

Silviculture.

S.O. Book 136. (Indexed.)

(28-74).



G.  R.



ROSE

Silviculture.

Study Hanson Chap. I.

Locality.

The soil, assisted by the subsoil, provides to the plant the means of stability and nourishment. The atmosphere overlying the soil gives certain nourishing substances — heat, light and moisture. Hence the soil, including subsoil, and the atmosphere are the media which act upon forest vegetation, and they together in silviculture are called the locality.

Factors of Locality.

The active agencies or factors of the locality depend on the nature of the soil and the climate, the latter being governed by the situation.

Growth.

Is an increase of volume of plant accompanied by permanent change of form. Rate of growth varies according to age of tree. To begin with growth is slow, then it tends to accelerate till maximum is reached after which it gradually falls till finally may cease. Age at which most rapid growth occurs depends on (a) Species (b) Locality (turn on two pages).

Locality. Scots Pine in suitable locality grows most rapidly between 10 and 20 years but in less favourable locality the most rapid growth may take place between 20 and 25 years. Spruce, in both cases about 10 years later than Scots Pine. Beech between 20 and 30 years. Oak between 50 and 70 yrs. Tree which is rapid grower during youth, may ultimately be overtaken and passed by another which is a slow grower during that period. Slow growth to start is caused by root system which must be established. This is probably more shown in plantations than in seeded areas. Season of growth begins Spring and ends Autumn. Resting period begins fall of leaf. External factors which influence growth are light, temperature and moisture. These vary with altitude exposure and general conditions of atmosphere. There is a minimum optimum and maximum amount of light. Isolated trees develop more branching crown than in shade. Formation of flower and seed are fuller and more abundant on trees grown in the open or on margins of woods than in shade. Absence of light delays tendency to produce seed. As regards light

light, trees can be divided into two classes, viz: -

Shade Bearers

Beech.

Hornbeam.

Silver Fir.

Yew.

Spruce.

(not too much).

Light Demanders.

Oak.

Ash.

Birch.

Pine.

Larch.

During youth, all trees will stand a considerable amount of shade but near maturity will grow best in full light. Shade prevents damage by frost, increases temperature and moisture and improves climatic conditions. All trees will bear more shade on good soil than on bad soil. The same applies to climate - more in milder climate. Better soil and milder climate trees require less light. Temperature is of vital importance but does not have same modifying effect as light. It does not alter the outer form of plants. It regulates the four months during which vegetation is active (May, June, July and August). Depth of soil regulates the rate of rise of temperature in Spring. Shallow soils / (turn back one page).

soils heat up more rapidly than deep soils.
Uncovered soils heat up more quickly than those
which are covered.

Importance of Sufficient Density in Woodland Crop.

By keeping trees sufficiently close they form long, clean stems as when competition is going on there is no seeding. Density prolongs vegetative growth and delays flowering period. Canopy occupies about $\frac{1}{3}$ of the length of the stem. In the forest where canopy maintains more moisture and temperature there is a better proportion of Spring and Summer wood. In a close canopied tree there is reduced transpiration which causes less demand of water - therefore less Spring broad-lumened cells. Trees are limited by northern & Southern limit and altitude limit. Between N. & S. limit there is a zone called the optimum. The bulk of our hardwoods are being cultivated slightly to the N. of their optimum. We are cultivating conifers more to the S. of their optimum. Close grown timber is cylindrical because of the distribution.

distribution of growth in space and time. Growth is more in top of stem therefore maintaining cylindrical form. Root activity commences earlier in isolated tree, and bole of tree exposed to the sun also commences earlier. Cambium growth in lower part commences first but top part is slower. In close canopy temperature of air owing to increase of heat of sun causes upper part to start growth before root. Upper part of stem is in a better position to obtain food material therefore it maintains a cylindrical form. Young trees start into foliage first owing to the root being nearer the surface than older ones. Shallow rooted species start sooner than deep rooted ones.

Stages in life of a Tree.

Tree may be propagated by seed or vegetatively by layering, budding, grafting, stool shoots or root cuttings. In grafting, the cambiums are placed in position close together and secured firmly.

Seed.

Suitable condition for Germination.
Sufficient (on two pages).

Sufficient air and moisture and suitable degree of temperature. Root growth precedes shoot activity. Growth is confined to tip of shoot, root and cambium. Height growth ceases long before girth growth. To begin with all trees have more or less symmetrical shape. Each tree assumes characteristic form at maturity. In early stage bark is smooth then it becomes deeply ridged and grooved.

Flowering.

Flowering stage should begin about time height growth is finished. This is affected by soil and density. In the forest, periods are for - Birch & Alder - 20 - 30 yrs.

Hornbeam & Elm	- 30 - 40	..
Maple, Sycamore & Pine	- 40 - 50	..
Spruce.	50 - 60	..
Silver Fir.	60 - 70	..
Beech.	60 - 80	..
Oak.	70 - 80	..

Light Demanders first, then shadebearers.
Time of Flowering varies with locality and

and Species. ~~Time of Flowering~~. Seed years are years in which trees produce a rich harvest of seed periodically - e.g. Oak and Beech - Mast Years. In the case of Beech a full mast year occurs every 10 years (partial 3 to 5 years). In the Oak a full mast year occurs every 5 to 6 yrs. (partial 2 to 3 yrs). Hornbeam, Elm, Ash, Eucamora, Alder & Birch every 2 to 3 yrs. Abies 3 to 6 yrs. Spruce 5 to 6 yrs. Pines 2 to 3 yrs. Larix 3 to 8 yrs. Period between seed yrs. is a period in which trees are laying up the necessary food materials. In Beech before seed years every part is fully stored with food. After seeding it disappears. A few flowers and seeds may be produced annually on all trees. In all trees time comes when seeding stage passes. The tree goes on living slowly & declining. First symptoms are noticed on the top of the crown. Twigs dry up and tree becomes stag headed. Roots are no longer able to force water to top.

top of tree.

Life of a Forest.

When trees become massed together struggle brings about certain modifications in contesting for food and water in the soil, and air and light. Trees are for one another mutual protection against wind. Canopy improves moisture content and physical and chemical condition of the soil. Formation of forest may be artificially by sowing or planting or naturally by seeding from mother trees. In early stages by seeding a great many die off. In earliest stages young plants are more sensitive to frost, drought, insects, fungi and weeds. So protection afforded by older trees is beneficial. Symptoms which indicate too long shade are (1) short, thin buds (2) small leaves (3) thin, short annual growths.

Second Stage - establishment of cover (formation of canopy). May take from five to ten years. Directly canopy is formed wood is established. During immediate period after completion of cover the greatest struggle begins when

when the whole of material is thrown into active height growth. The close canopy causes heavy shade which kills off the lower branches (natural pruning). In ~~the canopy~~ such a plantation when it is established on its way to rapid height growth we can classify shapes of stems as (1) wolves - large, coarse branching trees (2) dominant - average (3) dominated (4) suppressed - hopelessly outclassed or diseased (5) dead.

Better patches of soil may cause dominant stems or this may be caused through special individuality of parent. During earliest stage a plant may get the lead and thus shade the others and retard growth. Some of the trees in plantation may be attacked by insects or fungi. Struggle goes on until height growth is nearly finished. In a dry climate natural pruning is more effective and rapid than in a moist climate. There are 3 kinds of growth (1) height (2) girth (3) volume. Height is the first to cease & (2) & (3) later. Volume reaches highest point at end

✓

of height growth. With termination of ht. growth competition becomes less but takes another form in pressing one another (crown formation). The tree can then expose a larger leaf surface & produce more food. It is then ^{the} seed producing stage is reached so that struggle begins anew. Strongest crowns become dominant trees & produce more seed. In forestry these facts must be kept in mind. After seed producing period is ended vigorous growth is at an end & in economic forestry it is time to harvest the crop. Where natural regeneration is possible new growth takes place of the old trees as they mature.

Nurseries.

Home

Public

Temporary

Permanent.

Temporary nurseries are formed as near as possible to the intended plantation and when the planting is completed they are either given up or else form part of the plantation.

Advantages of temporary nursery.

- (1) Plants are in immediate vicinity which avoids cost of transport (2) danger lessened of drying up roots and more earth can remain on roots (3) young trees are accustomed to conditions under which they are to grow. (4) fencing is unnecessary (5) grubs, wire worms etc. have not time to become serious.

Advantages of permanent nursery.

Employment of skilled staff and yield much better plants and cost of area only happens once.

Consideration in choosing and laying out a nursery.

Successive

Successive plantations depend on quality of plants used. The position of nursery is more important than the soil (condition of soil can often be altered by draining etc). (1) Site - near house of forester and not far away from permanent road. (2) Aspect - of great importance as regards heat and cold. South and west aspects to be avoided. Choose by preference north, north east or north west. A north east aspect should only be chosen if there is sufficient shelter. With that ~~exception~~ exception north is preferable to South. On north exposures vegetation awakes later on in Spring. This is a safeguard against late frost and gives a longer planting season. A plant may be frozen solid but if slowly thawed may recover without permanent injury. On northerly aspects thawing is slow therefore less damage is done than on southern aspects. Frost hollows must be avoided also narrow valleys. Soil.

There must be sufficient mineral strength

strength but the physical qualities (depth, porosity and moisture) are of more importance. A flat raised or poor soil has a poor root system with very little fibres therefore it has very little chance of collecting nourishment when put out into a forest soil but one reared in good soil with a fibrous root has more advantage. Well nourished plants suffer less from injurious climatic and organic enemies than ill nourished plants. As regards tenacity, a sandy loam is preferable. Clay soil should be avoided. It is difficult to work, wet in Spring, useless for seedbeds and frost has far greater effect on plants. In summer on the other hand upper surfaces become dry and caked. Avoid too light a soil. Sandy soils are liable to become dry, and cause plants to develop a long tap root. Depth of soil required depends greatly on species of tree to be raised. e.g. Oak requires deep and spruce shallow. Shallow soils as a rule should be avoided, they are easily dried up and poor in nutriment.

nutriment. medium depth for nursery - eighteen inches to two feet. Pan or impermeable sub-soil should be avoided.

Slope - Choose level but slight slope is not a disadvantage (good drainage). Also if slope is towards north protection from sun. Steep slope must be avoided (rain washing). If no alternative terracing must be carried out. Soil which has lain bare for a long time is usually poor and old agricultural land is usually overgrown with weeds. Old meadowland is quite suitable. Ideal place is newly cleared area in an old wood. This is free from weeds and has beneficial shade and natural surroundings. Cost of formation however is heavier.

Shape - Best is rectangular.

Size - Governed by species to be raised, age at which plants are to be put out into forest and area of planting programme. As regards fencing this must be substantial. A wire fence on outside - rabbit proof - with an ever green hedge inside is best. Divide nursery in parts as nearly as possible equal to rectangles.

