches often open, so being on West side slit is not open to sun.
Turf is raised, plant roots spread out with plant stem in centre of turf. Turf replaced & slit closed. Plant roots therefore lie where two layers of vegetation are rotting where there is air and a good supply of nutrient materials.

Pit planting:-

Only method in which ball planting can be done but plants may be planted pot rooted also. Used only for special trees & rather large ones in arboriculture. Best method of planting but most costly. Pits dug at least 9" square by spade, if the soil is heavy should be done in advance, holes deep enough to take plant roots. Plant placed in pit, held and then firmed in with soil.

Dibbling:-

Very seldom used as it is only suitable for slight free soils. A wooden dibble iron shod is pushed into the ground & hole made. Plant same as for cabbage. Roots are not spread out.

Mound planting:-

Very rarely used. Roots of plants brought above

the level of the main soil instead of being put in direct.
Only practicable on very steep soils prone to rank grass or weeds or on soils having an unfavourable sub-soil which is not possible to plough or drain. Costly method - other methods with drainage more successful. The soil is scraped into a mound of fair bk about 1'. Plant is then dibbled or notched into the centre
Planting on ploughed land:-
No single standardised method has been adopted the main principle is to notch in a plant on the side of the out-turned furrow on the side next to the open drain where the roots will not dry out and where they will have the advantage of the aerated soil.
Density of Planting - Guiding principles.

1. Cost of planting, wider spacing - fewer trees to acre - cheaper roots.
2. Whether species is shade bearer or lt demander, former can be planted closer.
3. Rate of growth in youth - quicker growth produces early canopy + so plants can be wider spaced.
4. Probable future income from thinnings. If close planting is not necessary, plant according to demand for thinnings. Closer planting produces earlier thinnings.
5. Branch suppression and hence reduction in size of knots best achieved by close spacing.
6. Straighter stems as trees have to compete for light when more closely planted
7. Spacing depends on ground vegetation, if strong, plants should be spaced closer than normal so that canopy will be formed earlier and kill out strong vegetation.

Average distances apart now in use, see T.N. Sec I page 36 or 3.4 Forestry Practice.
If planting on steep slopes it is the horizontal distance between plants and not the distance down the slope.

Points in favour of regularity in planting

1. Each plant has same growing space.
2. Easier to regulate number per acre.
3. Easier to fill up gaps.
4. Easier to find plants when weeding esp in bracken.
5. Thinnings marked, for regular spacing later, made easier.

There are two regular methods of planting, the square or rect. and the triangular. To find no. of plants per acre triangular planting is as follows. Divide 43560 sq. ft by the square of the side of the triangle and multiply by 1·155.

In square or rectangular planting divide 43560 by square of side or sides of rectangle.

For age + size of transplants generally used see T.N. sec. 1 def. IV/5 20·35.

Having got the ground prepared for planting we have now to decide what species to plant. There are certain points which must be considered before finally deciding on the species to plant.

Later, a tabular statement which shows the species normally selected according to ground surface vegetation will be studied. By knowing the surface vegetation, we can often tell the type of soil lying underneath, but as surface vegetation may change after an area has been enclosed from grazing animals or after moor burning and its bad effects, it is safest to dig soil pits.

Points to consider :-

1. What species will the soil support and produce good timber.
2. What species will stand up to the climate and exposure.
3. Will the species to be used maintain soil fertility if not, what mixture of species would be planted.
4. The possibilities of future markets for both thinnings + final crop.
5. Consider elevation and aspect.
6. Compare trees in neighbourhood and see how they are doing.
7. In re-afforestation of felled woods other factors must be considered. We must bear in mind that weevil damage is a major risk when replanting felled conifer woodlands. Where such is the case, pine weevil and pine shoot beetle must be expected.

They may do damage from one to four yrs. after planting according to district. Postpone planting conifers until all feeding material has been exhausted. See F.C. leaflet No 25.

8. Amenity must be consider esp. in prominent places.

9. Risk from honey fungus in ex hw areas.

Resistant Species	Susceptible species.
Norway Spruce	Sitka Spruce.
D.F.	T.S.
E.L. + J.L.	S.P. + C.P.

