FORESTRY COMMISSION

Bulletin No. 14

FORESTRY PRACTICE

A Summary of Methods of Establishing Forest Nurseries and Plantations with Advice on other Forestry Questions for Owners, Agents and Foresters

Revised 1946

LONDON: HIS MAJESTY'S STATIONERY OFFICE
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PREFACE TO FOURTH EDITION

SINCE the first edition of this Bulletin was brought out in 1933 there have been many developments in British forestry practice, and the need for a complete revision of the text has long been realised. It was hoped to undertake this task as soon as the war was over, but shortage of staff and the urgent work of reconstruction have made this impossible. This Bulletin continues, however, to be much in demand, the latest issue of 2,000 copies being exhausted within a few weeks. Rather than hold up the publication until a complete revision could be made, the Commissioners have decided to issue a fourth edition in a partly revised form. While the bulk of the text remains substantially unchanged, certain sections have been amended or re-written. The major alterations are as follows :—

The tabular " Notes on Individual Species " have been entirely revised, as have Tables I and II concerning nursery treatment for each species. The section on " Thinning " has been re-written, and the list of suppliers of tools and equipment brought up to date. Another addition is the inclusion of the official Explanatory Note on the Dedication Scheme.

Labour costs have risen greatly since the last revision in 1939 and are not yet stabilised, so it was decided to retain the 1939 values. It should be observed that the wage of an adult male forest worker at that time was in the region of 38s. per week. Prices of tools have been omitted from this edition.

FORESTRY COMMISSION,
25, Savile Row,
London, W.1.

September, 1946.

PREFACE TO FIRST EDITION

THIS booklet contains little that will not be familiar to good foresters on the larger forestry estates who have kept an eye on the technical forestry journals. It is not suggested that well-established practices which have stood the test of time and trial should be abandoned for in each district that which succeeds best is best. Many, however, have little or no access to first-hand experience gained in their own districts, and it is hoped that they will be encouraged and helped by what they read here to embark upon forestry and to undertake the clearing of old woodland and its reafforestation on better lines. Those who doubt may find it useful to read first the section dealing with the treatment of forestry by the State.

Owing to the infinite variety in the conditions under which it is practised forestry cannot be an exact science in which it can be said with certainty that certain actions will always produce the same results. It follows that much of what is set down here with some definiteness will not be universally true, and a handbook cannot be a wholly satisfactory substitute for personal inspection and advice such as owners can secure from the Forestry Commission or, in some cases, from their Forestry Societies. Some may think that it is therefore a mistake to try to give general guidance in print and that everything should be a matter for the advice of the expert on the spot. But to the compiler of this publication, who is not an expert, forestry appears to be not a complex of abstruse mysteries, but a matter of learning to do a number of quite simple things in ways which as far as possible avoid waste of time, money and effort. No one can tell how well it will pay, but no one can doubt that if full advantage is taken of experience already gained, it will pay much better than most of the expenditure landowners lay out on their estates.

The Report on the Census of Woodlands published by the Commission in 1928 shows all too clearly the sad state of British woods. There were nearly 3,000,000 acres of woodland in 1924 or the years immediately preceding, and as only a little over 200,000 acres were definitely maintained for purposes other than the growing of timber, some $2\frac{3}{4}$ million acres should thus have been productive. Unfortunately, nearly one-third of this was scrub or areas felled and not replanted, while the remaining area of under 2,000,000 acres, though nominally economic, included over half a million acres of coppice with or without standards—a poor form of silviculture for most districts under present conditions. The balance is by no means fully productive. The best of the high forest—nearly half a million acres—was felled in the War, and not much of it has been replaced. The existing reserves of mature coniferous timber are equivalent to less than six months' consumption. The younger crops, though well distributed through the various age-classes, are on the same small scale. Oak planting in particular has gone out of fashion and future supplies of home-grown oak are endangered. The total area of woodlands tends to diminish, and the productiveness of the areas under coppice and coppice-with-standards will probably be reduced. There is thus plenty of room for improvement, and those who plant, as all of us must, for the future, should not be deterred by present unfavourable prices.

Mr. Owen J. Sangar has been responsible for nearly all of the technical matter here presented. But for Mr. Sangar's exact grasp of detail and practical knowledge the work of compilation would have been much more difficult. Mr. W. H. Guillebaud, Chief Research Officer, has given valuable assistance throughout and has prepared the section on thinning.

FRANCIS D. ACLAND,
Commissioner.

FORESTRY COMMISSION,
25, Savile Row, London, W.1.

February, 1933.

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PART I

NURSERY WORK

INTRODUCTION

THE FIRST QUESTION to be decided is whether to have one's own nursery, and the best guidance that can be given in answering it is this :—by having a nursery one should secure that really suitable plants will reach the planting area in thoroughly good condition, as and when required. Considerable financial saving should result unless the soil is very heavy, and there is the further advantage that the estate staff will take an increased interest in their forest work. Nevertheless, it is probably better for a planter on a fairly small scale not to have a nursery if supplies of plants in good condition can be relied on with certainty from outside. A nursery should certainly be dispensed with unless either a regular planting programme of at least 5 acres a year is to be followed, or at least 20–30 acres are to be planted within a few years, and unless a suitable area is available for the nursery, which is conveniently placed both as to supervision and in relation to the area to be planted.

Although it may be decided that it is desirable to have an estate nursery, it should not be taken for granted that it ought to be used for raising plants from seed. The forest tree goes through its most difficult stages in the first two years. It is then that it requires the most skilled treatment, as the following pages will show, and then that, even with such treatment, the greatest variations in yield and quality are liable to occur. It is therefore unwise to grow from seed unless skilled direction and supervision by a trained forester or gardener are available, and unless there is difficulty owing to local circumstances in obtaining supplies of seedlings from a reliable nurseryman, without considerable danger of damage in transit.

A nursery should be on a gentle slope ; places where mist collects or frost lodges should be avoided, as also should southerly aspects in the warmer parts of the country. The site should be well sheltered, particularly from early morning sun and drying winds. It will be more difficult to be sure of the nursery's success in a high than in a moderate (say, 25–40 inches per annum) rainfall area, but a high rainfall will not be fatal where other elements are favourable, though it will increase the cost of weeding. Under these conditions it is essential to start with the soil thoroughly cleared of weeds. To maintain supplies of plants of the ages recommended on pages 20–31, the nursery area should be one-twentieth of the estimated annual planting area and if all plants are raised from seed about one-fifth of this will be needed for seedbeds. In preparing the nursery, it is useful to leave a path which will take a cart lengthways through the middle, and to subdivide the area on each side of this by narrower paths about 4 feet wide, and about 30 feet apart. The nursery must, of course, be securely fenced against rabbits, and unless it is otherwise sheltered, hedges of thorn, beech, yew, *Cotoneaster simonsii* or *Thuya plicata* are useful inside the fence, also sometimes at intervals across the nursery. Owing to the risk of disease it is not desirable to use for hedges a species which is to be grown in bulk in the nursery.

The nature of the soil, more particularly its texture, will affect the success of the nursery more than any other single factor. Unless it works freely costs are sure to be high, and it may be almost impossible to raise conifers satisfactorily from the seed. If the soil is dirty to begin with, weeding costs will be high for a number of years. Soil which lacks humus, or worked-out agricultural land, will be expensive to get into condition. It is pretty safe to select the

nursery site as though one were choosing a garden, taking the lightest fertile soil available. Really good ground already under cultivation should generally be used in preference to permanent grass. If the soil texture is right a piece of open woodland, carrying birch or oak, is excellent. Extracting the stumps and roots is not a hopelessly expensive business, if it is tackled in the right way.

It is well worth while to take very considerable trouble in getting the soil as free as possible from weeds and weed-seeds before nursery work is started. Crops of potatoes are useful for this purpose, and the soil must then be worked up to a fine tilth in the ordinary way. The Rotary Hoe and Rototiller are implements which have been found useful for this work in the case of large nurseries. If the soil is being broken for the first time it must be thoroughly ploughed or double trenched and the turf well buried, or composted for use later. In this preparatory work the subsoil should not be brought to the top.

Land which is used for seedlings or transplants must be kept in a good state of fertility, and it is quite useless to start a permanent nursery unless one is prepared to keep it in good heart (see page 13). In choosing the ground for future seedbeds, the easiest working soil should be selected, and if the nursery has been made on an area which has been arable or grass it is very unwise to sow conifer seed in the first year or two. The ground should first be used for raising conifer transplants and thus inoculated with micro-organisms which may be lacking in soils which have not previously been under trees.

CHAPTER I

THE GROWING OF SEEDLINGS

Supply of Seed

SEED requirements will naturally depend on the annual area to be planted and on the spacing of the young trees when they are planted, as well as on the quality and origin of seed, whilst the yield of plants will necessarily vary with the season.

The following table gives average figures for 1 acre to be planted with 3- or 4-year-old transplants at the spacings recommended for general use and assumes that only really good selected stock will be lined-out or used for planting :—

TABLE I.—CONIFERS

Species	Spacing recommended	Per acre of Planting			Remarks
		Plants required	Seed to be sown in Nursery	Plants to be lined-out	
	(Feet)		ozs.		
Scots Pine	4½ × 4½	2,150	4	2,750	
Corsican Pine	4½ × 4½	2,150	12	3,000	
European Larch... ...	5½ × 5½	1,450	12	1,750	
Japanese Larch ... ... (also Hybrid Larch)	5½ × 5½	1,450	4½	1,750	
Douglas Fir	5 × 5	1,750	4	2,250	
Norway Spruce	4½ × 4½	2,150	5	2,750	Can be spaced 5′ × 5′ when turf planted.
Sitka Spruce	5 × 5	1,750	4	2,250	
Lawson Cypress ...	5 × 5	1,750	3	2,250	
Monterey Cypress ... (*Cupressus macrocarpa*)	5 × 5	1,750	6	2,250	
Western Hemlock ... (*Tsuga heterophylla*)	5 × 5	1,750	3	2,250	
Austrian Pine ... ... (*P. austriaca*).	4½ × 4½	2,150	8	3,000	For wind-breaks. Space wider for nurse crops
Lodgepole Pine ... ... (*Pinus contorta*)	4½ × 4½	2,150	6	2,750	
Maritime Pine ... ... (*Pinus pinaster*)	5½ × 5½	1,450	?	3,000	Best established by direct sowing of 3 to 4lb. of seed *per acre.*
Monterey Pine ... ... (*Pinus insignis*)	5½ × 5½	1,450	10	1,750	
Sequoias ... ... (*S. gigantea, S. sempervirens*).	5 × 5	1,750	(16?)	2,250	Seed usually of low fertility.
Grand Fir ... ... (*Abies grandis*)	5 × 5	1,750	16	2,250	
Noble Fir ... ... (*Abies nobilis*).	5 × 5	1,750	16	2,250	
Servian Spruce ... ... (*Picea omorika*).	4½ × 4½	2,150	4	2,750	
Western Red Cedar ... (*Thuya plicata*).	5 × 5	1,750	2½	2,250	

TABLE I.—HARDWOODS

Species	Spacing recommended	Per acre of Planting: Plants required	Per acre of Planting: Seed to be sown in Nursery	Per acre of Planting: Plants to be lined-out	Remarks
	(Feet)		(lbs.)		
Oak seedlings	4×2	5,450	140	—	
,, transplants ...	4×4	2,720	110	4,000	
Beech	4½×3	3,650	30	4,500	Wider spacing suitable when planted with nurses; e.g. 9×3′ requires 1,950 plants per acre.
Ash	4½×4½	2,150	4	3,000	
Sycamore	4½×4½	2,150	5	3,000	
Chestnut, Sweet ...	4½×4½	2,150	56	3,000	
Birch	4½×4½	2,150	1	3,000	Normally used as a nurse at half this density.
Poplar	16×16	170	—	250 (Cuttings)	
Willow, Cricket Bat ...	30×30	48	—	70 (Cuttings)	

NOTE: In all cases the quantity of seed stated is likely to provide, under favourable circumstances, rather more than the required number of trees. The balance, however, will be available for beating-up (replacing losses) in the season after transplanting.

N.B. Quantities of seed for conifers are stated throughout in *ounces*, but those for hardwoods are in *pounds*.

Seed should be obtained from nurserymen who are themselves collectors and importers, and if any considerable quantity of the more expensive seed is required it is well to obtain alternative quotations. Requirements should be considered and orders placed in the very early autumn and the seed delivered as wanted, though conifer seeds can safely be stored, provided they are kept in a cool, dry place, and protected from mice. It is generally worth while to try to collect hardwood seed from good trees of one's own, but care must be taken in storage; acorns are best kept in an open pit out of doors, protected against rain, mice and birds, and turned twice or thrice a week for the first six weeks after collection. In the drier districts they may be sown after collection if protected against vermin. Ash must be stored for 18 months mixed with sand in a box buried beneath the ground or better still in an open pit enclosed in fine (¼ inch) mesh wire netting to exclude mice and other marauders. It is a common thing in Scotland for owners to collect conifer seed, especially Scots pine and larch. This is an excellent practice, provided the cones are collected from good trees and arrangements can be made for extracting the seed.

The Forestry Commission have carried out careful experiments in the sowing of the principal conifers. The more important conclusions as to the condition of the ground, the preparation of the seed for sowing and the dates of sowing are included in the subsequent paragraphs; the main results as to density and depth of sowing are given in the following table, but it must be remembered that wide variations may occur from year to year in the quality and yield of seed. In calculating areas the paths between beds and the spaces between bands have been excluded:—

TABLE II—CONIFERS

Species	Sq. yds. of seed-bed per lb. of seed (average quality)		Normal Percentage Germination (Laboratory Test)	Depth of Cover (Inches)
	Drills	Broadcast		
Scots Pine	75	55	90%	¼
Corsican Pine	50	35	55%	⅜
European Larch ...	65	55	50%	⅛
Japanese Larch ...	80	60	50%	⅛
Douglas Fir	60	45	80%	¼
Norway Spruce ...	60	45	85%	¼
Sitka Spruce	115	85	90%	⅛
Lawson Cypress ...	55	40	45%	⅛
Monterey Cypress ...	40	25	—	¼
Western Hemlock ...	90	60	60%	⅛
Austrian Pine	50	35	—	⅜
Lodgepole Pine ...	90	75	90%	¼
Maritime Pine ...	30	25	—	⅜
Sequoias	?	?	?	⅛
Grand Fir	30	25	35%	⅜
Noble Fir	30	25	35%	⅜
Serbian Spruce ...	60	45	—	¼
Western Red Cedar ...	60	45	65%	⅛

TABLE II.—HARDWOODS

Species	Running Yards of seed-bed per lb. of seed (average quality)		Depth of Cover (Inches)
	3 ft. Bed	6 in. Band	
Oak	1	2½	1
Beech	4	10	¾
Ash	12	30	½
Sycamore	10	25	½
Chestnut, Sweet	1	2½	1
Birch	30	—	⅛
Poplar	—	—	—(cuttings)
Willow, Cricket Bat ...	—	—	—(cuttings)

PREPARATION OF GROUND

The site for the seedbeds should be the lightest and most free working part of the nursery. It should be, if possible, on a gentle slope. The ground should be divided up into seedbeds 3 feet to 3 feet 6 inches broad. The beds should be divided by alley-ways 14 to 18 inches wide, left to facilitate access for sowing, weeding, etc., and to help drainage in wet climates. The beds and paths are marked out on the ground with strings or nursery lines. Soil from the paths is heaped on to the beds so that when the latter have settled down they stand 3 inches higher than the paths. This aids drainage and prevents flooding in rain storms. On heavy soils the first digging or ploughing should be done in winter, and the soil left in the rough to weather. The soil is firmed and brought to the finest possible tilth, in the same way as for onion beds. The Rotary Hoe or Rototiller gives an excellent tilth. It is simply waste of money to sow conifers, especially Sitka spruce and the larches, unless the soil is in excellent tilth and working well.

Table II above gives the number of square yards which will be required by 1 lb. of seed, and from this the area required for the beds can be calculated. (Take the 3-ft. bed column for Hardwoods; each running yard equals one square yard.)

PREPARATION OF SEED FOR SOWING

Seeds of most conifers germinate better if they are given a preliminary soaking in water at ordinary temperatures. The seed, enclosed in canvas bags, is merely immersed in a bucket or other receptacle, in which case the water should be changed daily, or put between sacks which are kept wet. Larch should be soaked for one day, and other common conifers for from five to seven days.

Seeds of Douglas fir that have been stratified in sand germinate much more readily and uniformly than those which have been soaked in water. The seeds are weighed out into convenient lots and the lots are put in pots or jars with an equal bulk of sand. The pots are placed in a pit made in the ground to a depth of two feet. The pit is then filled up with sand. The whole is surrounded with fine mesh netting to keep out vermin.

Before being sown seed should be coated with red lead to give protection against mice and other vermin. About 1 lb. of ordinary commercial red lead is required to 10 lb. of seed—less for the larger sorts. It should be well mixed in with the seed, which should be wet enough for the red lead to stick to the seeds, but not for the seeds to stick together. Seed that has been soaked may have to be dried a little by being spread out before the red lead is mixed with it, and it will need a little further drying after red leading to facilitate sowing. The process of drying can be hastened without risk by mixing a small quantity of dry sand with the seed. Stratified seed of Douglas fir should be sown as soon as the roots appear, without red leading.

SOWING THE SEED

The best time for sowing seed depends on the soil and climate of the district. The beginning of April is the best time for all coniferous species, and this is usually possible in the warmer and drier parts of Britain. Do not prolong the sowing season into May if you can avoid it. Late sowing (after about May 7th) results in small poorly-rooted seedlings which are very liable to be thrown out by frost in the following winter. As a general rule the largest seedlings are obtained from early sowing but the number of plants obtained from each pound of seed is liable to be reduced. In some districts, particularly those where long cold or dry periods occur in spring, early sowings lose their advantage in height growth.

Birch seed when collected should be spread out in a shed and dried. At the end of December it should be stratified in slightly moist sand, and the mixture sown at the end of March.

Other seed of broadleaved trees can be sown after collection, say from January, but beech is better not sown until April so that spring frosts may be avoided. If earlier germination makes it necessary to sow beech before late frosts have ceased, it should be protected with a covering of lath screens; these also serve to discourage wood pigeons, which may be troublesome in nurseries near woodlands.

Many people sow conifers broadcast, but the simplest and best method for the forester who works on a small scale is in drills, except where the forester is skilled in broadcast sowing. Hardwood seeds are best sown in bands, but the bigger seeds such as chestnut may well be dibbled in.

Drill Sowing.—Drills can quite easily be made with a piece of inch board, the edge being pressed down into the soil the precise depth required for the particular kind of seed. The seed must of course be evenly distributed, which is made easier if the required dose of seed is emptied into the drill from a narrow tin trough or from a straight, even groove in a piece of wood along which it has been smoothly spread. In large-scale operations it is worth while to use for making the drills a flat board or light wooden roller which has slats 1 inch broad attached to it at intervals of 4 inches, but there should be different boards or rollers with slats of the depths required by the different seeds. Seed troughs also should be made, or the groove cut, specially for each type of seed.