The

main road should be sufficiently broad, 8 to 10 feet, to admit carts. Divide main sections into plots by paths three feet wide. Under average conditions the nursery would be divided into

$\frac{1}{10}$ paths &c.

$\frac{1}{10}$ seedbeds.

$\frac{5}{10}$ transplants.

$\frac{3}{10}$ greencrop.

Paths edged with privet keep soil in place. Box is more easily injured. One year old cuttings may be used. Deep working of nursery is necessary. The more the soil is broken up the better the aeration. This is essential for the formation of fibrous roots and makes it easier for plants to extract food. Valuable nitrifying bacteria are increased in the soil by this cultivation.

Manuring.

In nursery, best feeding is good leaf mould and compost earth with certain artificial manures such as Basic slag, Kaihit &c. In nursery, nitrogenous material can be quite easily supplied by growing

growing greencrop & digging it in. - e.g. winter
oats, lupins, mustard, buckwheat &c. $\frac{1}{3}$ of the
nursery could be so cropped every year.
Method.

Dig over ground and level with rakes.
Sow artificial manures in the following
proportions: - 210 lbs. slag per acre, 460 lbs
Kainit per acre, then rake in. Sow crop
preferably following day at the rate of $1\text{ to }1\frac{1}{2}$
bushels of lupins per acre. Sow sulphate
of ammonia about 14 days later at the
rate of 150 lbs. per acre - 1st. dressing. One
week after about 60 lbs. per acre, another
week after 90 lbs. per acre, 10 days after
60 lbs. per acre. Crop is cut before flower
shows colour, weighed, spread over area
and dug in. Another suitable greencrop is
black winter oats ($1\frac{1}{2}$ cwt. to the acre).
Manures used were 2 cwt. corn manure,
and 2 cwt. superphosphates to the acre.
Crop cut & dug in in July weighed $5\frac{1}{2}$
tons to the acre. Usually nurseries are
deficient in lime. Physically lime tends
to/

ease a stiff soil and break it up into small particles. It also neutralises acid conditions.

Quantity of lime required - 4 lbs. gravel lime to 30 sq. yds. of soil - slaked lime 10 lbs.

Nursery also receives lime by treating compost heaps with it after turning them over. To make leaf mould takes 3 yrs. A

pit is made $2/3$ ft. deep and $10/12$ ft. broad.

Bottom is given convenient slope towards ditch to obviate lodgement of water and resultant acid. Heap should be turned twice each year - May and September.

Length of pit depends on quantity required annually. It should have four

sections (1) fallen leaves gathered in Autumn (2) heap of leaves which have lain for 1 yr. (3) Ditto for 2 yrs. (4) Old compost ready for use. Heaps should be kept separate in pits for turning. In adding compost to seedbeds it should be riddled.

Seed.

Selection of good seed is of vital importance. It is easier to collect bad seed than good

of seed (easier climbing and gathering from
more scrubby trees). Scots Pine mostly
from north of Scotland; Oak from South of
England; Spruce from the Continent; Larch
from the Tyrol; Douglas Fir and Sitka from
So Canada; Ash, Beech, Elm and Sycamore
pr mostly from home sources. Some trees
tend to be very branched while others of
the same species but different type are
more compact. This tendency is reproduced
through seed. Home collection is preferable.
In collecting, study time of opening
(when seed naturally begins to scatter).
In the following trees seeds fall on ripening:
Oak, Beech, Birch, Elm, hazel, horse chestnut,
Douglas Fir, Weymouth Pine; which elm ripens
an early in Summer and does not retain vi-
tality long. Beech and Oak ripen about Oct.
ober - first fruits are usually not fertile
(shed first). Conifers when cones are ready
to collect. Abies in September. Scots Pine and
Norway Spruce after first touch of frost.
Larch at end of year (very difficult to open)
Weymouth

Weymouth Pine early in Autumn.

Duration of Vitality of Seed.

A few days or weeks - Salix Populus & Ulmus. Till Spring - betulus, quercus, fagus, castanea. One to two years - carpinus, tilla, acer, alnus. Two to three years - larix, pinus-strobus. Three to four years - robinia, fraxinus and pines. Four to five years. Picea and abies only keep for six months.

In storage seed is always deteriorating therefore should not be kept over two to three years whatever the species. When weather is too dry seed may not germinate until the next Spring. Seed usually rest during winter but some species germinate on falling - e.g. poplar, elm, willow and partly Beech. Some seed gathered in Autumn, stored during winter and sown in Spring will not germinate until next Spring - e.g. Ash, Hornbeam, Rowan, Lime, Holly, hothka and Yew. Hawthorn and Hazel - "eighteen months after ripening"; but with some of them germination can partly take place if they are sown immediately on ripening.
e.g. /

e.g. Ash.

Seed Testing

Seed tests should be carried out shortly ~~after~~ before sowing.

(1) Knife Test - Cut seed thro' - good signs are moisture present, colour white or yellow and if kernel fills shell.

(2) Water Test - Seed which float are inferior due to air inside seed coat, but does not indicate bad seed so this test is not very reliable.

(3) Heat Test - good test if ~~moisture~~ fresh seed explodes with sharp crack.

(4) Squashing Test - good sign if moist and fresh wood.

(5) Germination Test in Hearson Incubator.

Preserve equal temperature - about 20°C . and equal moisture. Look at them every day, remove all germinated seeds and enter count in register.

They are placed in hundreds on separate watch-glasses. Duration of Test - Twenty days -

Scots Pine, Corsican Pine, Norway Spruce, European Larch, Jap. Larch. thirty days - Sitka Spruce; forty days - Douglas Fir and Mountain Pine.

Pine.

(b) Flannel or Blotting Paper Test - Seed is put between two pieces of flannel or blotting paper and ends dipped in water. Put in 100 and keep record of those germinated. Seed has not really germinated until primary shoot shows curvature. If seed has to be bought it should be got from locality as near as possible to forester's own.

Example One - type (a) trees of rapid growth with few but long branches.

type (b) trees of slower growth but compact.

Seedlings from (a) & (b) showed marked difference; (a) seedling grew faster than (b).

Seedlings at six years old - (a) averaged 3 ft. 9 ins and (b) 2 ft.

This was not dependent on soil & climate but innate and transmissible to seedlings. No matter how carefully (a) was tended it still produced long branches.

Example Two. Age of Parent Tree has marked influence on Seedling. When seedlings were raised from young trees they grew much taller & burs. more than those from older.

older trees. If tree is too old seedling are liable to lack of vitality. Young trees are liable to produce light seed but have more vitality than seed from old ones. The best period is at finish of height growth.

5 Example Three Seedlings raised from parent trees of vigorous growth (dominant) were more healthy than seedlings obtained from dominated trees.

Sowing.

The most suitable soil is a light loam. Seed beds should be as level as possible. The best time to sow is from the middle of April to about end of May. Dry weather is preferable. Experiments in treatment of seed before sowing reach the conclusion that soaking in water at ordinary temperatures for a period not exceeding seven days is best for Douglas Fir and Sitka Spruce and one day in the case of European Larch. Seed beds should be $3\frac{1}{2}$ ft. broad with 15 ins. alleys between them. They should be dug over in previous Autumn and worked into a fine tilth before sowing. The benefits of a fine tilth.

tillth are that the small expensive seeds are offered no obstruction to the growth of their plumules and radicles and maximum number of good seedlings are obtained; also the capillarity of the soil is increased and top layers receive moisture from below which keeps young seedlings from drying up. The working of seed sowing implements is also easier. Spruce is greatly affected in germination by tillth conditions and this should be the principle conditions in selecting time of sowing. Great losses are incurred in E.L. and S.S. by surface caking. Two factors are involved in surface caking (a) tillth conditions at time of sowing & (b) the weather conditions after sowing. Good tillth conditions can usually be secured by introducing humus into the soil and by avoiding practices which tend to break up the "compound particles" e.g. working soil when wet, treading down wet seed bed before sowing &c. Seed should be sown only when the ground surface is dry, and dry covering soil should be used.

Weather Conditions after Sowing.

Weather

Weather wet-caking may be produced either by rain breaking down the compound particles or the action of hot dry weather on moist seed beds. It is doubtful if caking can be completely eliminated but it can be greatly reduced by using special soil for covering seed beds e.g. sand or mixtures of humus with ordinary soil. The proportion of vegetable matter to soil should vary with the type of soil. In sandy loams $\frac{1}{3}$ humus to $\frac{2}{3}$ soil should be sufficient but with the more sticky soil $\frac{1}{2}$ and $\frac{1}{2}$ mixture is advisable. The vegetable matter should be prepared by passing it thro' a riddle with a mesh of 3 ins. by $\frac{1}{4}$ ". The soil is similarly riddled and the two heaps thoroughly mixed but not by riddling. The seed is then covered by the mixture in the usual way.

Seed as sown either broadcast or in drills.

Drill sown seedlings are usually more uniform in size.

Broadcast Sowing.
Ground

Ground is prepared & surface soil pushed to edge of bed. This is used later for covering. Seed is sown and surface soil spread over and rolled (only do rolling if surface soil is very dry). In sowing Birch seed make surface very hard and cover with light sprinkling of soil.

Drill Sowing - Apparatus used - 3 ft 3 in. roller with strips of wood across it so as to leave depressions or boards of various kinds are used with strips of wood nailed across them. For scattering seed a grooved piece of wood the breadth of the bed is sometimes used (seed lathe). The groove is deep and wide enough to hold the correct quantity of seed for each line. In drill sowing weeding is easier also the digging up of plants and there is less chance of root damage.

Depth Seed should be Covered. Larch requires greatest care in covering. S.P., C.P., H.S. $\frac{1}{4}$ "
Alder $\frac{1}{2}$ ". Beech, Sycamore, Ash, $\frac{1}{2}$ " to $\frac{3}{4}$ ".
Oak, Chestnut, $1\frac{1}{2}$ ". Alder, Birch & Elm, sprinkling.

ling of soil. After Forestry Commission experiments on the influence of method and density of sowing on the germination and growth of h.S., S.P., C.P., Dg., S.S., E.L., the following are the principle conclusions

(1) h.S. responded favourably to drill sowing which gave larger plants. Then densities gave the best results but where frost lift is a danger they are inadvisable particularly in the drill method.

(2) S.P. was not improved by drill sowing.

(3) C.P. " " "

(4) Dg. benefitted from drill sowing which gave a slightly better production of seedlings and better growth. Method of sowing was, however, much less important than density of sowing. Thin sowing gave higher seedling production, better growth, and a larger out turn of good transplants.

(5) S.P. was improved by drill sowing, which gave higher seedling production and better growth, the difference, however, compared with the broadcast method not being large, drill sowing giving better growth.

