

**FORESTRY COMMISSION
TECHNICAL NOTES**

**SECTION I
AFFORESTATION**

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INTRODUCTION

In this work an attempt is made to place on record for the guidance of new forest officers and foresters the more arresting facts which have come to light since the Forestry Commission commenced operations. Its main purpose is to avoid repetition of the frequent mistakes which have been made in the past.

No attempt is made to cover the elements of forestry, in which it is assumed that the reader has already been grounded. Attention is drawn rather to specialised aspects which have been found to be of outstanding importance. An example of this method of approach is afforded by the reference lists of trees and plants. They are, of course, not comprehensive of all the species which the forester may encounter, but each one of them has a significant place in British forestry and the forester must be thoroughly familiar with at least such of them as occur in the forests under his charge.

It is not possible to cover in a booklet all the combinations of environment which have to be taken into account in deciding finally on a course of action, but there is always available superior direction on matters of doubt. The man who contemplates cutting across recommended procedure has reached the stage when he must proceed cautiously.

REFERENCE LISTS

TREES AND SHRUBS, GROUND FLORA AND NURSERY WEEDS

List 1 includes those trees and shrubs which the Forester may be expected to know.

List 2 contains the more important herbs and grasses which are often useful as indicating soil conditions and so form a guide to the choice of species. The effective use of indicator species is not easy, single specimens of a species may mean little or nothing; as a rule the more abundant and luxuriant the species the more it is likely to serve as a useful guide. The previous history of the area, e.g., whether it has recently been grazed or burned over, should also be kept in mind.

The Miscellaneous Plants given in List 3 are mostly common woodland plants but not as a rule of much use as indicator species.

List 4 gives the more common nursery weeds, but many other species may be found locally.

LIST 1

FOREST TREES AND SHRUBS

Forest Trees in General Use. Alphabetically arranged.

Broadleaves.

Alder, Common	<i>Alnus glutinosa</i> Gaertn.
Alder, Grey	<i>A. incana</i> Moench.
Alder, Oregon	<i>A. rubra</i> Bong.
Ash	<i>Fraxinus excelsior</i> L.
Aspen	<i>Populus tremula</i> L.
Beech	<i>Fagus sylvatica</i> L.
Birch, Hybrid	<i>Betula pubescens</i> x <i>verrucosa</i>
Birch, Silver	<i>B. verrucosa</i> Ehrh. (<i>alba</i> L.) (<i>pendula</i> Roth.)
Birch, White	<i>B. pubescens</i> Ehrh.
Chestnut, Horse	<i>Aesculus hippocastanum</i> L.
Chestnut, Sweet or Spanish	<i>Castanea sativa</i> Mill.
Elm, English	<i>Ulmus campestris</i> L. <i>U. procera</i> Salis.
Elm, Wych	<i>U. glabra</i> Huds.
Hornbeam	<i>Carpinus betulus</i> L.

Broadleaves—Contd.

Lime	<i>Tilia europaea</i> L.
Maple, Norway	<i>Acer platanoides</i> L.
Nothofagus	<i>Nothofagus obliqua</i> Blume.
Oak, Holm	<i>Quercus ilex</i> L.
Oak, Hybrid	<i>Q. pedunculata</i> x <i>sessiliflora</i>
Oak, Pedunculate	<i>Q. pedunculata</i> Ehrh. (<i>Q. robur</i> L.)
Oak, Red	<i>Q. rubra</i> L.
Oak, Sessile	<i>Q. sessiliflora</i> Salis. (<i>Q. petraea</i> Liebe)
Plane	<i>Platanus</i> species
Poplars, Balsam	{ <i>Populus balsamifera</i> L., <i>P. trichocarpa</i> Hooker.
Poplar, Black	<i>P. nigra</i> L.
Poplar, Grey	<i>P. canescens</i> Sm.
Poplar, Black Italian	<i>P. serotina</i> Hartig.
	<i>P. robusta</i> C.K. Schneider
Poplar, Black Italian	{ <i>P. serotina</i> Hartig. (<i>canadensis</i> var. <i>serotina</i> Rehd.)
Poplar, White	<i>P. alba</i> L.
Sycamore	<i>Acer pseudoplatanus</i> L.
Walnut, Black	<i>Juglans nigra</i> L.
Walnut, Common	<i>J. regia</i> L.
Willow, Crack	<i>Salix fragilis</i> L.
Willow, Cricket Bat	<i>S. alba</i> L. var. <i>caerulea</i> Sm.
Willow, White	<i>S. alba</i> L.

Conifers.

Cypress, Lawson	<i>Chamaecyparis lawsoniana</i> Parlatores.
Cypress, Monterey	<i>Cupressus macrocarpa</i> Gord.
Cypress, Nootka	<i>Chamaecyparis nootkatensis</i> Sudworth.
Douglas Fir, Green or Coastal	<i>Pseudotsuga douglasii</i> Carr. (<i>taxifolia</i> Brit.)
Douglas Fir, Grey or Intermediate	var. <i>caesia</i> Schwerin.
Douglas Fir, Blue or Colorado	var. <i>glauca</i> Mayr.
Hemlock, Eastern	<i>Tsuga canadensis</i> Carr.
Hemlock, Western	<i>T. heterophylla</i> Sargent
Larch, European	<i>Larix europaea</i> D.C. (<i>decidua</i> Mill.)
Larch, Hybrid	<i>L. eurolepis</i> A. Henry
Larch, Japanese	<i>L. leptolepis</i> Gord.

Conifers—Contd.

Pine, Austrian

Pine, Corsican

Pine, Ursuline

Pine, Lodgepole

Pine, Maritime

Pine, Monterey

Pine, Mountain

Pine, Scots

Pine, Weymouth

Sequoia, Redwood

Sequoia, Wellingtonia

Silver Fir, European

Silver Fir, Grand

Silver Fir, Noble

Silver Fir, Nordmann's

Spruce, Norway

Spruce, Serbian

Spruce, Sitka

Spruce, White

Western Red Cedar

Yew

Shrubs and Small Trees.

Apple, Wild or Crab

Box

Blackthorn, or Sloe

Buckthorn, Alder

Buckthorn, Purging

Cherry, Bird

Cherry, Wild or Gean

Cotoneaster

Dogwood

Elder

Guelder Rose

Hawthorn or Whitethorn

Pinus austriaca Hoess.(P. nigra var. *austriaca* A. & G.)*P. laricio* Poir.(P. nigra var. *calabrica* Schneid.)Variety of *Pinus laricio*?*P. contorta* Douglas.(and var. *latifolia* Engelm.)*P. pinaster* Ait.*P. radiata* D. Don.*P. montana* Miller.*P. sylvestris* L.*P. strobus* L.*Sequoia sempervirens* Endl.*Sequoia wellingtonia* Seem.*Abies pectinata* D.C. (*A. alba* Miller.)*A. grandis* Lindley.*A. nobilis* Lindley. (*A. procera* Rehd.)*A. nordmanniana* Spach.*Picea excelsa* Link. (*P. abies* Karst.)*P. omorika* Bolle.*P. sitchensis* Carriere.*P. glauca* Voss.*Thuja plicata* D. Don.*Taxus baccata* L.

Alphabetically arranged.

Pyrus malus L.*Buxus sempervirens* L.*Prunus spinosa* L.*Rhamnus frangula* L.*R. catharticus* L.*Prunus padus* L.*P. avium* L.*Cotoneaster simonsii* Baker, etc.*Cornus sanguinea* L.*Sambucus nigra* L.*Viburnum opulus* L.*Crataegus oxyacantha* L.

Shrubs and Small Trees—Contd.

Hazel	<i>Corylus avellana</i> L.
Holly	<i>Ilex aquifolium</i> L.
Juniper	<i>Juniperus communis</i> L.
Lonicera	<i>Lonicera nitida</i> Wilson.
Maple	<i>Acer campestre</i> L.
Privet	<i>Ligustrum vulgare</i> L.
Rowan, or Mountain Ash	<i>Pyrus aucuparia</i> L.
Sea Buckthorn	<i>Hippophae rhamnoides</i> L.
Service Tree	<i>Pyrus torminalis</i> Ehrh.
Spindle Tree	<i>Euonymus europaeus</i> L.
Wayfaring Tree	<i>Viburnum lantana</i> L.
Whitebeam	<i>Pyrus aria</i> Ehrh.
Willow. Goat	<i>Salix caprea</i> L.
Willow, Osier	<i>S. viminalis</i> L., etc.

LIST 2

SPECIES OF VALUE AS SOIL INDICATORS

1. Peat Soils.

(a) More or less favourable types.

Bog Myrtle	<i>Myrica gale</i> L.
Cotton Grass	<i>Eriophorum vaginatum</i> L.
Purple Moor Grass (pure)	<i>Molinia caerulea</i> Moench.
Rush, common	<i>Juncus conglomeratus</i> L.
Rush, shining fruited	<i>J. articulatus</i> L.
Wavy Hair Grass	<i>Aira (Deschampsia) flexuosa</i> L.
Brown Bent Grass	<i>Agrostis canina</i> L.
Sedges	<i>Carex</i> species

(b) More or less difficult types.

Bog asphodel	<i>Narthecium ossifragum</i> Huds.
Cotton Grass	<i>Eriophorum angustifolium</i> Roth.
Deer Grass	<i>Scirpus caespitosus</i> L.
Heath, Cross-leaved	<i>Erica tetralix</i> L.
Purple Moor, Grass (diffusely mixed with heather and <i>Scirpus</i>)	<i>Molinia caerulea</i> Moench.
Heather (poor and stunted)	<i>Calluna vulgaris</i> Hull.

2. Leached Soils

Bent Grass, Brown	<i>Agrostis canina</i> L.
Bent Grass, White	<i>A. alba</i> L.
Bilberry or Blaeberry	<i>Vaccinium myrtillus</i> L.
Crowberry	<i>Empetrum nigrum</i> L.
Club moss, Common	<i>Lycopodium clavatum</i> L.
Heath, Common or Bell Heather	<i>Erica cinerea</i> L.
Heath, Cross-Leaved	<i>E. tetralix</i> L.
Heather or Ling	<i>Calluna vulgaris</i> Hull.
Hair Grass, Wavy	<i>Aira (Deschampsia) flexuosa</i> L.
Mat Grass or Matweed	<i>Nardus stricta</i> L.
Purple Moor Grass (mixed with heather)	<i>Molinia caerulea</i> Moench.
Rush, Heath	<i>Juncus squarrosus</i> L.
Wood Rush, Hairy	<i>Luzula pilosa</i> Willd.

3. Indicating Nitrification and/or Abundance of Lime, usually in Woodland or Old Woodland.

Dog's Mercury	<i>Mercurialis perennis</i> L.
Hair Grass, Wavy	<i>Aira (Deschampsia) flexuosa</i> L.
Garlic or Ransoms	<i>Allium ursinum</i> L.
Foxglove	<i>Digitalis purpurea</i> L.
Lily of the Valley	<i>Convallaria majalis</i> L.
Nettle	<i>Urtica dioica</i> L.
Primrose	<i>Primula vulgaris</i> Huds.
Raspberry	<i>Rubus idaeus</i> L.
Strawberry	<i>Fragaria vesca</i> L.
Wood Spurge	<i>Euphorbia amygdaloides</i> L.
Willow Herb, Rose-bay	<i>Epilobium angustifolium</i> L.
Woodruff	<i>Asperula odorata</i> L.
Sanicle	<i>Sanicula europaea</i> L.

4. Wet Loams and Clays.

Hair Grass, Tufted	<i>Aira (Deschampsia) caespitosa</i> L.
Meadow Sweet	<i>Spiraea ulmaria</i> L.
Purple Moor Grass (pure)	<i>Molinia caerulea</i> Moench.
Rush, Common	<i>Juncus conglomeratus</i> L.
Rush, Shining fruited	<i>J. articulatus</i> L.

5. Indicating usually good Soil Aeration.

Bracken *Pteridium aquilinum* L.