10. If the previous crop consisted of conifers, particularly larch or spruce, stumps should be examined for evidence of butt rot. If butt rot is believed to have been present change the species to H.W.

11. There are extensive areas of poorer pine forest, particularly in the North which might well be replanted with D.F. or spruces which are likely to yield a higher volume of timber, exposure however, may prove a limiting factor to the successful growth of the species and D.F + N.S. should not be carried too far up the slopes. Shelter from W. wind is desirable.

12. Species for planting scrub areas include, D.F. T.S. N.S. Lawson Cypress, J.L. or S.S in places. Of those factors influencing the choice of species the most important is the soil + then the climatic factors. It may often be necessary to start off afforesting new land by using a species for a short rotation to improve the soil, eg. J.L. or P. contorta and fell early for pit wood or opening out and under plant with another species. Or, it may be advisable to start off with a mixture eg Pinus contorta or S.S. with a view to the contorta helping the Sitka to get away and later cut out the contorta leaving a final crop of pure Sitka. The climatic conditions such as valley frosts, sea-spray blast, dry wind blast are overcome by either using the most suitable species to soil and climate or by planting a nurse tree to help establish the more valuable final crop, eg. alder has often been used to establish Sitka but is now falling out of favour.

Manuring :-

After planting on very poor quality sites it is customary to add some manure. The chemical which plants appear to benefit from is phosphate which is supplied in basic slag or ground mineral phosphate at the rate of 2 ozs per plant. Only applied on turf planting either on top around collar of plant or sprinkled underneath the turf.

Beating Up :- Read F.P. Page 44 + T.N. Sec. 1 chap. pp 39-41.

Beating up is the replacement of failures after planting. By careful planting in good planting weather and by careful selection of species and grading of nursery transplants the number of deaths will be automatically reduced. Should deaths occur they may not show up in the first year (all) and in order to save over-doing the B.U. it is advisable to leave this operation until two seasons after planting except, on areas where deaths have been very numerous & where weed growth is likely to get a hold on the area. Before doing any beating up, bear in mind that if a B.U. plant is to succeed it will be more expensive than initial plants - due to years advance growth + B.U. plant must be weeded for two more years. Looking for + weeding B.U. plants which raises costs. Foresters inclined to B.U. too much, only large blanks should necessitate consideration for B.U.

Before B.U. study causes of failure and repetition. Causes of death such as faulty initial selection of species, inferior nursery stock, unsuitable planting weather and methods, bad planting and failure to weed at proper time are all within the control of the forester. With care + close attention can be avoided. Climatic, insect or fungal attacks after planting may from time to time upset the best regulated areas.

Beat up as soon as it is certain that blanks are large enough to justify it. The longer it is delayed the more costly weeding is. The B.U. plant must be such that it will require only the minimum attention after planting and that it will play a useful part in the development of the crop. Robust, quick grower or a shade bearer. Well planted + not too close. One plant may be sufficient to fill in where two or three have died. Be economic rather than over do it. Pay strict attention to weeding.

B.U. on Re-afforestation Areas:-

Young tree crop usually grows very rapidly on former woodland areas, therefore, necessary B.U. should be done during the first season after planting. Big plants may be used with care - avoid changing species.

Conifers:-

The rapid rate of growth that normally occurs when conifers are planted on re-afforestation areas, makes it even more essential than usual to beat up the crop during first few seasons. Losses to be estimated in autumn after planting. 90% of crop, evenly distributed over area is adequate, otherwise, fill in gaps with large transplants strong & carefully plant. After 1st. season, not worth while to fill in single gaps, two or three gaps are then best filled with a plant in the centre. Quick growing species, such as S.F. or J.L. are to be B.U. only where large gaps occur. Plants and money not to be wasted by filling in small gaps where plants will not come through. Use only resistant species in filling up gaps caused by H. Fungus.