After the seed has been sown each drill must be filled in with coarse sand or grit exactly up to the top so as to give a covering of the required depth. To facilitate this process a shallow wooden trough, 1 inch wide may be used; this should be filled level with sand and then emptied into the drills. It is important to do this correctly, and therefore the troughs should be of the same depth as the drill which has to be filled, and as wide as the seed bed.

Broadcast Sowing.—The simplest method, and one that gives good results with conifers and the smaller hardwood seeds, such as birch, is to sprinkle the seed by hand, either with the fingers or using a small tin, on to the surface of the bed. The seed is then covered with clean coarse sand or fine grit, applied through a sieve or riddle of a suitable gauge, to the appropriate depth as stated in Table II.

An alternative method is the use of a tool called a " cuffing board ", simply a flat board on a long wooden handle, to draw off a thin layer of surface soil and to replace it after sowing. Its use is not recommended for the smaller seeds, which give better results under a sand covering; but it may prove useful for sowing the larger hardwoods which require covering more deeply.

Band Sowing.—In band sowing a shallow trench 6 inches wide is opened and the soil is removed to the required depth. Seed is then sown by hand and the soil replaced and lightly raked over. Further parallel bands are placed 6 inches apart. The seed should not be sown too thickly; about 1 inch apart for middle-sized seeds such as beech and ash, and farther for the larger seeds such as acorns, will be found about right. The beds of the larger seed, such as beech, oak and chestnut, need constant looking at, as they are liable to be attacked by birds (particularly pigeons and pheasants) and by mice. It may, therefore, be well to sow them in a kitchen garden border where they can be looked after by the gardener and the garden cat.

COVERING THE SEEDBEDS

The need for a good tilth in the seedbed has already been emphasized; it is no exaggeration to say that the success of a nurseryman used to depend mainly on the quality of the tilth obtained during the sowing season. This is because the soil raked off the seedbed was used to cover the seed, but unless the tilth was perfect or the soil very sandy or humose the covering soil caked and the germinating seedlings failed to push their way through to the light. Modern practice is to use coarse sand or gravel to cover the small seeds of most of the conifers as well as of such species as birch and alder. Washed silver sand is the ideal covering material, but if a nursery is very exposed, coarse grit or fine gravel with particles from $\frac{1}{8}$"–$\frac{1}{4}$" in size is better because a sand covering is liable to blow away in windy weather.

The use of these non-caking covering materials has three important advantages: it makes the nurseryman much less dependent on weather conditions at the time of sowing, soil of a texture approaching that of a medium loam can

be used successfully for raising trees from seed, and the output of seedlings per pound of seed is often greatly increased.

CARE OF SEEDBEDS

Several kinds of coniferous seedlings need to be sheltered, particularly in the south of England, during the first summer after sowing. Shelter is not necessary for the pines, and other seeds need shelter only during periods of really hot weather (i.e., 70°F. or above, shade temperature in screen for two or more days running).

Branches of broom make the simplest shelter, if they are not available portable screens made by nailing plasterers' laths half an inch apart on to a light framework are the best. They should be laid across wires supported by short posts 9 to 12 inches above the beds. This shelter protects against heat, but not against prolonged periods of drought when watering must be resorted to, as in the garden, and, as in the garden, if watering is once started it must be continued until the drought breaks. For seed of broadleaved trees, shade is seldom necessary, except in the case of beech, as a precaution against frost damage.

The first weeding, especially in broadcast beds, is an expensive and tricky business, as many of the annual weeds germinate before the tree seeds do. A practice now rapidly finding favour is to burn off these weeds with a blowlamp before the tree seedlings are up. Special large blowlamps are obtained for this work (*see* page 68) or ordinary ones of the type used by painters or braziers can be used for small nurseries. In all cases the great danger lies in damaging the tree seedlings because the lamp is played too long in one place, or the work is left too late. The lamp should never be used if any germinated tree seeds are visible, or kept in one place long enough to discolour a card buried one-eighth of an inch below the surface.

During the growing season drills should be kept as free from weeds as in the case of onion beds, and a tool on the model of a Dutch hoe with a blade 2 inches wide is very useful. Onion hoes also are listed down to 2 inches. In broadcast beds nearly all the weeding has to be done by hand.

During the winter, protection from frost-lift must be given to beds of Sitka spruce and Douglas fir. In districts where late frosts may do damage it is an advantage to protect seedbeds of larch also. The same type of protection as is used in summer is suitable, and it should be continued until the danger of hard spring frosts is over and then removed gradually as the season advances. Large well-rooted seedlings suffer least from frost-lift, so damage is kept down to the minimum by securing good growth during the first year.

Seedlings should not be sheltered or watered during their second summer.

LIFTING THE SEEDLINGS

Seedlings may be lifted at the end of their first season, but are more normally lifted when they are two years old; the soil should be prised-up until the seedlings are quite loose and a handful comes away quite easily and without the least stripping of the roots; a trial will show whether a fork or a spade suits the soil better. The surplus soil should be shaken off and the handful of seedlings laid in a box or tray without further separating, for conveyance to the transplant lines. A rough count of the number lifted is necessary at this stage, as the number raised may exceed or fall short of the quantity required. *Culls*, i.e., weakly or malformed seedlings, are not worth counting and should be discarded and destroyed. If there is a considerable difference in size amongst the remaining seedlings, they should be *graded* into two sizes, which can then be lined out separately. (*See* also page 12.)

CHAPTER II

THE PRODUCTION OF TRANSPLANTS FROM SEEDLINGS

General Considerations

Before discussing technique under separate headings a general word of advice may be given. It cannot be too definitely borne in mind that a forest tree seedling is a delicate and tender plant which is only happy if its roots are kept constantly moist. If the rootlets dry, the plants die or suffer very severely. The difference between forest tree seedlings in this respect and other seedlings to which he is accustomed has to be impressed again and again on the ordinary forestry worker. He probably has a garden and allotment, and has, therefore, been brought up to ideas about seedlings which when applied to those of forest trees are utterly wrong. It seems to be thought in the country that most seedlings, at any rate of the cabbage family, like rough handling and exposure to air. It may be so ; at any rate the average garden boy, after pulling them up, cheerfully takes home a bundle of surplus seedlings tied to the front of his bicycle on an east-windy day, and his father will let them lie and take them up to the allotment next day and plant them, and they will survive, doubtless because if all the fibrous roots are destroyed or removed the plant can produce a new system. Forest tree seedlings, however, must be treated with very great care. When lifted from the soil they must be protected from bright sun, from cold air, and particularly from draughts, i.e., wind. When carefully lifted from the seedbeds and put in trays or boxes their roots should be kept covered while they are being moved to the lining-out ground and the seedlings should not be taken out until the trench has actually been dug, ready to receive them. Grading, if it is necessary, can be done on the lining-out ground under shelter. Counting, as a check on the nurseryman, can generally be done sufficiently accurately without opening the bundles, and an accurate count either of home-grown or bought stock may be left until after the plants are lined-out, when, if the lining-out has been properly done, the length of the lines in yards multiplied by the number of plants per yard will give the total count. At every stage care should be taken to avoid all unnecessary drying. As will be shown later this is very important in the stage when the transplant is finally planted out in the forest. It is even more important when the seedling is planted in the transplant lines.

SUPPLY OF PLANTS

The forester will first need to know the number of seedlings he will require in order to produce the transplants necessary for the area of annual planting to be undertaken.

This, of course, varies with the distance apart at which he will plant out. Table I on pages 3–4 gives the information required and allowance has been made in it for normal wastage and culling.

At the spacing recommended below, i.e., 10 inches between rows, 2 inches apart in the rows, the lines will accommodate 65 plants to the square yard, 1,966 to the rod, and 314,000 to the acre. In actual practice the figure per acre may be less, owing to the ground required for roads and pathways. A thousand plants will occupy 15 square yards.

Supplies of seedlings must be arranged well in advance of the time at which they will be required for lining-out, although they should not be consigned until the latest possible date before that at which they will be used in the nursery. Tenders should not be accepted without samples of the plants to

which they refer, and these should be preserved. Definite consigning instructions should not be given until the ground is ready for the reception of the plants, or it is quite certain that it can be made ready before their receipt.

Any seedlings, whether from the home nursery or a distance, which cannot be lined-out on the day they are lifted or received, should be heeled-in. This means that the bundles should be untied and the plants spread evenly in a standing position, not more than ten deep, with their roots in shallow trenches. The trenches should be well filled in with earth over the roots and at the ends of the trenches, the whole area being covered with straw or bracken. The trenches should be in a shady place if possible.

TIME OF TRANSPLANTING

Nursery operations should be so ordered that larch seedlings can be lined-out before the end of February, and Corsican pine during that month. Lining-out in autumn, especially in October, is best for beech. The dates of lining-out other species are comparatively unimportant, provided they are moved during the rest period, normally from October to April, and that if there is any sign of shoot activity special care is taken in handling them. Dry or frosty weather should be avoided.

PREPARATION OF GROUND FOR TRANSPLANT LINES

The treatment, whether by ploughing or digging, must vary according to the nature of the ground selected. It should bring the ground to the condition required for an average market garden crop.

METHOD OF GRADING

General consideration as to the objects and advisability of grading, both of seedlings and transplants, are given later (page 12) but if either are to be graded it should be done by taking only a handful of plants out of the earth at a time, and as this is separated into first and second grade and culls the two grades which are being kept should have their roots covered with earth before a fresh handful is dealt with.

LINING-OUT

This process consists in digging a series of straight trenches across the ground, in which the seedling trees are planted at their proper depth and at a predetermined distance apart, either by hand or by the use of transplanting boards. Although lining out by hand gives satisfactory results with skilled labour, the use of boards has become the accepted practice at most of the Commission's nurseries and at many trade nurseries also; that method will therefore be described first.

A gang of at least four workers is required, two of whom do the spade-work whilst the other two fill the lining-out boards. A pair of trestles is set up at a convenient point, and a windbreak of sacking erected to screen the roots of the plants as they are threaded into the boards. Each seedling is set so that its soil level after transplanting will be the same as it was in the seedbed. Its distance from its neighbour is fixed by a slotted spacing bar, and in practice a two-inch spacing gives good results. A board ten feet long therefore holds sixty seedlings which are lined out simultaneously. A set of six boards is the minimum number for economic working, so that some may be re-filled while others are holding plants in the lines. Suitable boards are obtainable from Benjamin Reid & Co. of Aberdeen (see page 68). Board filling is work that can well be done by boys or women workers at a cheaper, and often at a quicker, rate than by men.

The first " line " or row of plants, whether for board planting or for planting by hand, is marked out on the ground with a nursery line or string. A straight-backed trench—9 inches deep—or deeper if necessary, is cut along this straight line with the spade. Boards filled with seedlings are then set so that the tree roots hang vertically in the trench, and these boards are temporarily pegged in place. Then the spade-workers fill in the trench, covering the roots, and firm up the earth with a blow from the back of the spade. The catch that holds the seedlings in the board is then released, and the board itself lifted clear. This leaves the seedlings standing erect in the line. After each row is completed, the next one is cut, some ten inches from it, in the earth thrown up when planting the trees of the previous row.

Where lining-out is done by hand the worker takes a bundle of seedlings in his left hand and works along the trench, setting each plant in turn in its place, judging depth and distance apart by eye. Each seedling is temporarily secured with a clod of earth pressed against its roots, and when the planting of the trench is completed earth is thrown in with the spade to complete the filling in, and then firmed down. The speed with which this form of lining out can be done, and the success which it attains, depend very largely on the skill of each individual worker.

With either method, certain general rules apply. The roots of seedlings should be kept moist throughout and exposed to sun and wind as little as possible. Quick work is therefore usually good work. On windy or sunny days the roots should be moistened by putting the plants into a bucket containing a little muddy water (clay-puddle) before being inserted in the boards or trenches. The seedlings should be heeled-in close to the working point until just before they are handled. The back of the trench must be vertical, and the trees set upright against it ; and it must be deep enough to accommodate the roots without bending them.

WEEDING

The ground should be treated very much like that in which market garden crops are growing, and kept similarly in good tilth and free from weeds, with the minimum disturbance of the soil in which the plants have their roots. Ordinary garden hand hoes, wheeled hoes and cultivators should be used, and the weeds removed to the compost heaps. Frequent weedings, done before the weeds are big enough to seed, are the cheapest in the long run.

LIFTING THE TRANSPLANTS

When lifting the transplants the soil should be very well loosened with a fork so that the plants can be easily removed without damage to their roots. This is very important as careless lifting may undo all the good results of three or four years' work. Plants should be lifted the shortest possible time before they are required in the forest and, if possible, the day's supply should be lifted on the morning of the day on which the plants will be wanted. If they are not to be moved immediately after lifting they must be protected from the sun and wind by being properly heeled-in—as described for seedlings (page 10). It is convenient to tie lifted plants into bundles of 50 or 100 for conveyance to the planting area, but they should be heeled-in without counting and bundling if they are not to be moved until the day after they are lifted.

Whether trees are lifted after one or after two seasons' growth in the lines may depend partly on their species and size required, and partly on questions of supply and demand. Most species grow too large for forest use if left to stand for a *third* season, though the spruces may sometimes be carried forward in this way.

GRADING POLICY

Here some general considerations are given which may help to determine to what extent grading is useful both for seedlings and transplants. Grading to eliminate weak or malformed plants is always right, and the sooner it can be done the sooner the waste of space, and therefore of money in growing them, can be stopped. Particularly when the crop has come up strongly in the seed-beds are there likely to be many weakly plants, and these should be at once discarded. Whether it is advantageous to grade the rest depends on two factors. If the first-grade seedlings are so strong that they can safely be planted out after a year in the lines, the others requiring two years, it is obviously an advantage to separate them and to line them out by themselves. Also if, as in the south and west, bracken and other weeds give a great deal of trouble after planting out, it is clearly useful that the trees planted should be fairly even in size, for it is obviously impossible to weed exactly at the right time of year for plants of all sizes. If it is done once in the season it is either too soon or too late for the small plants ; if it is done twice it is unnecessary for the larger plants. Subject to these considerations, grading at the lining or planting stage is not essential, for the advantages which it is supposed to produce are rather doubtful. It is supposed to show good method if a large space of forest is covered with young trees of exactly the same size and quality, but provided no really poor plants are used—that is, no malformed plants and no plants which have not a good fibrous root system well proportioned to the plant—it is doubtful whether plants of first and second sizes should not be used in their natural mixture, and the best be allowed in time to suppress and eliminate the others, as under conditions of natural regeneration.

It cannot be too strongly emphasised that surplus stocks, unless grown for re-sale, and inferior plants, cost money every year they are retained in the nursery, and immediately it has been decided that they should not be used they should be discarded.

A good balance between root and top is what should be aimed at, exact uniformity in size being a secondary matter. To assist in producing such a plant, seedlings with very long tap roots will produce better transplants if the end of the tap root is cut off in the seedling stage, as otherwise there is a danger that the end of the tap root will be turned up in lining-out or planting. If this root-pruning is undertaken a sharp knife or garden shears should be used, and the seedlings should be cleanly cut a few at a time and not when they are in bundles. Excessive pruning should be avoided, and where the planting stock is to be used on leached soils, it is better not to prune.

The same object can often be obtained by undercutting drills of seedlings or lines of transplants with a sharp spade. This practice is also of some use in checking the growth of plants which for some reason it has not been possible to plant out at the right age, though very frequently it is better to sell or scrap them, and wait for the next batch to come on.

PACKING AND TRANSPORT

If the nursery is quite close to the planting area and small quantities of plants are to be used, the bundles can be put into receptacles which the planters will carry ; but in dealing with larger quantities or transporting to greater distances the bundles should be loaded into carts or lorries, and so arranged that the roots are together and inwards. Three or four layers of bundles can be packed in a vehicle in this manner, provided always that the roots on the outside are protected from the drying action of the air by wet moss, straw or sacking. As there is some risk that large loads may heat spontaneously

like a damp haystack, if the journey lasts more than a few hours, the stock should, if possible, be watched. It is not always necessary to use crates or boxes, but if the vehicle cannot approach close to the planting area the bundles should be made up into packages of burlap or, if they have finally to be transported on ponies they should be loaded ready packed in pannier baskets. The aim must be to avoid drying, unnecessary handling and risk of heating, and to do what has to be done at this stage quickly.

CHAPTER III

GENERAL

Maintenance of Fertility

Experience has shown that nursery tree crops rapidly exhaust the soil of essential nutrients such as nitrogen, phosphorus, and potash. This is due to the appreciable amounts of these elements which the young trees themselves absorb, as well as to the loss resulting from the removal, roots and all, of successive crops of annual and other weeds. Another factor to be borne in mind is the frequent cultivation which the soil receives which tends to exhaust the humus reserves in the soil. It is quite clear that a tree nursery should be regarded as a form of market gardening requiring regular and relatively heavy manuring.

The best form in which to supply the necessary manures is still a matter of doubt ; trees, with their fungus associations in their rootlets (mycorrhizas) seem to require different manurial treatment from ordinary agricultural crops, and all species of trees cannot be treated in the same way.

Like all other crops trees require lime but the majority of conifers, e.g. spruce, pine and Douglas fir, like a fairly acid soil and seem to be able to pick up the necessary Calcium provided the soil contains plenty of humus. So the first point to remember is not to apply lime to nursery ground on which conifers are to be raised. The second important point is that young trees, especially the commoner conifers, get their nutrition in nature largely from humus and one of the essential characters of humus is that it liberates its nitrogen gradually. Young trees appear not to like, and seldom respond to, doses of soluble nitrogenous manures such as ammonium sulphate or nitrate of soda. So avoid as far as possible the use of such manures or of fresh unrotted farmyard or stable manure.

The standard practice is to put a third or a quarter of the nursery area each year under a well-manured green crop, usually either mustard or lupin. The green crop is ploughed or dug in and, if the crop is a good one, the soil is enriched in organic matter. As many nurserymen (as well as farmers) know to their cost, the raising of a bumper green crop is not always an easy matter. If climatic conditions are unfavourable (e.g. drought) the crop is liable to fail and then the last state of the land is usually worse than the first. In recent years the short-term grass ley type of green crop has come more to the fore, e.g. a mixture of perennial rye grass, red clover, and broadleaved clover. If this can be fed off with sheep it is likely to be better than mustard or lupin as a means of maintaining the soil fertility : alternatively it may be ploughed in, in the same way as other green crops. As a normal rule all green crops require to be manured with phosphate and potash—3 to 4 cwt. per acre of superphosphate and the same quantity of sulphate of potash are usual dressings. Nitrogenous fertilisers should be applied with discretion but a top dressing of ½–1 cwt. of nitrate of soda may be necessary to get the crop to start quickly.