6. Chalk or Limestone Soils.

Rock Rose *Helianthemum* species

Sheep's Fescue Grass *Festuca ovina* L.

Strawberry *Fragaria vesca* L.

Thyme *Thymus* species

7. Sand Dunes.

Marram Grass *Psamma (Ammophila) arenaria* Link.

LIST 3

MISCELLANEOUS PLANTS

Anemone, Wood	<i>Anemone nemorosa</i> L.
Bluebell	<i>Scilla non-scripta</i> L. & H.
Bramble	<i>Rubus fruticosus</i> L.
Broom	<i>Cytisus scoparius</i> Link.
Bugle	<i>Ajuga reptans</i> L.
Campion	<i>Lychnis</i> species
Fern, male	<i>Aspidium (Dryopteris) filix-mas</i> Sw.
Gorse or Whin, common	<i>Ulex europaeus</i> L.
Gorse, small	<i>U. minor</i> Roth.
Grass, soft	<i>Holcus mollis</i> L.
Ground Ivy	<i>Nepeta hederacea</i> Trev.
Millet Grass, Wood	<i>Milium effusum</i> L.
Roses, Wild	<i>Rosa</i> species
Sage, Wood	<i>Teucrium scorodonia</i> L.
Saint John's Worts	<i>Hypericum</i> species
Sedge, Wood	<i>Carex sylvatica</i> Huds.
Spurge, Wood	<i>Euphorbia amygdaloides</i> L.
Violets	<i>Viola</i> species
Wood Rush, Great Hairy	<i>Luzula sylvatica</i> Gaud.
Wood Sorrel	<i>Oxalis acetosella</i> L.

Harmful Woodland Climbers.

Honeysuckle	<i>Lonicera periclymenum</i> L.
Ivy	<i>Hedera helix</i> L.
Old Man's Beard	<i>Clematis vitalba</i> L.

LIST 4

NURSERY WEEDS

Bindweed	<i>Convolvulus arvensis</i> L.
Buttercups	<i>Ranunculus</i> species
Charlock	<i>Brassica arvensis</i> Kuntze.
Chickweeds	<i>Stellaria</i> species
Chickweeds, Mouse-ear	<i>Cerastium</i> species
Couch Grass	<i>Agropyron repens</i> Beauv.
Dandelion	<i>Taraxacum vulgare</i> Lam.
Docks	<i>Rumex</i> species
Goosefoots	<i>Chenopodium</i> species
Groundsel	<i>Senecio vulgaris</i> L.
Horsetails	<i>Equisetum</i> species
Meadow Grass, Annual	<i>Poa annua</i> L.
Oat, False	<i>Arrhenathrum elatius</i> M. & K.
Oat, Wild	<i>Avena fatua</i> L.
Onion Couch	<i>Arrhenathrum elatius</i> M. & K. var. <i>tuberosum</i> Gilib.
Persicarias	<i>Polygonum</i> species
Plantains	<i>Plantago</i> species
Shepherd's Purse	<i>Capsella bursa-pastoris</i> Med.
Sorrels	<i>Rumex</i> species
Spurreys	<i>Spergula</i> species
	<i>Sagina</i> species
Thistles	<i>Cirsium</i> species
Sow Thistles	<i>Sonchus</i> species

LIST 5

COMMON BIRDS OF WOODLANDS AND AFFORESTATION AREAS

Listed alphabetically in the main groups, with scientific names and notes on habits.

S. = Summer migrants absent in winter.

C. = Species preferring coniferous woods.

B. = „ „ broad-leaved woods.

I. PRINCIPAL INSECT EATERS

Cuckoo	<i>Cuculus canorus</i> L.	S.	Almost the only eater of hairy caterpillars.
Flycatcher, Pied	<i>Muscicapa hypoleuca</i> Pall.	S.	
„ spotted	<i>M. striata</i> Pall.	S.	
Goldcrest	<i>Regulus regulus</i> L.	C.	
Hedge Sparrow	<i>Prunella modularis</i> L.		
Lark, Skylark	<i>Alauda arvensis</i> L.		Skylarks are frequent in nurseries but do little harm; "dusting" is their most troublesome trait.
„ Woodlark	<i>Lullula arborea</i> L.		
Nightingale	<i>Luscinia megarhynchos</i> Brehm.	S.B.	
Nightjar	<i>Caprimulgus europaeus</i> L.	S.	
Nuthatch	<i>Sitta europaea</i> L.	B.	
Pipits	<i>Anthus</i> species		
Redstart	<i>Phoenicurus phoenicurus</i> L.	S.	
Robin	<i>Erithacus rubecula</i> L.		
Tit, blue	<i>Parus caeruleus</i> L.	B.	
„ cole	<i>P. ater</i> L.	C.	
„ crested	<i>P. cristatus</i> L.	C.	
„ Great	<i>P. major</i> L.		
„ Long-tailed	<i>Aegithalos caudatus</i> L.		
„ Marsh	<i>Parus palustris</i> L.	B.	
Treecreeper	<i>Certhia familiaris</i> L.		
Wagtails, several species	<i>Motacilla</i> species		Common in nurseries probably beneficial.
Warblers, all genera and species	<i>Phylloscopus</i> spp.	S.B.	
	<i>Locustella</i> spp.	S.B.	
	<i>Acrocephalus</i> spp.	S.B.	
	<i>Sylvia</i> spp.	S.B.	

Woodpecker, Greater	<i>Dryobates major</i> L.	Feed on insects which attack rotting wood. Woodpeckers do more good than harm.
„ spotted		
„ Lesser	<i>D. minor</i> L.	
„ spotted		
„ Green	<i>Picus viridis</i> L.	
Wren	<i>Troglodytes troglodytes</i> L.	
Wryneck	<i>Jynx torquilla</i> L.	S.B.

SEED AND INSECT EATERS WHICH FEED THEIR YOUNG ALMOST WHOLLY ON INSECTS

Bullfinch	<i>Pyrrhula pyrrhula</i> L.	May attack Conifer Seedlings.
Goldfinch	<i>Carduelis carduelis</i> L.	May attack Conifer Seedlings.
Linnet	<i>Carduelis cannabina</i> L.	
Starling	<i>Sturnus vulgaris</i> L.	May injure trees at winter roosting places, but is otherwise beneficial.

OWLS

Barn Owl	<i>Tyto alba</i> Scop.	All the owls are useful as they eat mice, voles and insects.
Little Owl	<i>Athene noctua</i> Brehm.	
Long-eared Owl (C)	<i>Asio otus</i> L.	None are to be molested.
Short-eared Owl	<i>A. flammeus</i> Pontopp.	
Tawny Owl	<i>Strix aluco</i> L.	

HAWKS AND EAGLES

Buzzard, Common	<i>Buteo buteo</i> L.	Eats rabbits; does little harm. To be strictly preserved.
Eagle, Golden	<i>Aquila chrysaetus</i> L.	Confined to Scotland.
Kestrel	<i>Falco tinnunculus</i> L.	A harmless hawk, eats mice, voles and beetles.

Sparrow Hawk	<i>Accipter nisus</i> L.	The Sparrow Hawk feeds on useful birds. Other Hawks are <i>not</i> harmful to the forest.
Harriers	<i>Circus</i> species	None of the rarer species should ever be molested.
Merlin	<i>Falco columbarius</i> L.	
Hobby	<i>Falco subbuteo</i> L.	
Kite	<i>Milvus milvus</i> L.	

CROWS AND ALLIED BIRDS

Crow, Carrion	<i>Corvus corone</i> L.	Nuisance to flock masters. Eats eggs of game birds and other useful wild birds.
Crow, Hooded	<i>Corvus cornix</i> L.	
Jackdaw	<i>Corvus monedula</i> L.	Game preservers believe it is harmful.
Jay	<i>Garrulus glandarius</i> L.	Eats eggs of other birds.
Magpie	<i>Pica pica</i> L.	Eats eggs and young birds. May attack sheep, but is rare and only to be killed where numbers are troublesome.
Raven	<i>Corvus corax</i> L.	
Rook	<i>Corvus frugilegus</i> L.	Destroys wireworms, etc.

PIGEONS

Stock Dove	<i>Columba aenus</i> L.	} Harmful to field crops. } Require control.
Wood Pigeon	<i>C. palumbus</i> L.	
Turtle Dove	<i>Streptopelia turtur</i> L.	S. Usually harmless.

GAME BIRDS

Blackcock	<i>Lyrurus tetrix</i> L.	C. Require control in C. young conifer areas.
Capercaillie	<i>Tetrao urogallus</i> L.	
Grouse	<i>Lagopus scoticus</i> Lath.	Eats seed in nurseries.
Pheasant	<i>Phasianus colchicus</i> L.	
Partridge	<i>Perdix perdix</i> L.	
Partridge, Red-legged	<i>Alectoris rufa</i> L.	
Ptarmigan	<i>Lagopus mutus</i> Yarrell	

MISCELLANEOUS FOREST BIRDS

Blackbird	<i>Turdus merula</i> L.	
Crossbill	<i>Loxia curvirostra</i> L.	C. Eats conifer seed.
Gulls, various species	(<i>Laridae</i>)	Greater Black-backed Gulls (<i>Larus marinus</i>) are to be kept down.
Sparrow, House	<i>Passer domesticus</i> L.	May attack seedlings.
Thrush, Mistle	<i>Turdus viscivorus</i> L.	
Thrush, Song	<i>T. ericetorum</i> Turton	
Woodcock	<i>Scolopax rusticola</i> L.	

CHAPTER 1

THE LAY-OUT OF PLANTATIONS

General.—Before deciding on a plan for laying out plantations on new land, make a careful examination of the whole area. Points to bear in mind include the following:—

- Siting of roads for extraction of produce and access for fire-fighting.
- Siting of fire breaks. (See Section IV, Fire Protection.)
- Siting of main drains, which should conflict as little as possible with roads and rides.
- Amenity considerations.

Remember that it is much easier to plan roads, etc., on the most suitable lines or gradients when the land is bare, than after the tree crop has grown up and the lie of the land is hidden from view.

Laying Out Compartments.—When the first planting plans are made, the whole area must be divided into compartments for purposes of administration. This is only to be done by an officer who is thoroughly familiar with the actual area. Boundaries drawn on the map without close inspection of the ground are certain to cause difficulties later on.

Wherever possible, compartment boundaries are to follow access roads, fire traces, or well-marked natural features. Artificial boundaries should be negotiable by traffic (except in very steep or broken country) as this makes extraction of produce much cheaper and easier. The grid system of compartmenting is only applicable to flat or very easy country. Elsewhere the boundaries are likely to be determined or influenced by contours.

Uniformity in shape or size of compartments is not essential. A good average area to aim at is 25 acres.

A compartment boundary may, or may not, coincide with the allocation of land to different species of trees. Local conditions vary so widely that no hard and fast rule can be laid down.

Unplantable Land.—The extent of plantable and unplantable land is ascertained as far as possible when each acquisition is made. The boundary between the two may require adjustment in either direction in the light of later experience. Land may be classed as unplantable for a variety of reasons, such as:—

Elevation,

Exposure,

Inadequate drainage, more particularly where it cannot be remedied except at an uneconomic cost,

Unsuitable soil.

Allocation to other uses.

Some of these conditions may be altered in course of time. Make certain that no suitable available land is left unplanted, but do not try to extend plantations on to land where a timber crop cannot reasonably be expected. Experience and observation of similar sites are the best guides here.

External Boundaries.—These require careful consideration in the light of local circumstances. Alongside railways and roads it is frequently necessary to leave wide fire breaks, either ploughed or planted with fire-resisting species. (See Section IV.). In moorland districts where it is possible to burn fire traces on neighbouring land, it may be preferable to plant right up to the legal boundary.

In some cases the external boundary provides the best means of access to a portion of the forest, or it may follow the line of a right of way; in such cases room should be left for the passage of traffic.

External Rights of Way.—Rights of way over tracks or land outside the forest boundary are frequently secured when land is acquired. These are nearly always essential for future timber extraction, and rides and roads should be planned to link up with them.