Hardwoods:-

Neglect to beat up young ~~H~~ plantations means a lengthening of the weeding period and added costs. Use large plants. Failures occurring in groups should receive special attention: gaps, not filled up during first season or so may be often best filled by encouraging coppice growth; coppice-grown trees and natural seedlings need not be of same species as main crop. A small admixture is unlikely to prove detrimental to the growth of the plant.

Weeding:- Read F.P. pp. 44-45, T.N. Sec 1. pp 41-42.

Weeding is the removal of all weed species which will harm the trees of the ultimate crop, and are mainly, grasses, heather, bracken, brambles, whin, broom, honeysuckle and coppice shoots. Weed at proper time - reduce cost, if bracken weeding is done when young fronds are uncurling and when trees are seen easily, it is much cheaper than when the bracken is fully developed

and much time wasted looking for the trees. Weeding can be done in autumn before trees are smothered in winter. Coppice shoots are much easier cut when the sap is in flow, but the plants which are being choked by coppice are more easily seen when coppice leaves are absent. Honeysuckle should be kept down from the start. Gorse or whin weeding can be done in frosty weather and be completely cut to the ground, otherwise trees develope very spindly and when gorse is removed, the trees are too weak to stand erect & are easily blown.

Drainage upkeep:-

For the first few yrs after planting all drains should be looked over regularly, esp necessary where Molinia grass blows and chokes up drains; where soft wet peats fill up drains and where paths cross drains. Bridge over.

Establishment of Plantations:-

In the F.C. an area which requires no more B.U., weeding or drainage is said to be established. After a forest is established the term weeding is discontinued and the removal of any weed species as well as some of the poorer or rougher types of the planted crop, is classed as cleaning.

Cleaning:-

Before cleaning can be done, and as the P. is now in the thicket stage something must be done to allow the forester to see the conditions of growth.

Racks:-

At about 1 or 2 ch. intervals are made through the young wood. Branches on the adjoining sides of two rows are pruned off to a height of 5' or 6'. It may now be necessary to go through to remove all wolf trees which may be damaging the final crop eg birch, hazel, willow, sal etc. It is essential to get in early to remove wolf trees.

Weeding & cleaning conifers on Re-afforestation Areas:-

Many factors combine to make weed growth of all kinds troublesome and costly to clear on re-afforestation areas; the chief of which are

a. High soil fertility encouraging strong growth of brambles, thorn etc.
b. Natural seeding of tree species such as Birch, Goat Willow, etc.
c. Coppice growth of various Hw. species.

Weeding :-

Complete weeding from the outset is the safest policy with most coniferous species. Where the crop is slow to get away the cost of weeding may be lighter in the 2nd or 3rd yr. of the crop's life than it was in the yr. of planting, but it is cheapest in the long run to keep soft herbaceous weeds and woody growth down until the plants have outgrown the risk of damage by suppression and whipping.

a. Coniferous crops on former Bf. woodlands :-

Owing to the risk of damage by the Pine weevil Hylobius or by the Hylastes beetles, cleared Cf. woodlands should not be replanted until two to four seasons after felling. During this time many sites become invaded with brambles, bracken or the seedlings of willows, birch, thorn briars or gorse. It may be necessary to cut these back in order to plant at all, if it hasn't been done, cut them hard back during first (season) summer after planting to give the conifers a good start; then the early closing in of the canopy will suppress hw. weed growth.

B. Bf. crops on pre. Hw areas :-

Old hw. areas may be replanted as soon as they have been felled and cleared, but weeding problems may arise from two main causes.

a. re-growth of coppice
b. The intensification of growth of all species of weeds due to their exposure to full light on relatively fertile soils.

Ground which was practically bare when planted, may, a season or two later, require much work to keep down coppice, brambles. The only safe plan is to combat these weeds intensively until the Cf. are clear of danger. The normal ground cover of a newly felled hw. area is of low herbs and grasses, so that

cf. planted at this stage will require little weeding. but bracken might tack once or twice per season if necessary.