Another method of introducing humus is the use of compost prepared by breaking down organic residues such as straw, bracken, and spent hops. Spent hops (hop waste) make a compost which is usually very rich in phosphate and has been found to be most satisfactory manure for forest trees. Hop waste, if obtained fresh from a brewery, requires no composting agent to set the composting process going, but straw or bracken need the addition of some source of available nitrogen in order to start the breakdown of the cellulose. Of such sources, dried blood, poultry manure, and fresh farmyard manure are among the best. Compost made from chopped straw or bracken tends to be deficient in phosphate, requiring additional P_2O_5 in the form of bonemeal or superphosphate. This should be applied to the soil when the compost is dug in. The standard rate of application of compost to nursery soils is from 15 to 20 tons per acre.

Farmyard or stable manure has for long been the backbone of nursery as it has of agricultural practice, but it is getting increasingly scarce in most districts and has besides the very serious disadvantage that it brings into the soil a superfluity of weed seeds. Owing to the small size of tree seedlings it is necessary to keep the seed beds meticulously clean and any form of manuring which is liable to increase the trouble is undesirable, to say the least of it. Old, well-composted farmyard manure is less of a nuisance as a weed carrier than fresh manure. Probably the most effective way of using fresh manure is to mix it with moistened chopped straw or chopped bracken in the proportion of 1 part of farmyard manure to 3 parts of straw or bracken. The heap should not be very large and should be turned at intervals and water added when the inside of the heap shows signs of drying.

Compost making is a rather tricky business and requires a considerable amount of labour, but compost applications have proved very successful in improving the condition of nurseries which have been overcropped with trees. Compost is especially useful in districts such as East Anglia where soil and climatic conditions are unfavourable for green crops. But in most parts of the country the green crop, taken on a regular rotation, seems likely to remain the basis of nursery soil manuring, though there is still much to be learnt about the technique of greencropping.

ROTATION OF CROPS

It is a generally accepted practice that only two-thirds of a nursery should be under trees at any one time, the other third being either fallowed—if very weedy or infested with chafer grubs—or a soiling crop raised for digging in in the autumn. There are various types of soiling crop such as oats and tares ; Italian rye grass, red clover and broadleaved clover ; lupins ; or mustard. Whatever the crop it will need generous manuring with compost or failing that with a balanced fertiliser, a starved unsuccessful soiling crop is worse than nothing.

NURSERY WEEDS

Nursery weeds removed from the seedbeds and lines should be stacked at a convenient point and allowed to decay for two or three years. (N.B.—Do not add lime to the heaps.) The resulting compost may then be spread over the ground that is to be green-cropped or fallowed. Weed compost should never be applied direct to seedbeds or lines because in practice it is impossible to ensure that all the weed seeds are destroyed. Perennial weeds, particularly those with creeping underground stems, such as couch grass, should never be included in such heaps, but must be burned.

PROTECTION AGAINST PESTS

Rabbits.—It is, of course, absolutely essential to fence securely against rabbits by using good rabbit wire of sufficient height in the right way (see page 33), and by keeping the outside of the nursery clear of anything by which rabbits could gain access. It is often necessary to keep gates locked, or to give admission to the nursery only by stiles. One rabbit may do £10 worth of damage in a night.

Moles.—May do considerable damage to seedbeds. An effective treatment is to watch and to employ a man who really knows how to set a mole trap. Poisoning and gassing may also prove effective.

Birds and Mice.—It must not be assumed that red-leading will always be effective against birds and mice. Watch must be kept, and if damage occurs ordinary kitchen garden practice must be followed—traps, cotton, nets, etc.

Insects.—The larvae of chafer beetles feed during their soil life on plant roots and may do considerable damage. One of the most effective remedies is to hand-pick the grubs whenever the land is turned over, but the grubs may go down as deep as 3 feet in the winter and therefore digging after April when the grubs are near the surface, such as is associated with summer fallow or green-cropping, is many times more effective than winter digging, such as is done in preparing seedbeds or lines. Thorough cultivation of the ground with a Rotary Hoe or Rototiller, during summer fallowing or green-cropping is effective in restricting their number. The injection of carbon bisulphide during the growing season is sometimes of value as an emergency measure (see Forestry Commission Leaflet No. 17).

Wireworms and the caterpillars of night-flying moths also do damage. There is no certain known cure, but numbers may be checked by hand picking from simple traps, consisting of bundles of weeds or sods baited with potatoes, set at intervals throughout the seedbeds. The grubs hide in these during daylight hours ; daily examination is essential.

Of smaller insects, the most troublesome are probably the greenfly family, which can be dealt with as on roses by the usual soft soap and paraffin sprays, or by immersion of the plants (except the roots) in the solution (see also Forestry Commission Leaflets Nos. 2 and 7).

Fungi.—Nursery stock is liable to attack by many different fungi, several of which are mentioned in Part II (see page 59). The cases in which serious damage is likely to be done and the treatment recommended are also dealt with.

RAISING POPLARS AND WILLOWS FROM CUTTINGS

The method described below has given good results at one of the Commission's research nurseries.

Cuttings are taken in autumn or winter from stool beds or standing trees. Each cutting consists of a shoot of the current year's growth, about one foot in length, and ¼" in diameter at the base. This is cut back to a bud, discarding the tip, and retaining the well ripened portion, 9 inches long.

These cuttings are struck in rows 12 inches apart, with 9 inches between each cutting. They are set deeply, leaving only the uppermost bud above ground. If more than one shoot develops, the additional ones must be pruned off.

After one growing season, the rooted cuttings are lifted, and *stumped*, by cutting back to within a few inches of ground level. They are next lined out at a spacing of 3 feet by 2 feet, in ground previously well dug and manured.

Here they remain for two seasons, only one strong shoot being permitted to develop from each. This method produces "standard" stems 8 to 10 feet high, from which all side branches are removed by disbudding or pruning.

It has been found beneficial to shorten *all* the branches, before transplanting these large trees to their final situation. Care is required when lifting as the roots extend over a 2-foot radius, and they must be protected in transit with straw or bracken. Planting in specially prepared pits is recommended, with additional soil moulded around the stems.

PART II

PLANTATION WORK

CHAPTER IV

PREPARATION

Selection of Land for Planting

Any one undertaking forestry will probably have made up his mind in advance as to what areas he ought to plant, and the number of men he can employ wholly or mainly on forestry work. There are certain points that it may be useful to consider before a final decision is come to, such as: What land is likely to give the best return? How important is it to make the piece to be planted annually the most economical shape from the point of view of fencing? What can be done to make the annual area which it is desired to plant regularly available? What amount of annual planting should a stated number of men be able to prepare and plant and maintain? On these questions some guidance can be given.

A public department is bound to try to obtain for forestry land which has little or no agricultural value, but it does not follow that this is always the best policy for a private estate. It will often pay better to take marginal agricultural land for forestry, particularly if it is in hand, and cannot easily be let, than to plant a high hill-side or moor. At first sight it may seem relatively unimportant whether land will produce a certain value of timber in 50 or in 80 years; but it should be borne in mind that at 4 per cent. compound interest accumulated capital costs will double themselves between the fiftieth and seventy-second year, and a difference in the time factor is financially important. Provided suitable species are selected, the better the quality of the land, the higher will be the financial return, taking all factors into consideration including the value of the land.

The Forestry Commission have collected much information as to the rates of growth and yields of timber of existing plantations; details are contained in their Yield Tables. It must be remembered that it is unwise to assess the productivity of an area without very careful examination of existing plantations on similar ground in the neighbourhood; they provide the only really reliable guide.

It is very important to consider the area and shape of the piece of land to be planted each year. Costs of fencing different sizes and shapes of areas are such that it is clearly not economical to plant up small waste corners if fencing (particularly rabbit or deer fencing) is involved—though this may be desirable from an amenity or sporting point of view. It is shown, too, that fencing narrow amenity or shelter belts which are frequently only 20 yards wide will often cost more than the freehold value of the land.

Some guidance as to the cost of fencing of different types is given later, pages 33–35; the following figures are calculated on the assumption that fencing (including rabbit netting) costs £1 per chain. This is a pre-war price, but will enable calculations at costs now prevailing to be made on a *pro-rata* basis.

A single acre if square will cost £13 to fence.

A 2-acre strip 20 chains by 1 chain will cost £21 per acre to fence.

An area of 12 acres if long and narrow, say, 30 chains by 4, will cost £68 or £5 13*s*. 4*d*. per acre to fence.

If the same area (12 acres) can be made half as long and twice as broad (15 chains by 8) it will cost £46 or £3 16*s*. 8*d*. per acre, a saving of £1 16*s*. 8*d*. per acre.

If the narrow 12-acre strip can be doubled in width and area, *i.e.*, 30 chains by 8, the cost will be £76 or £3 3*s*. 4*d*. per acre, a saving compared to the smaller area of £2 10*s*. per acre.

If the width and area can again be doubled making an area of 48 acres, *i.e.*, 30 chains by 16, the cost will be £92 or £1 18*s*. 4*d*. per acre.

Doubling again, which gives an area of acres practically square (30 chains by 32), makes the cost of fencing £124 or £1 3*s*. 6*d*. per acre.

To show how even with the best shape smaller areas add to fencing costs :— A quarter of this area (24 acres) the same shape, which will be 15 chains by 16, costs £62 or £2 12*s*. 10*d*. per acre, and if it be again quartered and reduced to 6 acres, 7½ chains by 8, the cost will be £31 or £5 13*s*. 4*d*. per acre.

These illustrations show that when the replanting of a narrow strip of old woodland which will require new fencing is under consideration, it may often be wise to take in some adjoining land and to plant in blocks rather than to replant the strip in its old shape. They also show that the area to be fenced should always be made as large as possible.

Great care should be taken in making contracts for the felling and clearing of woods. The timber merchant naturally likes to have as long as possible to clear a wood, so as to fit in as suits him best with his markets and with other operations. It is, however, absolutely necessary to divide up the area covered by any large contract and to arrange that the different parts of it shall be cleared and finished with annually, in succession, so that planting may be begun before the area is smothered with heavy weed growth. This is of very little, if any, disadvantage, to a good timber merchant, but it may make all the difference to costs of planting. Care must, however, be taken on coniferous areas to guard against pine weevil and beetle, and on this subject Forestry Commission Leaflets Nos. 1, 3, 4 and 25 should be consulted.

In considering the area which can be planted and tended by a certain number of men it will be convenient as an illustration to consider the labour necessary to deal with square blocks of 12 acres each annually.

If the block is old woodland left in the state of average untidiness by the English timber merchant, it may require 30 man-weeks' work to make ready for planting. If it is wet moorland which needs intensive drainage, it may also require 30 man-weeks' work. If it is sound rough pasture, it may only need 2 or 3 man-weeks' work, or even nothing at all.

In fencing 12 acres square the labour costs, including preparing the stakes, may be taken as say 11 man-weeks.

In planting if a man plants 400 plants a day at wide spacing (6 ft. × 6 ft.), he should cover 2 acres a week—6 man-weeks.

In weeding a man should cover 2 acres a week, and if this be done twice in the season the area will take 12 man-weeks. Beating-up, which means putting fresh plants in to replace those which have died, will be required on the older planted areas, and though the amount will vary it should not give work for more than 4 man-weeks on an average.

Weeding and other attention to established plantations not yet in the thinning stage should not need to be given after the fourth summer following planting, and it should need less than a week's work to the acre :—for 36 acres, say, 30 man-weeks' work. It will, however, need an extra man to do it at the right time of year, but in return for this the forestry men should be able to do other (say, nursery) work when planting is finished and before cleaning begins.

This gives in man-weeks for ground needing moderately heavy preparation—clearing or draining 30, fencing 11, planting 6, weeding 12, beating-up 4, weeding, etc., of previous years' planting 30—total 93 man-weeks or allowing for wet weather and hard frosts, fairly full work for two men. The work can, however, be done by two men only if they are continuously available for it, and if clearing and planting are not delayed on account of shooting, or weeding on account of young birds.

With regard to aspect—if there is any choice—attention must be paid to local conditions ; shelter is often the most important consideration and, for that reason, general northerly or easterly aspects are to be preferred. Also, if a large and uniform area is to be planted it is correct to start with the part farthest down wind and to plant up wind, but if this or any other consideration interferes with the steady annual planting of an area of even size it should be disregarded. For instance, if wet spots in an area cannot be got dry enough for planting, they should be left unplanted rather than delay the planting by a season.

SELECTION OF SPECIES

Before the advantages and defects of particular species are considered there are some general points which it may be useful to think over. Though their consideration results in fairly definite advice being given, the argument is intended rather to suggest matters which each owner should think out for himself, than to assert positive conclusions, applicable to all circumstances. It may be that when an owner is thinking of afforesting or re-afforesting the plantable parts of his property, the primary considerations of soil and climate on the one hand, and of probable yields and prices on the other, will point to a single species as likely to give, for most of his land, the best financial return. If he came to the same conclusion about agricultural land this would not lead him to plant it all with the same crop—he would plant it with different crops, some of which would pay better than others, the whole being planned to suit his requirements and probable markets as well as to secure the maintenance of soil fertility at least expense. It is suggested that the owner of forest land may well look at the matter in the same sort of way. Forest crops have to serve many uses, and thus several sorts of timber are needed ; in particular it is often advantageous to follow up one forestry crop with a different one, so what is to happen after the first crop has been cleared should be thought of from the first.

The forest owner should do as the farmer does, breaking up the whole area into convenient parts and treating them in different ways ; this will mean planting different kinds of trees, so far as conditions are suitable, for many reasons contribute to the same conclusion, that it is a mistake to have all one's eggs in the same basket. It is useful for estate purposes to have some hardwood and some conifer, and different sorts of each, also to have plantations

yielding revenue at different ages. So it is from the point of view of shooting—though the major consideration is to have one's trees at different stages of growth, and to have the different growth stages grouped together, from the youngest to the oldest, in convenient beats. Variety also makes for beauty, particularly if hard lines between species are avoided. And if attention is given to the shape and distribution of the plantations, natural boundaries being followed, and fringes of fine trees are planted along rides and roads, forests need never be ugly. Variety also very often creates a series of natural firebelts without any expense in maintenance. Also timber merchants do not always want the same thing at the same time, and if the seller has a good variety they cannot so effectively say that what they will give a good price for is what he has not got! One point, however, should not be overlooked in planting a reasonable variety of the trees which suit the area—the areas planted with the same species within any short period of years, should be large enough to market advantageously whether felled by the owner or sold standing to a timber merchant.

It may be asked why the variety of species cannot be secured by mixing them in the same plantation. This has been a common practice in the past, but nearly all mixtures are risky. If there is neglect for even a few years, they are liable to suffer more than crops which have been planted pure. Also a timber merchant will generally give less for a mixed than for a pure crop, for he is normally buying one particular sort and size of timber to fill a particular order, and though the owner who may be offered a good price for some special parcel of a particular sort of timber can generally extract it from a mixed plantation, he risks doing severe damage in the process; one cannot always, for instance, take the spruce out of a spruce-larch mixture without damage to the larch, and if the larch is taken out some of the spruce may blow over.

It must not be overlooked that there are some drawbacks to pure plantations; certain conifers (notably Scots pine and spruce) when growing on the poorer soils are liable to cause soil-deterioration, because the fallen needles do not decompose quickly. In such cases fertility can sometimes be maintained by an admixture of a broad-leaved tree, or even a different conifer; the use of such mixtures is, of course, fully justified, but on the whole, except where there is a certainty of expert management, the simplicity of a pure crop outweighs its disadvantages.

Certain mixtures originate not from a desire to secure a final mixed crop, but because one species is used to establish another which is desired as the pure final crop. For instance, Scots pine may be used to nurse spruce, which gives a mixed crop at first, but may leave a final stand of pure spruce, the Scots pine being taken out at the pole stage. As will be seen under the notes on individual species which follow, mixtures of this kind may be the best way of establishing certain crops, and they should then be adopted.

Except in the cases mentioned it is better to plant pure, for in the ordinary way, without constant skilled attention, mixtures are apt to get out of control.

It will be noticed that in the following tables some species have been dealt with beyond the two well-known pines, larches and spruces, and the easiest hardwoods. This does not mean that any of them is recommended for general use as better than, or as good as, the old-established favourites, which should be adhered to by any one who takes "safety-first" as his planting motto. Experiment, if wisely conducted, however, is a great enlivener of private forestry, and less frequently used timbers have been included so that an owner who may be inclined to back his fancy with them shall be more likely to find them among the winners than in the "also ran" class. Nevertheless, the seven species described as "Major Conifers" account for the great bulk of planting on both Forestry Commission areas and private estates.

NOTES ON

A.—

Species	Conditions justifying selection	Unfavourable or unsuitable conditions
SCOTS PINE ... ... *Pinus sylvestris*. L. The timber imported as red or yellow deal, Baltic redwood, or Riga fir, is derived from the same species.	Succeeds over a wide range of conditions. The easiest and often the only tree to plant on dry heather and bilberry sites. Very frost hardy. Thrives on light or sandy soils, and at low or moderate elevations. Does well in low rainfall areas on the eastern half of Britain. A useful " nurse " species.	Avoid high elevations, smoky localities, and soft ground where there is appreciable exposure. Unsuitable for chalk or limestone soils, except as a nurse for beech.
CORSICAN PINE... ... *Pinus laricio* Poir. (*P. nigra* var. *calabrica* Schneid.) Important to secure the true strain, distinguished by its soft twisted needles.	Low elevations, particularly areas near the sea and light sandy soils in South and East of England. Low rainfall areas. Suitable for smoky localities. More successful in chalk districts than Scots pine.	Avoid high elevations and soft soils in exposed situations, particularly in the north and west. Avoid shallow limestone soils.
EUROPEAN LARCH ... *Larix europaea* D.C. (*decidua* Mill.)	Very exacting as to site. Does best on moist but well-drained loams in open but not exposed situations. Bracken-covered slopes are frequently suitable. Raise from seed of Scottish origin, if possible.	Avoid damp, ill-drained, or very dry sites, frosty places, shallow soils over chalk, poor sands, peat soils, leached soils, exposed sites at high elevations or near the sea, areas carrying a dense growth of grass or heather, and smoky districts.
JAPANESE LARCH. *Larix leptolepis* Murray HYBRID LARCH. *Larix eurolepis* A. Henry.	Thrives over a wide range of conditions in the high rainfall districts of the west and north. Suitable for hilly country, including grassy and heathery slopes. Of great value on coppice areas, as it quickly outgrows and suppresses coppice shoots. May be planted on ground which has previously carried European larch. Stands smoke reasonably well.	Avoid dry sites and areas where the annual rainfall is less than 30 inches; also ill-drained sites and frost hollows, and very exposed situations. On very fertile soils wind-sway and corkscrew-like growth may occur, owing to too rapid growth.
DOUGLAS FIR (Oregon or Green form) *Pseudotsuga douglasii* Carr. (*taxifolia* Britton). Timber also imported as " Oregon Pine ".	Likes a firm well-aerated soil of good depth and of a sandy rather than a clayey texture. Often does well on bouldery or rocky ground.	Definitely unsuitable for exposed situations, heather ground, badly aerated or wet soils, shallow soils and areas subject to smoke or fumes. Very prone to wind-blow on damp and soft soils.