Roads.—Forest roads serve three main purposes:—

Extraction of produce,

Access for fire fighting,

Transport of plants, stores and labour.

Remember that every portion of the forest will eventually have to be thinned and felled, and site your road traces so that each compartment is readily accessible. Always leave ample width for road and verges.

The problems are greatest in hilly country. Utilise every available opportunity of siting tracks up easy gradients to the higher levels. In deep valleys or glens a road on one side does not help extraction from the other, nor can thinnings be carried out cheaply across a wide stream.

All useful existing roads are to be carefully preserved and maintained by filling in ruts and clearing drains.

New Roads.—As a rule, only the trace is laid out in the early stages, the actual road being built later. In average country satisfactory lay-out may be obtained by walking over the alignment, but surveying instruments are needed on difficult ground.

Plan new road traces with an eye to construction expenses. Avoid stretches of boggy ground, cuttings, or embankments, and site the lines so that bridges and culverts are reduced to the essential minimum.

Working Space.—Allow ample room for turning vehicles and stacking forest produce at points where these operations are likely to be needed—e.g., at cross roads and the main exits from the forest.

Fire Belts.—Although existing belts of hardwood trees may be effective, it is seldom worth while to plant new ones as a protective measure. The usual result is a grassy area that forms a fire hazard rather than a precaution.

The best species tried so far is Japanese Larch, in belts of at least half a chain wide and at normal planting distances; but it is not a suitable species for every situation.

Amenity Belts.—These require special consideration. A satisfactory result is seldom obtained by a haphazard mixture of species. It may be preferable to plant each kind in a definite block or strip. Remember that only the better types of land will support the more exacting species.

In prominent places, aim to avoid straight boundaries and hard edges that may produce an ugly effect. The boundary line between two sharply contrasting species, such as larch and Douglas fir, may often conveniently follow hillside contours.

Drainage.—Make sure that main drains have the right alignment and will not need altering later. Site them so that they cross roads and rides at as few points as possible. Every crossing means a costly bridge or culvert. Avoid oblique crossings, except where strictly essential.

If the line of a drain falls too steeply, severe erosion may result, and it may be advisable to follow a longer, more gently sloping, course down-hill.

Much care and forethought are needed to plan a forest that can be economically and efficiently worked. It is much easier to plan wisely at the start than to carry out makeshift alterations later on.

CHAPTER 2

PREPARATION OF GROUND

This chapter is concerned with the preparation for planting of ground which has not previously carried a substantial tree crop, i.e.:—

Open land, with ground vegetation only.
Scrub.

Open Land.—Instances in which open land can advantageously be planted without special preparation are rare. As a rule, one or more of the following operations is advisable:—

Ploughing, Draining, Turfing.

Burning off surface vegetation.

Fixation of surface layers, e.g., on sand dunes.

Consider carefully which operations are appropriate for each particular area, and make sure that every portion of the forest is prepared in the most satisfactory way. Work that can be carried out cheaply and easily before planting is done may prove impossible or costly later on.

FOREST PLOUGHING

There are few types of afforestable land that are not improved by ploughing in some form or another. Generally speaking, the plough does good wherever it can go; but it cannot, of course, be used in very steep or rocky country or ground containing large tree stumps.

The type of ploughing to be undertaken must be decided in advance, and appropriate equipment provided. Careful organisation is essential to avoid wasting the time of the equipment and the driver. The technique of ploughing is constantly being developed in the light of experience, and only the broadest outlines can be stated here.

The present trend is towards the increasing use of single-furrow deep ploughs, which work to a maximum depth of 18 in. or 2 ft., and not only break up pan (where present) but also cultivate the surface layers, smother surface vegetation and improve drainage in a marked degree. A measure of their effect in some soils is the amount of subsoil from beneath the "pan" which is brought to the surface.

Ploughing is the most effective method of draining wet soils. See that the furrows run at a proper slope and that the water discharged from them

is led away into natural water courses. Whether ploughing precedes or follows the digging of main drains is a matter for decision according to local circumstances.

The designs of ploughs are still undergoing development. "Solotracs" give good results on the easier soils, whilst the "R.L.R." is effective on difficult ground with "pan". The "Cuthbertson" gives good results on peaty areas.

Important subsidiary benefits of ploughing are:—

- (1) Lowering of weeding costs.
- (2) Temporary lessening of fire risk, particularly on *Calluna* ground.

In both cases the best effect is secured by the use of a deep furrow plough. The costs of spacing the plants and actually planting them, are usually lowered also.

A specialised use for the plough is as a screefing implement, e.g., on the sandy grass heaths of East Anglia, where a furrow is screefed clear of vegetation by two ploughshares arranged like a letter V, preceded by a central disc and two side discs, the trees being planted in the furrows.

Partial ploughing, i.e., the cultivation of a single or double furrow at the appropriate planting distance, is the standard procedure. Complete ploughing of the whole ground surface is expensive and must not be carried out without express sanction.

Tractor drivers and others concerned with the actual execution of ploughing operations must be given full and adequate instructions, and receive frequent supervision. It is a simple matter to plough across a ride or road-trace in error, and such mistakes, once made, are not easily put right.

The advantages of ploughing are usually so great that if suitable equipment is not available operations should be postponed until the job can be done properly. Where practicable, aim to have a reserve of ploughed ground in hand; it will improve rather than deteriorate if allowed to lie fallow for several months before planting.

When dealing with soft or ill-drained ground, take advantage of spells of dry weather to plough up the more marshy areas; harder and drier ground can be dealt with at other times. Damp ground may occasionally be rendered ploughable by making cut-off drains around it, together with run-off drains, some months before the actual ploughing is undertaken.

DRAINAGE

Main Drains.

Before planting any stretch of ground, make sure that it is effectively drained. Inspect the outlets, particularly where the general level of the land is low. In some instances, rights to keep open drains *outside* the forest

boundary are secured when acquisition is made. In other cases the co-operation of Drainage Boards may be sought to secure a satisfactory run-off.

Each outlet from the forest has its own appropriate natural drainage area. Study the boundaries of these, both on the map and on the ground. In hilly country the contours are often an effective guide, but on flat stretches it may be necessary to consider spot levels (if marked on O.S. maps) or even to carry out instrumental levelling on the ground.

The lay-out of the main drains running to each outlet can only be determined on the ground. Points for decision are:—

Number of drains and distance apart.

Sizes.

Degree of downhill slope.

Amount of "batter" of banks.

Numbers and dimensions adopted depend on local factors of soil, rainfall and the lie of the land, and no hard-and-fast rules can be laid down.

Cut-off and Contour Drains are designed to *intercept* water flowing down from a higher level and prevent it flowing on to low-lying areas of ground. They must be cut right through the surface peat to the mineral soil below, and have adequate outlets.

Subsidiary Drains.

Draining by hand is more costly than using the plough, and should therefore be restricted to unploughable areas. Hand drainage is also required in some instances to collect water from low-lying points in the ploughed furrows.

Subsidiary drains are frequently combined with turfing, drains set 20 ft. apart being normally sufficient to provide enough turfs for 5 ft. by 5 ft. spacing.

General Notes on Draining.

The steepest and shortest course is not always the best. Too rapid run-off may lead to erosion with consequent silting lower down. It is often preferable to lead the water downhill by a longer and less direct route.

See that the drainers are equipped with adequate and appropriate tools for their work. The nature of these will vary with the soil, examples being: Rutting spades, Hacks or Drags, Clay Grafts and Scoops.

The maintenance of drains is as important as their first construction, and inspection should be made at frequent intervals.

Where erosion results in silt being carried off forest land into streams outside, sand traps may be needed at the exits to prevent complaints and claims from catchment boards or other parties.

The possibility of draining by machinery should be considered in suitable instances. No particular machine can be generally recommended

as yet, but the Cuthbertson plough has given excellent results on certain peat soils; it may be drawn by a winch where direct hauling is impracticable.

TURFING

The cutting of turfs by hand has been superseded to a large degree by ploughing, which is a cheaper and quicker way of obtaining them on peat soils. Hand turfing is still required on difficult or inaccessible areas, such as small "flushes" on high or rocky slopes. Several kinds of turfs have been developed, including:—

- (a) *Ordinary flat turfs* cut on peat soils and inverted away from the cutting point. Used mainly for spruces, which are planted either *through* or *in* the turfs, usually by notching.
- (b) *Hinged turfs*, similar to the above but connected to the ground by one uncut edge.
- (c) *Inverted turfs*, set upside down in the holes from which they were cut.

The size and depth of turfs may be varied according to local circumstances, such as the nature of soil, and size of plant to be used. These factors will also determine whether planting is done *in* or *through* them; in the latter case the roots should be spread out on the surface layers below the turfs.

BURNING-OFF

The burning-off of surface vegetation prior to planting is an operation that has frequently been overdone in the past. It is costly, destroys a certain amount of shelter, and may result in the deterioration of the soil. Heather should not be burned in advance, unless this is necessary to facilitate ploughing; i.e., in old heather. Gorse, however, may require burning, particularly if very dense.

Burning-off is always a tricky operation and care must be taken to see that fires are kept within control. Very dry weather should be avoided, as troublesome peat fires may arise under such conditions. (See notes on Ride-burning, Section IV.)

TREATMENT OF SCRUB

When dealing with an area that carries scrub or old trees, decide first of all how much should be retained for shelter or fire belts. Then see if any market or use (e.g., for fencing stakes) exists for the remainder. Do not fell it unless a profitable outlet exists. Girdling is cheaper and often more effective. This work should be done when the bark comes off easily (never in winter). "Laying-in" or cutting below the bark, is only necessary in special circumstances, e.g., when dealing with oak. Inspections should be made later on to make sure that the work has been effective.

Girdled trees may present an ugly appearance in later years, especially when viewed against the sky-line from along roadsides. Discretion is

necessary where trees are growing in prominent places, and at well-known beauty spots an amenity fringe should be left or the work done in stages. As the young trees of the planted crop grow up through the ringed scrub, the damage to scenic values is made good.

CHAPTER 3

FENCING AND WARRENING

1. Fencing.

The type of stock to be excluded varies at each forest unit. The Forester must ascertain what animals are likely to be present either on the area or alongside its boundaries. For instance, it is futile to erect only cattle fencing against a farmer's field if in a few months time he will be using it for sheep. On the other hand, the expense of sheep netting or wiring is to be avoided on areas where sheep are never kept; wiring is more durable than netting.

No single standard type of fencing can be laid down for all the Commission's areas. The method and materials used are varied according to local conditions. All timber except larch, sweet chestnut, yew and oak *must* be creosoted before use; even these species last longer if creosoted, as their sapwood is not durable.

RECOMMENDED FENCES

Standard Rabbit Proof.—Stakes (poles or stobs) 5 ft. 6 in. long, 3 in. top diameter driven into the ground 2 ft. leaving 3 ft. 6 in. clear, set 9 ft. apart. Wire netting 42 in. wide, $1\frac{1}{4}$ in. mesh, 18 gauge. The bottom 6 in. of netting is turned outwards and held down by sods. Strengthening wires of No. 8 gauge plain galvanised wire are set at heights of 18 in. (centre of netting), 3 ft. (top of netting) and 3 ft. 6 in. (top of posts). These wires are strained by using wire strainers, to stout strutted straining posts set at corners, gateways, or 4-chain intervals.

The netting and strengthening wires are secured to the stakes by staples. Fine No. 18 gauge tying wire, or metal clips, may be used to secure the netting to the strengtheners. Where stock are troublesome the topmost wire may be barbed.

N.B.—In smoky areas netting of 17 gauge should be used.

Light Rabbit Proof.—Where there are no stock to fence against, a single plain wire, at the top of the netting, will be enough. Otherwise this type resembles the foregoing.

Temporary Rabbit-Proof.—Wire netting, as above, supported on stakes 12 ft. apart without strengthening wires or straining posts, may be employed

for purely temporary work, e.g., when it is desired to fence off one year's planting pending clearance of rabbits from adjoining areas.