C. bf. crops on former bf. areas:-

Clean weeding of all kinds of growth, coppice, tree-seedlings or herbaceous weeds, should be the general rule for cf. planted on pre bf. areas. cheapest in the long run. exceptions are

1. Retention of light, controlled cf. growth to shelter frost tender species such as Sitka in frost hollows.

2. Replacement of high bf. by coniferous woodland, by under planting. see. chap II part 2. Here the overhead shade will usually reduce the amount of weeding needed, but the under planted cf. must be kept free of bracken etc.

Cleaning:-

If weeding has been thoroughly done little cleaning in cf. crops should be required. any neglect in weeding may call for heavy work at the cleaning stage. Birch, sallow and even Oak may do serious harm to young cf. by whipping their leading shoots, the spruces are particularly prone to suffer such damage. The retention of a self-introduced hw. stem in order to fill a gap is exceptional in cf. P; it may however, be advisable to do so provided it does no damage. Pay attention to woody climbers.

Weeding & cleaning hw. on re-afforestation areas:-

The areas suitable for the raising of hw. are usually those that carried a previous crop of hw. which usually produce in profusion four classes of weed growth.

2. Herbaceous weeds, bracken, coarse grasses, cleavers, woodruff, Bedstraw.
3. Woody shrubs and trailing plants, such as gorse, broom & bramble.
c. Natural seedlings of unwanted tree species.
D. Coppice shoots.

Keep all alive in check, cut back from outset, a light, controlled cover may be of advantage for the establishment of Beech, Red and Sycamore particularly on chalk areas.

Where there is much woody weed growth of brick coppice, gorse etc the best practice is to keep the newly afforested area clean cut to ground level by annual weeding. Annual cutting back not only weakens the coppice substantially but also the annual re-growth can be easily and cleanly cut with a light reap-hook or hagging hook.

On what species is weed depends on how long to weed. Oak sowings usually require the most long continued weeding and after that, areas planted with oak seedlings, oak transplants, ash or sweet chestnut. When the crop becomes established and out of danger, then is the time to make the first careful cleaning. Little further attention should be necessary until first thinning stage - watchful eye always.

Oak:-

Should be weeded intensively for 1st few yrs. and kept clear of bracken. Lp. shoots must be kept right down, later, trees about 3' high require weeding only at intervals of 2 & 3 yrs. Don't over do weeding.

With Bel, sycamore and sweet chestnut light re-growth of stool shoots, seeding birch etc. may be tolerated with advantage. Do not, on that account, neglect bracken, bramble or similar low spreading growth. But cut any spiny or thorny shrubs - thorn etc. Aim at a light shelter which can be removed cleanly & speedily when trees can stand on their own: then remove shelter growth in stages. A natural seedling or Lp. stem may be retained to fill up a gap. Trees of this type must have their heads free throughout and should have more & more room as they progress.

Beech:-

Because beech is a shade bearer some foresters think it will tolerate the cover of weed growth in general and bracken in particular. Side shelter is beneficial from taller coppice stems provided it is controlled and kept within limits. The simplest way is by 'strip' weeding which involves the clean cutting of all

weed growth between the plants in the rows whilst allowing natural seedlings or fairing thee cf. shoots to grow between the rows. Once the clean weeded ranks have been formed, it is much simpler to weed but must be thoroughly done.

Watch for any check in growth of beech caused by too dense a shade indicated by occasional plants showing feeble stems lacking a well developed leading shoot and very dark foliage which is often riddled by leaf mining insects. More light necessary cut back side shelter - never let shelter outgrow beech.

But shelter grown back whenever beech becomes established to enable beech to spread out and suppress any further regrowth.

Regen. under coppice:-

The only tree to be considered here is Beech. Keep it clean weeded at the lower levels. Increase overhead shade as demands for light increases. Occurs at an early stage after trees are established.

Former Coppice ground:-

Land which previously carried a conifer crop will seldom be selected for replanting with beech but where this is done do not be mis-lead by the clean nature of the ground at the outset. Gradually, scrub etc will appear and require to be treated as above.