INDIVIDUAL SPECIES

MAJOR CONIFERS

Age to plant	Notes on timber	General remarks
On open ground sturdy 1 yr. + 1 yr. transplants are best. 2 yr. + 2 yr. transplants should be used in sheltered situations where dense weed growth occurs.	A good general utility timber for constructional work, building, fencing, and flooring. Thinnings are used for pitprops, telephone poles, and fencing, but are not durable unless creosoted.	Although volume production is low compared with more exacting species, it is generally speaking a " safe " tree to plant. It has a special part to play in mixture with other conifers.
Sturdy 1 yr. + 1 yr. transplants are best, except on very weedy sites where 2 yr. + 1 yr. or 2 yr. + 1 yr. + 1 yr. transplants should be used.	Timber resembles that of Scots pine, but is slightly poorer in quality. Volume production is more rapid making it a profitable crop on suitable sites. Not durable unless creosoted.	It is *essential* that the plants are transplanted in the nursery the year before planting out, and that the roots are not unduly exposed during handling. Should be planted before the middle of February, if possible.
2 yr. + 1 yr. or 1 yr. + 1 yr. transplants. 2 yr. + 2 yr. transplants may be satisfactory, but anything older is useless.	The volume yield per acre is not high, but larch is exceptionally useful and saleable at all sizes and for a great variety of purposes, such as fencing, mining timber, floors of boats and wagons. Naturally durable.	Essential to select really suitable sites if larch canker and die-back are to be avoided.
2 yr. + 1 yr. or 1 yr. + 1 yr. transplants. Anything older is usually too big. Should be transplanted the year before planting out.	Timber resembles that of European larch, but is somewhat inferior. Growth and volume production are normally more rapid.	Practically immune from larch canker and most of the other pests and diseases which afflict the European larch. The Hybrid has much the same requirements as the Japanese, and may grow even more rapidly.
2 yr. + 1 yr. or 1 yr. + 1 yr. transplants. 2 yr. + 2 yr. transplants are suitable where there is shelter or heavy weed growth, but older plants are too big.	Used for general building and constructional work, joinery, plywood, panelling, boxes, sleepers, and boarding. Thinnings are useful as pit props and fencing material. Only the heartwood is durable, and thinnings should be creosoted before being used in contact with the ground.	On suitable sites Douglas fir grows rapidly and produces a very high volume of timber. Frequent thinning is essential for a stable crop. The Douglas fir *Adelges* has not proved a serious pest.

NOTES ON

A.—

Species	Conditions justifying selection	Unfavourable or unsuitable conditions
NORWAY SPRUCE ... *Picea excelsa Link.* (*abies Karst.*) Timber imported as "White Deal", or whitewood.	Moist grassy or rushy land, and shallow peats derived from grass or rushes, are most suitable—Succeeds on old woodland sites and most soils of moderate fertility.	Apt to fail on heather land and does poorly on dry sites, particularly on the eastern side of Britain. Dislikes smoke and fumes. Dislikes marked frost hollows, but can usually be nursed up by an admixture of Scots pine.
SITKA SPRUCE ... ... *Picea sitchensis* Carr.	Damp sites generally, including exposed high-lying land. Stands exposure to wind, smoke, and fumes. Thrives on most kinds of peat, and succeeds better than Norway spruce on the poorer types of moorland, especially when mixed with Scots pine. Very suitable for high rainfall areas.	Avoid frosty sites or very dry sites. If there is much heather in the vegetation Sitka spruce requires a Scots pine nurse. Unsuitable for use in former scrub or coppice areas, owing to damage by Honey Fungus.

INDIVIDUAL SPECIES—*continued.*
MAJOR CONIFERS—*continued.*

Age to plant	Notes on timber	General remarks
2 yr. + 2 yr. transplants are suitable for most situations. Older transplants and twice transplanted trees are also satisfactory. Shallow planting, or on turves or mounds, is very advisable.	Used for constructional work, joinery, boxes, barrels, and wood pulp. Thinnings, which are often remarkably straight, are used as poles of all kinds, and for pit props. Not durable out of doors, and difficult to treat satisfactorily with creosote.	Produces a high volume of timber and is a very accommodating species. Good drainage is essential if windthrow is to be avoided. Also grown as Christmas trees.
2 yr. + 1 yr. transplants are usually satisfactory. 2 yr. + 2 yr. transplants may be better on weedy sites, but older plants are apt to be too big. Shallow planting, or on turves or mounds, is most advisable.	Timber is similar in properties and uses to that of Norway Spruce.	Produces timber much more rapidly than Norway Spruce, and is much more tolerant of exposure.

NOTES ON

B.—

The species described below have only been planted on a comparatively sites unless definite evidence of their successful growth is available locally.

Species	Conditions justifying selection	Unfavourable or unsuitable conditions
LAWSON CYPRESS ... *Chamaecyparis lawsoniana* Parl. NOOTKA CYPRESS, *C. nootkatensis* Sud., has similar requirements.	Requires a good deep fertile soil, preferably in a sheltered situation. Stands shade well.	Fails on hot dry sites. Dislikes heather ground and leached soils.
MONTEREY CYPRESS ... *Cupressus macrocarpa* Hart.	Useful as a shelter belt tree on firm ground along the south coast and in the south-west of England.	Not recommended elsewhere. Subject to windthrow on soft ground and when planted in blocks.
WESTERN HEMLOCK ... *Tsuga heterophylla* Sarg.	Grows rapidly on moderately fertile soils but will establish itself slowly on poor exposed moorland sites. Excellent for underplanting, and useful for beating up other conifers. Thrives best when somewhat sheltered.	Unsuitable for dry sandy soils. Plant with a pine nurse on upland heaths.
AUSTRIAN PINE ... *Pinus austriaca* Hoess. (*P. nigra.* var. *austriaca* Asch. et Graebn.	Shelter belts in exposed situations near the sea, and as a nurse for beech.	Not suitable for moorland planting in the West and North.
LODGEPOLE PINE ... *Pinus contorta* Doug.	A substitute for Scots pine, more particularly as a nurse species, on wet and difficult sites in the north-west of Scotland.	Not worth planting on the better soils. Usually crippled by *Tortrix* in the south and east of England.
MARITIME PINE ... *Pinus pinaster* Ait.	Thrives on sandy soils in the south and west of England.	All other sites.
MONTEREY PINE ... *Pinus insignis* Doug.	Shelter-belts on sandy soils in the south-west of England.	All other sites.
WEYMOUTH PINE ... *Pinus strobus* L.	Not recommended owing to its susceptibility to Weymouth Pine Rust (*Cronartium ribicolum*).	—
REDWOOD SEQUOIA ... *Sequoia sempervirens* Endl.	Deep fertile soils in high rainfall areas. Sheltered situations. Tolerates a great amount of shade.	Avoid poor soils, dry areas, exposed situations, and frost hollows.

small scale so far. They should be limited to small areas on carefully chosen

Age to plant	Notes on timber	General remarks
2 yr. + 1 yr. transplants are suitable.	Timber strong, naturally durable, and suitable for a wide range of uses.	Lawson Cypress might be planted more extensively on good sites. Grows rapidly but is subject to windthrow and snowbreak. Its tendency to fork is a considerable drawback. Often regenerates freely.
Difficult to transplant. Best pricked out into pots in August, and planted with a ball of soil later on.	A good timber, naturally durable.	Difficult to establish.
2 yr. + 1 yr. or 2 yr. + 2 yr. transplants, according to size and site.	Timber widely used in western North America for building, joinery, and paper pulp. Strong and naturally durable.	It is important to obtain a true strain derived from seed gathered at low elevations in Oregon or British Columbia, or from good trees in Britain. Must be sheltered in the nursery *for the whole of its first year as a seedling*.
2 yr. + 1 yr. transplants.	Timber poorer than Scots or Corsican pine.	Not worth planting except as a shelter belt or possibly as a nurse for beech.
2 yr. + 1 yr. or 1 yr. + 1 yr. transplants.	Timber resembles that of Scots pine.	—
Hard to transplant but easy to raise by direct sowing. A small (1 oz.) dose of basic slag to each seed patch is advisable.	Timber coarse-grained, soft, and weak. Poorer than Scots or Corsican pine.	Usually a crooked-growing tree. The Portuguese form may be worth a trial.
1 yr. + 1 yr. transplants.	Coarse, inferior to Scots pine in quality.	Not hardy, except in the south.
—	—	—
2 yr. + 2 yr. transplants.	Timber strong, naturally durable, and suitable for a wide range of indoor and outdoor uses.	Usually slow in establishing itself. Best planted under tall cover

Species	Conditions justifying selection	Unfavourable or unsuitable conditions
WELLINGTONIA SEQUOIA *Sequoia gigantea* Dec.	Deep moist fertile soils in sheltered situations.	Not definitely known.
EUROPEAN SILVER FIR *Abies pectinata D.C.* (*alba* Miller).	Not recommended for planting in the West owing to insect damage caused by *Chermes nusslini*. Very frost-tender.	Frosty localities.
GRAND FIR ... ... *Abies grandis* Lindley.	Good well-drained loamy soil. Useful for underplanting.	Avoid frost hollows and poor soils, particularly those of an acid character.
NOBLE FIR ... ... *Abies nobilis* Lindley.	Well drained loamy soils. Tolerates more acid soils and is less frost-tender than other *Abies*.	Poor soils and exposed situations.
SERBIAN SPRUCE ... *Picea omorika* Bolle.	As for Norway Spruce.	As for Norway Spruce, but is frost-hardy.
WHITE SPRUCE ... *Picea alba* Link.	Not recommended except possibly as a shelter belt at high elevations.	—
WESTERN RED CEDAR *Thuya plicata* D. Don.	Good loamy soils, including fairly heavy clays. Stands shade well.	Avoid poor, sour, or peaty soils, and frosty sites.

INDIVIDUAL SPECIES—*continued.*
OTHER CONIFERS—*continued.*

Age to plant	Notes on timber	General remarks
2 yr.+2 yr. transplants.	Timber similar to that of Redwood.	Tolerates drier and more acid soils than does the Redwood, may be worth trying for restocking poor coppice woodlands.
2 yr. + 2 yr.	Timber resembles white deal. Useful for general joinery, etc., but not durable out of doors unless creosoted.	May be worth planting experimentally under tall cover on light soils in the East of Great Britain.
2 yr.+2 yr. transplants.	Timber similar to that of European Silver Fir.	Produces large volumes of timber very rapidly in favoured situations. A useful substitute for *Abies pectinata*.
2 yr. + 1 yr. or 2 yr.+2 yr. transplants.	As for European Silver Fir.	As for Grand Fir.
2 yr. + 2 yr. transplants, or older.	Timber similar to Norway Spruce.	Frost-hardy. Useful in frost hollows where other spruces fail.
—	—	—
2 yr. + 1 yr. or 2 yr.+2 yr. transplants, according to size and site.	When clean grown the wood splits readily into posts and rails. It is light in weight, of a beautiful colour, and exceptionally durable in contact with the soil. Useful for fencing, ladder poles, telegraph poles, gates, roof shingles, and general joinery.	Useful for underplanting, and probably worthy of more extensive planting on the poorer types of former oak or coppice woodland. Liable to attack by *Didymascella* (syh. *Keithia*) *thujina* in the nursery stage.

NOTES ON
C.

In general, hardwoods should be restricted to the best sites and most Beech, however, may be the best tree to plant on chalk downs or limestone

Species	Conditions justifying selection	Unfavourable or unsuitable conditions
OAK ... ... *Quercus pedunculata* Ehre and *Q. sessiliflora* Salis. (*Q. robur* L. and *Q. petraea* Liebe).	Well-aerated deep fertile sands and loams in lowlands. Deep rich loam overlying chalk. Clays, if well-drained.	Avoid shallow, ill-drained, or infertile soils, frost hollows, and exposed areas. Remember that inferior oak is of little value or utility.
BEECH ... ... *Fagus sylvatica* L.	Chalk and limestone soils. Good loams of all types, if well drained.	Avoid frost hollows, ill-drained sites, and leached soils.
ASH ... ... *Fraxinus excelsior* L.	A most exacting species which 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 indicator plants are : Dog's mercury, nettles, garlic, and woodruff.	Not a suitable species for large-scale planting or use on open ground. Avoid dry or shallow soils, grassland, heath, or moorland, ill-drained ground, heavy clays. Frost hollows and exposed situations are also unsuitable.
SYCAMORE ... ... *Acer pseudoplatanus* L.	Requires the same favourable soil conditions as ash, but is more frost-hardy.	As for ash.
CHESTNUT, SWEET or SPANISH. *Castanea sativa* Mill.	Needs a deep fertile soil and may be very profitable as coppice, but should not be grown for timber unless there is local evidence that big trees remain free from shake.	Unsuitable for the less fertile soils and frosty or exposed sites, ill-drained ground, or heavy clays.
BIRCH, SILVER and WHITE. *Betula verrucosa* Ehrh. (*B. pendula* Roth. and *B.p ubescens* Ehrh.)	Not worth planting for its own sake. Useful as a nurse for frost-tender conifers or beech. Prefers light soils in the drier parts of the country, but is ubiquitous as natural growth on felled woodlands.	Should not be used on any site where it is not definitely wanted either for shelter, soil improvement, or beauty. Difficult to establish on open ground with no previous tree crop.

INDIVIDUAL SPECIES.
HARDWOODS.

fertile soils. Good results are unlikely on poor land or in exposed situations. hills, provided it is *nursed* in the early stages by some more hardy species.

Age to plant	Notes on timber	General remarks
2-yr. or good 1-yr. seedlings make the cheapest and best planting stock.	Only the heartwood is naturally durable, but the sapwood is readily preserved with creosote. Thinnings useful for fencing, including cleft posts and rails, and as pitprops. Timber very strong and useful for many constructional and decorative purposes. Good oak is always in demand.	Sessile oak is less subject to defoliation by caterpillars and mildew than the Pedunculate, and is to be preferred, especially on the lighter soils. May require underplanting with beech in later stages.
2 yr. + 1 yr. transplants are best. Should be transplanted in the nursery the year before planting out. Autumn planting is best.	Thinnings are of little use except for turning or bending. Timber has a wide range of uses in furniture making and similar manufactures, but is not of great utility on estates. Not durable, but can be creosoted.	Requires a nurse on exposed areas; Scots pine is the most suitable species. Also useful for underplanting. Grey squirrels can be very destructive to young beech.
Good sturdy transplants about 2 feet high. Minimum 2 yr. + 1 yr. transplants. Twice-transplanted trees 4 or 5 years old are also satisfactory. Careful planting is essential.	Ash combines elasticity with strength better than any other timber. Small poles are used for sports goods and turnery; large timber for coach work. Not durable out of doors.	It is no use planting ash unless there is local evidence that first-rate timber can be produced. It is rare to find suitable conditions except in small patches or strips. Best established in small areas, *e.g.*, as natural regeneration, or strips, or groups in coppice or in mixture with other hardwoods.
As for ash.	Poles used for turnery. Timber for furniture, rollers, and tableware. Not durable out of doors.	Grey squirrels can be very harmful and must be kept down where Sycamore is grown.
2-yr. seedlings; 2 yr. + 1 yr. or 2 yr. + 2 yr. transplants.	Naturally durable, and useful in small sizes for fencing, either round or cleft, and hop poles. As big timber it is very similar to oak, but lacks its distinctive figure. Sound timber is in good demand in the furniture trade, and for coffin boards.	Inadvisable to start coppice chestnut areas unless there is a local demand or one can be worked up. For coppicing, plant at 4 to 5 feet apart and cut back either 5 yrs. later, or in the early pole stage.
1 yr. + 1 yr. or 2 yr. + 1 yr. transplants. Frequently comes in naturally in more than sufficient quantities. Natural seedlings do not transplant well.	Not in much demand. Poles useful for turnery, timber for spools and similar small articles; selected logs yield plywood. Good for firewood and charcoal. Highly perishable when untreated, but makes serviceable fencing material if properly creosoted.	Makes useful fire brooms. Natural growth may be worth retaining as shelter or a soil improver on coniferous areas, but must be checked before it damages the crowns or leaders of more valuable trees.

NOTES ON

C.—

Species	Conditions justifying selection	Unfavourable or unsuitable conditions
POPLAR (Various Hybrids). Black Italian Poplar *Populus serotina* Hartig, (*P. canadensis* var. *serotina* Rehd.) *P. robusta* C. K. Schneider, *P. regenerata* Hort.	Rich alluvial or fen soils both well-drained and well-watered. Well-drained clays. Is frost-hardy.	Avoid high elevations, exposed sites, and shallow soils. Stagnant water is fatal, but occasional floods do no harm.
CRICKET BAT WILLOW *Salix alba* L. *var. caerulea* Sm. Essential to secure true strain.	Margins of flowing streams or water courses with alluvial soil.	Will do no good anywhere else.
MISCELLANEOUS HARDWOODS. Norway Maple. Wild Cherry. Elms. Limes. Hornbeam. Walnut. Alder. Hazel. Plane. Aspen. White Poplar.	Not worth planting unless there is definite evidence that they grow and pay well locally. Require fertile soil.	Poor soils and exposed situations.

INDIVIDUAL SPECIES—*continued.*
HARDWOODS—*continued.*

Age to plant	Notes on timber	General remarks
3-yr-old rooted cuttings, 8 to 12 ft. high, planted 16 ft. apart. (170 per acre).	Not durable unless creosoted. Good for crates and packing cases, and when creosoted for rails, weather-boarding, etc. Does not splinter, and is therefore specially useful for floors of warehouses and stores, cart bottoms, and brake-blocks.	Poplar grows very rapidly but only succeeds on really suitable lowland sites. *P. serotina* is the safest variety to plant.
Selected sets, 8–10 feet long, either rooted or unrooted. Pit-planted. Set 30 to 40 feet apart (48 to 27 per acre).	Used for cricket bats and artificial limbs.	Growing cricket bat willows is a highly specialised business. For full details see F.C. Bulletin No. 17.
Sturdy transplants, 2 yr. + 1 yr. or 2 yr. + 2 yr. Space 5 feet apart.	Timbers have varied uses but the demand for them is uncertain. The supply of Hazel coppice far exceeds the likely demand in most districts.	Best confined to amenity or experimental plantings of small extent.

THE ESTABLISHING OF OAK CROPS

The successful establishment of oak on the poorer soils such as clay, or in frosty localities, must always require skilful management, and may often prove costly. But where soil and situation are really suitable, though the work calls for more patience and optimism than conifer planting, it has been found neither difficult nor unduly expensive.