(6) E.L. did not respond favourably to drill sowing

sowing and broadcast is recommended. Thin densities gave better seedling production both as regards quality and quantity and a higher out turn per lb. of good transplants.

(7) The more shallow-rooted species, N.S.S.P. and to a lesser degree Dg. benefitted from the drill method of sowing while the deeper rooted pines and larches were not influenced.

Table of Sowing Density for normal Conditions per lb. of Seed (F.C. Bulletin).

<u>Broadcast.</u>	<u>Drill.</u>
N.S. 250 sq. ft.	350 sq. ft.
S.P. & C.P. 250.	not recommended.
E.L. 300.	" "
Dg. 300.	400 sq. ft.
S.S. 600.	800 "

Drill sowing does about 30% more than broadcast.

In sowing densities, soil degree of cultivation and germinating % of seed must be considered, also previous results in nursery act as a guide.

Broadcast

Broadcast of Hardwoods.

Ash - 80 seeds to the square foot.

Beech - 70 " " "

Hornbeam - 80 " " "

Sycamore - 80 " " "

5 Oak - 40 " " "

f In drills two inches apart.

Alder, elm and birch - sow thickly about one lb. to a hundred sq. ft. of bed.

Protection. Seed is liable to attack by mice, voles and birds. Before sowing, moisten seed and coat with red lead - 1 lb. to 10 lb. seed.

u Transplanting. Objects are (1) to raise plants of
u sufficient size for subsequent planting in
thick herbage (2) to check excessive development
s of tap and side roots and induce formation
a of a compact, fibrous root system. It is most
t important to maintain root system in a
h straight, natural course. Permanent malformation
a of root and stem is often caused by lining
C out in too shallow trenches.

+ Distances between trees in lines.

a Average spacings in Forestry Commission
+ nurseries

nurseries are :-

E.L. $2\frac{1}{2}$ ins. in rows.

S.P. $2\frac{1}{2}$ " " ; if to be left for 2×2 transplants $1\frac{1}{2}$ in. in the rows; also $1\frac{1}{2}$ " for 2×1 transplants.

N.S. $1\frac{1}{2}$ in. in rows.

S.P. 2 ins. in rows grade one seedlings.
 $1\frac{1}{2}$ ins. for other grades.

Dg. 2 inches.

Beech. 3 " "

nine inches between the lines. Average price for lining out $1\frac{1}{7}$ to $2\frac{1}{2}$ per thousand. "Puddling" is not recommended, as it forms dry casing round roots, also causes fibres to adhere together. Nursery work - hard woods should be dealt with before conifers, and larger & older conifers before younger plants. When seedlings are purchased note following points :- It is not always the largest seedlings which make the best plants. Seedlings of excessive size are liable to be soft and being such are prone to suffer from drought. Plants with long shoots usually have long roots. One year S.P. & E.L. seedlings should be 2 in. to $2\frac{1}{2}$ in. above soil.

Two/

Two year E.L. 5 ins. to 12 ins. Two year S.P. 3-6 ins.

All coniferous seedlings with damaged leading shoot must be rejected with possible exception of larch. Buds should be firm, turgid and well ripened. Conifer seedlings should have no brown dead leaves (except cotyledon).

Transplants.

Plants which for a year or two back show long shoots have not been transplanted. There is a shorter shoot and needles in the year plant is transplanted. Stout, well-rooted, short jointed plants are much preferable to tall plants. Plants should be seen in the public nursery or samples sent. Avoid nursery which is in too mild a locality. Cuticle of seedling should be firm, green underneath and moist. If plants arrive in frozen condition bundles should be placed in shade so that they will gradually thaw. If frost should last keep plants in a place near 32°F . Hardwoods are liable to less damage than conifers. In sheathing, conifers should not remain too long. They transpire during winter and it is essential to

to open and spread out the ~~bundles~~ bundles.

Average number of two x one transplants fit to plant out in the forest derived from one pound of seed sown in nursery. S.P. - 1,500. E.L. 7,000.

J.L. 6,000. D.g. 6,000. S.P. 30,000. N.S. 20,000. Beech 1,000.

Nursery Costs.

Preparation of seed beds without seed, sowing $16\frac{1}{4}^d$ per 100 sq. yds.

Seed sowing 3^d per 100 sq. yds.

Grading seedlings 8^d to $1\frac{1}{6}^d$ per thousand (average $1\frac{1}{2}^d$). Grading transplants $6\frac{1}{2}^d$ per thousand.

Preparing green crop area and sowing $6\frac{1}{5}^d$ per hundred sq. yds. Digging in green crop 5^d per 100 sq. yds. Lifting & bundling transplants 1^d to $1\frac{1}{7}^d$ per thousand (average $1\frac{1}{2}^d$). Lifting seedlings 3^d per thousand.

Preparation.

Preparation of Area for Planting, Fencing & Draining.
Study Hanson Chap. 13.

Specification of a rabbit proof fence used in some of the Commission areas.

Posts - 5 ft - 7 ins. quartered - S.P. 9 ft. apart.

Strainers 6 ft. 6 ins. cut from logs lying about on hill. (two hundred yards apart). Plain wire

no. 8 galvanised 500 yds. estimate to cwt. 546

yards exact. Barbed wire 12 gauge 2 strand

4 point 6 ins. apart - 550 yards estimate to cwt.

595 yards exact. Tying wire no. 16 sold per lb.

- 80 yards to the lb. Staples for wire 1 in. gauge

10 (1000 to 7 lbs. and staples for netting $3\frac{1}{4}$ in.

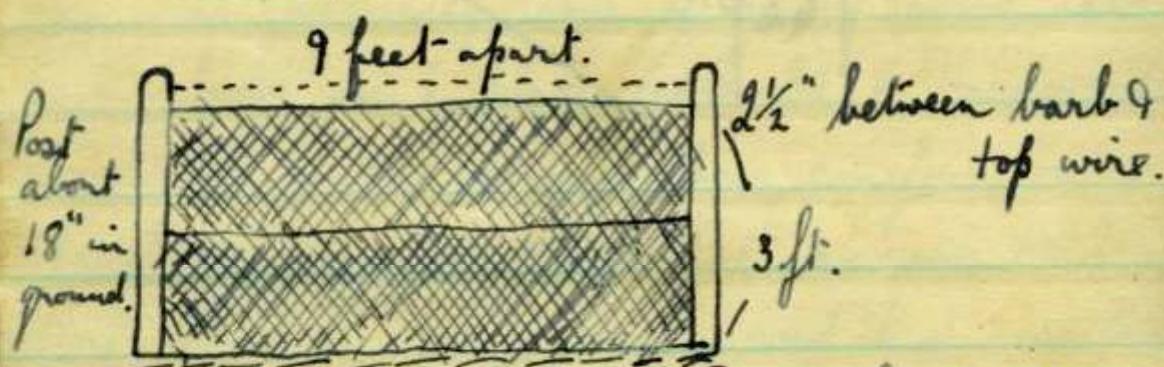
gauge 12 - 2000 to 7 lbs) netting 3 ft. 6 ins. -

gauge 18, $1\frac{1}{2}$ in. mesh.

Total cost $22\frac{1}{6}$ per chain (approx. 1/ per yd).

includes $6\frac{1}{8}$ per chain for labour exacted

on hill rising to 200 ft.



Turf cut and laid on 6" of netting bent out.

Drainage.

Trees vary greatly in their demands for water. Some will stand wide range of moisture although none will stand too much. On wet ground the failure of trees is due to (1) want of air in the soil (root respiration) (2) bog or marsh means low temperature in the soil; (3) incomplete decomposition of humus which becomes acid; (4) wet soils - more danger of frost lifting; (5) Red rot is liable to occur which causes root to decay. This is most liable to occur when thin, gravelly soil overlies clay soil (tensionous subsoil); (6) windfall often happens when marsh is caused by an impervious layer of soil thro' which the root cannot penetrate. (7) transport of timber is more difficult.

In order to improve wet areas find out the cause. If due to springs it may be possible to catch spring and lead off to a ditch. If due to an impermeable subsoil this may be partially broken up by ploughing.

Drains are best made in late Summer or Autumn and, in some cases, a year or two previous to planting. Start work at lower level and work

work to higher level. Draining should be completed before planting commences. This allows the ground to settle.

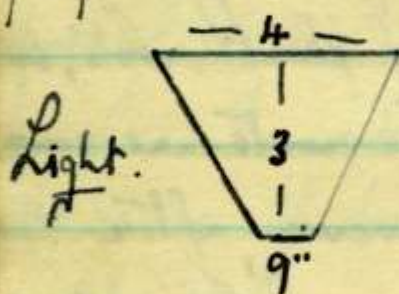
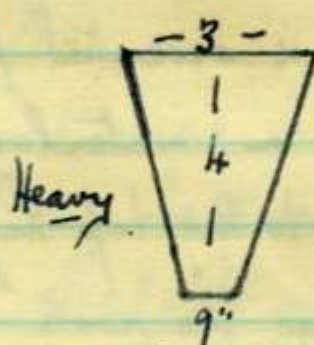
Why We Drain.

The depth at which a soil can receive no more water is known as the "water table". Plant roots are unable to penetrate below the level of this water table. The benefits derived from draining depend 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 above the drain. Previously, the portion not waterlogged was available for root growth, but now a portion is available at a greater depth. Oxygen from the air is essential for the growth of plant roots, so that in a waterlogged area the roots are confined to the top layers only; however, after drainage the roots can penetrate as far as the air extends.

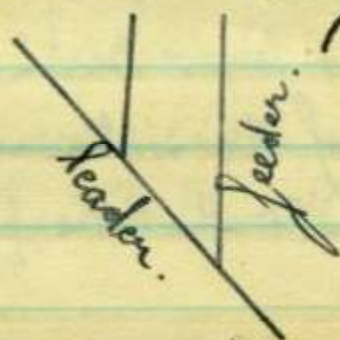
In an undrained soil the roots are confined to a shallow layer which is soon deprived in dry weather of the water available for the plant with the result that the plant may suffer greatly.

greatly. In a drained soil, however, the roots are ~~able~~ able to penetrate deeper, thus water is available for the plant and the plant will be in a better position to withstand a period of drought. This is probably the main reason why Spruces are most suited for planting in wet places as the trees are termed "shallow rooters".

Distance apart of drains depends greatly on porosity of soil. Feeders should not be too large nor too far apart. Depth depends on nature of the soil. Humus soil may sink to $\frac{1}{3}$ or $\frac{1}{4}$ of former depth. In light land drains should be $\frac{1}{3}$ wider at the top than deep. In stiff soil $\frac{3}{4}$ proportion.



Greater slope of drain more obtuse angle between feeder and leader. Angle of 45° is best.