Cleaning:-

Where weeding has been well done the main objects of the cleaning shall be:-

1. The elimination of tree weeds, shrubs or cf. growth that are competing with the main crop but are not required to form any part of it.
2. The checking of woody climbers. In some localities such climbers become so troublesome that periodical cleanings are necessary on their behalf alone. Climbers pulled clear of trees then cut.

Natural seedlings or stool shoots to fill gaps - any species, severe dealings with all other weeding. Watch for coarse and rapid growing species such as Sweet Chestnut and Sycamore which may develope into wolf trees.

Brashing:-

The next stage in the life of a plantation is when it is decided to brash. Brashing was originally used to define the process of knocking off dead branches with a blunt instrument. It has come to be used for pruning dead branches with a staff instrument up to a height of 5'-6'. Much money can be spent on brashing, points to guard against are:-

1. Trees to come out at cleaning or in first thinning are not pruned.
2. Use best tool, with least damage to the tree.
3. Prune close to stem, no snags left on stem.

In brashing, no serious effects result from removing first whorl of green branches. The best tool to use is the curved pruning saw with an 18" to 24" handle until such time as the mechanical saw can prune its world.

Several methods of brashing:-

1. Brash every tree not to come out at the first thinning
2. Brash every row. 3. Brash every third lane.
4. Brash only selected final crop trees.

There is no great difference in cost per acre o per cu ft felled.

After brashing the cleaning takes place removing all wolf trees where possible and this may be linked with a first thinning. At this stage, trees may be removed to form drag roads for later thinnings - attention must now be given to the drains first since canopy has formed and trees entered thicket stage.

Pruning, High Pruning + Underplanting.

Read leaflet no 22, also Chap X page 48, part I. T.N.

Thinning of Plantations. Read. F.P pp. 45-58, leaflet on thinning T.N. part I. pp 42-48.

N.B. Fire protection - read F.P. pp 65-66
TN. S IV pp 1-24
Forest code Sec IX.

Silvicultural Notes on Sf. and Hw.

Pinus Sylvestris:-

When grown in this country this species is known as Scots Pine, pine or Scotch fir. When imported from N. Europe the timber is usually known as Redwood, fir, red or yellow deal also by various names according to its origin such as Baltic, White Sea, Gulf, Memel, Soderhamn and Norway fir, Siberian Redwood and also Archangel Redwood. In Scotland imported timber is known as Red pine.

The tree is most widely distributed of all the pines, found in most parts of Europe, W. & N. Asia, native to Scotland and just over the border into England. Found growing from N. Norway throughout Lapland, Sweden, Finland, Esthonia, Latvia, Germany, Poland, Czechoslavakia, France, Switzerland and Spain, also widely distributed throughout Russia & parts of Serbia.

The tree varies from 70' to 100' when mature with a dia 30" to 36" or girth 10'. Dimensions vary according to site.

S.P. is very accommodating with regards to soil as to good gravel and will grow on any except on very shallow, very wet & excessively lime soils. It thrives best on a deep, well drained sand or gravelly loam. Generally very wind firm but no use as shelter belts as it loses its lower branches early. Will grow up to 1500' - 2000' on S aspect. Liable to suffer from snow-break at high elevations. Strong light demander and should never be grown under the shade of other species. In close forest it cleans itself of branches fairly well. Very hardy tree, it withstands spring frosts. Rather slow growing and most economic rotation is not more than 80 yrs. S.P. is generally raised from seed though nat. regen. can be quite successful ref. on Deeside and Spey. Usually grown pure when soil deterioration takes place, mixtures best for soil improvement, eg. birch, beech & sycamore. Main damage is caused by Pine Weevil, Pine saw fly, Pine shoot beetle, pine shoot moth.