Rabbit fencing of all kinds is made more effective by an *additional* top wire, above those supporting the netting. This checks climbing, and also discourages hares.

Sheep Netting.—Netting 36 in. wide, 4 in. mesh, 14 gauge, is effective against sheep, but is less durable than plain wire fencing. Where it is liable to damage by larger stock, it should be protected by a barbed wire at the top. It also requires strengthening at the centre by one No. 8 gauge plain wire, unless "centre-strand" netting is used.

Sheep and Stock-Proof Wire.—Use 5 No. 8 gauge plain wires, at heights of 6 in., 12 in., 18 in., 26 in. and 36 in. Top strand to be of barbed wire at 42 in. above the ground. Stakes, strainers and stays as for rabbit-proof fencing.

If this stock-proof fencing is also required to be rabbit-proof, 42 in. rabbit netting must be added.

Hares.—Brown and mountain hares may be excluded to some extent by fixing a very fine wire a few inches above the rabbit netting.

Deer Fencing.—To be fully effective, a combined fence of wire and netting is required. The stakes are 8 ft. 6 in. long, 3 in. top diameter, standing 6 ft. above ground, and 18 ft. apart. They carry 5 No. 8 gauge plain wires at the following heights: 5 in., 20 in., 3 ft., 4 ft. and 5 ft. and one barbed wire just below 6 ft. All these wires are secured to straining posts, not more than 100 yards apart in the straight, and wherever required on corners. These straining posts are 10 ft. 6 in. long, 9 in. top diameter, sunk 4 ft. 6 in. in the ground, and supported by struts 10 ft. long, 5 in. top diameter; 1½ in. staples secure the wires to the stakes.

The wires are strengthened by wooden or metal droppers, set 3 ft. apart, requiring 5 to each 18 ft. bay. Each dropper measures 3 ft. 6 in. long (by 1½ in. by 1¼ in. if of wood), and the wires are attached to it with wire or 1 in. staples. Three droppers are fixed to the four lower wires and the other two, which alternate with them, to the four upper wires.

Inside the wires, rabbit netting of the usual 42 in. width, 1½ in. mesh, 18 gauge, is fixed with the lowermost 6 in. turned out. Above this comes a strip of sheep netting, 24 in. wide, 4 in. mesh, 14 gauge, giving a total height for both types of netting of 5 ft. The netting is secured to the wires with No. 18 gauge fine tying wire.

A fence of this description will check red deer, roe deer, and rabbits. Where roe deer do not occur, an economy may be made by omitting the

sheep netting at the top. Similarly, where there are no rabbits to consider, netting of wider mesh than $1\frac{1}{4}$ in. could be used for the lower strips.

Light Deer Fencing.—Where only roe-deer are present, they may be excluded by a cheaper type of fence erected as follows: Stakes 8 ft. 6 in. long, 3 in. top diameter, are set with 6 ft. above the ground, at 18 ft. apart. Ordinary rabbit netting, 42 in. wide, $1\frac{1}{4}$ in. mesh, 18 gauge, is put up in the usual way on the outside of the stakes, with 6 in. turned outwards, leaving a net height of 3 ft. It is attached at the top to a single wire, preferably barbed. Above this, sheep netting, 3 ft. wide, 4 in. mesh, 14 gauge, is erected to make a total height of 6 ft. It is secured to the lower netting and the strand of wire by No. 18 gauge fine tying wire.

At the centre of each 18 ft. bay a shorter stake, 5 ft. 6 in. long, 3 in. top diameter, is driven in outside the netting to give a clear height of 3 ft.; this is attached to the strips of netting and the centre wire with staples, and serves the same purpose as a dropper.

FENCING MATERIALS;

No. 10 WEIGHTS, MEASURES, AND USUAL DIMENSIONS

No. 8 gauge, Galvanised Plain Fence Wire	1 cwt. =	546 yards	854 yds.
Barb wire, 2 ply, 6 in. apart, 4 points	1 cwt. =	560 yards	220 yds per reel
No. 18 gauge tying wire	1 cwt. =	6,222 yards	
Rabbit Netting, 42 in. $\times$ 18 g. $\times$ $1\frac{1}{4}$ in. mesh	1 roll =	50 yards	
		(33 rolls per ton).	
Sheep Netting, 36 in. $\times$ 14 g. $\times$ 4 in. mesh	1 roll =	50 yards	
Staples, 1 in., 10 gauge, 1 lb. contains	143 staples	(7 lbs. per 1,000)	
" 1 $\frac{1}{2}$ in., 8 " 1 lb. "	59 "	(17 lbs. per 1,000)	
Stakes (stobs or piles), round	5 ft. 6 in. $\times$ 3 in.	(top diameter)	
" " " " sawn	5 ft. 6 in. $\times$ 3 in. $\times$ 3 in.		
" " " " hewn	5 ft. 6 in. $\times$ 6 in.—8 in.	face	
Straining posts, round	7 ft. $\times$ 5 in.	(top diameter)	
" " " " sawn or cleft	7 ft. $\times$ 5 in. $\times$ 5 in.		
Struts, round	7 ft. $\times$ 3 in.	(top diameter)	
" sawn	7 ft. $\times$ 3 in. $\times$ 3 in.		
" cleft	7 ft. $\times$ 4 in.	(face)	
Gate posts, sawn or hewn	8 ft. $\times$ 6 in. $\times$ 6 in.		

$\frac{3}{4}$ " staples 12 gauge.

Deer Fencing.

Stakes (stobs)	8 ft. 6 in. $\times$ 3 in. $\times$ 3 in.	(or 3 in. top diameter)
Straining Posts	10 ft. 6 in. $\times$ 9 in. $\times$ 9 in.	(or 9 in. top diameter)
Struts	10 ft. $\times$ 5 in.	(top diameter)

Materials for Standard Rabbit-Proof Fencing.

	<i>Per Chain</i>	<i>Per 100 Chains</i>
Stakes, 5 ft. 6 in.	7 to 8	742
Netting, 42 in., 18 gauge, $1\frac{1}{4}$ in. mesh	$\frac{1}{2}$ roll	45 rolls.
No. 8 gauge wire (2 wires)	9 lbs.	8 cwt.
Barb wire, 2 ply, 4 points, 6 in. apart (1 wire)	4 lbs.	$3\frac{1}{2}$ cwt.
Staples, $1\frac{1}{2}$ in., No. 8 gauge	$\frac{1}{2}$ lb.	$\frac{1}{2}$ cwt.
Staples, 1 in., No. 10 gauge	$\frac{1}{2}$ lb.	$\frac{1}{2}$ cwt.
Tying wire, No. 18 gauge	$\frac{1}{2}$ lb.	$\frac{1}{2}$ cwt.

Also, strainers and struts at appropriate intervals.

General.—The use of mixed-mesh netting is *not* recommended.

Barbed Wire.—Discretion is required in the use of barbed wire for fencing. It is very effective for excluding horned cattle and horses and for discouraging trespassers. On the other hand, it is costly and is disliked by hunts. It should therefore only be used where really necessary.

Gates.

No standard type of gate is laid down. Materials and construction will vary with locality and the amount of usage to which the gate will be subjected.

No gate on a roadway should be narrower than 10 ft. Where timber haulage is frequent, wider gates may be needed.

Wicket gates, only 3 ft. 6 in. wide, may be needed on bridle paths or hunting tracks. Where only foot traffic is concerned, it is safer to erect a stile, so avoiding a gap in the fence-line which occurs if the wicket gate is left open. Stiles are required where public footpaths cross fence-lines. They must be so constructed that rabbits, and in some cases deer, cannot cross them. But bridle paths where a right of way exists for horses, etc., must be gated.

Every gate is a potential gap in the fence line. Therefore, no gate should be erected unless required for some definite purpose, e.g.:—Timber Extraction; Fire Protection; or across a Right of Way.

Locking of Gates.—No standard practice is laid down. Gates across rights of way, other than footpaths, cannot be locked. Elsewhere, locking may be desirable to check trespass. But a locked gate might also, in an emergency, exclude or delay fire-fighting vehicles.

Self-closing Gates.—It is a simple matter to hang gates so that they are self-closing. The hanging pins are set out of line and the lower pin must be longer than the upper. This gives the gate a slight tilt inwards. When

opened it rises slightly, and falls automatically when released, closing itself with the usual strap fastening. Such gates are specially useful on tracks used by the public.

II. WARRENING

All rabbits must be exterminated before planting begins. It is useless to attempt final extermination until the fence-line has been completed. The methods adopted vary with locality, according to soil and vegetation. Gassing is sometimes practicable.

A combination of several methods is frequently desirable. In any event the number of rabbits secured in each day's work falls steeply as their numbers are reduced. Efforts must not be relaxed until the last rabbit has been eliminated.

Once rabbits have been exterminated, a ceaseless watch must be maintained to prevent their re-appearance. It may still be worth while to maintain a warrener or trapper, at least on a part-time basis. He will catch few rabbits, and the cost per head will be high, but *prevention is cheaper than cure*. His duties should include the patrol of the fence line, minor repairs, etc. But general responsibility for maintaining a rabbit-proof boundary remains with the forester.

The presence of rabbits is soon shown by droppings and scrapings, even before damaged trees are seen. The absence of burrows is not a reliable guide, as on some soils and at some seasons few burrows are dug.

Control of Deer.

The head of deer on an area can be controlled in one of three ways:—

- Shooting,
- Driving and shooting,
- Snaring.

Snaring and shooting are only effective when the head of deer is small. Elsewhere, driving is necessary, and must be carefully organised. Advance planning is essential if deer are to be secured without accidents to dogs or beaters. In many cases, co-operation with neighbouring landowners is essential.

The following species of deer are now found wild in Britain.

Common Name	Scientific Name	Distribution
Red deer	<i>Cervus elephas</i> L.	Scotland and locally in England.
Roe deer	<i>Capreolus capreolus</i> L.	ditto
Fallow deer	<i>Dama dama</i> L.	Chiefly in England.

Japanese deer	<i>Sika nippon</i>	Chiefly in England.
Chinese Muntjac or Barking deer	<i>Muntiacus reevesii</i>	ditto
Siberian Roe deer	<i>Capreolus pyargus</i>	ditto

Miscellaneous Animals and Birds.

The forester's duties normally include the control of certain animals and birds which do no direct damage to his trees. The Commission's policy is to protect wild life, particularly all rare species so far as is possible without prejudice to agriculture or forestry. No animals or birds are to be wantonly destroyed. If in doubt regarding any species, seek advice.

Squirrels.

The Grey squirrel has increased enormously in many districts during the war, and is generally an unmitigated pest. Shooting is the usual method of control, but some experienced hands can trap them quite successfully. Stringent control is necessary where sycamore or beech have been planted.

The Red squirrel damages Scots pine and sometimes other conifers, by ringing the soft bark of the upper branches, and also eats the seeds. An occasional Red squirrel does little harm, but where they are numerous control is necessary, and in coniferous woodlands their numbers must be kept down.

Foxes.—The Commission's policy is to control the stock of foxes on its areas, in the interests of adjoining farmers. This is best done by finding breeding places in spring and early summer and destroying the cubs.

Badgers.—Are not to be molested unless continual damage is done to fencing.

Field Voles.—Exceptionally, a plague of voles may cause damage to plantations. Any outbreak is to be promptly reported. Owls, hawks, and weasels help to control this pest.

Birds of Prey.—On the whole birds of prey do little harm in a forest unless their numbers become excessive. Indirectly they do harm by killing insectivorous birds, the sparrow-hawk being the worst offender in this respect. None of the rarer hawks should be destroyed. Buzzards are harmless to forestry. All the owls are helpful and are not to be molested.

The crow tribe, jays, magpies, jackdaws, hooded and carrion crows do no direct harm to trees, but may need control in the interests of useful insect-eaters whose eggs they attack; and also in the interests of good neighbourliness. In general, ravens and choughs should be spared.