The natural regeneration of oak has many advantages, and every opportunity should be taken in years of heavy mast ; unfortunately, these occur so seldom, especially in the sessile variety, that the method is rarely practicable. Direct sowing, which is a common practice on the Continent, is risky where game is preserved, for even a small number of birds, especially pheasants and pigeons, can destroy the whole of one's work in a few weeks. There remains the method of planting ; this is the cheapest and safest, but oak must not be treated as if it were a conifer, especially in the matter of spacing. In order to produce clean, straight trees there must be plenty of scope for selection—much more than was provided by the popular pre-war method of planting a few oak sandwiched amongst a large number of so-called nurses, mainly conifers.

To provide sufficient material for selection it is essential to plant densely ; it is, therefore, specially desirable to choose the cheapest suitable plants and the cheapest satisfactory planting method. One-year seedlings have proved entirely satisfactory, and can be recommended on both counts, but weakly plants must be discarded.

To establish a pure stand of oak the spacing should be 4 ft. by 2 ft. (5,444 plants per acre) ; if there is danger from frost, Scots pine nurses must be introduced unless sufficient natural shelter can be retained in the form of existing coppice, bushes and the like. Pure oak crops started in this way will probably provide the best timber, but a long time must elapse before there is any appreciable revenue.

The estate owner may do well to plant his oak in pure strips say 10 rows in width, each oak strip being separated from the next by a narrow belt of larch 3 or 4 rows wide. The larch belts will yield some early returns in the way of thinnings and can ultimately be replaced by beech.

Good planting is very important ; the best method should be determined by trial ; it must be such that the root is vertical in the ground, and the root tip not turned up. Seedlings with long roots must generally be pruned, but pruning must be reduced to the minimum and the root must not be shortened to less than 6 inches. The vertical notch, with Schlich spade, is generally the best method of planting, but the mattock is sometimes used. In any case, conscientious work and careful supervision are essential.

Oak requires weeding every year until the plants are thoroughly established and starting to grow, thereafter the frequency of weeding can be reduced. Neglect of weeding in the early stages is often fatal.

When the plantation is about 8 feet high it must have special attention ; weed species which are threatening damage to the oak should be cut ruthlessly. In subsequent years growth must be carefully watched remembering that oak is to be the main crop, and there must never be any hesitation over cutting anything which threatens to damage it.

SUPPLY OF PLANTS

The procedure should be the same as given under the supply of plants for nursery work on page 9.

The following points bear repetition :—

Supplies should be arranged well in advance.

Samples should be secured and carefully retained.

Supplies should actually arrive the shortest possible time before the plants are to be used ; the mode of transport must be carefully considered.

Quantity and quality should be checked immediately upon arrival.

Delays and exposure of the roots must be reduced to the absolute minimum. Bundles should be opened and the plants well heeled-in on the planting area as soon as possible ; if necessary, the plants may be kept for a few days on the floor of a shed or outhouse, protected by moss, straw or sacking.

FENCING

Sheep, deer and cattle must, of course, be excluded. If the position is such that deer-fencing is necessary, small-scale planting is not economical. The great problem in most districts is the rabbit, and a decision has to be taken whether to exterminate rabbits absolutely and ruthlessly from the part of the estate where the planting is being done and risk an occasional immigrant, or to fence against them at an additional cost of 8*s*. to 18*s*. or so per chain (1939), according to whether netting is added to a stock fence, or a new rabbit-fence is required. It is stated that it is impossible to exterminate rabbits, and this may be so in some districts. Certainly extermination is seldom possible if there is divided responsibility or unless the policy is adopted of discharging the keeper who fails in his job, but in certain cases this has proved effective. If the forester can use only small and odd-shaped bits of land, the only hope of economical planting is to exterminate. The method of killing rabbits by using poison gas may prove an effective means of getting rid of the pest particularly where there is trouble from old banks riddled with burrows. Gassing is a painless and simple process if Cyanogas or Cymag is used.

Where rabbit-netting is used, the type recommended is 42-inch, 18-gauge, 1¼-inch mesh ; the considerable easing of the first cost resulting from the use of wider or mixed-mesh netting is generally more than offset by the damage done by occasional rabbits which gain access, and the cost of exterminating them. It is better not to be tempted. The netting must be so fixed that the bottom 6 inches can be turned out horizontally and laid under a sod. Also care must be taken never to erect the wire on the top of a bank, which the rabbits merely burrow through, or in a spot where they will have a take-off, such as an old coppice head, within jumping distance ; a few such points *inside* the netting will, however, permit the rabbits to jump out, and may prove distinctly useful. This must be specially thought of when an existing hedge or bank is to be maintained as a protection against stock as in such cases there is no alternative to the erection of a new rabbit-fence on the inner side of this boundary.

The cost of fencing will necessarily depend upon the type of fence required, on whether the owner uses his own material for stakes or has to buy, on the length and difficulty of haulage, and on the owner's feelings as regards barbed wire. (Whilst the control of iron and steel continues, licences for the purchase of wire netting, fencing wire, and staples for use in connection with afforestation, are issued by the Forestry Commission. Applications should be addressed to the Director of Forestry for England, Scotland or Wales, as appropriate ; addresses are given on page 88.)

The following table is based upon the assumption that netting, wire and staples will be bought in the best possible market, that they have to be carted about five miles, and that the owner will use uncreosoted posts cut in his own woods not more than two miles away, with an average haul. The exact type of fence adopted must vary with circumstances, and is unlikely to accord exactly with any one of the examples given, but the figures provide some indication of the probable average level of costs.

Type of fence	Details	Cost per chain erected (1939)	Remarks
		s. d.	
1. Light Rabbit-proof	42 in. × 1¼ in. × 18 gauge netting, top strand twisted over barbs of one 2-ply × 4-point galvanised top wire; barbs at 6 in. Stakes spaced at 12 ft. Netting turned out 6 in. at bottom.	16 0	The spacing of the stakes may be varied. Top wire not always necessary, or can be stapled 4 in. above netting and lashed to it with tie-wire. The last is good where hares are troublesome especially if top wire is barbed.
2. Strong Rabbit-proof	As No. 1 with netting tied to well-strained barb or No. 8 plain galvanised top wire, stapled 4 in. above netting and with No. 8 plain galvanised centre wire *behind* netting. Stakes at 9 ft. apart.	19 6	Good especially if top wire is barbed, against public, hares and occasional stock or sheep.
3. Sheep-netting	As No. 1 or 2, but with 36 in. × 4 in. × 14 gauge netting, not buried at foot.	14 0 to 17 6	Centre-strand netting may be used instead of a centre wire. A stiffening wire may also be added behind netting 6 in. above ground, extra cost 8*d.* to 1*s.* per chain. May be much damaged by occasional horned stock.
4. Sheep- and Stock-proof	5 plain galvanised No. 8 wires with one top barb (2-ply, 4-point, barbs at 6 in.) at 4 ft. from ground. Stakes at 9 ft., strainers at not more than 150 yards.	14 0 to 17 0	Fewer or more wires may be used. Each represents 8*d.* to 1*s.* per chain.
5. Rabbit-, Sheep- and Stock-proof	As for No. 4 with 42 in. × 1¼ in. × 18 gauge netting on inside of fence and buried straight down.	25 0	Where not much risk from horned stock, netting can be put outside, backed by fewer wires, and bottom 6 in. turned out as Nos. 1 and 2. Saving about 1*s.* per chain plus 8*d.* to 1*s.* per wire, but tensioning and repair become difficult.
6. Deer fence	6 ft. high, 5 plain and 5 barbed wires. Larch or creosoted pine posts at 20 ft., wooden droppers at 5 ft. Where exposure is great iron posts and droppers should be used.	30 0 to 35 0	Rabbit-netting often also needed, or sheep-netting —against roe-deer—with enhanced total cost. Wooden posts can sometimes be used and/or galvanised iron droppers (staggered).

Note.—The length of life of netting can be increased, particularly in smoky districts and near the sea, by dipping the rolls of netting into a bath of quick-drying black Japan varnish which coats the netting. Suitable varnish can be purchased at 2*s.* to 3*s.* per gallon which will treat 3 to 4 rolls of netting. Alternatively, material of heavier gauge can be used; 17 gauge wire netting is satisfactory.

Where there is much trespass, two top barbed wires at the same level but on different sides of the stakes, are an excellent deterrent, but nothing really avails if people (not excluding shooting parties, beaters and estate workmen) are bent on getting over at certain points, and the final result of such preventive measures is often more damage to the fence and perhaps the admission of rabbits to the plantation. In such cases it is much better to provide a stile or to have a light pole nailed along the top of the fence, between two stobs, so that it is easy to get over.

In hunting counties a close liaison with the hunt is essential; but, in spite of it, fences will be damaged unless sufficient gates are provided, and if sufficient gates are provided most of them will generally be left open. It is fortunate that rabbits do not usually take full advantage of these opportunities, for in the majority of cases nothing can be done but to arrange for all gates to be looked to at the end of each day's run, or, better, as soon as the field has got well clear. It is worth taking a good deal of trouble to strike the happy mean between too few gates—and consequent damage to fences—and too many, for every gate is a danger point, and must be well hung and fitted. If wire is used, jumping places with wooden rails will have to be provided. This is usually done by the hunt. Stiles, instead of gates, should be used for footpaths wherever possible, as they are much safer, provided they are constructed so that rabbits cannot hop over them.

DRAINING

If land is to be planted with forest trees it must be reasonably well drained—for two reasons. Roots cannot get proper anchorage in soft ground, and without anchorage the trees will blow over, and though roots will stand temporary immersion they cannot thrive if land, through being water-logged, contains insufficient oxygen. Ground, therefore, which is permanently water-logged, or on which water lies about for long periods after heavy rain, must have some treatment if the roots are to live and the plant to prosper. If treatment is not possible the land is not worth planting.

Except in the high rainfall areas of the west most of the difficulties arise from water which either flows down from rising ground in the immediate neighbourhood, or comes out in the form of springs. The best method of draining is to deal first with this water, and not to proceed further until the effect of doing so has been seen. This should be done by cutting a *trap* or *intercepting* drain, which should encircle the area on the side from which the water comes, being as near as may be at right angles to its flow, and leading to a good outlet. Straight *relief* drains or *carriers* may have to be taken from the trap drain across the area, to prevent it overflowing in storm, and these may be so sited as to pick up the springs on the area, or other similar carriers may be made for this purpose. If this is properly done a complicated system of surface drainage will often be found unnecessary.

The most important points to attend to with regard to intercepting and carrier drains are (1) that they must go down at least 3 inches into the mineral soil; (2) that they should be so laid out and dug that with normal rainfall water does not flow more than 3 inches deep in them; (3) that they must have sufficient gradient to give a free flow, and (4) that there should be no sudden changes of direction or gradient, as this leads to scouring of the channel or to damming up and overflow.

After these main channels have been made round and through an area to be planted, it is well to wait a season so as to judge of their effect before doing anything more.

In addition to the system described some further action may be necessary to deal with the water which collects on the surface; for this purpose "feeders" are constructed running into the main channel, or into subsidiary drains which run into the main channels or parallel to them into the main outlet. These feeders must be as nearly as possible at right angles to the natural seepage of the surface water, the idea being that no water should have to soak through or run over a longer distance than that between two feeders. These feeders and the channels they run into give the well-known herring-bone system of drainage, though where the channel changes direction in order to preserve a uniform gradient, the angle of junction between feeder and channel, *i.e.*, rib and backbone, will often vary. Frequently feeders cannot well be got down into the mineral soil, and where this is so their gradient must be increased, unless they are quite short, so that the water may get away quickly. There is, however, an obvious conflict between obtaining quick flow and cutting the feeders at right angles to the natural seepage. All that can be said is that maximum efficiency is secured if the slope of the feeders is as gentle as is consistent with a free flow.

A special case arises in gently sloping peat areas in high rainfall districts, where particularly if there are patches of bog above or in the area to be planted, the surface water does not get away quickly enough, but finds its way from top to bottom of the slope, getting more acid and unfavourable to tree growth as it goes. This needs a succession of more or less parallel intercepting channels, possibly with some contributory feeders, and produces a modified herring-bone system, with the ribs on one side of the backbone only.

The main outlets will generally be down valleys in or at the foot of the area to be planted. Danger from scouring, choking and overflow must be expected if the result of the drainage system is to add largely to the water volume which the outlet may have to take. It will generally be found that the use of the course which a stream has naturally made for itself is the best guarantee that the outlet will be self-cleaning, for the natural winding will have taken account of differences of soil and gradient. If an attempt is made to cut corners it generally leads to more trouble than it cures.

The size of drains is so big a factor in their cost that it deserves more consideration than it is generally given. There is no point in making any drains bigger than will suffice to carry the maximum anticipated flow on the gradient on which they are laid out. In fact a drain that is too big will generally silt up at the bottom and adjust itself to its flow. Therefore, it is better to err rather on the side of cutting too narrow in the first place, as widening is easy. It is, however, almost invariably false economy to cut drains too shallow. The main channels and intercepting drains must, as has been said, go down well into the mineral soil, and the depth at which the mineral soil is found, on different parts of the area, must, therefore, be a prime factor in their lay-out. It is useful to remember that in hard soils drains may be easily deepened a few inches after they have been exposed for a year or two to the weather.

There is a tendency sometimes to rely on a few large channels, each with an extensive system of long feeders. This is a mistake. The channels into which feeders run should not normally exceed 2 feet in width at the top, 6 inches a the bottom and 18 inches in depth, and where channels of this size will not take the water it is much better to cut further channels than to increase their size. It rarely pays to cut feeders less than 6 inches wide at the bottom (*i.e.*, a spade's width), and the dimensions given are an example of a good general rule:— width at top should equal bottom width plus depth; this gives an angle for

the sides of a little over 60 degrees, which a young bird can climb up. In very spongy ground drains tend to close in quickly, and the slope may sometimes need to be as little as 45 degrees.

Nothing can be said of the spacing of main channels or of feeding drains, for conditions vary too much; but if it is worth while trying to take off water falling on the surface of land at all, it is rarely any good to place the feeders more than 50 yards apart—25 yards is a more useful maximum.

The cost of draining is so much affected by soil conditions, the presence of old roots and so on, that it is difficult to give any figure; as an indication, it may be said that in good going, drains 15 inches wide at the top, 6 inches at the bottom, and 9 inches deep should not cost more than 2*s*. 3*d*. per chain.

OTHER PREPARATORY WORK

Old Woodland.—A preliminary point may be made. In making a contract with a timber merchant to whom the standing timber on an area is sold, it is important to take care that the ground is left in a condition which makes it reasonably easy to replant. A case is known in which a merchant was given ten years to deal with the whole of an area of quite moderate size, with the result that at the end it was so thick with new growth that the expense of the necessary clearing, preliminary to planting, was prohibitive.

If it had been divided into compartments to be cleared in succession, replanting would have proceeded at once, compartment by compartment, with very little expense in clearing. The actual method of felling the old crop is also important, for it is almost always possible so to fell that the refuse is left in compact windrows which, particularly in the case of conifers, can be burnt where they lie. Such a method of felling actually helps (cheapens) removal of timber.

As to treatment of an old woodland area:—(1) never grub up stumps; (2) always burn lop and top, as it is difficult to plant properly or to exterminate rabbits unless this is done; (3) if coppice shoots or young hardwood plants are coming up on the area, cut them down to ground level before starting to plant. The last point may be disputed. It is quite natural to want to retain young growing hardwood to provide shelter, or to contribute to a mixed crop. Only a very skilful and experienced staff can make a good job of planting in strips, or in and out, among hardwood growth. Experiments of this sort made by the Forestry Commission have generally not paid in the long run. Clearing the coppice and other growth away greatly facilitates planting, and this outweighs the gain there may be from the shelter given by the old growth in the year or so immediately following planting. The stools will shoot again, and it is easy then to judge what use can be made of the old soil-occupants in establishing the new ones. If even one or two pines have been felled do not omit precautions against weevil and beetle (see Forestry Commission Leaflets Nos. 1, 3, 4 and 25) as it is much better to lock the stable door *before* the horse is stolen.

Scrub—Where old coppice or scrub growth is properly dealt with it can be made of very great assistance in starting young conifers and hardwoods. It is a mistake to clear-fell oak, birch, or alder scrub. Experience has shown that spruce, *Tsuga*, *Thuya*, and even Douglas fir thrive well under moderate shade when young. When these species are to be planted only part of the scrub need be cut. More light may be allowed in to the young trees when they show need of it, by ring-barking a portion of the scrub growth. Later the whole of the scrub trees may be ringed. This is critical work, demanding skill, but it may advisedly be undertaken if it can be regularly inspected by the owner or agent.

Old Agricultural Land and rough Pasture.—Gorse, broom, thorn and other woody growths must be cut and burnt, unless an old hedgerow is deliberately kept to provide shelter.

The treatment of bracken depends upon whether, with the accumulation of old dead fronds and stems, it is so dense that it impedes rabbit extermination and will hamper planting. If it would do so this old material must be burnt.

On areas covered with dense grass, particularly Yorkshire fog (*Holcus lanatus*) or bent grass (*Aira* spp.), ploughing of strips or, indeed, ploughing of the whole area may be useful. In couch grass areas (*Agropyron repens*) ploughing may do more harm than good, and should not be carried out as a routine measure, but only under expert advice, or if experience has proved its advantage.

Moors and Sandy Heaths.—For the treatment of moors having much peat see Peat Planting (page 41). Other moors and heaths frequently lend themselves very well to preparation by ploughing. Furrows are cut—one for each line of plants—in which they can be planted in the shelter of the intervening heather, or in the upturned sod, but without competition from the heather or other vegetation. This practice has proved very satisfactory in the Commissioners' areas in Norfolk and Suffolk.

The treatment of dense, old heather presents some difficulty. Generally, if planting can be done in it burning is not to be recommended. After heather is burned the surface of the soil becomes hard and plants frequently start slowly.

Pan Areas.—The application of ploughing to a wet and peaty moor has great possibilities. Where the pan is within 18 inches of the surface, deep ploughing with a caterpillar tractor can break it and thus improve conditions for the plant root, by giving it more growing space and better drainage. It is the sort of work which should not be undertaken by a private owner without expert advice, but it will often pay.

Peat Areas are dealt with under Peat Planting (page 41).

CHAPTER V

ESTABLISHMENT OF PLANTATIONS

Planting

On most private estates too much trouble is taken in planting to secure 100 per cent. survival. It is a luxury which is apt to be very expensive. The man in charge of the planting knows, and minds, if a tenth of the plants have not grown, for it looks like slovenly work by his planting gang. He also knows if three men plant 2 acres a week instead of in three days, but this he does *not* always mind, nor, too often, his employer, and so he prefers a slower pace, with its greater avoidance of losses, to a quicker pace with more losses. His defence might seem reasonable—that "beating up," *i.e.*, the replacement of dead plants, extends the weeding period and costs at least three times as much per plant as the original planting—which is true. But the point to be borne in mind is that only about one out of every ten of the plants put in will survive to make saw timber; it is therefore of very little importance if only, say, nine out of ten survive the planting process, provided the losses are not so grouped as to leave large gaps which will not close over at a reasonable date. Any one in charge of planting should therefore be quite content if, say, nine out of ten plants survive, and should not bother to replace the dead ones unless they occur in definite groups. Those in charge of planting will never learn this from books,

or from frequent telling. The only hope of getting planting done in the way which best suits the land and the plant—and this will frequently vary—is for the owner himself or his representative, to be constantly trying and timing different methods and watching their results. Men should be willing to change readily from pitting to notching, and to vary their methods of doing both according to circumstances, quickening up the moment that conditions allow. It will always mean a good deal of trouble to get this done ; but if an owner does not take some trouble, and lets things alone for a year or two he will very often find his men planting as if each young pine transplant, which has cost a halfpenny, were a 7s. 6d. magnolia !