Corsican Pine :-

The tree has a very wide range from Spain to Greece and Asia minor. Attains best development in Corsica where it sometimes reaches 150' with a dia. 6'. Not native to Britain was introduced in 1759 in the belief that it was a maritime form of S.P., was not cultivated to any extent until at least 70 yrs. later. In Britain, the tree grows to 100' 6200' in ht with dia 3' or more. Length of clean bole may rarely exceed 60'. Largest recorded is at Stanage Park, Radnorshire which was planted in 1828 and in 1924 reached 130' in ht. Even when grown in close forest it does not clean itself very readily and may need pruning, it has been grown in shelter belts for this reason. Corsican is most useful conifer for growing on the poorest grades of forest soil. Will succeed on poor sandy types and even on pure sand also on thin chalky soil; for its best development a deep, dry light sandy loam is best, wet clays should be avoided. The F. C. have used the tree widely in East Anglia and for fixing sand dunes eg. Culbin and Tentsmuir (Fife) a cold, wet climate is unsuitable eg. N. Wales, W. Scotia (Transjordan is to try out on sands).
Very hardy him and is excellent for sheltering other species, is a light demander but will tolerate more shade than S.P. Is a fast grower and produces about 25% greater volume than S.P. but has a best rotation of 80 yrs.

European Larch :-

Native to the mountain regions of central and Southern Europe and is particularly abundant in the Alps where it forms extensive forests and is found up to the timber line not native to Britain but has been widely planted. Grown on a small scale in England for ornament since beginning of 17th cen. Several plants to Atholl estates in 1728 and later planted on a large scale. Grows grows to a ht of 80'-100', occasionally, more than 3'-4' dia. Clean holes up to 60' or more.
Larch is the only deciduous conifer which has been grown on any

scale, but planting is now confined to ideal larch sites. Will grow best on a deep, fertile soil or a deep gravel where there is free moving moisture; subsoil must be porous. Very wet, dry and peaty soils are bad. Grows in Br. from highest timber line down to almost sea level. Low elevations and wet soils produce early growth and snow damage by frost often results. For the same reason N. aspects generally give best results, although wind firm, larch is of no use for shelter belts as its thin branches and foliage give little protection. Greatest light demander amongst conifers grown in Br. Produces so little shade that the soil is apt to deteriorate unless and it can well be underplanted by shade bearers such as Beech, Tsuga, Sp. Spruce, A. grandis or grown in mixture with other light demanders such as Bch.

Is hardy against winter frost and cold but under to late spring frost because it flushes very early. One of the slower growing conifers but reaches its max. ht. in 40 to 60 yrs. and full maturity about 80 yrs.

Larch suffers from several diseases but many are due to planting in unsuitable soils; diseases include, Larch canker, Aphis Saw fly. Heart rot occurs on bad soils esp. poor sands + old arable land, also from 'Die-back' which at present is not yet confirmed as being due to insect, fungus, soil or atmospheric conditions. Has been very serious in Larch P. all over the country.

Japanese Larch:-

Native of Japan and was first introduced into Br. in 1861. Has not been grown under forest conditions long enough to be able to determine its max. size. Grows much faster than E.L. for the first 25 yrs. but probably does not ultimately attain such large dimensions as E.L. Great asset is its immunity from canker. Will also succeed on poor types of soil and peat but needs a considerable amount of moisture. If turf planted on poor soil and 'slagged' it can be used as a first crop to improve the soil for a better second species to follow.

Hybrid Larch.-

Sometimes called Dunkeld larch as it was first grown from seed trees there. Not sufficient areas or quantities to get its full value. Appears to be immune from canker and to grow straighter than Jap. Larch.

Grows very vigorously and beats both parents. Timber is likely to be almost as durable as J.L. It can be planted on soils poorer than those required for E.L.

Douglas Fir:-

Pacific or green Douglas fir is a native of W.N. America from Br. Columbia S. to Mexico. It forms huge forest in the Pacific coast regions of Br. Columbia, Washington and Oregon. Was first introduced into Britain in 1828 by David Douglas, the famous botanist explorer. Under the most favourable conditions in the W. coast of this country the tree will attain 110' in ht. in 50 yrs. Max. growth is not known as yet. In Canada and U.S.A. it reaches abt. 300' with a dia. 12' or more in a period of 150-200 yrs.

Retains its branches and after they are dead, clean stems must be high pruned. D.F. was extensively planted by the F.C but when it showed it signs of crooked growth and wolf-like characters (possibly due to seed of poor type) the demand fell and sites taken over by N.S.