Black Game and Capercaillie frequently damage the shoots of young conifers. They require control where serious damage occurs.

Woodpeckers do no serious harm and destroy many insects.

The Greater Black-backed Gull is a menace to game.

Wood pigeons should be destroyed where unduly numerous, but rooks are not to be molested.

CHAPTER 4

CHOICE OF SPECIES

General Considerations.—Almost every area has its own peculiarities which are not always obvious at first sight. Look at it, therefore, with a critical eye in the certain knowledge that optimism will let you down. Many areas are only available for forestry because they are too intractable for other uses.

Bear in mind the "Factors of the Locality" and satisfy yourself that these are favourable to the species which you select.

Soil.—Ascertain the underlying bedrock by reference to a geological map. Drift maps should be referred to if they are available, particularly in northern Britain. Soils may differ sharply on different sections of the forest, e.g., leached sands may adjoin clays. Make a note of important differences, and if necessary, prepare a sketch map.

Dig soil pits to examine the surface layers, and note the depth and profile. Such pits must be well distributed, as the soil is likely to vary from point to point. Watch especially for the presence of "pan" under leached soils. Decide whether ploughing is feasible, and if so, what tackle is necessary.

Vegetation.—The existing vegetation is a good guide but not always certain. Remember that the dominant vegetation may change when grazing stops, and try to find out what the change will be. A frequent example is the reversion of grassland to heather, after grazing has ceased.

Each species of tree has its "indicators" amongst the ground flora, but these only serve as guides and other factors must be considered.

Exposure.—Watch the exposure to west and south-west, and do not plant larches, Douglas fir, or Norway spruce too high on exposed slopes. Avoid using Scots pine on high ground near the west coast.

Frost.—The only really frost-hardy species is Scots pine; more tender trees can often be established on frosty sites by judicious use of pine nurses. Make use of birch or other existing cover, where present, as shelter for introducing other species.

Timber Requirements.—In general, those species giving a high ultimate volume production are to be preferred; hardwoods, especially oak, ash and sycamore, should only be planted if conditions are really suitable for these species.

Pure and Mixed Planting.—Before planting mixtures make sure what your objective is. The hope that one species may succeed if another fails is

not a legitimate reason for deciding on a mixture. Pure plantations are easier to control, but mixtures are clearly indicated where one species is required as a nurse for another, e.g.:—

Spruce and Pine on *favourable* heather sites where it is desired to secure a final crop of spruce. (Not all heather sites are suitable; Sitka spruce is more tolerant of heather than is Norway spruce.)

Beech and Pine on bare exposed sites where a beech crop is required.

Oak and Pine on frosty sites only; nurses are unnecessary for oak elsewhere.

Pine nurses may also be needed for Douglas fir and tsuga on sites which suit these species except as regards surface vegetation.

CONIFERS

The seven species mentioned below, two pines, two spruces, two larches and Douglas fir, account for the bulk of our planting. It is necessary, therefore, to use them properly.

SCOTS PINE.

This species succeeds over a wide range of soil and climate, but its volume production is comparatively low. Its use as a pure crop should be considered wherever difficult conditions make more exacting species a doubtful proposition. It is a "safe" species to plant in most situations, and is exceptionally useful as a nurse.

Types.—Home-collected seed has, generally speaking, proved quite satisfactory. Every opportunity should be taken to collect seed from old natural pine in the west of Scotland—for use in the high rainfall zone along the west coast of Britain, where the east-coast strain is apt to fail.

Favourable Conditions for Pure Crop.—Light or sandy soils. Low elevations. Low rainfall areas (Eastern half of Britain). Very frost hardy.

Warning.—Avoid high elevations (particularly in the west), regions of heavy snowfall, soft sites where there is appreciable exposure, and smoky localities. Unsuitable for chalk or lime soils, except as a nurse for beech or other lime-tolerant species.

CORSICAN PINE.

Has a higher volume production than Scots Pine, and is therefore preferred on sites in the south and east of Britain that are too difficult for conifers other than the pines.

Types.—There are a number of types passing more or less under the name of Corsican pine, ranging from true C.P. to Calabrian pine and the Ursuline types. Where mixed in the nursery the typical C.P. must be sorted out and alone used for pure planting.

The chief distinguishing feature of true Corsican pine is its softer twisted needle which has no hard prickle at the tip.

Favourable Conditions.—Light soils (including sand dunes) especially in East and South of England and generally near the sea. Has also done reasonably well on heavy soils, especially near the sea. Suitable for smoky localities.

Warning.—Avoid soft sites in exposed places, also high elevations. The cambium is active late in the autumn and unripened growth may be damaged by early frosts. Avoid shallow limestone soils, except when using C.P. as a nurse for establishing a crop of beech.

Especial care is needed in handling. Roots are easily damaged and must not be exposed. Plant before the middle of February, if possible, moving plants from the nursery to the forest with as little delay as possible. The best plant for most purposes is a sturdy 1 yr.-1 yr.

EUROPEAN LARCH.

Die-back has occurred recently in plantations in many parts of the country, and the inference is that this species has been planted too indiscriminately; moreover, it is a low volume producer.

Types.—There are strong indications that plants from home-grown (Scottish seed) are more reliable than those from seed of Continental origin.

Favourable Conditions.—Hard to define, but soils naturally well drained on airy (but certainly not exposed) sites seem best. Well-drained loams are suitable.

Indicators.—Bracken, indicating usually good soil aeration, is a favourable indicator, provided other conditions are suitable. Note: Very strong pure bracken may indicate a site which is too moist for E.L.

Warning.—Be cautious if not wholly satisfied with the site. Avoid damp and grassy sites, frosty places, dry sites, poor sands, shallow soils on chalk, peat soils, badly drained soils, exposed sites at high elevations or near the sea, leached soils, and land which has carried a larch crop just previously.

JAPANESE LARCH.

This tree thrives on a much wider range of sites than does the European Larch, especially in the North and West of Britain.

Favourable Conditions are not necessarily those giving quickest growth, which may lead to corkscrew leaders and wind sway. Well suited to high

rainfall areas (and conversely not too dry). Prefers firm soil and not too much exposure.

Advantages over European Larch:—

- (1) Quicker initial growth, of great value, e.g., on coppice sites, where it quickly outgrows and suppresses coppice shoots.
- (2) Thrives on sites, in hill country (generally wet) where E.L. may be a total failure.
- (3) Freedom from Larch canker.

Warning.—Fails in very dry conditions, frosty places and badly drained sites.

HYBRID LARCH.

Hybrid larch, *L. eurolepis*, grows rather faster than Japanese larch and the stems are usually straighter, otherwise its requirements are similar. Given phosphatic manure it grows well on peat-covered slopes (if reasonably sheltered) in the West of Scotland.

DOUGLAS FIR.

A very rapid volume producer on good sites, but its use must be restricted to really suitable places.

Types.—Care is required in differentiating between green, grey and blue Douglas Fir which have different silvicultural properties.

Green Douglas.—Subject to attack by the leaf-sucking insect, *Adelges (Chermes) cooleyi*, which does not prove fatal.

Grey Douglas.—Slower growing than Green Douglas.

Blue Douglas.—Very slow growing and susceptible to *Rhabdochline*. Only the Green Douglas is recommended for general use.

Favourable Conditions.—Sheltered sites with deep firm soil. Rocky conditions are often very suitable. Prefers the better types of soil, such as deep, well-drained and fertile loams. Probably the best species for under-planting where soil conditions are suitable.

Warning.—Liable to windthrow, so avoid soft and wet soils. Avoid also shallow soils over chalk and limestone, areas subject to smoke or fumes, and sites liable to late frosts. Can only be grown on heather ground if in mixture with Scots pine or *Pinus contorta*.

The use of Douglas Fir has been neglected in the immediate past because many earlier plantings were unsatisfactory, due in part to insufficient care in choice of planting sites.

NORWAY SPRUCE

A safe tree to plant on typical "spruce" sites, if free from heather and not unduly exposed. Produces a high volume of timber per acre.

Favourable Conditions.—Damp sites, but very adaptable. Has two advantages over Sitka spruce.

- (1) Relatively immune to Honey Fungus and therefore to be preferred on former hardwood sites.
- (2) Somewhat less susceptible to spring frosts and to be preferred accordingly on low-lying sites.

Indicators: *Juncus conglomeratus* and *Aira caespitosa*.

Also *Molinia caerulea*, if growing pure (in tussocks).

Warning.—Avoid heather sites, but if obliged to use Norway Spruce, mix it with pine. Remember that apparently grassy sites may revert to heather when grazing ceases. Ground carrying *diffuse* *Molinia* grass, intermixed with heather, is better under Sitka spruce with pine nurses.

There is risk of heart rot in low rainfall areas, and on derelict arable land.

SITKA SPRUCE.

A very high timber producer under all reasonable conditions. Preferable to Norway spruce on exposed sites and on the more difficult vegetation types, particularly at high elevations and near the sea.

Favourable Conditions.—Damp sites *free from frost*. Useful on sites exposed to prevailing winds, smoke or fumes or when types of peat not suitable for Norway Spruce (e.g., those with considerable heather) have to be planted. Has two advantages over Norway Spruce:—

- (1) Produces at least 50 per cent. more timber in a given time.
- (2) Stands exposure much better and is therefore to be preferred for high elevation or seaside planting.

Warning.—Avoid really dry sites. Also avoid felled scrub and coppice areas (on account of Honey Fungus). Use a pine nurse where there is appreciable heather in the vegetation.

MISCELLANEOUS CONIFERS.

Most of the species detailed below are still in the experimental stage. Their planting should normally be confined to small areas where the conditions appear specially suitable.

Cypress, Lawson

Produces a durable timber and stands shade well. Requires a good deep fertile soil.

Types.—A wide variety of types occurs, and the collection of seed from badly forked stems should be avoided.

Warning.—Lawson Cypress fails on dry as well as on very frosty sites, and is probably unsuitable for heather ground on leached soils. Tends to form multiple leaders.

Cypress, Monterey

Mainly used for shelter belts in south-western areas of England. Very subject to windthrow when planted in blocks. Has possibilities on chalk soils.

Cypress, Nootka

Requirements similar to Lawson Cypress, but less subject to forking.

Hemlock (Tsuga)

One of the most useful species for underplanting, especially on poor soils. May be used for beating up Sitka Spruce and other conifers.

Types.—It is essential to secure the true Western Hemlock, *Tsuga heterophylla*.

The Eastern Hemlock, *T. canadensis*, is useless for forest planting; it throws multiple leaders and yields a poor timber.

Warning.—Hemlock is susceptible to frost, honey fungus, and butt rot. On poor land the use of a pine nurse may be desirable. Avoid high exposed sites and heather areas.

Pine, Austrian (*Pinus austriaca*)

Use confined to shelter belts in exposed situations, near the sea, and as a nurse for beech on chalk.

Pine, Lodgepole, *Pinus contorta*

Useful for mixture with spruces on wet and difficult sites in the north and west. Very subject to *Tortrix* damage in the south and east of England.

Pine, Maritime, *P. pinaster*

Produces an inferior timber and harbours *Pissodes* and other insect pests. Not worth planting.

Pine, Monterey, *P. radiata*

Used occasionally for shelter belts in the south-west of England.

Pine, Weymouth, *P. strobus*

No longer planted owing to its liability to the Weymouth pine rust (*Cronartium ribicolum*).

Sequoias

Redwood, *S. sempervirens*, is an extreme shade-bearer in its early stages. Probably unsuitable for planting in the open. Avoid dry frosty, or poor sites.

Wellingtonia, *S. wellingtonia*, appears to tolerate drier and more acid soil conditions than Redwood.

Silver Firs

The European Silver Fir, *Abies pectinata*, is little used owing to its susceptibility to disease and *Adelges* attack.

Grand Silver Fir, *Abies grandis*

Requires good well-drained loamy soil and stands shade well. Useful for underplanting and a rapid timber producer. Avoid frosty sites.