Where side drains run into main drains sole should be one to two inches higher. This tends to help flow and ward off debris and silt. Kinds of drains may be classified under

- (1). Leaders, or ^{main} ~~side~~ drains.
- (2). Feeders, or side drains.
- (3). Surface, or shallow drains.
- (4). Trap or catch drains, running along the bottom of a slope like rhones in a roof. 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. All tap root trees e.g. Oak, Larch and Pine, derive great benefit from drainage.

Soil Preparation.

Undesirable vegetation, if left, would interfere with young growth so should be cleared & burned. If heather is very rank it should be burned at least two years before planting as the surface soil becomes caked after burning and requires to be weathered. In ordinary growths of heather the shelter is beneficial. On Birch scrub areas trees may be girdled. This cuts down cost of preparation and also gives young crop the benefit of shelter if required.

required. The trees should gradually die and decay. The danger is windfall and smashing of young growth. If birch is young, dense growth, strips only may be cut ~~only~~ out and plants inserted there. Girdling should be done previous to planting and only plants which can bear shade used. In cutting bracken previous to planting this should be done for three seasons to thoroughly impoverish the rhizomes and diminish the leaf fronds which they are capable of sending up. Cutting when the fronds are about eight weeks old has proved the more economical of labour, because, after that, the new growth is relatively small, the fronds have used up the storage in the rhizomes and are then starting to manufacture more food for storing up for the next resting period. This operation is costly and would only be done where bracken was very tall and dense.

In order to grow timber on soil with impervious subsoil, breaking up is necessary. If pan is broken up in strips sufficiently deep to allow air to penetrate it disintegrates. Moor pan is formed (1). if iron (Fe) in soil binds sand tightly.

tightly together (2) slow decomposition of humus gives rise to humic acid and makes the parts of the soil cohere.

Planting of shifting sand on sea coasts.

- (1) Arrest surface movement of sand by forming a network of turf, branches or heather, or plant sand grasses. (2) After surface movement is arrested, sow or plant crop of trees which will permanently fix the sand.

The best trees are C.P., S.P. & M.P. It is much easier to plant once a wind shelter has been established.

In the Landes, south of the Bay of Biscay, the advance of soil was 30 yards per year into fertile land, and before the end of the 18th. century all the district was barren. In 1851 systematic measures were taken.

Sand was fixed and planted with M.P. This huge area now produces large quantities of timber & turpentine and is the main supply of pit-wood for Welsh collieries.

Planting - Hanson 5.

- Advantages of planting are (1) independence of seed years (2) time saved (3) cover established more quickly (4) in planting not so much difference in age of plants (5) easier to replace failures.

Methods

Methods of Planting

Whatever methods are adopted, the following rules are general:— Plant should be placed in ground at same depth as that at which it stood in nursery allowing for possible settlement of soil. The root system should receive a natural position and not be huddled together or bent to one side. In planting, an opening is made in the ground into which the plant is inserted. The size & shape of the opening depend on the nature of the plant and tool used in making the opening. In planting, ball or free-root plants may be used. Ball planting may be done at any season and is usually performed with circular spade and requires a tenacious soil. Free-root planting may either be notched, slitted or dibbled into light, porous soil, or planted in pits, trenches, mounds or up-turned turves. Notch planting is usually done with a common spade. It consists in making an L, T or U shaped incision into the surface of the soil, opening this up from below by pressing down handle of spade, inserting plant into opening of angle, and then firming down soil again with the foot. It is self evident that such a method can only

only be successful on a fairly light, porous soil and even then the roots are cramped and unnatural so far as their position is concerned. This differs greatly from the more or less vertical position. Compression by spade hardens the soil. Another point against this style is that the notch opens up in dry weather, roots dry up and are killed. Notch planting, however, cannot lightly be condemned, as it was the method used in establishing the dense, coniferous woods of Scotland. A great deal depends on the care & efficiency of the planter and the friability of the soil. Screening should never be done on wet ~~plant~~ places as it gathers water and "drowns" the plant. The great advantage of this method is cheapness as, under average conditions one man will notch in 100 per hour while, in pit planting he will only do half that number.

Dibbling - Fairly cheap method in sandy soil. Root liable to be pressed flat or fan-shaped.

Pit planting is perhaps the best method of planting all kinds of trees. The holes or pits can be prepared either by specially prepared spades or the planting mattock. In stiff soils open pits in previous autumn. This allows frost to pulverise soil. In light soils it

it is necessary to open and plant at the same time. Two by two conifers require pits 9" to 10" deep and 10" by 10" square top. The stiffer the soil the larger the pit. In mattock planting on the hillside turf and any stones turned out should be kept on the lower side of the slope. This acts as a trap for water running down the slope. Planting should be undertaken from above downwards (obvious damage from released stones) and planters do not repass through planted ground. On steep hillside planting, it is important that distance between plants should not be measured along slope of ground but by assuming ground level.

In pit planting only fine earth ought to be put near the roots and clumps of turf etc. should be broken up in bottom of pit.

Mound Planting In this method the roots of the plant are brought above the level of the soil in place of being put below it. It is a form of planting which is practically only in application on very damp soil prone to rank growth of weeds or on land having an unfavourable subsoil which is not convenient to trench or plough.

plough. It is rather a costly business and involves drainage. Simpler methods of planting will usually be more successful. The soil has to be scraped together and arranged in a mound of greater or less height according to circumstances. When the plant is brought into position and earth placed at roots the whole is turned over with the grass sods cut away from the spot occupied by the mound.

Conifers suffer most from deep planting, especially spruces. If the young plant is put too deep it develops adventitious roots at right depth which proves that planting is too deep. If root system is unavoidably damaged a certain amount of pruning is admissible.

Larch stands pruning to some extent with pines if you wish to check branch growth.

Factors which determine time of planting.

(1) Climate, which includes temperature of soil, atmosphere and moisture.

(2) Cost and supply of labour.

(3) Best period is just before or after greatest growth (Spring or Autumn).

Advantages of Spring Planting.

(1) Period of rest between time of planting and awakening.

awakening of vegetation is less than in Autumn.

(2) Damage by frost lift is less.

(3) In Spring planting plants are not so long exposed to action of wind.

Advantages of Autumn Planting.

(1) Labour is sometimes more easy to obtain.

(2) Hardwoods may grow on late in Autumn and establish themselves. When very large areas are to be planted it is necessary to use both seasons. When planting in Spring trees which come into leaf early e.g. larch & elm, should be planted first. Plant deciduous before conifers. Conifers should never be planted if leaves have started into growth. Warmer exposures should be planted before colder. On the whole Spring planting is preferable for evergreen species, attributable to the fact that transpiration occurs throughout the winter on sunny days and as roots are unable to take in water there is a great danger of the plants drying up.

Roots of deciduous trees may go on vegetating late, but roots of conifers usually come to complete rest at beginning of winter. - Another

Another reason why hardwoods stand planting in the winter better than conifers.

Density of Planting.

Guiding principles - (1) Cost of Planting - is less the smaller the plant. hatching seedlings in sand is the cheapest form. (2) Whether species is shade bearing or light demanding, or quick or slow grower. (3) Probable future profit especially thinnings.

If close planting is not necessary, plant according to demand for thinnings. With close planting begin thinning earlier.

The main object in planting is to get a certain number of trees at certain ages of timber crop. See table (number of trees per acre after thinning) in Hanson - p. 78.

On porous soil there will be a larger number - slower growth.

Average distances apart - Spruce - Thinnings not of much account - $4\frac{1}{2}$ ft. apart quite close enough.

Sitka Spruce - 5 ft. apart.

Douglas Fir - 6 ft. apart.

If too close planted it becomes spindly and easily bent down by snow or wind. It

is/

is difficult to find a species to plant along with it owing to its rapid growth.

Larch - 6 ft. apart.

Scots Pine - $4\frac{1}{2}$ ft. apart - liable to become coarse if wide.

Oak has strong tendency to form side branches. Fairly close planting and grown in suitable mixture e.g. Beech.

Ash - about $4\frac{1}{2}$ ft. apart.

Preservation of Soil.

Canopy should be formed in 5 to 10 years. Up to 15th. year should not be too crowded. Soil should be sufficiently shaded as a rough average thinning may commence about 15th. year. Light demanders, larch &c., have rapid growth and should accordingly be planted wider apart than shade bearers which take longer to form a close canopy. Trees which tend to form wider spreading crown e.g. oak, Scots Pine, must be planted close. In order to get suitable size of crown and length of stem it is usually necessary to keep cover unbroken until the 30th. or 40th. year. With hardwoods and shade bearing conifers, oak, spruce, Silver Fir - until

until 40 to 60 years. In exposed situations plant closer. In sheltered situations and good soil, larger plants should be used.

Regularity of Planting.

To find number of plants used in triangular planting divide 35460 by square of side of triangle multiplied by 1.155 equals 43560 over square of triangle multiplied by 1.155 .

Points in favour of regularity in planting.

- (1) Each plant has same amount of growing space.
- (2) Easier to regulate number per acre.
- (3) Easier to fill up blanks; less danger of treading on plants.
- (4) Easier for cleaning plants. When fencing is done, cost is greatly increased. Shape and size of area affects this cost. The greater the area the lower the proportional cost. Rectangular shape is less costly than narrow strips.

Waste land suitable for afforestation may be (1) rough mountain pasture (2) moorland with good quality peat (3) low-lying marshes or swamp land (4) Sandy tracts near the coast.

Profitable afforestation in (1) & (2). No. (3) quite

quite productive after drainage. The better classes of waste land is often covered with whin or bracken. Moorland or exposed upland is often covered with heather. Near peat bogs we find bell heather (heath). If shelter and drainage are good trees are likely to succeed. In afforested waste land forest should be large - cost less per acre, cheaper fencing and trees grow much better in large masses (shelter, soil and moisture degree are improved).

As regards rough mountain pasture area should be surveyed and definite scheme adopted. The possibility of extracted timber should be considered and if area is very exposed shelter better be formed. Roads can easily be projected from large survey map. At first only a track is left and in late years the road is formed. Compartments (of 15 to 40 acres in area) are laid out with main rides running at rt. angles to the prevailing wind. Rides are also laid out then and left unplanted.

horway and Sitka Spruce planted
with special reference to difficult sites.
Growth of spruce roots. Careful dissection and study of the roots of Spruces has shown that when

when a Spruce is planted deeply (eg. by vertical notching) the lower part of nursery root system dies. This may result in death of plant but more frequently it remains in a state of "check" until it has formed a new root system. This new root system either develops from the upper part of original root system or new roots are put out at the collar of the plant. The new root system is thus essentially a shallow one developing in the aerated soil or vegetation layers. It is frequently marked by long pioneer roots with here and there bunches of mycorrhiza roots and decaying vegetation such as *molinia*. Apparently the plant feeds through the mycorrhiza rootlets. As the new root system develops the host plants regain their normal colour and grow.