D.F. prefers a deep, fresh soil but light, it will grow in poor sand and also on clays although easy to blow on such situations. Will grow on old river terraces at the foot of slopes where there is plenty of fre, fresh moisture. Chalk and limy soils to be avoided. High rainfall, not less than 35" per annum. Requires a rather sheltered situation as the leading shoots tend to be malformed and broken by the wind (or other agencies). Not very suitable for E. coast conditions but of most value for mild and moister parts. Bears a considerable degree of shade and sometimes used to underplant such species as larch. Suffers from autumn frosts and should not be planted in frost hollows.

D.F. is a very fast grower and so timber is coarse and every effort should be made silviculturally to stop too rapid growth. Chermes or Adelges cooleyi which infests leaves often seriously impeding growth. It appears to be more prevalent on young trees and on areas or seasons which are dryer.

Abies Pectinata :-

This is known as the common or European S.F. Swiss Pine, White deal or white wood in parts. Silver fir is widely distributed in Central and S. Europe reaching as far S. as Corsica. Tends to grow mostly in the mountainous regions and is found at altitudes up to 6000' in Pyrenees. In France, Germany and Switzerland it forms large forests either pure or as the dominant species. Was introduced into Britain about the beginning of the 17th century and has been grown both as an ornamental tree and in plantations.

S.F. forms a very large tree, before the introduction of American conifers it was the tallest species in Britain and is in fact the largest of European trees. In Br. it reaches 140' and 5'-6' in dia. In central Europe trees 200' high are known. A specimen at Aberfergwm in Wales measured 140' x 13'3" g. Br. Ht. in 1933. A number of trees contained 300-400 cu. ft. at 100 yrs. old. The bole is straight and tapering and the branches persist almost to the ground for 40-50 yrs. even when close grown after which they drop off and clear boles of 70' are not uncommon in older trees. The tree is one of the few conifers which will endure a heavy clay, it thrives best in a deep, moist loam but will not succeed in very sandy soils. Better planted in N. or E. aspect to prevent the young foliage from appearing too early and being killed from spring frosts. Is wind firm and maybe used for shelter belts, will also endure heavy shade and often used to underplant Oak, S.F. or Larch etc.

Fairly Hardy when old but tender when young. An economic rotation is between 80-100 yrs.

A. grandis :-

A.N. American species also called Oregon fir & Western White pine on the Pacific coast and sometimes Larch in Br. Columbia Introd into Britain in 1832; native to Vancouver to California. In W.N. America it grows up to 300' in ht and 15' girth in 200 yrs. In Br. specimens over 120' in ht. are not uncommon. Fastest grown tree and produces the heaviest yield of timber of any species in G.B. In Montgomeryshire, a grove 50 yrs old measured 130' in ht. and was estimated to have 14000 cu ft. of timber per acre.

grandis succeeds best in a deep moist soil in a moist climate it will thrive in heavy clays. Well suited to many parts of Scotland where it grows well in altitudes up to 1200'. Least tolerant of shade of all the Abies but still comes under the category of shade bearers. Fairly frost tender but is windfirm. Rotation of 80 yrs. grandis is very free from disease, practically immune from blisters and is therefore preferable to Pectinata. Liable to snow damage when in close canopy.

A. Nobilis :-

Native of N. America where it is also known as Red fir and Oregon Larch. There it grows to 250' with a girth of 24' in about 150 yrs.

Introd in 1825, there are specimens over 100' in ht in Br. Does well at high elevations but is not suitable for the warmer parts of the country as it is there liable to attack by blisters Aecia; this insect attacks the buds and causes swellings around the shoot and ultimately kills the tree. Good forest tree for Scotland and similar cold climates. Nobilis has been planted fairly extensively as an ornamental tree but few plantations have been formed.

Prefers a heavy to clay soil, is a shade bearer, windfirm & fairly frost hardy. Timber of better quality than Pectinata, is lt. yellow to brownish, hard & fairly strong and one of the best N. American Abies; maybe used for better class work.