Noble Fir, *A. nobilis*

Is more tolerant of acid soil conditions and less frost tender than other Silver Firs.

Nordmann's Fir, *A. nordmanniana*

Is a Caucasian species which has only been used experimentally so far.

Spruce, Serbian, *Picea omorika*

The latest of the major species of spruce to flush, and so useful for frost hollows. Difficult to procure, so should be restricted to such sites. Liable to Honey Fungus on old woodlands. Has grown well in an experimental peat bog planting.

Spruce, White, *P. glauca*

A Canadian species formerly used occasionally in Scotland and Northern England in cold, exposed positions at high altitudes, particularly for shelter. Not recommended.

Thuja plicata, Western Red Cedar

A productive tree on good loamy soils. Very shade bearing. On old woodland is subject to severe butt rot but gives useful poles. Difficult to raise in a nursery which is infested with *Keithia* (Syn. *Didymascella*.) Makes a good hedge. Avoid frosty sites and poor soils.

HARDWOODS

In general, restrict these to good sites where ultimate success is assured. There are, however, special sites, e.g., beech on chalk or limestone, also amenity planting, where other considerations come in.

Principal Species.—Oak, Beech, Ash, Sycamore, Chestnut, Birch, Alder and Poplar.

OAK.

Weeding troubles apart, oak is probably the easiest of the hardwoods to establish on open ground. Small-sized, inferior oak timber is of little value, so plant only on deep and fertile soils.

Types.—The common oak in most districts is a hybrid between *Quercus pedunculata* and *Q. sessiliflora*. Collect seed from trees of a sessile type whenever possible, as sessile suffers less from caterpillar attack.

Favourable Conditions.—Well-aerated deep fertile loams in lowlands. Deep rich loam overlying chalk. Certain clays, if well drained.

Use of Nurses.—Undesirable except on frosty sites and possibly on heavy clay. Scots pine is probably the best nurse.

Warning.—Avoid all shallow, ill-drained, or infertile soils, frost hollows, exposed areas.

BEECH.

Probably the best timber-producer on chalk and limestone soils but thrives best on good loams. The most generally serviceable of the hardwood timbers during the war.

Types.—None generally recognised, but trees with a habit of multi-forking and often with badly fluted stems are common in this country. Collect seed from the best types of trees available.

Favourable Conditions.—Well-drained fertile loams.

Nurses.—On open downland plant with a pine nurse. Does well under a light canopy of birch or coppice; but beware of excessive shade.

Warning.—Avoid frost hollows and ill-drained sites. Very susceptible to damage by mice, rabbits, deer and other grazing animals.

ASH.

Not a species for planting on open ground. Likes semi-shade conditions, e.g., as small groups in tall coppice. Can be introduced sporadically (on the damper sites) with beech on chalk land, where there is a deepish soil.

Types.—None recognised, though some strains of ash appear more prone to fork than others.

Favourable Conditions.—Demands good soil conditions. Likes deep calcareous loams, moist but well-drained and sheltered situations. Thrives on chalk and limestone, but only where soil and shelter are favourable.

Useful soil indicators are: Dogs Mercury, nettle, garlic, and woodruff.

Warning.—Avoid shallow or dry soils, grassland, ill-drained ground and heavy clay; also frost hollows.

SYCAMORE.

Very similar to Ash in its silvicultural requirements but not quite so exacting. Use in the same way.

Favourable Conditions.—As for Ash.

Warning.—As for Ash, but Sycamore is rather more frost-hardy. Grey squirrels can be very harmful and *must* be kept down where Sycamore is grown. Avoid high elevations and acid soils.

CHESTNUT.

Has its uses as a coppice crop, where there is a local industry and good road facilities. Timber usually shaky.

Favourable Conditions.—A good deep fertile soil.

Avoid.—Frosty sites and ill-drained ground, heavy clay, and very light soils; will only thrive on chalk where there is a good depth of surface soil.

BIRCH.

Ubiquitous on felled woodlands. Often not easy to establish on poor ground with no previous tree crop. Growth conditions are much improved by soil cultivation. May not be worth planting for its own sake, but is useful as a nurse.

Types.—The common birch is usually a hybrid between *Betula verrucosa* and *B. pubescens*. The *B. verrucosa* types are preferable for dry conditions.

Favourable Conditions.—A tree for the light soils and drier parts of the country. Useful as an advance crop for beech.

Warning.—Do not attempt to establish birch by planting out natural seedlings. It is much safer to line them out for a year in the nursery.

ALDERS.

Three species, *Alnus glutinosa*, *A. incana* and *A. rubra*, have been tried, but have served no useful purpose in our plantations. Existing alder coppice may be retained where a market exists for poles. *A. rubra* is very frost-tender.

POPLARS. (See Leaflet 27.)

Not to be planted in large blocks. Occasionally useful for small areas with favourable soil and moisture conditions, as along streamsides. In the first or second summer after planting throw up a mound of soil round the base of each tree, to smother the herbage and encourage development of new roots.

Types and species.—The native species of the White poplar group, *Populus alba*, *P. canescens*, and *P. tremula*, are not worth planting. Existing beds of Aspen, *P. tremula*, are to be retained.

The best of the hybrid Black poplars are *P. serotina*, *P. robusta* and *P. gelrica*.

Balsam Poplars, *P. balsamifera*, *trichocarpa*, etc., are subject to canker and other diseases.

Favourable Conditions.—Rich alluvial or fen soils both well drained and well watered. Well-drained clays.

Warning.—Avoid high elevations, exposed sites, shallow soils and grassland. Stagnant water is fatal, but occasional floods do no harm.

MISCELLANEOUS HARDWOODS.

Few other species are worth consideration, except for amenity planting. Where they already exist on the ground, some may be retained to shelter the new crop.

Cherry.—A possible nurse species. Has proved frost-hardy and easy to establish on the deeper chalk soils.

Horse Chestnut.—Mainly an ornamental tree.

Elms.—Seldom used for forest planting.

Hornbeam.—Not worth planting.

Limes.—Only planted for amenity; but *Tilia platyphyllos* may be worth trying on clay soils.

Norway Maple.—Hardier than Sycamore, but has much the same requirements. A useful species for amenity planting.

Nothofagus.—Only used experimentally so far.

Oaks, various.—American Red and White oaks are useful. Turkey oak yields unsaleable timber and can only be regarded as a weed.

Plane.—For amenity planting only.

Walnuts.—Black and Common Walnuts are exacting species, and very frost tender; suitable conditions are not yet sufficiently known for general recommendations to be made.

Willows.—Timber willows, such as the White, Crack and Cricket Bat varieties, require special cultivation, and are not grown as a forest crop. The sallow is often a noxious weed.

CHAPTER 5 PLANTING

Sound planting implies the choice of the right methods, tools and type of planting stock, and intelligent organisation and supervision of the actual work. Aim to secure a crop that will go ahead from the start, without the necessity for beating up. The less time elapsing between lifting stock in the nursery and actual planting, the better.

METHODS

The right method to adopt depends on the species, size, site, and previous preparation of the ground, e.g., ploughing. Consider the various possible ways before making a decision, and choose the right tool. Planting tools are remarkably varied, including mattocks, notching spades, garden spades, and dibbles, semi-circular spades and forks. See that every man is equipped with the right tool, and that it is in good order. Planting bags should also be issued to each member of the gang, and maintained in good repair.

Pit planting is only to be used for special trees or particular conditions. The "L" or "T" notch is the standard method for many types of ground. If the screefing of surface vegetation is necessary, it can usually be done more cheaply with a plough than by hand.

Conifers.—Notching is best as a general rule. With pines and larches the notch must be made deep enough to avoid bending up root tips. Douglas fir requires either very good notching or pitting. It is essential to plant spruces in turfs, or else very shallow.

Hardwoods.—A well-made notch or pit is best for large transplants of most species. For oak, a long-bladed notching spade, such as the Mansfield, is the most suitable tool; if necessary, the roots should be pruned slightly to avoid bending up. Poplar must be pitted.

SPACING

Conifers.—See table below:—

TABLE OF SPACING AND NUMBERS PER ACRE
FOR PLANTING CONIFERS

Species.	Spacing.	Plants per Acre.
Scots Pine	$4\frac{1}{2}$ ft. $\times$ $4\frac{1}{2}$ ft.	2,150 $\checkmark$ 207
Corsican Pine	$4\frac{1}{2}$ ft. $\times$ $4\frac{1}{2}$ ft.	2,150 430000
European Larch	$5\frac{1}{2}$ ft. $\times$ $5\frac{1}{2}$ ft.	1,450 10050
Japanese Larch	$5\frac{1}{2}$ ft. $\times$ $5\frac{1}{2}$ ft.	1,450 405000 $\times$ 40
Douglas Fir	$5\frac{1}{2}$ ft. $\times$ $5\frac{1}{2}$ ft.	1,450 100
Norway Spruce	5 ft. $\times$ 5 ft.	1,740 178020
Sitka Spruce	5 ft. $\times$ 5 ft.	1,740
Thuya	5 ft. $\times$ 5 ft.	1,740
Hemlock (<i>Tsuga</i>)	5 ft. $\times$ 5 ft.	1,740
Other Conifers	5 ft. $\times$ 5 ft.	1,740

Hardwoods—Oak.—Recommended spacings are:—

For Seedlings, 4 ft. $\times$ 2 ft. = 5,450 per acre.

„ Transplants, 4 ft. $\times$ 4 ft. = 2,720 per acre.

Beech.—Close planting is advisable, as the proportion of badly-shaped stems is usually high. Where a nurse species is used, rows are normally $4\frac{1}{2}$ ft. apart, with beech and the nurse in alternate rows; the beech should be set at 3 ft. apart, i.e., 3 ft. by 9 ft. between rows (1,615 per acre), and the nurse species at $4\frac{1}{2}$ ft. apart, i.e., $4\frac{1}{2}$ ft. by 9 ft. between rows (1,075 per acre).

When planting pure, set at 3 ft. by $4\frac{1}{2}$ ft. (3,230 per acre).

Poplar.—Plant 20 ft. apart (109 per acre).

Ash, Sycamore, Sweet Chestnut, etc.—Set transplants $4\frac{1}{2}$ ft. each way (2,150 per acre).

SEASON OF PLANTING

Late planting is the cause of many failures and is usually the result of bad organization. Plant early, and do not carry on too late in the spring. If time presses, it may be better to let stocks stand over in the nurseries, rather than run the risk of heavy planting losses.

Conifers.—Early planting is particularly desirable for pine and larches. Spruce on high ground can be left to the last.

Hardwoods.—Plant beech in the autumn if possible, especially on thin chalk soils. October is the best month, even if some of the leaves are still green.

DIRECT SOWING

Conifers.—Direct sowing of conifers is always a chancy business. Planting is much more reliable and usually cheaper in the end.

Hardwoods.—Oak is the only species to be considered. Direct sowing is practicable in good mast years, but grassland or exceptionally weedy areas are unsuitable. Do not economise in seed, i.e., use about 4 cwt. per acre. Beware of mice, squirrels and pheasants. Do not cover the seed too deeply, 2 in. is ample.

SIZE OF PLANTING STOCK

Select the best size and age of planting stock with the following points in mind:—

- Species,
- Soil conditions,
- Degree of shelter or exposure,
- Density of weed growth,
- Method of preparing ground.

Conifers.—On exposed ground, small transplants are best. Larger ones may be preferable in heavy weed growth, for planting through deep turfs, in frosty localities and for beating up. Pines and larches are better at the "plus one" stage than as "plus two's". Corsican pine should always be planted at the "plus one" stage.

Pine and spruce *seedlings* are sometimes successful, but only on favourable and sheltered sites; the plants must be well-rooted and sturdy.

Hardwoods—Oak.—The use of transplants is seldom advisable. On good loams, strong 1-year seedlings, not below 6 in. in height, give good results; but on heavy clays 2-year seedlings are preferable.

Beech.—Strong transplants are best. Where shelter is sufficient, the bigger they are within reason the better.