It has been possible to indicate fairly definitely in the tables on pages 3, 4 and 20–31 the spacings at which to plant, and the right ages for planting, but it is not possible to give for each species the best method of planting, as this depends on the nature of the soil and its texture and humidity, as well as the species. Different methods of planting can be described, and how planting should be organised, and the time it should take can also be given. The discovery of the best method in a particular case is, as has been suggested, a matter to be decided only by repeated trial—and error. In general it may be stated that pines and larches should be planted so that the roots go downwards, especially on leached soils, while the roots of spruces should be kept near the surface, particularly on poorly aerated soils, e.g. peat (see page 41). More care is necessary with hardwoods, particularly ash, than with conifers.

Pit planting is the most expensive method. A hole is dug big and deep enough to take the roots of the plant in their natural shape, the soil being placed at the side of the hole. In heavy land it is often convenient to dig the holes well in advance, so that the soil may weather, but this is impracticable in wet areas where the holes merely become full of water ; in many of such cases turf-planting or mound-planting is the only safe method. Holes can readily be dug with the ordinary garden spade in the same way as preparing for a small shrub in a garden.

Special semi-circular planting spades like overgrown trowels with a long handle and cross bar have also been evolved for this work ; they are undoubtedly quicker when men have got the knack of using them, except on heavy clays where the soil cannot easily be freed from the curve of the spade. On all soils not too stiff the semi-circular spade is used as follows :—with one hand each side of the haft the man holds the spade by the cross-handle, hollow side towards him ; he then drops it downwards and slightly inwards, with a jab so that the haft is canted away ; then, with increasing swings of the hips (and pressure from the foot if necessary), the spade is forced down until the cut takes up at least three-quarters of a circle. The aim should be to bring most of the contents of the hole out with a flick after one or two swings, the rest being dug out as with a trowel. It needs a knack, and when used by the right man on the right soil is almost as quick as notching, even on gravelly or stony soil. In stiffer soils the tool may be used in the same way as the ordinary spade, when it cuts out the hole with one less stroke.

Another method of making pits is with the mattock. It is quicker, and therefore cheaper, than using the spade, and has been used successfully, particularly with small plants on steep hill-sides, and on hard leached soils. With plants of the size normally planted it is, however, not recommended except for ground which cannot reasonably be planted in any other way ; great care must be taken to see that the hole is made deep enough, and that the roots of plants are not cramped.

Notch planting.—The essential difference between pit and notch planting is that, in the former, the soil is lifted right out, leaving an open hole, whilst in the latter a space is held open with the tool just long enough for the roots of the plant to be inserted, the soil being returned exactly to its original position. The method is first to make a cut along the line where it is intended that the plant roots shall go, and then to make another at right angles, and to prise the soil up so as to make a cleft. Into the cleft a plant is inserted with the tips of the roots below the prised-up soil ; it is inserted rather too deeply, and then slightly pulled up, to make certain that the roots are straight. The tool is then removed, and the soil falls back taking the plant with it, and the hole is consolidated with a firm pressure of the heel.

The simplest form is the L notch, which can be made by an ordinary garden spade which had not too much rise, *i.e.*, the blade should be nearly straight with the haft. In the first cut the edge of the blade is towards the planter, and the near corner of the spade is depressed 3 to 4 inches deep into the ground. The next cut is made at right angles to the first, the left edge of the spade coming exactly to the near end of the first cut. The spade is forced *straight down*, with the minimum disturbance, to the requisite depth. Drawing the handle inwards towards him the worker levers up a triangular chunk of soil, thus opening the line of the first cut for the insertion (with the left hand) of the plant roots, which are kept in the deepest part of the cleft—that is, as near as possible to the planter. The spade is then removed, the soil falls back, the plant is pulled up a bit, and the whole thing is consolidated with the heel.

There are many varieties of this notch such as the ' T ' in which the second stroke is made across the first like the top of a T, the double ' L ' and the ' H ', in which the soil is lifted with a third stroke placed across the base of the ' T '. These have merits and demerits, and with the possible exception of the ' T ', need not be considered unless it and the ' L ' prove unsuitable. In all cases the principle is the same.

The most important variation is the use of a mattock instead of a spade. A double-ended mattock is essential, having an axe-, as well as a hoe-end although a pick-mattock may be found necessary in very stony areas. A mattock of the correct type is essential (*see* page 69). An L notch only is used and the first stroke is made with the pick or axe-end, the haft is then raised so as to cut or tear a slot towards the planter ; the second stroke is made, fully embedding the hoe-end about an inch to the side of the far end of the first ; the soil is then prised up and the plant inserted, the tool being then removed.

Vertical notching and dibbling are sometimes used for seedlings, an ordinary dibble, or a steel timber-wedge fitted to the end of a haft, or a special spade—the Schlich vertical notching spade—being used to make a narrow cleft just sufficient to take the roots. Another form of notching spade is the Mansfield, this is an excellent tool for planting oak seedlings. Whichever implement is used the notch is closed by re-inserting the tool alongside the original cleft, and forcing the soil together again in the way that a gardener uses the dibble. This plan has the merit of rapidity, where the conditions are suitable for seedlings of larch or pine. Care must be taken to see that the plant is not hung, i.e., the top of the slit closed while the bottom remains open.

If trees have been properly grown in the nursery and are planted at their optimum size the roots should not be too big for notching ; unfortunately, some nursery stock may have straggly roots, and the root is much better cut off if it cannot be properly arranged by the planting method adopted. This should be done carefully with a sharp knife or garden shears, only a few plants at a time being dealt with. When dealing with a soil in which there is a layer

of bleached appearance near the surface, root pruning must be avoided. Indeed it is better to avoid root pruning whenever possible and to grow plants of such a size and type that this operation is not required. Pit planting is necessary for poplar and large sizes of oak and ash and may be desirable for Douglas fir and larch, which need special care to ensure a natural arrangement of the root, but as a rule, on ordinary soils, the results from pit planting other species do not justify the cost.

Peat Planting.—Peat is not itself at all impossible to plant, particularly the type which bears a thick crop of rushes ; all but the worst peats can be successfully planted, provided their situation is such that trees would grow if the surface soil were of some other type. Unless, however, there is a thick crop of rushes it is better not to embark on peat planting without expert advice. All peats with more or less rushes do better than those which carry no rushes. Complete absence of rushes may mean relatively stagnant water or more highly acid soil. The second-best peat carries purple molinia (*Molinia coerulea*) and other grasses, but not cotton-grass and deer-grass (*Scirpus*). Private owners may generally be justified in tackling peat of this type. Any considerable percentage of ling or heather indicates conditions requiring special care, and advice should be sought. Things are even more difficult when cotton-grass and deer-grass are present with the heather.

Recent developments in the technique of forest ploughing have made possible the economic afforestation of most types of peat, at a cheaper cost than draining and turfing by hand. The various methods cannot be described in detail here and anyone wishing to undertake work of this kind over a large area is advised to obtain specific advice from the Commission's local officers. Draining and mounding (or turfing) by hand, as described below, remain the best method for small or scattered areas.

The first essential is drainage—if possible, a year in advance. Under-drain rather than over-drain at first, because the more drains put in to start with the more will have to be continually kept open or the crop will be blown down. But *you must do enough draining*. One of the most difficult things is to assess the sufficiency of the drainage. The main species to be employed are Norway and Sitka spruces ; Japanese larch, birch, alder, *Pinus contorta* and *Tsuga* may be tried on an experimental scale. All these trees in such areas have a power of developing a very shallow root system which lives in the drained stratum close to the surface into which air can penetrate, the roots dying if they are in a water-logged medium. It is obviously wrong to put the roots deep in the first instance, for they die, and the tree dies, unless it has energy to make a new root system in the desired stratum. It is whilst trying to establish this that plants remain " in check ", as is so often the case with spruce which stands still with yellow needles, looking miserable, for years after planting (even on sites other than peat), if it is originally planted too deep or the soil is too compact. One must therefore try to keep the roots up, and two methods of doing this will be described, *turf-planting* and *mound-planting*.

For planting on thin turfs the procedure is as follows :—an inverted turf from 4 to 6 inches thick, according to the nature of the surface vegetation and 10 to 12 inches square, is placed where each tree is to grow. With a sharp spade a cut is made from the middle to the side farthest away from the prevailing wind direction. This edge is then lifted high enough to open the slit, and to permit the roots to be inserted under it, while the stem is brought right into the centre of the turf. The roots are then spread out flat between the turf and the natural surface and the turf is dropped into position, the slit being

knitted together again as well as possible with the heel. It will be evident that the tree roots are in no way sunk into the peat, but simply rest between two layers of surface vegetation. Another method is to use turfs 9 inches thick and plant the trees *in* them. Unless the peat is exceptionally tough, the turf will subside in a few months to less than half its original thickness.

A useful tool for this form of planting is the Belgian trowel spade, which cuts a hole the size of a flower pot in the turf. In this the plant is placed, the hole being filled up with the broken-up plug or, if the peat is of a very low grade, with mineral soil. It is important to get the roots into their proper position, and there is some risk of the roots drying out, in those types of peat that dry hard.

There is thus no risk that the nursery root system will be suffocated in a water-logged soil, and in fact, the root tips grow vigorously, dip down into the peat just before they reach the edges of the turf, select the exact level that suits them, and spread rapidly in all directions, just under the surface, and particularly towards the prevailing wind. In this direction pioneer roots 2 to 3 ft. long running almost above the grass roots, may establish themselves within two years, and at intervals along them will be found little groups of feeding roots and occasionally " sinkers," which are branch roots growing straight down to provide moisture when the peat dries, and develop into anchorages. Plants set out on turfs on this way should start into growth the first year ; they will probably have a slight check the second, but thereafter there should be steady growth.

The application of about 2 oz. of basic slag or 1½ oz. of ground mineral phosphate, well scattered round the base of each plant or under the turf, markedly assists growth on the *poorer* types of peat. The operation costs from 20s. to 30s. per acre, but any attempt to plant peat which is so poor that the slag will materially help, requires expert guidance.

The most efficient way of cutting turfs by manual labour is to take them in long continuous strips ; this saves one cut for each turf, and provides an additional drain if the strips are properly laid out, though this is often purely a help in surface drying, and not necessarily a substitute for any part of the drainage system proper. The drains should yield a lot of the turfs, and if these have been properly spread, the number of extra strips to be cut will be comparatively small. If turfs are 12 inches square and the strips are cut 12 inches wide, a chain length of strip will give 66 turfs or five rows of turfs at 5 feet, spacing one row close to the strip and two on each side. To carry on this method the next parallel strip will be 25 feet away from the first one. If turfs and mounds are prepared some months in advance of planting, the risks from drought and frost-lift are small, especially with thin turfs, and if the plants are also planted rather deep—a practice which must *not* be followed in ordinary planting—neither beating-up nor weeding should ordinarily be required.

Mound planting is more suitable when it is desired to lift the plants higher out of dense surrounding vegetation than can be done on turfs. It is not a great deal more expensive when the area has been very heavily drained, and the material from mounds is thus provided. A stick indicates the position for each mound and the material is thrown round it. The mounds should be well trodden down before they are planted.

In describing these methods, only the problem of *establishing* plants has been dealt with. The planter must remember that this is not the whole story. Unless there is free circulation of air and water to a depth of some 2 feet the trees may grow well enough for a few years, but will not be able to maintain their footing.

Screefing and Ploughing.—In dry, grassy areas a plant very rarely does well if there is tight-packed sward all round its root-collar, and in such a ground a patch 15 inches square should be cleared at the place the plant is going to occupy. This operation is called " screefing ", and is best done with the planting tool at the same time as planting operations, and is on the same principle as the ploughing of furrows for the planting of transplants which has been already referred to. It must be emphasised that where spruces are to be planted, screefing will usually do more harm than good, and if plants are not planted on the natural surface they should be placed on turfs or through the strip of sod thrown out by ploughing.

Protection of Plants before Planting.—The necessity for protecting the roots of plants has already been mentioned in the nursery section, and is of perhaps even more importance before planting. Plants should be heeled-in as soon as they arrive on the planting area, in small dumps properly distributed. Each planter should carry a canvas bag, or even a galvanised pail with a mud puddle at the bottom. The receptacle should be filled at the dump and the plants should remain in it until the man is ready to take out plants singly and plant them in the soil. Roots should not be exposed for more than a few seconds and a man should never be allowed to carry one plant, let alone a handful, loose in his hand.

Depth of Planting.—Depth is most important. Except in turf-planting a plant should always be planted as if it were being restored to its old place in the nursery, and should be planted at precisely that depth. In turf-planting it is the position of the roots that matters most, and normally the tips of these must be placed under the sod, even if some of the old stem of the plant is covered by the top of the turf. In fact, such placing helps to steady the plants, particularly if they are on the big side. In ordinary planting, however, it is a great mistake to think that a lanky, top-heavy plant can be helped by putting some inches of its stem as well as its roots in the ground. If they are deeper than they should be the roots will die, and a dead plant, however firm and upright, is useless. Warning should be taken from the case of a well-known garden architect who, wishing to have ordinary rose bushes in a certain place, and having only standards available, planted the standards in a trench 4 feet deep, and was surprised when they did not live.

Firming.—No matter how plants are planted it is essential that the soil should be well firmed and packed in round the roots before the plants are left. This should never be done with the sole of the foot, which is a lazy, slow, and generally useless way to work—the heel should always be used ; but care must be taken not to bruise the stem of the plant.

Organisation of the Planting Gang.—It is a definite economy to plant trees in straight lines because this makes it quicker and, therefore, cheaper to find them in weeding and beating-up, but the lines should be only as straight as is necessary to secure this. Time spent on dead accuracy is a mere luxury. Planters should work up and down in parallel lines, keeping their direction by using two or more pickets or stakes as sighting poles. Until men get sufficiently experienced to judge without assistance, the correct spacing of trees in the line and the correct distance between lines is best got by using a light measuring rod. When men are working in a gang, and have got a certain amount of experience, only the leader should need sighting poles, the others following in echelon, and having measuring rods until they learn to do without them. Unless dumps can be so located that men can conveniently refill their bags or pails at the ends of the lines it is obviously a good thing to have a boy with spare containers rather than that the men should walk a long way to fetch the plants.

Rate of Planting.—This depends on soil, the method of planting and the size of the trees. With vertical notching in prepared furrows a man may plant a thousand seedlings in a day, but this would be exceptional. In turf-planting of seedlings or stocky 2 year + 1 year spruce, a man unaided should do quite 500 a day on prepared and placed turfs. The simplest forms of notching without heavy screefing are a little slower than this. With heavy screefing in more difficult soils a man may not do more than 400. The rate of pit planting with the semi-circular spade varies enormously with the skill of the men and the nature of the soil, and a gang of two men and a boy will sometimes do as much as 1,200 plants a day or even more ; but on more difficult ground this method may be quite as slow as ordinary spade-pitting, where the whole operation of opening the hole and planting ought to be done at the rate of 300 plants a day.

The cost of cutting turfs varies with the nature of the peat and their spacing. Thin turfs should cost about 1s. 3d. per 100 for cutting and spacing at 5 ft. × 5 ft. Thick turfs cost rather less when the texture and depth of the peat are such that less care is required in lifting.

Beating up, *i.e.*, the Replacement of Failures

As has been noted under planting, the first tendency for most foresters is to aim at securing a very high percentage of survival, and they are inclined to spend too much of their employers' money in gratifying this desire. There are only three things that need be made sure of : (1) that there are enough living trees to secure by selection the provision of a satisfactory final crop ; (2) that these are evenly distributed, and (3) that any plants put in afterwards for these purposes are of such a type, and so planted, and put in at so early a date that they will do their job. This means that " beating-up " must be done a year after planting, and with trees no smaller than the originals, and that they must be thoroughly well put in. Where beating-up is unavoidably delayed it is better not to do it at all unless one is quite satisfied that the plants introduced will really serve some useful purpose as part of the crop. If the gaps are large this should not present any great difficulty. If they are small it is essential to use a shade-bearing species, or, alternatively, one which is faster growing than the original. It goes without saying that the very best plants should be selected for the purpose. One can introduce an undercrop such as beech later on if the ground is suitable.

WEEDING

Weeding means the removal of the growth naturally springing up round the young trees which would otherwise damage them. The most economical way of weeding is for a gang of men to work in echelon behind a leader, each following up a row of plants, and having a stick in his left hand, both to check the spacing, when he cannot find the plant, and to part any particularly dense growth. The best tool is the ordinary brushing or reaping hook or, if the men are accustomed to it, the long-handled type, or staff-hook. When a man knows that he is coming near a plant he must find it *before* beginning cutting strokes. Those who make a habit of cutting plants should be put on to less risky work without too many warnings, as such carelessness is quite unnecessary.

Where weed growth is dense, and especially the first year or so after planting, pines, larches and even Douglas fir and Sitka spruce, whose tender shoots are liable to damage from bracken fronds, may have to be weeded twice or even three times in the season. It is not always necessary to cut the whole of the weed growth on an area, and it is frequently sufficient to cut lanes along the

rows of such width that the intervening uncut strips, when blown over or beaten down by rain, cannot fall on the lines of plants. From this it is obvious, however, that with very tall growth and narrow spacing the whole area will have to be covered.

Economy may be secured in pure bracken areas planted with small plants if the bracken is whipped before the fronds have uncurled. Each successive whipping is also carried out before fronds uncurl, and the final weeding of the season will be a cutting, the whole area being treated in this case, the object being the extermination of the bracken and not only cutting lanes through it. A whipping of this kind may cost up to 4s. or 4s. 6d. per acre. Cutting lanes in bracken should not cost more than 7s. 6d., and clear cutting not more than 10s. These costs will be increased by the occurrence of patches of bramble, gorse, dense grass or coppice, but it is rare to see weeding which ought to cost more than 12s. per acre, even in the worst conditions, unless it has been allowed to get out of hand.

The weeding of coppice must be tackled on a plan and with foresight. It is better to be sure that it never outgrows the planted tree than to attempt to repair damage after it has done so, but it is essential to secure that men do not cut individual coppice shoots which it is desired to retain in order to fill gaps, and in this matter men generally need careful supervision.