On poor peaty sites Spruces may remain in check from 15 to 20 years, and yet ultimately come away. Owing to this habit of checking the establishment of spruce plantations is often a costly business. The first planting is cheap enough but costs ~~are~~ accumulate for following reason.

(a) excessive death.

(b) bringing up plants that look sickly but are merely

merely in check; much money wasted in this way. The rule should be never to beat up a spruce which is alive.

(c). Prolonged weeding.

(d). Check increases the length of rotation.

Obviously, also, a plant which remains in check has not the same power of ultimate growth as a plant which uses its growth in a more profitable manner. From the above consideration it appears probable that the main problem in spruce planting (assuming the site to be otherwise suitable) was to secure adequate root aeration. If the original root system (the nursery one) could be kept alive and made to function the check period would be reduced to a minimum. A method has accordingly been developed known as the side notch method, which has given very promising results. Method described below. Briefly the advantages secured by using this method are (a) seedlings - e.g. top sizes of 2 to 3 years seedlings can be used. (b) the losses are low (4% with seedlings on a very bad site at Inchnacardoch). (c) no weeding is necessary. (d) at the end of two years plants have an excellent colour.

colour. If these claims are maintained in planting, it is clear that not only will the total costs in establishing spruce plantations be greatly reduced but also that in spite of extra cost of preparing turf the costs at end of first year may not exceed the present costs.

Note. It is not claimed that side notch method is going to deal with the whole problem of planting poor sites and dispense with proper drainage. It does not, however, appear to be a promising method of establishing spruce on "Spruce ground".

Description of Method of Turf Planting.

Belgian System - The principle of this system is the laying out of parallel drains of such dimensions and spaced at such distances apart that each turf taken from the drain and placed inverted between the drains provides a site for plants at the planting distance desired.

The operations are as follows: - The herbage is burnt or cut. Drains are marked out diagonally across the slope with a gradient of about $1\frac{1}{2}\%$. The present practice is to space the parallel drains 18 ft. apart centre to centre. The drains are 18" wide at top 9" at bottom and 9" deep. The turves cut are thus

thus 18" by 18" by 9" and are placed upsides down in three rows between each pair of drains. Two rows are each 3 ft. from centre of drain and the third row is made midway between them. The turves are placed 4 ft. 6 inches apart. All turves taken out of drain are thus utilised. The best type of tool for cutting side of drains is a small type of rubber spade. The under side can be cut with a turf lifting spade and turves lifted out with a peat back. The practice is to carry out these operations two years before planting. Plant turves with a semi-circular spade. The core removed by spade can be replaced in part with earth or with a mixture of earth and basic slag. The mixture consists of 7 parts of mineral soil and 1 part of basic slag.

Successes have been achieved both with soil-basic slag mixture (e.g. at Coroner) and with the plain turfs (e.g. at Hatwill).

Side hatch method.—As with the Belgian system the turf (which in this case should be 16 x 16 x 8 x 6 ins. thick) is inverted but in planting it is essential that the roots are spread out horizontally on the natural surface of the vegetation and the turf rests on

on them. In order to get the spruce into position the turf is slit vertically from one side to the centre with a spade. The turf is then raised up by the outside ends of slit which at the same time opens the slit. The plant is pushed in the slit to the centre of the turf and its roots are spread horizontally below the turf which is then dropped back into position and firmed. Care should be taken to make the notch on the lee side of the turf - on the side sheltered from the sun. It seems reasonable to conclude that the turf should be prepared well in advance of planting in order that the natural vegetation should be killed and wilting by winter frosts &c. should take place.

In local forests the drains are 13" wide, 12" to 18" deep and 12" at bottom. 12 to 16 chains of drains to acre; $1/8$ per chain for draining alone; $2/4$ per chain for mounding and draining.

Strong seedlings should be used when possible as it means 20¢ per acre of a saving compared with 2x1 transplants. There is, in addition, considerable saving in transport.

Beating up. A beat up plant costs on an average five times as much from start to finish as any

an initial plant. It is ~~therefore~~ therefore clear that the problem of beating up is worth the most careful investigation. Causes of failure are faulty initial selection of species, the use of unsuitable nursery stock, unsuitable planting methods, bad planting and failure to weed. These are within the control of the forester. Others, mainly climate may from time to time upset the best regulated plan. Study the causes which give rise to failures under the specific conditions and avoid the repetition of processes which led to failures. Beat up as soon as it is certain that the blanks are numerous enough to justify it. The longer it is delayed, the more costly the weeding, and beat up plants must be such that they will require a minimum of attention after planting and will play a useful part in the development of the crop. It must consequently be a first class plant in itself. It must be either a quick grower or a shade bearer; it must be well planted and so located with reference to its neighbours and to coppice and weed growth that one year or at most two years weeding will afford it room for full development.

Selection of Species - Hanson Two.

Consider

- Consider (1) Will species preserve productivity of locality.
(2) Are trees to be grown as pure crop or in mixed woods (as a general rule if light demanders are selected we may have to underplant at some later period).
(3) Market price and demand for different kinds of timber.

Many soils which are unsuitable for hardwoods are splendid for pines.

Where locality is suitable ash and larch are economically safe.

Local demand and quality of timber offered determine net profit.

Hardwoods give best results on stiff loams or clay soils not too dry.

Conifers are much more profitable on poorer, lighter sandy loam where often moisture is not sufficient for growth of hardwoods.

On heavy soils or chalk, beech should always form bulk of crop with other species singly or in groups.

On very poor heavy soils plant Austrian pine.

Silvicultural

Silvicultural Notes.

Hanson - Chaps. 11 and 12.

Alder.

Ash.

Beech.

Birch.

Elm.

Oak.

Poplars.

Sycamore.

Norway Maple.

Douglas Fir.

Silver Fir.

Larches.

Pines.

Spruces.

Grouping and Combination of Forest Trees.

Hanson Chaps III & VII - Pure and Mixed Woods and Methods of Treatment.

Silvicultural System. The method and manner in which the regeneration, tending and felling is carried out in a forest.

There are three principal forms of forest -

(1) High Forest, in which the wood consists of trees which have sprung from seed grown until maturity before harvesting and then replaced by trees again sprung from seed. We may have two different

different kinds e.g. pure (one species) and mixed.
(2) Low Forest or Coppice, which depends on the existence of a property possessed by broad leaved trees of producing shoots from the root stalk after the whole or part of the stem has been removed. Rotation is generally short.

(3) Middle Forest or Coppice with Standards consists of a combination of high and low forests on the same area. A part of the crop present is raised from seed and the other part from stool shoots.

As regards timber production we can grow conifers only in high forest as they do not coppice.

Objects for which trees are maintained and cultivated.

- (1) Ornament (arboriculture).
- in (2) Timber production (silviculture).
- or (3) Protection e.g. in cases where shelter is required. This also ensures regular drainage and prevents landslides.

In connection with grouping, some species are capable of producing pure woods and others require to be mixed. Species which we find only in small woods are maple

maple, ash, hornbeam and alder. In large, pure woods we find oak, beech, silver fir, spruce, pine and birch. In Britain generally, mixed woods have come about from an arboriculture point of view.

Advantages and Disadvantages of Pure and Mixed Woods.

Mixed Woods. (1) Thicker crop and species can be adapted to places where soil is suitable. (2) Some species are deeper rooting than others. Thus deep rooters give the necessary shelter to shallow rooters. (3) Fertility of the soil is preserved. Light demands are bound to open up later and cause the soil to deteriorate. (4) More yield in timber and demands for different kinds of wood are more easily satisfied. (5) Mixed woods are less exposed to injuries than pure woods (fire, wind, drought, insects and fungi).

Natural Conditions which Tend to Produce Mixed Woods.

- (1) Soil. The better the quality the more do mixed woods prevail and species more numerous.
- (2) Climate. The colder the climate the fewer the

the species occur in mixture (North Pole to Equator - pure to mixed ---- high to low altitudes - pure to mixed). (3) All species tend to produce pure woods in their own optimum (soil and climate more suitable). (4) All shade bearers incline to form pure woods. (5) Clear felling followed by sowing or planting leads to pure forest but natural regeneration tends to lead towards mixed wood. (6) all silvicultural mismanagement leads towards wood becoming pure e.g. overthinning, underthinning, too long delayed thinning and removal of humus.

Species which it is Possible to Combine.

Spruce forms Pure Wood.

also occurs with Silver Fir.

" " Larch.

" " Beech.

" " Pines.

" " Birch.

" " Alder.

" " Silver Fir and Pines.

" " " " Beech.

" " " " Larch and Beech.

Spruce and Oak are unsuitable as either

either must be out of its optimum.

Silver Fir forms Pure Woods.

also occurs with Beech.

" " Larch.

" " Pines.

" " Oak.

" " Beech and Larch.

" " " Oak.

" " " Oak and Pines.

Beech forms Pure Woods.

also occurs with Oak.

" " Larch.

" " Pines.

" " Alder.

" " Pines and Oak.

Pines form Pure Woods.

also occur with Birch.

" " Alder.

Larch does not form extensive pure woods.
occurs with Pines

" " Birch in higher regions.

Conditions under which Pure Woods
Cannot be Avoided.

(1) /

(1) Where special product only is wanted e.g. willows for baskets. (2) On soils which will support no other species (3) In climatic zones where only one species will grow e.g. Birch in far north where climate is too severe. (4). On small properties where short rotation is desired for pitwood. (5) On large properties where staff is not sufficient (pure woods require less work).

Notes on Different Pure and Mixed Crops.

Pure Spruce grows fast from fifth year and by tenth year canopy is formed which remains close till maturity. Being a shade bearer it preserves density. The maximum in height growth is reached in the 20th. to 30th. year. A suitable soil is light sandy loam with a covering of from six to eight inches of humus. It ~~prefers~~ prefers a fresh soil. Timber is useful for structural purposes.

Pure Silver Fir is slow in growth to begin with until 10th. year and reaches maximum height growth by 30th. to 40th. year. It is deep rooting and storm proof. In its younger stages it suffers from frost and dry winds and prefers

a light loamy soil, fresh and with a good covering of humus - a better soil than Spruce.

Pure Beech maintains canopy from 10th. year. Greatest height growth not until 40th. year. It is liable to suffer from snow in pole stage. Grows fairly well on chalky soil and preserves the fertility of the soil and improves conditions. Humus from beech leaves is very good and contains a considerable amount of potash.

Pure Oak usually begins to open out after 15th. year then continues rapidly until 30th. year. On places less suited for oak, opening out does not occur till 30th. year which causes short & branchy stems. It requires a soil rich in minerals and physically suitable with a strong, tenacious subsoil. Tap Root must get down into a good, firm layer.