Ash and Sycamore.—Use strong transplants, 2 ft. high and upwards, but avoid slowly-growing over-aged stock.

Sweet Chestnut.—Strong well-rooted transplants or sturdy 2-year seedlings give good results.

Poplar and Willow.—Rooted cuttings from 5 ft. to 10 ft. high are normally used.

Other Hardwoods.—Use sturdy well-rooted transplants, especially in sheltered situations where high weed growth is expected.

LINING AND SPACING

On ploughed ground the furrows normally serve as lines. Spaces along the lines may often be judged from the length of a tool handle, and it is seldom necessary to use a measuring stick.

On unploughed land, sighting rods are the simplest method; string lines are only to be used in special cases.

In hilly country it is often advisable to take the lines straight up the slopes. They may then serve as extraction routes for wire ropeways.

PLANT SUPPLY

Organize this well in advance. Allow for hold-ups due to hard weather, etc., especially when importing from a distance. Order imports in good

time—the supplying nursery may be very busy or frozen up, and so unable to execute rush orders.

Make sure that supplies are up to sample, properly counted, culled and graded. Do not lay the blame for all failures on imported plants. It is up to you to see that you get the right type at the right time.

Handle planting stock carefully, and get it as close as you can to the planting point by lorry, cart, sledge, launch or tractor-drawn trailer. Carrying by hand is costly and not good for the plants, and double-handling should be avoided. Corsican pine should be planted as soon as possible after lifting.

Heel-in carefully. If plants must remain more than a few days in the "sheugh" or "bury", open the bundles before you heel the plants in. If plants arrive at the last moment, when there is no time for heeling-in, they may be protected from night frosts by stacking in a conical heap, with roots inward and shoots outward, and covered with sacking.

Use of Basic Slag or other forms of Phosphate

On particularly sterile soils the establishment of Sitka spruce and Japanese larch can be much assisted by applying to the base of each plant an ounce or so of basic slag or ground mineral phosphate at the time of, or shortly after, planting. It is emphasised that "slagging" is an exceptional procedure requiring special sanction at Conservator level.

CHAPTER 6

BEATING-UP

The object of beating-up is to fill gaps and secure even growth in what would otherwise be an irregular crop. It involves expense, uses up plant stocks and extends the weeding period. Try, therefore, to cut it down to the minimum by sound planting in the first instance.

As a first step, estimate losses by taking sample rows across your plantation. Count the missing trees and work out percentage survivals. Watch out for local cases of failures in groups.

Be sure that the missing trees have failed beyond hope of recovery. Spruces and Douglas fir may recover after appearing moribund. Larches may break away from the base after being bitten back. Hardwoods frequently die back and then shoot away from a side bud.

Timing

As a rule, the sooner beating-up is done the better. Fill up unmistakable blanks without delay. Rapid growing species such as Japanese larch, European larch, and in some places Douglas fir, must be beaten-up at the first opportunity. It is usually futile to beat-up Japanese larch after the

first winter. Corsican pine is a species in which deaths often occur in the second year after planting, so beating up may be left until the second winter.

Plantations of four years and over are not to be beaten-up except on explicit instructions.

Species.

As a rule, it is a mistake to change the species, but note the following points:—

Conifers.—Scots pine may be used to beat-up:—

- (1) Corsican pine.
- (2) Spruces, especially on heathery ground.
- (3) Beech on chalk soils.

Japanese larch and tsuga are both useful for delayed beating-up, but use large plants and be sure that the gaps are big enough to let the Japanese larch through.

Hardwoods.—Beech has been much used in the past to beat-up other species, such as conifers and oak, but seldom with any success, and the practice should not be continued. The time to bring beech into oak is later, in the underplanting stage.

Methods.

Use selected sturdy plants and employ your more experienced planters. Beating-up is naturally more costly than planting; therefore, it must be done well and carefully supervised.

After the first beat-up it is not necessary to fill every gap, and single gaps may often be ignored. One tree can be used to fill two gaps and two trees to fill three gaps. It is not essential to preserve the same distance between plants, provided that straight rows are maintained, but long runs of gaps are best replaced plant for plant. Treat groups of failures on the same plan, remembering that it is not always advisable to beat up right to the edges of a failed group.

Teach your beating-up gang to estimate the future prospects of each tree. Unless a beat-up tree has a reasonable chance of entering the canopy and taking a useful place in the stand, it is futile to plant it. Remember that the established plants have a good start, and their height growth and side-shoot growth can be very rapid.

Avoidance of Waste.

The striving after one hundred per cent. stocking in your plantations, though praiseworthy, may be very uneconomic. The first beating-up of a plantation should aim at replacing the failures provided these amount to more than 10 per cent., or occur in groups. Single failures, scattered uniformly over an area and amounting to less than 10 per cent. in all, should not be beaten-up.

Subsequent beating-up requires much more careful consideration because it is here that money is most commonly wasted. A plantation which is 85 per cent. stocked, and in which the failures are evenly distributed, should not normally be further beaten-up.

Complete Replacements.

All complete replacements, from whatever cause, of areas up to one acre, are to be regarded as beating-up. Areas of over one acre which require to be completely re-stocked, should be regarded as re-planting.

Later Losses.

Later losses, due to various causes, such as fungal or insect attack, voles, frost, etc., call for special treatment, e.g., the retention of birch or coppice to fill gaps in broadleaved plantations, introduction of pines in frosty hollows, the use of tsuga, etc.

CHAPTER 7

WEEDING

Weeding varies so much with seasonal and soil conditions that it is impossible to lay down hard-and-fast rules. The careful selection of tools for the type of weed growth to be tackled leads to speed, efficiency and economy.

Troublesome Weed Species.

There are two outstanding weeds, the neglect or mishandling of which in the past, has led to serious losses on some of our afforestation areas; these are gorse and bracken. Gorse can be very troublesome, but attempts to economise by drifting or lane cutting have generally failed. The only remedy is to make a clean job and keep hard at it until the young trees can carry on unaided. Bracken is a menace wherever it is tall and dense; patches of dense growth often occur in areas where bracken is generally sparse and innocuous, and are commonly associated with local water seepage. Watch out for such areas which may want weeding for several years after the rest of the plantation is safe. In wet years it is often necessary to cut bracken twice in the season. Switching prior to planting is not worth while. The best time for cutting is when the bracken is still in the curl, but on large areas this is a counsel of perfection.

Grass weeding, where there is neither gorse nor bracken, is often overdone; the work should be concentrated on any weakly plants which are liable to be smothered; vigorous plants of most species tolerate a good deal of cover. The larches are exceptions, especially E.L.

Watch out for patches of shrubby growth such as privet, aspen, and bramble, and for birch or sallow which may seed on to the area after planting. There are danger spots in most plantations and a good forester should have these always in his mind.

CHAPTER 8

RACKING, CLEANING AND BRASHING

Cutting of Racks.

As soon as a plantation has got into the thicket stage, cut inspection racks every three to four chains. Brash either two sides of one row of trees, or one side of two rows. In hill country, racks may usefully follow the contours, unless they are required for downhill extraction by wire ropeway. On level ground, they should run with, or at right angles to, the planting lines. Plan the racks so as to divide up each compartment into sections for fire control purposes.

Cleaning.

After cutting racks, see if a cleaning is necessary. The tendency has been to leave this too late. Remove weed species (sallow, dominating birch, etc.), bad wolf trees, climbers (especially honeysuckle) and other harmful plant growth.

Brashing.

Brashing is necessary for fire control and marking and extracting the first thinnings of coniferous plantations. Complete brashing of every tree is very expensive and is only to be done on specific instructions. A usual practice is to brash every third row, omitting suppressed trees.

The curved pruning saw is one of the best tools. Edged tools such as bill hooks should not be used. The height to which brashing should normally be taken is six feet.

CHAPTER 9

DEFINITION OF TENDING AND THINNING OPERATIONS

Cleaning.

This operation is carried out in a plantation when it has reached the thicket stage. It consists (a) of removing weeds such as birch, sallow and coppice shoots, which if left would harm the planted trees; and (b) large, forked or otherwise badly mis-shapen trees (wolf-trees), which tend to crowd out better trees and are themselves unlikely to produce useful timber. It should be observed that the mere fact that a tree is exceptionally large is not a sufficient reason for condemning it as a "wolf"; such trees, if well shaped, are usually valuable members of the crop.

Pre-thinning.

If the large misshapen trees have not been got out at the cleaning stage they must either be tackled at the first thinning or it may be necessary

to remove them as a separate operation—pre-thinning—a few years before the plantation is ready for thinning proper.

Whether this separate operation is necessary is a matter which calls for considerable judgment; the species most usually concerned are: Scots pine when damaged by the Shoot Moth, Japanese larch, Douglas fir, and oak.

Thinning.

Thinnings aim at the gradual development of the best trees in the crop; two main types are distinguished: *Ordinary thinning* and *Crown thinning*.

Ordinary thinning works on the principle of removing progressively the smaller and weaker trees, so giving more and more growing space to the better trees remaining, until ultimately the final crop has been singled out.

Crown thinning works on the principle of "spotting the winners" at an early stage; selected trees—often called "Elite trees"—are given extra room, while the small, backward trees are retained as long as possible to cover the gaps so caused.

The simplest way of making intelligible the distinction between different types and grades of thinning is to define these in terms of tree classes, of which at least seven can be distinguished in any more or less normal stand. The definition of the various tree classes are given in the text which follows, but reference should also be made to the diagram on page 47.

I. ORDINARY THINNINGS

In the sample plot work of the Research Branch four grades of Ordinary Thinning are recognised. These are known by the letters A, B, C, D respectively. Of these Grades, A is the unthinned control treatment and requires no further mention, B is a Light Thinning, C a Moderate Thinning, and D a Heavy Thinning. The definitions which follow do not tally exactly with the official research grades, which are of necessity very rigid, but it is hoped that Foresters will find them useful as a practical guide.

Light Thinning

A *Light Thinning* does not break the upper canopy of the crop to any appreciable extent; this does not mean that the canopy is nowhere broken, here and there wolf-trees have to be cut out as well as spindly whips which are in the upper canopy. But, looking at the plantation as a whole after the thinning has been carried out, it should be possible to say that the main canopy has not generally been broken.

A *Light Thinning* will remove:—(a) All dead and suppressed trees, the latter being trees whose leading shoot is under part of the crown of a taller adjacent tree. (b) Those sub-dominants which can be removed without breaking the canopy; these are usually trees which are badly shut in on one side but not yet actually suppressed—they are in any case short trees. (c) Whips; these are tall spindly trees which sway about in the lightest wind and may do a lot of harm by stripping the branches of adjacent good dominants. If whips are very numerous, as they sometimes are in a

neglected plantation, it may be impossible to remove all of them without exceeding the grade of thinning. On the other hand, if only sporadic (i.e., occurring at irregular and infrequent intervals), they can and should be all cut out in a *Light Thinning*. (d) Lastly, there are the wolf-trees and other trees with badly shaped stems; even in a *Light Thinning* it is correct to remove occasional malformed trees in the upper canopy. This will involve local breaks in the canopy but as long as they are only local the general character of the thinning will not be affected.

Moderate Thinning.

This removes the same class of trees as the *Light Thinning*, as well as some additional ones, but involves a definite though strictly moderate break in the upper canopy. How this opening of the canopy is achieved depends very much on the character of the stand. In a typical young stand, containing relatively few whips or wolf-trees, a *Moderate Thinning* will include all the classes marked under a *Light Thinning*, and, in addition, a fair number of co-dominants (i.e., trees in the upper canopy but shorter than the dominants), more particularly those with flattened crowns which are also interfering with the development of adjacent good dominants.