Gorse and brambles are very unpleasant to cut. They also have a habit of appearing harmless to the trees, and then suddenly springing up and smothering them. Half measures are completely useless, and they must be dealt with ruthlessly from the start. It probably pays to provide men with gloves unless they use the staff-hook. It is generally useless trying to cut lanes only with these pests, and utterly hopeless to think that one can put off the work till next year with but a small increase of costs. Broom falls in the same category except in those places where it is specifically required for shelter.

CHAPTER VI

THINNING

Thinning is an essential operation in the tending of every even-aged plantation. The number of trees planted per acre is usually between 1,500 and 2,000. and despite early losses most of these survive until the thicket stage is reached. Thereafter the accepted and recommended practice is to reduce their numbers by thinnings repeated at frequent intervals, until only about 200 trees per acre remain to form the final timber crop. Thinning has several objects to fulfil :—

(*a*) By reducing the number of trees per acre it gives those that remain more growing space both above and below ground. This makes for quicker growth and earlier maturity.

(*b*) By eliminating stems that are badly shaped and weakly, it favours the growth of the better-formed trees that yield more useful timber.

(*c*) Thinnings, where saleable, improve the financial return from the plantation.

(*d*) The removal of dead and dying trees reduces the risk of the spread of fungus and insect pests.

(*e*) By increasing the amount of sunshine and rain that reaches the forest floor and facilitating the movement of air, the decay of leaves and needles is accelerated and food materials are released for the trees.

The main object of thinning is the benefit of the final timber crop. However desirable an early cash return may be, it should be a secondary consideration; and whenever a thinning is necessary it should be undertaken, even though no use whatever can be made of what is taken out. Neglect may lead to the loss of the whole crop through wind-throw or snow damage, and may therefore be very false economy. Where thinnings are delayed the bulk of the timber may be formed on many thin stems of low total value. It is usually much more profitable to grow a smaller number of larger trees of better quality.

PREPARATORY MEASURES

Inspection Racks. These are paths cut through the plantation so that those in charge may judge what thinning or other treatment is necessary. They are best made by sawing off the lower branches of two adjacent rows of trees with a pruning saw. Enough racks should be cut to enable one to form a good idea of the state of the plantation as a whole. They are usually made whilst a plantation is still in the thicket stage, from ten to fifteen years old.

Brashing. When it is clear that the thinning will shortly be due, brashing, that is the removal of the lower branches to head-height, is required. This enables the forester to move about freely to view the individual trees and to mark those to be cut. Incidentally brashing helps greatly to reduce the risk of fire.

Brashing every tree is an expensive operation and is not necessary for marking thinnings. There is no point in spending money on trees that will not repay the cost, such as small and useless stems that will come out at the first thinning. The exact procedure therefore requires consideration in the light of local circumstances.

It is important in brashing that the branches should be cut cleanly and close to the stem. Probably the best all-round tool, especially with inexpert labour, is a *sharp* curved pruning saw with 6–8 teeth to the inch, and with a straight 2 ft. handle. The use of bill-hooks is *not* recommended. Brashing should not normally be taken more than 6 feet up the stem. The removal of *higher* branches is dealt with under pruning in a subsequent section.

Cleaning. This term covers the work which may have to be done in a young plantation at the thicket stage, before it is ready for thinning. It includes the removal of the following kinds of unwelcome growth :

(*a*) Harmful climbers, such as honeysuckle, ivy, old man's beard, etc., which must be cut away.

(*b*) Trees of fast-growing weed species such as birch or goat willow, and coppice shoots from a former hardwood crop, that may be outgrowing the planted crop. If numerous these should be cut out before the first systematic thinning.

(*c*) " Wolf-trees," which are trees of the planted species that outgrow their neighbours considerably, assume a defective shape, and damage a number of more desirable trees by suppressing them. Similar " wolves " may arise from the advance growth of natural regeneration. In either case they should be cut out at the first opportunity.

Development of Extraction Routes. In large plantations easy access is desirable for the removal of produce from thinnings. On flat or moderately sloping ground it may be possible to remove single lines of trees at intervals,

thus providing sufficient space for the passage of a lorry ; if this is done when the crop is young the break in the canopy closes over rapidly and there is little or no loss in production, provided the plantation is well-stocked and uniform in growth.

CLASSIFICATION OF TREES

In order to discuss and describe methods of thinning it is necessary to distinguish between the types of trees found in a crop. The classification given below is based on the assumption that there may be 4 layers in the leafy canopy and works from the top downwards.

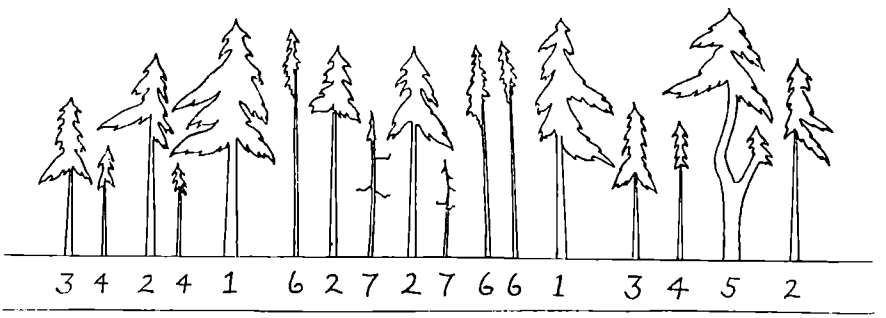
1. *Dominant Trees.* The tallest of the crop.
2. *Co-dominant* Trees.
3. *Sub-dominant* Trees.
4. *Suppressed* Trees.

As this classification takes no account of the future value of a tree, which may for example be badly forked or diseased, it is necessary to differentiate the following classes also :

5. *Wolf Trees.* Mis-shapen trees, with large crowns, which outgrow their neighbours.

6. *Whips.* Slender, usually tall, trees without stability, which damage neighbouring trees when they sway.

7. *Dead and Dying Trees.*



Other things being equal the *Dominant* trees, being the tallest and usually the largest, are normally retained for the final crop, unless they happen to be *wolf trees*, badly-forked, or otherwise defective, in which cases they should be removed as soon as possible.

The *Co-dominant* trees have their crowns in the upper canopy but are shorter than the dominants, and usually to some extent shut in. The best of them may be required for the final crop, and all of them have the useful function of shading and so killing off the lower branches of adjacent stems, which makes for cleaner timber. Therefore treat them carefully, retaining good stems to fill in gaps. *Whips* usually enter into this class. They are a menace to the crop and should be cut out as soon as possible.

The *Sub-dominants* are relatively short trees that do not enter into the upper canopy, but are not directly overshaded by others. They play a useful part in killing off the lower branches of their neighbours, and in covering the soil. In course of time they mostly become suppressed by their taller neighbours.

The *Suppressed* trees have no direct access to light and stand beneath the crowns of adjoining trees. They rarely have any useful future as timber producers, and as a rule are best cut out before they die and decay.

Wolves, *Whips*, and *Dead* and *Dying* trees are all more or less injurious to the crop and call for early removal.

PROCEDURE

When marking for thinning there are four objects that should be carried simultaneously in the mind, as follows :—

(*a*) The removal of definitely harmful trees particularly *Whips* and *Wolves* and *diseased* stems.

(*b*) The provision of more growing space for the best of the *Dominant* and *Co-dominant* trees.

(*c*) The even distribution over the ground of the trees that are likely to form the final crop.

(*d*) The utilisable value of the stems that are removed.

The question of distribution must always be borne in mind. In its simplest form thinning consists in singling out the more desirable Dominant and Co-dominant trees so that their competing crowns receive more and more light as time goes on. If these desirable stems were all evenly spread over the ground, the problem would be simple. But this seldom occurs in practice, and the forester is often obliged to retain somewhat inferior trees in order to avoid gaps in the canopy. Where there is a choice of trees to be removed, attention should be given to stem form and shape of crown. A well-shaped Co-dominant tree may be preferable to a larger Dominant tree growing beside it, if the latter has a crooked stem or a one-sided crown.

Methods of Marking. Although one man can select and mark the trees to be removed, the work is done better and more speedily if he has an assistant to do the actual marking.

In practice it is desirable to look at the crop from more than one direction. This means that every tree selected must be marked on *two* sides. Otherwise it is impossible to see, from every angle, which trees have already been chosen for removal and which have not.

Marking may be done with paint, with a timber scribe, or by cutting a " blaze " on the side of the tree with a bill-hook. The last-named method is quickest and gives an easily-seen mark, but it is only suitable for indicating those trees that have to come out. If it is decided to mark the trees that are *to be retained*, paint should be used. White paints with a titanium base are used in Forestry Commission Sample Plot work ; lead or zinc paints are apt to blacken in course of time.

FREQUENCY

The frequency with which thinnings are desirable depends on the rate of growth of the crop, which varies with situation, soil, and species. As a general rule, a thinning is required for every increase of 10 feet in height. In the early " pole " stages of the crop, this will usually mean :

Thin every 5 years with Scots Pine, Norway Spruce and most hardwoods.
Thin every four years with Corsican Pine, European Larch and Ash.
Thin every 3 years with Douglas Fir.
Thin every 3 years, or *less*, with Sitka Spruce and Japanese Larch.

Later on, when height growth falls off, less frequent thinnings will be required. A ten-year interval may be enough as crops approach maturity.

GRADES OF THINNING

It is important to realise that the development of a tree crop may be to some extent controlled by varying the grade or intensity of thinning. Three such grades are defined below :

1. **Light Thinning.** This does not break the canopy to any appreciable extent, although here and there the removal of whips or wolves may cause small gaps.

A *Light Thinning* will remove :

(*a*) Dead and Suppressed Trees.

(*b*) Any Sub-dominant trees that may be taken out without breaking the canopy.

(*c*) Whips.

(*d*) Occasional Wolf trees.

2. **Moderate Thinning.** This involves a definite though strictly moderate break in the upper canopy, which should still retain the character of an over-hanging shelter. Looking upwards after a Moderate 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. Only in rare instances should a dominant or co-dominant tree be completely isolated ; normally their crowns should remain in contact with their neighbours over at least half their circumference.

A *Moderate Thinning* will therefore remove :

(*a*) All the classes of trees detailed above for removal in a Light Thinning.

(*b*) A fair number of Sub-dominant and Co-dominant trees, particularly those that may be interfering with the development of adjacent good dominants.

3. **Heavy Thinning.** This involves a general and considerable breaking of the canopy, though there are limits beyond which it is not permissible to go. After such thinning only about two-thirds of the overhead view will be covered by the tree crowns, leaving one-third as open sky. Many of the dominant and co-dominant trees will have more or less completely free crowns, only touching their neighbours at a few points, if at all. But the thinning should not be so heavy that the gaps will not close over by the time that the next thinning is due, i.e. in five or at the most ten years time.

A *Heavy Thinning* therefore removes :—

(*a*) All the classes of trees detailed above for removal in a Light Thinning.

(*b*) All the Sub-dominants except for any that may be needed for soil cover.

(*c*) As many of the Co-dominant and Dominant trees as may have to come out in order to give those remaining additional light on at least one side.

A *Heavy Thinning* enables the breaking-up of groups of the taller Dominant and Co-dominant trees to be done, but careful attention must be paid to the even distribution of the remaining stems over the ground. At times, therefore, a well-placed Co-dominant tree may have to be retained in preference to a larger Dominant one, though normally the smaller class is selected for removal.

CHOICE OF GRADE

The factors that determine the correct grade of thinning to adopt include the following :

Species.

Age, height and general vigour of the crop.

Previous treatment.

Markets for produce of various sizes.

Advice can only be given in general terms and each plantation must be considered on its merits. General recommendations for each species are given below, but it should be noted that rather different treatment is required in all cases where thinning has been delayed.

STOCKING DENSITIES

As the number of trees on each acre of ground is steadily reduced as they increase in age and height, it is possible to make up a table to show the usual numbers that should be found in a well-thinned plantation at each stage. These numbers vary with species, the original planting distance, the quality of the site, and other factors. Therefore any figures that can be given may only serve as a general guide.

The following tables show how the number of trees per acre diminishes with increasing height. The heights given are " top heights ", meaning the average height of the larger (dominant) trees in the crop. The figures show the number of stems per acre that should remain *after* thinning has been carried out.

At the start of the thinning the top height may be determined by measuring a few of the larger trees ; a few " wolves ", which would have to come out in any case, may be felled for that purpose. The existing number of stems per acre may be found by counting all those on a *sample plot.* A suitable unit is one square chain, i.e. 22 yards each way, which is equal to one tenth of an acre. The difference between the existing number per acre and that shown in the tables will indicate how many trees should be cut out.

NORMAL NUMBER OF TREES PER ACRE AFTER THINNING

(Q.C. = Quality Class of the Site)

Top Height of trees in feet	Scots Pine (England) Q.C. II. Moderately thinned	Scots Pine (Scotland) Q.C. II. Moderately thinned	Corsican Pine Q.C. I. Moderately thinned	European Larch Q.C. I.–III Heavily thinned	Japanese Larch Q.C. I. Moderate to Heavy thinning
30	1,500	1,700	1,600	1,350	1,500
35	1,150	1,350	1,230	1,100	1,240
40	900	1,020	930	850	1,000
45	680	800	730	650	800
50	540	600	610	490	640
55	410	470	510	390	470
60	310	370	440	275	340
65	230	280	390	205	250
70	175	200	345	—	190

NORMAL NUMBER OF TREES PER ACRE AFTER THINNING

(Q.C. = Quality Class of the Site)

Top Height of Trees in feet	Douglas Fir Q.C. II–IV Moderate to Heavy Thinning	Norway Spruce Q.C. I.–III. Heavily Thinned	Sitka Spruce Q.C. II Moderately Thinned	Oak Heavily Thinned	Ash Heavily Thinned
30	—	—	—	—	1,500
35	1,450	1,430	1,500	1,650	1,250
40	1,150	1,120	1,300	1,350	900
45	950	910	1,100	920	500
50	800	730	930	700	300
55	680	610	780	500	175
60	550	520	660	350	110
65	460	450	575	260	—
70	380	380	490	200	—
75	310	—	420	150	—
80	260	—	360	110	—
85	220	—	300	—	—
90	—	—	260	—	—

TREATMENT OF INDIVIDUAL SPECIES

A. CONIFERS—PURE CROPS

Scots Pine. This is seldom a fast growing tree, average rates of growth* being 24 feet at 20 years and 46 feet at 40 years. This means that fairly long intervals may be left between successive thinnings, but systematic treatment is nevertheless necessary.

In southern England attacks by the Pine Shoot Moth may lead to the formation of many " wolves " owing to the distortion of leading shoots ; the removal of the worst of these requires attention at the earliest thinnings. Scots pine is relatively intolerant of shade, and suppressed trees seldom survive long under their taller neighbours.

Thinnings cut during the winter or early spring should be barked or removed from the plantation before the Pine Beetle, which breeds freely in the butt lengths, can emerge to attack the surrounding trees in late April or May.

In *normal plantations* the first thinning should start when the top height is between 25 and 30 feet. A Light to Moderate grade is recommended. Wolves, whips, dead, suppressed, or weakly sub-dominant trees should be removed. Subsequent thinnings should follow at 5-year intervals, on a Moderate grade. Trees with straight stems should be favoured wherever possible. In the later stages the interval between thinnings may be lengthened gradually to a maximum of 10 years.

* The rates of growth specified in this section of the Bulletin refer to the growth expected when the species in question is planted on favourable sites at elevations not exceeding about 600 feet above sea level.

It should be noted that there is a tendency for plantations in Scotland to carry more trees per acre at a given height than is the case in England and Wales. This difference is brought out in the tables.

Where thinnings have been delayed a Light grade of thinning is recommended at the outset. Subsequent thinnings should follow fairly closely, every 3 or 4. years, until normal conditions are re-established. It is important to remove dead and diseased trees early, as these harbour pests.

Corsican Pine. In southern Britain Corsican Pine is a moderately fast growing tree, reaching top heights of 35 feet in 20 years and 62 feet in 40 years. It is less subject to damage by the Pine Shoot Moth, so that wolf trees are comparatively rare. Thinnings cut during the winter should be removed or barked before the end of spring to avoid Pine Beetle damage to neighbouring trees.

In *normal plantations* the first thinning should be made when the trees are about 30 feet high, working to a Light grade. The second thinning 4 or 5 years later should be intensified to the Moderate grade, and any closely packed groups of Dominant or Co-dominant trees broken up. Subsequent thinnings should be made on a Moderate grade, at intervals of 4 to 5 years, increasing in the later stages.

Where *thinnings have been delayed* they should be light and frequent at first, attention being paid to the removal of whips, suppressed trees, and occasional wolves.

European Larch. Of all the commoner coniferous species European Larch is the most seriously affected by insufficient thinning. The tree requires ample room for healthy development, and if this is denied, canker and checked growth usually result. It is a fast growing tree, reaching a height of 40 feet in 20 years. As it is very intolerant of shade, suppressed trees quickly die and become worthless as produce. Whips may also prove troublesome. All this indicates the need for frequent and heavy thinnings, and the rapid reduction that occurs in the number of stems per acre is shown in the tables. A thinning that does not break the canopy is of no value.

In *normal plantations* the first thinning should be made before the trees are 30 feet in height, removing whips, weakly suppressed trees, and wolves, and breaking up any dense groups of dominants. Subsequent thinnings should follow at intervals of 3 to 5 years, aiming at providing ample growing space for the crowns of the best trees. In the later stages these selected final crop trees, numbering 150 to 200 per acre, should be virtually isolated from each other.

Where thinnings have been delayed there is a strong tendency for a large proportion of the trees to become whips. The treatment of such overcrowded plantations needs care and patience. Very frequent thinning is the best remedy, and even so the response will be slow. It is desirable to repeat thinnings at 2 year intervals, starting with a Light or Moderate grade.

Japanese Larch. Between the ages of 10 and 25 years Japanese Larch is usually the fastest growing of all our coniferous trees, reaching top heights of 36 feet in 15 years, and 61 feet in 25 years. Unless frequently thinned, a crop may easily get out of control. Some plantations contain many badly-shaped dominants with wavy (corkscrew) stems, which are liable to become wolf trees, and must be removed at the first opportunity. If thinning is delayed the whole crop may tend to develop into whips, whilst suppressed trees seldom survive for long.

In *normal plantations* the first thinning should be made at a top height of 30 feet, working to a Moderate grade and concentrating on wolves, whips, suppressed trees, and weakly sub-dominants. Subsequent thinnings should follow at 3-year intervals, extended to 5 years when height growth begins to slow down.

Where thinning has been delayed, considerable difficulty may arise through the presence of wolves, whips, suppressed trees, and dense groups of dominants. Therefore it may prove the best plan to select and mark the best trees and give each of them more growing room. This should be done gradually. It is better to thin annually for 2 or 3 years than to attempt to clean up the crop in one drastic operation.

Hybrid Larch. The treatment of this variety should follow that recommended for Japanese larch.