Lawson's Cypress :-

Known as Port Orford Cedar. Native to S.W. Oregon and N.W. California. Has been planted extensively in most European countries. Introd - in 1854 when it was sed. at Lawson's nursery, Edinburgh. In its native habitat it grows up to 200' with dia. 6'-8', such trees are of a considerable age. Has not been grown long enough here to determine its max growth but specimens 80' to 100' are found. Ornamental tree and mostly planted for amenity purposes and as hedges. Commonest cypress in Br. and has become of interest recently to the forester and is being planted in close forest. Foliage used extensively by florists. Will thrive on most types of soil which are not too wet or heavy and is one of the few conifers that will succeed on a chalky soil. Best growth attained on a good fairly dry loam in a situation that is not too exposed. Will tolerate a considerable degree of shade and is useful for under planting Oak - clean stems. Exceptionally frost hardy and fast growing, its main disadvantage is its tendency to fork and to retain its lower branches. Very free from disease but may be attacked by voles.

Cupressus Macrocarpa :-

Only native to a small coastal area of Monterey and Is of Guadeloupe. Has been planted successfully in Australia, New Zealand, S. & C. Africa. Introd. in 1838. When older the tree becomes flat topped and liable to snow damage. Planted extensively as an ornamental and for hedges, suitable near the sea. Is adaptable as to soil thriving on even clay and chalky soils. Not very hardy, only plant in warmer parts, not windfirm, avoid exposed parts. Will endure shade, can be used for under planting.

Yellow Cypress Nootka :-

Native of W.N. America where it stretches from Alaska to Oregon. Introd. in 1853. Reaches 120' ht. and 5-6' in dia in 150 yrs in America. Planted mainly for ornament here. Most soils will support growth even poor gravels and thin soils over lime stone

fairly windfirm, very hardy and of fairly rapid growth.

Western Hemlock :-

Hemlock, Alaska pine, H. spruce; native of W. coast of N. America from S.W. Alaska to B.C. & N. California. Introd in 1851. In America it grows to 250' ht and 6-7' dia in 200 yrs. Although of recent introduction there are specimens over 100' and up to 2'6" dia. Is a shade bearer and useful for underplanting Larch, SP etc. Very useful in Birch scrub in strips or groups. A good mixture is To. D.F. and Th. Sh. Very adaptable as to soil growing in most types from sandy loam to almost stiff clay and also fresh peaty soils. Best on a deep moist loam and is more suited to the Western side of Britain but will succeed in the East under shelter. Is very wind firm, fairly frost hardy and a fast grower. Bark is rich in Tannin and supplies 2/3 of the tannin of N.W. America.

Common Spruce :-

Pinus contorta: Douglas Beach Pine Shore pine

Tree varying in habit and stature, according to situation, from a stunted bush a small tree 10'-30' short, twisted branches to a tree 40'-200' high

Found on Pac coast from Alaska to N Cascade mountains

Recorded as having been discovered by D Douglas in 1825, near mouth of Columbia river in Washington, and was apparently introduced about 1855 when it appeared in Lawson's catalogue under the name of Pinus Macfarlaniana Hort - Twisted branch pine, shore pine, Tamarack, Sand pine

Var- Latifolia S. Watson - Lodgepole pine P Murrayana Balfour; Black pine, Pitch pine, Red pine, White pine

Tree 40'-200' high with a tapering trunk and scaly bark differing from the type in its more vigorous habit, broader leaves and larger cones Usually found under more favourable conditions of growth, and so these differences may be entirely due to soil and shelter

Common tree from Alaska to California - 1805

Introduced into Britain by Jeffrey in 1853 & 1854

Lodgepole - centre pole of hut of N American Indians

Coast form - sand dunes exposed to violent winds fixing sand

Latifolia high land 7000-11,500' elevation best stands on N + E slopes. Dry, gravelly soils, not limestone

Intolerant of shade, clears well of branches, seeds every year. Tree cone, when in open often at an age of 2½ to eight years In Britain prone to attack by Pine shoot borer moth