If a neglected plantation has to be thinned it will often be found to contain many evenly-distributed whips. In a *Moderate Thinning* all the whips might be removed in addition to the suppressed trees, shut-in dominants, and occasional wolf-trees; such a thinning, which would result in a moderate break in the upper canopy over the stand as a whole, would accord with the definition. Another fairly common case is that of a plantation with many mis-shapen trees. The removal of the worst of these trees more or less uniformly throughout the plantation, plus the suppressed trees and a few whips, might break the canopy only to a moderate extent and so also accord with the grade. In both these cases any additional thinning in the upper canopy might break up the canopy so much as to merge the grade into a *Heavy Thinning*; but it is all a matter of degree.

It is difficult to define in words what constitutes a moderate break in the canopy, but there are two pointers which may help. Firstly, the upper canopy in a *Moderate Thinning* still retains quite definitely the character of a canopy, i.e., an overhanging shelter. Looking upwards after the thinning has been done, at least four-fifths of the sky should be shut out by the crowns of the taller trees and less than one-fifth be free light. Secondly, only in very rare instances should a dominant or co-dominant be completely isolated; as a rule the crown of each dominant should be in more or less close contact with its neighbours on more than half the circle of the crown.

Heavy Thinning.

This is an intensification of the *Moderate Thinning*, involving a general and considerable breaking of the canopy, though there are limits beyond which it is not permissible to go.

After removing the dead and suppressed trees and whips, attention should be focussed on the well-shaped dominants, and the endeavour made; (1) to secure as even a distribution of such trees as possible; and (2) to give each of these trees additional light on at least one side. In some cases this may mean sacrificing an almost equally good dominant, but if this is the only way of helping the tree it may have to be done. As a rule, however, a *Heavy Thinning* goes in the main for the co-dominant class, breaking up the groups of trees of almost equal height, and ruthlessly removing malformed trees, however much space they occupy unless there is nothing which will replace them. When marking the thinning the sub-dominant trees in each group may be left until it has been decided what else should be removed, sometimes these trees are useful to fill a gap caused by the felling of a dominant. No sub-dominant should be retained unless it is required for soil cover.

The pointers indicating a *Heavy Thinning* are as follows:—(1) Something like one-third of the overhead canopy is sky and two-thirds occupied by the tree crowns, as compared with less than one-fifth sky and four-fifths crown in the *Moderate Thinning*, viewed just after the thinning has been made; (2) a considerable number of the dominant and co-dominant trees will have more or less completely free crowns, some quite free, and others touching only at a few points; (3) the thinning must not be so heavy that most of the gaps will not close over by the time the next thinning is due, i.e., in five, or at the most, ten years' time.

II. CROWN THINNINGS

This type of thinning is designed to give a steadily increasing amount of growing space to the crowns of a relatively few well-shaped Selected Trees, while retaining an under-storey of smaller trees whose object is partly to keep the ground covered, and partly to help kill-off the lower branches of the selected trees. From the very start attention is focussed on the trees which are to be specially favoured. Because the retention of a moderately dense under-storey forms an essential part of the method, Crown thinning is seldom applied except to more or less shade-bearing species, such as beech, thuya, tsuga, the silver firs, Norway spruce and Douglas fir.

Two grades of Crown-thinning are recognised in Sample Plot work:—

1. Light Crown-thinning (L.C. Grade).
2. Heavy Crown-thinning (H.C. Grade).

Light Crown-thinning.

In a young plantation about twice as many Selected Trees are required as will be necessary to form the final crop; the equivalent spacing is then calculated. For example, if a final crop of 100 trees per acre is aimed at, about 200 trees per acre might be selected, and these should stand about five yards apart. In making the thinning the object would be to give

substantially more light to the best tree in each group, at as nearly as possible the given spacing. Nature seldom spaces the best trees evenly and some compromise is necessary. The Selected Trees are not necessarily the largest in every group, straightness of stems and good form of crown are the more important considerations.

In practice this type of thinning means removing mainly dominant and co-dominant trees which are crowding against the Selected Stems. Wolf-trees are, of course, cleared out as completely as possible, as are any whips or dead and dying trees. The Sub-dominant and suppressed trees are left intact, provided they seem likely to survive until the next thinning.

In the *Light Crown-thinning* the process of freeing the Selected Trees is a gradual one and, in the early stages at least, there is no question of isolating them. In the later thinnings the best of the Selected Trees are retained for the Final Crop and the remainder gradually removed.

Heavy Crown-thinning

This only differs from the L.C. Grade in the rate at which the Selected Trees are freed. In the heavy grade of Crown-thinning the process is much more rapid and drastic, the aim being to remove all competitors of the Selected Trees as soon as possible, the restraining factor being the necessity of killing the lower branches of the Selected Trees and so obtaining the required length of clean bole.

POSTSCRIPT

The above definitions are an attempt to describe and classify the types of thinning recognized in forestry theory. In practice, the distinction between Ordinary Thinning and Crown-thinning tends to disappear; a good thinner will keep his eyes all the time on the best trees and try to favour these and will leave smaller trees where he can to cover gaps; in doing so, he approaches closely to the ideas of Crown-thinning. On the other hand, he will often find it unnecessary, or even undesirable, to allow the stand to get cluttered up with a lot of backward trees (especially if there is a market for the poles) and he will thin these out lightly or heavily according to the species and the condition of the stand. Thus the operation of thinning tends, in practice, to be neither Ordinary Thinning, nor Crown Thinning in the strict sense of the terms, but a combination of the two.

SUMMARY OF THINNING GRADES.

ORDINARY THINNINGS

1. Light Thinning

- Remove: Class 7 : Dead and dying.
 4 : Suppressed.
 3 : Sub-dominants (where their removal hardly
 leaves a hole in the canopy).
at least some of: 6 : Whips.
 5 : Wolf-trees.

2. Moderate Thinning

Remove: Class 7 : Dead and dying.

4 : Suppressed.

6 : Whips.

most of 3 : Sub-dominants.

as many of 5 : Wolf-trees as possible without seriously opening up the canopy.

If the above operations have left the upper canopy reasonably intact, space out the 1's and 2's (Dominants and Co-dominants) by taking out an odd 1 or 2 here and there to give space for the development of the crowns of the better trees left.

3. Heavy Thinnings

Remove: Class 7 : Dead and dying.

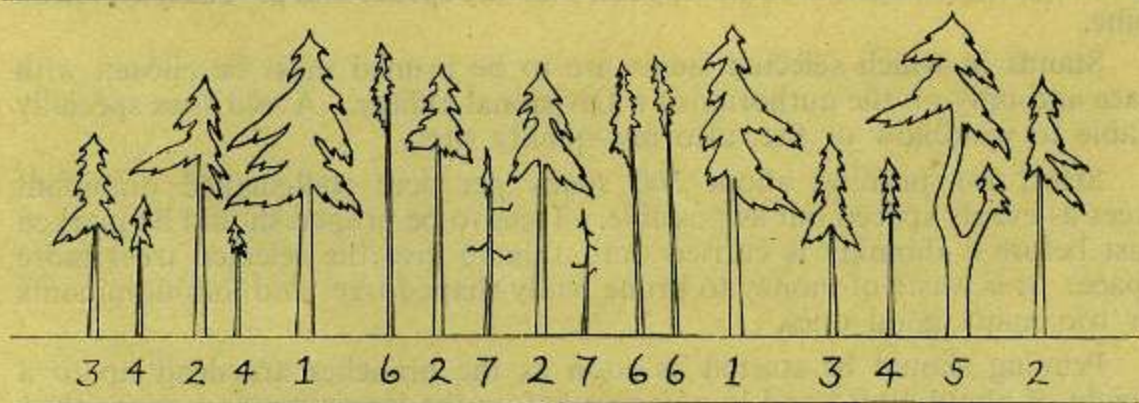
4 : Suppressed.

3 : Sub-dominants.

6 : Whips.

5 : Wolf-trees.

Break up the groups of 1's and 2's (Dominants and Co-dominants), favouring the best stems throughout the crop, leaving good Sub-dominants, where available, to fill up gaps.



- Class 1. Dominants.
- Class 2. Co-dominants.
- Class 3. Sub-dominants.
- Class 4. Suppressed.
- Class 5. Wolf-trees.
- Class 6. Whips.
- Class 7. Dead and dying.

CROWN THINNINGS

1. Light Crown-thinning.

Remove: Class 7 : Dead and dying.
6 : Whips.
5 : Wolf-trees.

and sufficient 1's and 2's to give a moderate amount of additional growing space to each of the Selected Trees.

Leave all of Classes 3 and 4 capable of surviving.

2. Heavy Crown-thinning.

Remove: Class 7 : Dead and dying.
6 : Whips.
5 : Wolf-trees.

Leave all of 3 and 4 capable of surviving.

Give as much growing space as possible to the Selected Trees, remembering, however, the need for branch suppression.

CHAPTER 10

PRUNING

1. Conifers

The object is to obtain a large zone of clean timber free from knots. Fast-growing species with retentive lower branches are most likely to repay pruning, i.e., Douglas fir, Sitka spruce, Norway spruce and probably Corsican pine.

Stands in which selected stems are to be pruned must be chosen with care and only on the authority of a Divisional Officer. Avoid sites specially liable to windblow or fire, also low-quality sites.

Select for pruning about 300 stems per acre well-shaped dominant trees as evenly spaced out as possible. Trees to be pruned should be marked just before a thinning is carried out; thin to give the selected trees more space. It is waste of money to prune badly shaped trees and Sub-dominants or too many good ones.

Pruning should be started as soon as the branches are dead up to a height of about 10 ft., and in any case before the larger trees are more than 5 to 6 in. quarter-girth at breast height. Carry the first pruning up to a height of at least 12 to 15 ft., removing the lowest whorls of live or practically live branches; but the length of tree under live crown should not be less than about 40 per cent. of the total height. A second pruning, to a height of about 20 ft., should follow during the next 5 to 10 years, depending on the rate of growth. A thinning must precede this pruning in case some of the previously pruned trees may have to be removed.

Pruning is an operation in which the technique is highly important. Good pruning involves in the first place the clean removal of each branch, leaving no outstanding snag, especially on the lower side of the branch; and secondly, avoidance of injury to the adjoining part of the stem. The second condition rules out the use of edge tools such as bill-hooks, even in the hands of experienced workmen. The best tool is a hand saw with a replaceable blade of the Bushman type; it is essential that the blades should be kept sharp. The closer the cut can be made to the base of the branch the better. If pruning is done by piece work intensive supervision is necessary and when arranging rates it must be made clear that faulty work will have to be made good by the men.

Pruning can be done at any time of the year except during the spring and early summer, the reasons being that bark injuries are hard to avoid when the sap is rising, also in some species, e.g., Sitka spruce, the young leaders are so brittle that they are apt to snap off when the tree is jarred.

2. Broad-leaved Trees

The primary object is to obtain straight main stems; in most cases pruning becomes a matter of removing or shortening one branch of a major low fork, when the crop is in the thicket or small pole stage.

The main point to remember is that misshapen trees will normally be removed in the cleaning or first thinning operations; hence money spent on pruning such trees is wasted. It is only when there is a high proportion of forked stems among the dominant trees that pruning has to be considered.

Oak.—The young trees have a natural tendency to fork, but, provided close canopy is maintained, one of the shoots will take the lead, the others being suppressed in course of time. Occasionally, wolf trees may be corrected by pruning (shortening of major side branches) but mostly they are better removed.

Beech.—Well-stocked beech plantations should not normally require pruning, but some strains of beech are very prone to forking, and it may then be necessary to prune. Aggressive side branches should be shortened, not cut flush with the main stem.

Ash and Sycamore.—As a result of their opposite buds equal forks are commoner than in other species. Early attention is necessary to secure a straight main bole of at least 20 ft. in length. It is usually better to shorten one limb of a fork rather than cut it off flush with the stem. The treatment should be reserved for carefully selected dominants. Long-handled pruning shears are convenient for this work.

Birch.—The provisional recommendation is to prune selected stems in the same manner as a conifer, in the hope of preventing stem fluting. Keep at least 50 per cent. of the tree under live crown, and do not prune while the sap is running.

Poplar.—Owing to the wide spacing at which poplars are planted, live pruning every 3 to 5 years is essential. Epicormic shoots developing from