Pure Pine forms canopy in fifth year. Maximum height growth in 20th. year. It opens out then, hence branches cease to be suppressed and grass and weeds appear as soil covering. As regards soil it must have a certain proportion of sand. If

this

this is absent, stems usually of bad formation. Pure woods are found on extremely poor soils as pine is a non-exacting species. A sandy loam is the most suitable. Height of stem is an indication of depth of soil. Pure larch opens out early and it is impossible to keep close canopy. It is a mistake to try to maintain a close stand as the woods become very liable to disease and snow break. Soil should be fresh and overlying a ~~smooth~~ loose subsoil which ensures good drainage.

Shade Bearers (with) and Shade Bearers.

Spruce and Silver Fir is more storm proof than pure spruce. Shape fairly similar and pack well together. Spruce is a more rapid grower at first and silver fir may require a start and protection in thinnings.

If rate of growth is very different it may be necessary to adopt group or strip system. Danger becomes greater the colder the climate. Silver fir has more serious enemies than spruce and is more sensitive to draught and frost. In this mixture silver fir gets protection from frost and insects also shelters spruce from wind.

Spruce with Beech. Shapes differ also depth of root. Beech stands more shade. In warmer climates /

climates beech woods suppress spruce but in colder climates vice versa. In places less suitable to beech, grouping may be necessary. Advantages of combination is that Beech grows taller, spruce is protected from wind and insects and soil is improved.

Silver Fir and Beech. Silver Fir increases in value; natural regeneration is easy; but Beech is liable to suppress Silver Fir which should be protected in thinnings. Towards end of rotation silver fir tends to outgrow Beech.

Spruce, Silver Fir & Beech. During earlier stages silver fir weakened. In cold stage beech rather threatened and lastly spruce.

Shade Bearers with Light Demanders.

Spruce with Pine. On Spruce soil not suitable for pine which may remain stunted. On pine soil of good quality, spruce will reach timber dimensions but is an endangered species. It might be confined to wetter places.

Spruce and Larch. Larch requires to be grown fairly open. If kept thick larch is suppressed and final result is disappointing

at

At first larch is quicker in growth then slowly
spruce overhauls it.

Beech with Oak. Amongst hardwoods, most
important mixture especially on oak soil on
which oak keeps pace with beech. This mixture
benefits the soil greatly and produces the best
form and quality of oak. After 20th. year, in
a colder climate it is difficult to maintain
mixture. There it is much better to form an
uneven wood. About 30th. to 50th. year, oak woods
open out. At that time they should be heavily thinned
and underplanted with beech. In 10 to 50 years,
when beech is established, another thinning
should be made from intervals of 5-10 years.
Thus the oak is free to develop and the fertility
of the soil is maintained by beech, which hastens
the development of the oak. Under this treatment R
150 yr. old oak equals in bulk 200 yr. old P
oak without beech. T

Beech and Pine. On good quality soil
for pine, beech is normal; on poorer quality
shrubby. V

Beech and Larch. Larch grows better
than Y

than with any other species. Beech will stand light shade of larch which is not likely to be overtaken if planted with beech at 15th. year.

Shade Bearers with Half Shade Bearers.

Beech with Maple, Sycamore, Ash, Lime or Elm. Birch does not do much good, and is better underplanted as a soil protecting species.

Light Demanders with Light Demanders.

Oak and Larch. Not a possible mixture owing to soil, climate and character of each.

Oak & Pine. Pine is here taking up room where more valuable timber may be grown. On first class pine soil it may be possible.

Pine and Birch. This mixture occurs naturally and yet cannot be recommended because such woods are thin and soil deteriorates. They are generally the result of unfavourable conditions in localities where no other species can compete with them. Up to 15th. or 20th. year birch grows quicker. The Scots Pine, if it survives that period, comes up and passes it. The birch then requires help if it is to be preserved. Birch is ready
for

for the axe at a comparatively early age where Scots Pine requires a longer rotation. Birch may be used as a nurse e.g. in frost hollows.

Scots Pine and larch. This mixture leads to unsatisfactory results where the locality is not thoroughly suitable for larch. Up to 15 or 20 yts. larch grows quicker and may injure the Scots Pine crop. Nevertheless, this mixture extends over extensive areas in Britain and especially Scotland not because it is best, but because S.P. thrives well and it yields higher returns than most of the species that could be substituted for it. In selecting species, conditions and climate vary greatly and forestry is usually confined to poor soils, therefore species require to be as non-exacting as possible. Trees should not only grow but should improve soil conditions. Whenever you have any doubt as to soil being good, choose less exacting species. Shade Bearers protect soil better than light demanders and during the earlier stages trees are more dependent on quality of soil than at later stages.

Agricultural

Silvicultural Notes on Broad-leaved Trees and Conifers.

Study Hanson 11 & 12.

Acacia.	Plane.
Gean.	Spanish Chestnut.
Hazel.	Tulip Trees.
Holly.	Walnuts.
Hornbeam.	Willows.
Horse Chestnut.	Cypresses.
Laburnum.	Thujas.
Lime.	Yew.
Rowan.	

Natural Regeneration.

Study Hanson p.p. 90-98.

Restocking of ground by seedlings which spring from naturally scattered seed.

Advantages of Natural Regeneration are (1) Crop can be formed with comparatively small outlay for soil preparation (2) Crop is generally thicker and therefore forms canopy sooner, thus protecting the soil better than when formed by artificial sowing or planting. (3) There is little danger of the crop not being suited.

sintered to the soil. (4) It affords good protection against drought, frost, insects and fungal diseases.

Disadvantages of Natural Regeneration are (1) The time of regeneration depends on good seed years which cannot always be relied upon so that the regularity of the annual falls and other provisions of the working plan may be interfered with to a greater or less extent. (2) more supervision and technical knowledge are required than for sowing or planting. (3) the young crops are usually somewhat irregular. (4) It is only cheaper when the operation is successful but not when there are many blanks to fill in.

Necessary Conditions for Natural Regeneration.

(1) Good seed bearing trees.

(2). Good germinating bed.

Different Systems of Natural Regeneration.

(1) Compartment System. (2) Strip System.

(3) Group System. (4) Selection System.

1. Compartment System. A compartment is a compact unit in which trees are of the same age and condition and regeneration takes place over the whole of the compartment. It may require two or more seed years before the ground becomes stocked with seedlings and from five to fifteen years.

years to thoroughly stock the ground. For all practical purposes, wood is even-aged. With most of our trees limit of success of regeneration is from eighty to one hundred years. The old crop is gradually removed and ground becomes sown. Old trees are replaced by new growth without soil being exposed. To bring this about, successive cuttings are generally arranged into three stages each of which represents a distinct stage (a) preparatory stage (several cuttings) (b) seedling stage (one or at most two cuttings) and (c) final stage (gradual and successive).

Preparatory stage. A time arrives in the life history of a wood which is most favourable for natural regeneration. It occurs generally towards the end of principal height growth. The trees may not be in the best period of life for the production of good seed in sufficient quantities or the soil is not in the best possible condition to serve as a germinating bed. It is the object of the ~~preparatory~~ preparatory cuttings to counteract these and other drawbacks by hastening the decomposition of the humus and making the soil more suitable for germination.

The objects are (1) to prepare soil so that the seedling

seedling may reach mineral soil. If this is not a success, artificial preparation may be necessary e.g. hoeing the soil. (2). to increase stability of seed trees. We can, during preparatory stage, leave trees of the best type equally distributed over the area. The denser the crop, the more preparatory cuttings are required. With shallow rooters canopy should be opened up very gradually.

(3). Increased light stimulates seed production. (4) Economic several period cuttings distribute yield of timber. However, in preparing for natural regeneration, demand for timber should not influence fellingings. (1), (2) and (3) are the important considerations. If trees produced crops of seed annually we could regulate cuttings but crops of seed vary according to species. The number and character of cuttings and whether the preparatory stage should comprise one or several cuttings cannot be determined beforehand. It depends on the circumstances of each case. Sometimes such cuttings are altogether unnecessary e.g. in very open woods. In others one cutting suffices and in others again two or even more are required. The period over which the preparatory stage may extend is from one to fifteen years. The longer the period over which preparatory

preparatory cuttings are to take place, the less severe they should be. Preparatory cuttings may remove from $\frac{1}{5}$ to $\frac{1}{4}$ the number of trees. In selecting the trees to be cut during this stage a commencement is made by the removal of diseased trees and all species that are neither required nor desired for reproduction. Trees are removed with bad crowns and unsuitable habits, care being taken throughout that the trees destined for the ultimate shelter wood are as evenly distributed over the area as possible in order to give the shelter required for the species under regeneration.

Summary of Objects. (1) Germinating bed (2) Stability of Trees (3) Seed production (4) Yield.

Seeding Stage. Just before seed years, trees and soil should be into a condition fit to produce a new crop. To avoid opening up too much, last preparatory stage is held back until practically certain that seed are on the trees.

Then seed felling is done which opens up wood sufficiently to allow seed to reach ground and allow seedlings light. The trees left after preparatory & seed cuttings form the shelter wood which produces seed and prevents drying up of soil. If too dense, seedlings suffer from insufficient light and

and humus is not decomposed.

Density of Shelter Wood depends on (1) Locality - if unfavourable or if growth of grass or weeds likely, keep dense. (2) Number of trees and density depends on species and density of crown, and also its age & height of crown above the ground. (3) Existing conditions of soil. If more favourable conditions shade may be lighter. (4) Where trees are slow to begin, keep shelter wood dense. If hardy, quick growing light demanders e.g. oak, scots pine and larch, lighter shelter wood. If conditions vary, then density should vary also. In exposed margins leave shelter wood dense. Under ordinary conditions seed felling takes $\frac{1}{4}$ to $\frac{1}{3}$ the number of trees left after preparatory cuttings.

Summary of Objects. Seed felling winds up preparatory felling and leaves only shelter wood trees. If function is to sow the ground, shelter soil and give shelter to young generation.

Final Stage. This comprises the period from the execution of the seed cutting until the removal of the last part of the shelter wood. The final felling takes place after the ground is fully stocked with seedlings. The principal objects of the shelter wood are to protect the young growth against various damages e.g. frost, weeds.

weeds and insects; to preserve the activity of the soil until the new crop can undertake that duty. At the same time, the shelter wood will act obstructively as regards the admission of light and rain and therefore it must not be left longer than is actually required. Its removal is effected so as to meet these various requirements by one or several cuttings carried out at intervals of one, two or more years. The rate of these cuttings and the time within which the removal takes place, depends on various considerations as (1) Light required by new crop. Seedlings themselves indicate best; small leaves, yellowish foliage and small thin buds all indicate too heavy shade. (2) Until the new wood closes overhead, the old wood must provide soil covering. Tender species require shelter wood longer. If physical and/or chemical conditions of soil are inferior leave shelter wood longer than on good, fertile soil; this also applies in the case of rank growth areas and frosty places. First felling usually takes place two or three years after crop is established. In light demanding species, shelter wood may be removed in five to ten years; shade bearers from ten to fifteen years. The longer shelter wood is retained, the more damage will be done.

done on removal of timber. The young growth will indicate when to remove shelter. Planks may be filled up by sowing or planting. In treating mixed woods in natural regeneration the forester must be very careful to preserve the proportion of mixture. Considerations are (1) relative reproductive powers along with frequency of seed years (2) relative light requirements and (3) nature of germinating bed.

Relative number of species is best adjusted towards end of thinnings in preparatory stage and before seed is shed. In seed cutting, arrange felling when principal or more tender tree is in seed. Natural regeneration in mixed woods is more difficult than in pure woods. When it fails mixture must be adjusted artificially.

Strip System - is a modification of the compartment system. Instead of conducting the regeneration possessed uniformly over a whole wood or compartment the area is divided into a number of strips which are taken in hand one by one. As soon as one strip has been completely regenerated a fresh strip is taken in hand and so on until the process is gradually extended over the whole area or compartment. Seed may be sown from a light shelter wood or the adjoining wood.

wood. Shelter wood may be removed when the crop is three years old. Then, in the fourth year, a second strip is taken in hand. This system is more common with spruce and silver fir than with oak and beech (lighter seed).

Group System. Groups scattered over the compartment are taken in hand and when these have been regenerated they are gradually enlarged by regenerating successive narrow bands round them and this process is continued until the several groups merge into each other. If rotations of species are not the same, this system should be employed. Patches of trees can be grouped according to the suitability of the soil. The size of each group varies with light demanders and shade bearers; in case of shade bearers $\frac{1}{8}$ acre or less; with light demanders they may be $\frac{1}{4}$ to $\frac{1}{2}$ acre. If area of group is very small, all trees may be removed. Expansion of rings does not take place until regeneration is established. Merging of groups should not take longer than rotation.

Selection System - consists of taking mature trees and no more. It is really the reduction of the group system to a minimum. Under selection system soil is better protected and in Europe

Europe is confined to localities where the uninterrupted maintenance of a crop of forest trees is necessary for the protection of the soil against heavy rain &c. In large forests where there is no working plan, this system is safest. A disadvantage is that the young plants are very shaded and they are slow to establish themselves. Under this system, exposure of soil and danger of wind is less than under any other.

Comparative merits of Various Systems.

1. ~~Comparative merits of~~ Compartment System. (a) work is concentrated and can be carried out more expeditiously with easier supervision (b) produce is concentrated and therefore transport is more convenient and cheaper, with fewer roads to maintain (c) the compartment being clear, there is no side shade to hinder light demanders (d) whole wood or compartment is being treated uniformly and if regeneration successful, formation of the young wood is assured over a large area. If natural regeneration fails, the soil is bound to suffer, due to a thin stand being left over the whole compartment. In such a case, the forester must await another seed year.

year with the resulting disappearance of humus and adopt expensive artificial planting. Compartment system is possible only under favourable conditions such as (1) where wood is sheltered from the wind (2) soil should be uniform (3) age should be fairly uniform (4) compartment system suits pure better than it does mixed woods and gives better results with shade bearers than with light demanders.

Drawbacks become less the smaller the compartment.
2. Strip System. There is less risk of failure and old trees are less liable to be blown by wind, but work is more scattered and transport more costly and difficult.

3. Group System. Advantages are: - the soil is better preserved; it is the most suitable system on unfavourable conditions, and should failures occur they are confined to small, isolated groups; each group is regenerated at the most favourable time; in removing shelter wood trees they can be hauled through unregenerated areas with less damage to young plants. Disadvantages are: - work is scattered; transport is more costly; supervision is more difficult.

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On the whole, it is suitable where soil and crop varies and it is better adapted to mixed woods than compartment system. It is also safer than compartment system in extremes of climate.

4. Selection system. Here we have the disadvantages of the group system intensified. The soil, however, is thoroughly protected, but young crop is retarded.

In small strip or group, all trees may be removed and seed shed from side trees. On sloping ground and with taller stems seed is carried further. Group should not be too broad if clear felled.

The following distances of carriage of seed for a number of species under the influence of a moderate air current may be given: Birch and Elm easily carried four to eight times height of tree; Spruce, Scots Pine and Larch, three to four times height of tree; Lycamore and Hornbeam, two to three times height of tree; Lime and Silver Fir, one to two times height of tree; Oak and Beech fall just below the crown.

Whichever system is employed, the essential factors are (1) condition of germinating bed,

bed (2) condition of seed trees.

Pure Spruce. In natural regeneration, compartment system is out of the question (danger from wind). Clear strip cutting is best. Strips should not be broad and direction of cutting must be against wind. If wood is small and locality is sheltered, shelter group cutting might be adopted so long as groups are not too large.

Pure Silver Fir. Clear strip regeneration or sheltered group. Shelter cutting in whatever form is more applicable with silver fir than spruce (fir in roots).

Pure Beech. Is well adapted for shelter compartment system and also shelter group cutting.

Pure Pine. Difficult to get full group naturally regenerated and wood uniform.

Read Schlich's Manual of Forestry, vol. II.

Sylviculture pp. 232-263.

Coppice and Copse.

Coppice and copse are woods of low rotation. Products are poles, rods, bark & brushwood. Copse is sometimes called coppice with standards or stored coppice.

Products

Products are timber, bark and coppice products. This used to be the principal tree growth in Britain. Standards comprised oak, ash and elm and the under coppice hazel, ash, beech and spanish chestnut. The general rotation was eight to twenty four years. The demand for this timber has almost dropped and areas are being converted into high forest. Coppice can only be formed by broad-leaved trees. Suitable species with necessary reproductive powers are: spanish chestnut, oak, ash, lime, sycamore, hornbeam, rowan, alder and hazel. Rotation depends on the size of material required. In the case of oak, ash, alder and willows, they can be kept pure. Other kinds of coppice must be mixed. Mixing hazel and ash is out of the question as hazel rods are saleable at seven to eight years but ash coppice is not of much value until thirty years old. The longer the rotation, the less often is the soil laid bare. Coppice takes more out of the soil than timber. Production of oak bark - rotation was usually twelve to sixteen years. The ideal arrangement in coppice with standards was an overwood

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of light demanders and an underwood of shade bearers. In future, this form will only be used for ornamental purposes, shelter and game cover. The better the soil, the greater the number of standards it is possible to maintain. The time to regulate the number of standards is when the underwood is being cut. Sometimes pure coppice may be maintained for game cover. Where the locality will produce no other or places where transport is inaccessible, light material may be grown. In cutting the stems it should be done as low as possible and made slanting so that water will not rest on it. The bark should not be severed from the wood around the edge of the cut. The best season of the year for cutting is a few weeks before the buds begin to swell. Pure spanish chestnut for hop poles is the most profitable crop. Next comes ash and hazel. The best market is in Kent and Sussex.

Conversion of Coppice.

Coppice which has been abandoned and left to itself is now only suitable for game cover and must be sacrificed. If there are a number of suitable poles in the coppice, these might be used.

used as seed trees or heavily thinned out and underplanted with a quick growing conifer. On poor soil or light demanding undergrowth, standards should not shade more than one quarter of the area. Shade Bearers may be completely shaded. Good returns can only be expected on lands of good quality.

Tending of Woods.

Study Hanson - Chaps. VI.

Protection of very young woods. Whether formed by natural regeneration or planting, all plantations usually require more or less artificial protection against such dangers as frost, snow, wind and drought as well as from insects, fungi &c. before they establish themselves. When woods are reproduced either naturally or by sowing under some of the matured trees, sufficient shelter can be usually given by leaving a certain number of trees per acre. Most of the trees grown in Britain are fairly hardy, have rapid growth at first and soon outgrow danger from frost and drought. Protection against wind may be secured by making the annual falls of matured timber or by planting young woods in the direction

direction directly opposite to the prevailing wind. This secures protection to the older woods against windfall and at the same time gives the young crop the benefit of the shelter of the high woods lying to windward. Rank growth of weeds, whether soft grasses, bracken, molinia, whin, broom, heather or quickgrowing soft woods like birch, aspen and willows must be cleared away so far as they interfere with the young crop during the first or second year. In case of bracken, it is often desirable, especially in exposed localities to leave thinly covered areas uncleaned, also on dry, sunny parts, a thin shelter of brackens during summer is beneficial. This could be removed in autumn if likely to fall down on the top of the plants. A careful lookout must also be kept to prevent damage by rabbits &c.

Tending of Crops when once established.

When once the young plantations can be considered to have established themselves, different operations of tending are still necessary thro' all the remaining stages of growth as thickets of saplings, young pole woods or fully developed.

opened high woods. The manner in which plantations are tended, affect the whole of their subsequent development. The quantity, quality and market value of the future mature timber crop are all more or less dependent on the way it has been tended by cultural operations all very much of the character of thinnings. Such operations include:-

- (1) weeding and cleaning so long as the value of what is cut out fails to cover the cost of the operation. It therefore forms a charge against the young crop.
- (2) thinning when the cost of cutting out poles &c. is covered by the value of produce removed.
- (3) partial clearance of poles or trees after the main growth in height has taken place. It is made to stimulate increment in girth or to prepare for seed production in natural regeneration. Weeding consists of the removal of all such trees e.g. undesirable species (brack &c.) except to any extent required for filling blanks together with the cutting back of rank grasses or other herbaceous growths while Cleaning is the removal of all such weaklings forming part of the original crop as may, if left longer, compete with the better part for light and air - such

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as the cutting back of nurseries when no longer required. Here the object is not to remove as much as one safely can but to confine the operation merely to what is best for the future crop. Careful weeding and cleaning are the best means of obviating damage by snowbreak, insects and fungal diseases.

Thinning in Pole Woods and Young High Woods.

One of the most important objects in the formation of a wood is to stock the area sufficiently so that the complete cover overhead may be established as early as possible. This is desirable, not only for the preservation of the soil, but also for a proper development of the trees. In order to ensure early closing overhead, it is necessary to plant a much larger number of plants than can find room on the ground for any prolonged period. Soon after a complete leaf canopy has been established the trees commence pressing one against the other. There is not enough growing space for all, and their struggle for existence sets in. The quicker growing kinds or individuals outgrow and

and suppress slower growing species or less vigorous plants. If left to nature, this struggle for existence is slower on poor than on rich soil and slower on unfavourable than on favourable situations. Thinning includes all operations for removing all unnecessary species or individuals in pole woods or young high woods. This struggle, if not interfered with, would continue as long as height growth would last and would gradually reduce the growing space of each dominant tree to such an extent as to hinder their development in the most advantageous manner. Consequently, such trees would likely assume a thin, lanky shape, so that they frequently would be unable to stand upright if deprived of the support of their immediate neighbours. They would also be liable to be broken by wind and snow. To obviate this, the forester intervenes in good time by removing a portion of the trees. He thins the wood.

Thinnings, then, are cuttings which have for their object to provide for each tree left standing and especially to those which are to remain until the end of the rotation that growing space which is best suited for its future development according to the objects

of

of management. As the objects of management differ, so must the most suitable growing space. Apart from this, that space differs according to the age of the wood, species, soil, elevation and aspect of the locality. As regards the objects of management, it suffices in practical forestry to distinguish between the two following cases (a) production of the greatest quantity of material (b) production of the highest quality of material. Experience has shown that the greatest quantity is produced in the shortest possible time by a vigorous development of the dominating trees so that the suppressed trees are only retained as long as they are required for the protection of the soil. Thinnings should commence early, be heavy in this case and frequently repeated during the first half of the life of the wood and be more moderate and repeated at longer intervals during the second half. Where the production of the highest quality of timber is aimed at, the quantity to some extent must be sacrificed. Heavy thinnings at an early age must be avoided until end of principal height growth when a selected number of the best-formed trees is assisted by the removal of the others.

Age

Age of Wood. As the number of trees decreases, gradually from several thousands to a comparatively small number, it follows that the growing space increases with advancing age though not evenly. Statistics show that (1) the increased requirements of space are very great between the ages of twenty to sixty years, and then falls gradually up to the age of one hundred years. (2) many trees must be removed during the earlier part of a wood's life and comparatively few later on, always assuming that the area is to remain fully stocked.

Species. In comparison with light demanders, shade bearers only require about one half to two thirds the average growing space.

Soil. Until some time past middle age, the number of trees is larger on a poor soil than on a rich one; afterwards the richness disappears. The reason is that the struggle for existence begins earlier and is more energetic on good than on poor soils. In this respect, considerable difference exists between the various species.

Altitude. The higher the locality, the greater number of stems per acre but the smaller the trees.

trees in height and girth and therefore volume. Aspect. South and West exposures carry a larger number of stems than north and East aspects.

Objects of Thinning. 1; Utilisation of material before it is killed out by other trees. This gives substantial early returns. 2; To stimulate growth and development of remaining trees of crop and to increase timber production (thinning directly influences total production, quality of crop and time of maturity). 3; Remaining trees are more resistant to high winds and snow. Danger from insects, fungi and fire is greatly reduced by the prompt removal of dead and sickly trees. 4; They afford the means of preserving a suitable mixture in the case of mixed woods.

In judging of the desirability and the degree of thinning in any particular wood the forester must take into consideration (1) objects of management (2) density of crop (3) age of crop (4) species (5) character of locality, soil, climate, and the special external influences to which it is exposed.

Thinnings begin sooner and end sooner with light demanders than with shade bearers, in warmer climates than in colder climates, on good soil.

soil than on poor soil and with close planting than with wide planting. Thinnings influence soil and total amount of timber production. Different trees respond differently to thinnings. In oak, if too long delayed crown is reduced and never responds to thinning. Sudden thinning in this case causes stag-headedness due to development of epicormic shoots which transpire the water. Earlier thinnings are intended to produce length of clean timber. Later thinnings are intended to produce increased crown development. Inferior dominant trees should only be cut when there are dominated trees in immediate vicinity, otherwise a gap would be left.

General Rules for Thinning.

1. In all stages, especially younger stages, those trees which interfere with the total mass and quality production must be removed e.g. badly formed trees &c.
2. Till height growth is finished main endeavour is to stimulate length and cleanness of stem. Preservation of density must never be allowed to interfere with crown of best trees, nor must they be allowed to be too drawn up.
3. During earlier periods, thinning must be moderate especially

especially where dominant trees have been removed.

4. Sudden and severe thinnings must be avoided, especially in earlier stages.

5. On poor soils, thin more cautiously and less severe than on good soils.

6. After height growth is finished, thinnings may become stronger in order to encourage crown development and increased timber production. If wood is mixed, favour more valuable or more delicate species.

7. Suppression of trees by vigorous neighbours, the appearance of outbreak of disease or development of bad stem form may occur throughout the life of a wood, hence thinnings should be made periodically.

Classification of Thinnings used in Forestry Commission Sample Plots.

Class I. Predominant or Dominant Trees.

(a) Trees with normal crown development and good stem form.

(b) Trees with slightly defective stems or crowns.

(c) " " very " " " "

(d) Whips.

Class II.

Class II. Co-dominant Trees.

(a) Similar to I(a).

(b) " " (b).

(c) " " (c).

(d) " " (d).

Class III. Sub-dominant Trees.

(a) Similar I(a) and II(a).

(b) Trees with defective stems or crowns.

Class IV. Suppressed Trees.

These are trees under the shade of other trees but still capable of development.

Class V. Dead or Dying Trees.

Which includes bent over and leaning trees.

Class VI. Diseased Trees.

(a) Dominant and Co-dominant.

(b) Sub-dominant and suppressed.

Note. In larch crops, when *Dasyctypha Calycina* is generally prevalent, class VI is not used. The trees are classified as though they were free from disease, but in the case of cankered stems the letter K is added to the symbol for stem classes - e.g. I(b)K.

Grades of Thinning employed are:-

I. Low Thinnings.

B. Grade - Light Thinning

B. Grade - Light Thinning.

Remove classes $\overline{\text{VI}}$, $\overline{\text{V}}$, $\overline{\text{IV}}$, $\overline{\text{IIIb}}$, $\overline{\text{II d}}$ and $\overline{\text{I d}}$.
i.e. Dead, Dying, Suppressed, Bent Over, Diseased and Whips.

C I Grade - Moderately Heavy Thinning.

Remove classes $\overline{\text{VI}}$, $\overline{\text{V}}$, $\overline{\text{IV}}$, $\overline{\text{II d}}$, $\overline{\text{I d}}$ and gradually all trees of classes $\overline{\text{III}}$, $\overline{\text{II c}}$ and $\overline{\text{II b}}$ and part of class $\overline{\text{II a}}$ and $\overline{\text{I c}}$. i.e. All Dead, Dying, Suppressed, Bent Over, Diseased and Whips, also all sub-dominants, the majority of co-dominants and some of the worst formed dominants.

C II Grade - Heavy Thinning.

Remove classes $\overline{\text{VI}}$, $\overline{\text{V}}$, $\overline{\text{IV}}$, $\overline{\text{II d}}$ and $\overline{\text{I d}}$ and gradually all trees of class $\overline{\text{III}}$, $\overline{\text{II}}$, $\overline{\text{I c}}$, $\overline{\text{I b}}$ and part of class $\overline{\text{I a}}$. i.e. dead, dying, bent over, suppressed, diseased, whips, sub-dominant and co-dominant, defective dominant and some of the well-developed dominant.

There remain only trees with normal crown development and well-shaped boles distributed as regularly as possible over the ground, so that each has room to develop its crown normally. At the same time, no permanent break

break in the leaf canopy is permitted. In all cases in which a dominant tree would make a hole in the canopy suitable suppressed or backward trees should be left to cover the hole and so shade the soil. The removal of trees with bad crown development or poorly shaped boles should be carefully conducted with reference to the canopy and development of the whole crop.

II Crown Thinning - D Grade.

Light Thinning in the Dominant Crop.

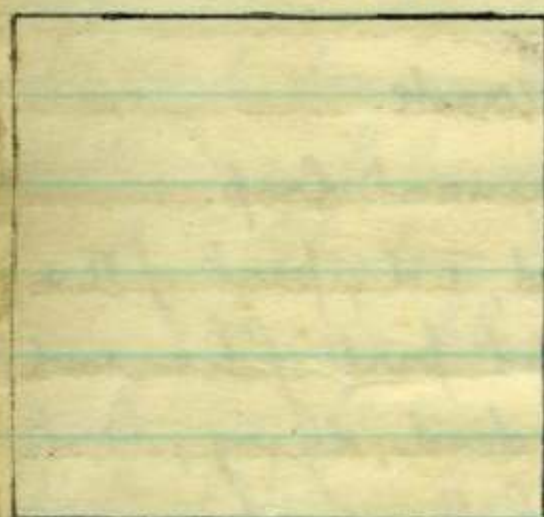
Remove classes VI, V, II d, I d, part of II a, II b, II c and I b, a great part of I c and also some stems of I a. i.e. - dead, dying, bent over, diseased trees, part of the co-dominant, a large number of the defective dominant and some well-shaped dominants where these are overcrowded. The removal of trees with poor stems, defective crown and forks, may be spread over several thinnings in order to prevent too extensive a breaking of the canopy.

E. Grade. Heavy Thinning in Dominant Crop.

The

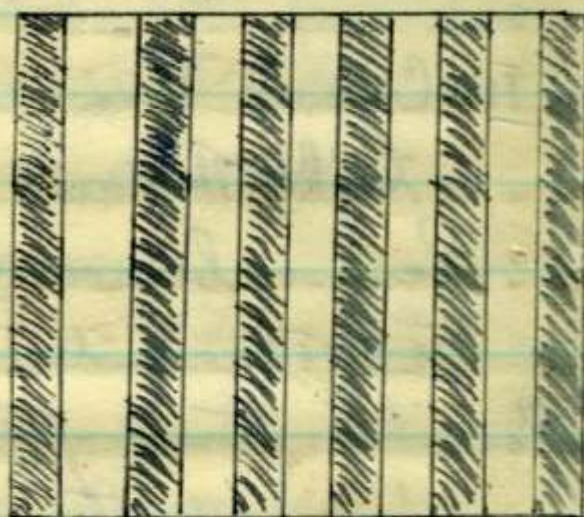
The grade is concerned with the development of certain stems - the elite - which are to form the final crop. Remove Classes VI, V and many stems from II and I. i.e. all dead, dying, bent over and diseased, as well as all trees which hinder the development of the crowns of the selected stems.

NATURAL REGENERATION.

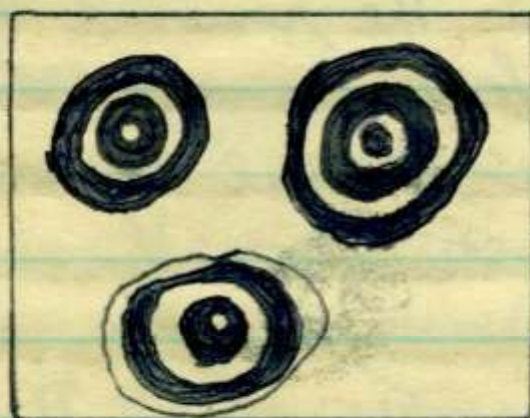


Compartment System.

WIND.
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Strip System.



Group System.