Douglas Fir. If planted on soft rich soils, Douglas fir is very liable to windthrow or damage by wet snow, and *it is therefore essential to start thinning early and to repeat it at frequent intervals.* Wolf trees are frequent and where they cannot be cut out without damage to the surrounding trees, it may be necessary to ring them. But Douglas fir responds rapidly to thinning, and large gaps, such as occur where wolves are removed, very soon close over. Height growth is rapid, up to 50 feet at 20 years and 80 feet at 40 years. Delay in thinning at this stage may have serious consequences.

In *normal plantations* the first thinning should be made when top height is about 35 feet, working to a Moderate grade and concentrating on wolves, whips, suppressed trees, and weakly sub-dominants. Subsequent thinnings should follow every 3 years, subsequently lengthened to 5, and the grade may be intensified from Moderate to Heavy. Well-shaped dominants, which are seldom the largest of the crop, deserve encouragement in the early stages.

Where thinning has been delayed the chief risk to the plantations is damage by snowfall or windthrow. As the largest trees are usually the most stable, caution is needed in removing wolves, and if in doubt they should be ringed. Early thinnings should tackle chiefly the whips and crowded Co-dominants. Annual light thinning is the safest way of treating such stands until the stocking has been reduced to a reasonable figure for the actual height.

Norway Spruce. The rate of growth of Norway Spruce is only moderate, reaching 33 feet at 20 years and 60 feet at 40 years. It is a moderate shade-bearer, requiring more light in the drier areas. Sub-dominant trees that have fallen below the level of the canopy have an exceptional power of recovery; if freed in time they may develop into useful dominant trees within 20 years. Wolf trees are relatively uncommon.

In normal plantations the first thinning should start at a top height of 30 feet, working to a light grade. Subsequent thinnings may follow every 4 to 5 years, on a Moderate grade.

Where thinnings have been delayed, the first ones should be rather light, and repeated at intervals of 2 or 3 years until normal stocking is restored. After that they may be intensified to the Moderate grade.

Sitka Spruce. On favourable sites Sitka spruce is a very fast-growing tree, reaching heights of 46 feet in 20 years and 79 feet in 40 years. As a result windthrow is a danger, especially on soft wet soils, such as peats. Wolves are rare but may develop on exposed sites through the breakage of crowns. Usually the crop is very uniform.

In normal plantations the first thinning should be made at a top height of about 40 feet, on a Moderate grade, removing whips, wolves, and suppressed trees. Subsequent thinnings should follow at 3-year intervals working on a Moderate to Heavy grade in order to break up the groups of Dominants and Co-dominants. Later the interval may be lengthened to 5 years.

Where thinnings have been delayed there may be considerable risk of snow break or windthrow. Light thinnings repeated annually, or every two years, provide the best means of saving the crop. Caution is needed in removing wolves whose loss might let in the wind, and early thinnings should go firstly for whips and sub-dominant or suppressed trees.

Other Conifers. Shade-bearing conifers such as Lawson Cypress, *Thuya plicata*, Tsuga, and *Abies grandis*, should all be lightly thinned until the trees are from 40 to 50 feet in height. After that, if branch suppression is satisfactory, thinnings on a Moderate grade may be made. Where thinnings have been delayed they should be light and frequent at the outset. Normally the interval between thinnings should be about 4 years.

B. HARDWOODS—PURE CROPS

When thinning hardwoods, attention may have to be given to coppice shoots from old stumps, and naturally-sown trees. These may outgrow the planted crop and become wolves, but at times it is worth while to retain them in order to fill gaps.

Oak. Oak grows slowly by comparison with conifers, reaching 25 feet at 20 years and 45 feet at 40 years. It is a strong light-demander, but if given too much room in the early stages, tends to form a bushy crown, whilst its height growth is checked. If kept dense it usually forms a straight stem, not necessarily from its leading shoot, so that pruning is seldom required. Wolf trees, especially those developed from coppice shoots, are numerous and can be very harmful. Too rapid opening up leads to the formation of epicormic shoots on the surface of the trunk, and these are a defect.

In normal plantations it is necessary to keep the crop dense in the early stages to ensure straight stems ; but a thinning is necessary as soon as close spacing causes the formation of whips. The first thinning should be made at a top height of 30 feet, working to a Light grade, and paying close attention to wolves and whips. Subsequent thinnings should follow at 5-year intervals for the first half of the rotation, being increased to 10 years later on. The intensity should be gradually increased through Moderate to Heavy. The object is to open up the crop in the pole stage, in order to secure large-sized timber on a moderately long rotation of 120 to 150 years.

Where thinnings have been delayed the usual defect is the presence of both wolves and whips in large numbers. Both these undesirable classes should be removed in frequent light thinnings, after which attention may be paid to the dominants. Subsequent treatment should follow that laid down for normal plantations.

On former oak coppice areas, a proportion of the stems is often derived from stool shoots. Such trees grow vigorously and tend to become wolves, and their future value is uncertain since they may become unsound at the butt. Some may be required to fill gaps, but the general policy should be to favour the planted stems in order to secure a more uniform crop.

Beech. On chalk soils the rate of growth of beech varies from moderate to slow, varying with the depth of soil. But on fertile loams it grows faster, reaching 60 feet in 33 years in the Forest of Dean. Some strains show a tendency towards repeated forking. So it is advisable to keep the crop dense in the early stages, and to favour the straight-growing trees. Beech has great recuperative powers ; trees long suppressed are capable of recovery when freed and gaps formed by thinning close over remarkably quickly.

In normal plantations a Light grade is advisable for the first and second thinnings ; first thinning should be done at a top height of 30 feet. Badly shaped trees should be cut out in the early stages. Subsequent thinnings at 5-year intervals should be intensified to the Moderate grade, and when a top height of 60 feet has been reached, the whole crop should be opened up by Heavy Thinning in order to produce large timber stems as soon as possible.

Where thinning has been delayed, there are likely to be a large number of mis-shapen stems, either bent, or forked, or actual wolf trees. These should be removed early, and the ability of partially suppressed beech to recover will enable smaller trees around them to fill up most of the gaps so formed. After this the removal of whips and suppressed trees should be considered.

No data are available to show the number of stems normally found at a given height in beech plantations.

Ash. Ash is a light-demanding tree, capable of very rapid growth on favourable soils ; unless frequently thinned, many of the trees develop into whips. The opposite position of the side buds usually leads to forking of the trunk whenever the terminal bud is injured ; this defect can be put right by the early removal of one of the branches of the fork. The best ash timber is quickly grown, so early and frequent thinning is indicated.

In normal plantations the first thinning should be made at a top height of 25 to 30 feet on a Light grade. Wolf trees must be cut out wherever there are better trees adjoining and whips should also be eliminated. If a dominant forked tree must be left, one of the fork branches should be cut back to allow the other to take the lead. Endeavour to obtain straight stems at least 20 feet long. The second thinning should follow 3 or 4 years later on a Moderate grade, giving the better dominants more room to develop. In subsequent thinnings the grade should be increased to Heavy, so as to give the best trees room to develop large symmetrical crowns.

Where thinning has been delayed it is essential to begin with light and frequent thinnings. The crop is likely to contain many whips and wolves, and the worst of these should be removed at the outset. As the well-shaped trees of the main crop classes begin to fill in the gaps, the grade may be gradually increased to that suitable for a normal plantation.

Sycamore. Thinning treatment should follow that for ash, but sycamore is more shade tolerant and can carry more stems per acre. Pruning may be necessary. Large straight stems suitable for rollers or rotary-cut veneers are valuable, and it is better to produce a small number of them rather than a larger number of smaller and inferior trees.

Sweet Chestnut. Treatment of High Forest crops should follow that laid down for oak.

Birch. Birch is seldom planted as a forest crop, but existing stands of naturally-grown trees may be worth improvement by thinning. It is a quick-growing light-demanding tree, and any individuals outgrown by their neighbours

soon become suppressed and die out. It is therefore important to ensure that the lead is not taken by mis-shapen trees, with bent, forked, fluted, or elliptical stems. As the chief demand is likely to be for large veneer quality butts, preference should be given to large straight cylindrical stems free from defects. It may be worth while to prune the side branches of these to a height of 20 feet.

Birch requires ample head room, and after the whips and wolves have been cut out, the grade should be moderate to heavy. Seedling trees should normally be preferred to coppice shoots.

Poplar. The thinning of poplar plantations differs from that of other trees owing to the wider spacing of their original planting. At 16 feet apart, only 170 trees are used to each acre. Consequently, thinnings cannot be classified under the usual grades, and it is impossible to distinguish the usual types of tree in the crop. But frequent and careful thinning is still necessary. A three-year interval is advisable in the early stages, and the number of stems per acre should be reduced from around 150 at 55 feet top height to 80 at 70 feet, and 45 at 90 feet. Retain the finest stems, and remove the poorly shaped, diseased, or cankered specimens. Pruning is important in poplar growing and should be done after each thinning.

Other Hardwoods. No detailed rules can be laid down for the thinning treatment of these. Actual plantations are few and far between, and each case must be judged on its merits, though the main principles still apply.

Mis-shapen trees, however large, should be removed early to secure a more even crop. Light thinning should be the rule until straight stems and reasonable height growth have been secured. Then opening up may commence at a rate varying with the species and particularly with its ability to tolerate shade.

C. MIXTURES

In mixed crops the forester is able to exercise control, by well-planned thinning, over the composition and development of the mixture. Thus, a mixture of larch and beech may be converted into a beech wood by eliminating the larch; or alternatively into a larch wood with a beech under-storey. Mixed woods of conifers and broadleaved trees may prove difficult to manage where the conifers outgrow their partners. Where thinning has been neglected it is seldom worth while to try to rescue badly suppressed oak and ash and it may prove preferable to accept the conifers as the crop. But where sturdy sub-dominants survive, much may be done by skilful thinning. Often it is better to thin group-wise rather than to try to obtain an even mixture over the whole plantation.

Scots Pine and European Larch. These species consort well together, though there is a tendency for the larch to outgrow the pine, especially if the crop is underthinned. The general rule should be to encourage the best-formed trees of either species, and to eliminate all wolf trees and whips.

Scots Pine and Norway Spruce. The development of this mixture depends on locality conditions. On light soils in East Anglia the pine usually go so far ahead that they suppress the spruce and even heavy thinnings are unlikely to save that species. But on heavier soils in the north and west of Britain the spruce tends to outgrow the pine, though the latter may take the lead in the early stages. It is advisable to keep a proportion of the deeper-rooting pine to the end of the rotation, though in order to do so some of the larger spruce may have to be cut out.

Douglas Fir and European Larch. This mixture can seldom be maintained to an advanced stage, as the Douglas fir usually outgrows and suppresses the larch. It is therefore advisable to remove the larch in the early thinnings, when it will provide useful pole material.

Douglas Fir and Thuya plicata. This mixture may go one way or another, depending on the rate of growth of the Douglas fir. Where a mixed crop is desired, either species may have to be favoured at the expense of the other.

Japanese Larch with Douglas Fir or Sitka Spruce. Here again the mixture may tend to become a pure crop of either species, and an early decision must be made as to what is wanted. By timely action the forester may swing the mixture either way, provided he keeps his objective before him all the time. A point for consideration here is that the early thinnings of both Douglas fir and Sitka spruce are of low value, whereas both species produce high yields of large-diameter timber in their final crop. Larch, on the other hand, yields valuable early thinnings, but is a light cropper at the timber stage. As a rule, therefore, it will be more profitable to eliminate the larch.

Oak and Conifers. A common mixture in the past has been oak, European larch, Scots pine and Norway spruce, the oak usually planted at a wide spacing such as 12 or 15 feet. It is almost impossible to obtain a satisfactory oak crop from such a mixture, and usually the oak are suppressed, leaving a conifer plantation.

Mixtures of oak with one conifer (such as larch, pine, or spruce) in equal proportions are somewhat easier to deal with but the oak is very intolerant of shade, and tends to be suppressed by the faster-growing conifer when that reaches a height of 25 to 30 feet. It is essential to get in early, cutting out the most dominating conifer stems before they have time seriously to damage the oak below them. Three of four years neglect at the critical time can result in the suppression of most of the oak. It is usually necessary to cut out the conifer before it has reached a useful size, though in the case of larch the thinnings may be saleable.

Oak and Beech. This mixture is rarely found in this country because the beech usually outgrows and suppresses the oak before the thinning stage is reached. The only hope of obtaining an even-aged oak and beech mixture on average oak sites is to cut out any beech that threatens to become dominant, retaining the backward beech to form an understorey to the oak.

Ash and Conifers. Mixtures of ash with European larch and Norway spruce are difficult to handle unless the conditions are very favourable to the growth of ash, and in any case vigorous thinning is necessary. It usually pays better to retain a thriving conifer rather than to sacrifice it for the sake of a weakly ash ; whilst even the more thriving ash trees must be given ample head room in good time.

Ash and other Hardwoods. Where soil conditions are favourable, natural ash seedlings often spring up in mixture with other hardwoods. Provided such groups are carefully tended, favouring the ash wherever possible, useful mixed crops containing clean well-developed ash can result.

Mixed Plantations where Thinning has been Delayed

Any delay in thinning a mixture is likely to result in the dominance of one species,—not always the most desirable one—over the whole or part of the area. A frequent example is the suppression of oak by coniferous nurses. It may be wisest to accept the situation as it stands, as any attempt to put the clock back and rescue the suppressed trees, is likely to ruin the crop. Outstandingly good hardwoods that are holding their own against a coniferous partner may, of course, be retained.

Other cases arise where each of two species is locally dominant, and the crop may include coppice shoots and natural seedlings of various intruding species. Here the only useful rule is to accept the best trees, regardless of species or method of origin.

The usual consequence of neglect is a preponderance of wolf trees, whips, and suppressed or dying trees, and a shortage of well-formed specimens in the dominant and co-dominant classes. Thinnings at first should be light and frequent, aiming at the removal of the worst wolves and whips, allowing the better stems so freed to recover. This should be followed by a gradual intensification to the grade appropriate for the chief species present.

POST-THINNING OPERATIONS

As soon as thinning is completed, attention should be given wherever necessary to drainage and pruning.

Drainage. One of the objects of thinning is to secure the stability of the crop. But a well-thinned plantation may still be subject to windthrow if the drainage is neglected. Time and again windblows are found to occur along blocked main drainage channels ; once a blow has started it may spread through an entire plantation. So look to the drains at each thinning and make sure that the water can get away freely.

Pruning. The quality of timber, and so the price which can be obtained for it, depend to a large extent upon its freedom from knots. This is especially the case with the quick-growing conifers. Clean serviceable timber can be produced by careful pruning when the trees are small. This removes the side branches that might otherwise form knots in the wood.

Pruning above a height of 6 feet is only likely to repay its cost on the trees of the final crop. It is therefore advisable to select a portion only of the trees, about 200/300 per acre, well formed and evenly spaced, and to restrict pruning to these probable final crop stems. It will seldom pay to prune conifers averaging over 4½ inches quarter girth at breast height, so the work should be done at one of the earlier thinnings.

When pruning, the branches must be cut flush with the stem and the bark of the stem should not be injured ; a saw is the best tool to use. A curved pruning saw mounted on a pole is satisfactory for branches that cannot be reached unaided, provided the height does not exceed 15 feet. Above this height a hand saw is recommended, the workmen climbing the trees and working downwards, standing on the branches ; each should have a safety belt. For further information on pruning see Forestry Commission Leaflet No. 22, " Pruning in Young Plantations ".

CHAPTER VII

GENERAL

DISEASES

There are few plantations in which a smaller or greater number of diseases do not occur, but wholesale destruction is, fortunately, not common. The sporadic distribution of sickly trees in plantations causes a certain amount of loss through reduced production. It is useful to know something of the factors which cause this loss. The general attitude is to blame fungi, insects and so on for the diseased condition of the trees without looking deeper into the matter. An occasional investigation into the causes which allowed the fungus or insect to become established and to damage the trees will repay its cost. Much may be learned from it.

In many cases the cause is readily apparent; in some it may be obscure. It would be incorrect to say that all fungus or insect attacks follow on faulty environment. There are, for instance, certain insects which appear to be able to thrive on trees that seem to be healthy. The pine sawfly which causes some defoliation in Scots pine is an example of this. It can be said, however, that fungi and insects occur most commonly as destructive pests attacking trees which have become in some respect unhealthy through the influence of an unsuitable environment. The forester may find one or more of several indications that help him. As instances; wrong species may have been selected, thinning may be much overdue, planting may have been badly done, there may have been damage by animals and so on. To enumerate the reasons which cause sickness that may ultimately give entry to fungi or insects would entail a recital of the whole gamut of errors into which the silviculturist may fall and the disasters to which nature subjects trees. Therefore, the best advice that can be given to the forester who would avoid disappointing losses in his woods is to practise careful and sound silviculture. The determination of the name of any fungus or insect found attacking a plantation is generally best left to experts and advice may be sought from officers of the Forestry Commission. Nevertheless it is desirable that those tending woods should know some of the more common pests. The descriptions given here are necessarily short. For convenience the pests are described first under types and then under the trees they infect. Notes on fungicides are give at the end of the section.

A. Fungi attacking Plants in Nurseries

Many of the fungi that occur in plantations may also be found in nurseries, but there are some which are most deadly when they attack very young plants.

Fungi causing Damping-off.—In conifer seedbeds under one year old, plants may be found dying off in groups. The stems of diseased seedlings present a rather shrivelled up appearance and the plants droop and fall to the ground. There are several fungi that produce this condition and their diagnosis is best left to the mycologist. Generally damping-off does most damage in dense seedbeds in wet weather and in clayey soils. These conditions help the spores of the fungus to spread from one plant to another.

In small nurseries something may be done to prevent the fungus from spreading by isolating infected parts with shallow drills and burning infected seedlings. In other cases spraying with potassium permanganate or sulphur is the only way (*see* under *Fungicides*, page 62).

The beech may also suffer from a damping-off fungus which is known as *Phytopthora cactorum*. Black spots occur on the leaves and the seedlings may be killed.

B. Fungi attacking Conifers.

Needlecast and Blight in Scots Pine.—Seedbeds, transplants and older trees occasionally suffer from needlecast. Needles may become brown during winter and fall off. In some cases the tops of the plants die. This may be caused by drought or by a fungus. Drought effects may be produced by the roots of the plants being frozen in the soil so that water cannot be taken up to replace that lost. This trouble is worst in those places where thawing of the soil is delayed.

Plants affected by the leaf cast fungus (*Lophodermium pinastri*) have a different appearance. In autumn or early winter brownish blotches appear on the leaves which otherwise may have a purple colour. Sometimes a number of small, black spots can be seen on the needles. This is most commonly the case when young seedlings are attacked. Fallen leaves of older plants affected by this disease show greyish patches and quite easily seen black spots.

Plants severely affected by *Lophodermium pinastri* should not be planted out. Although many will survive, the disease may have so weakened the stock that a high death-rate can be expected. The disease is worst in moist climates in wet summers, and in dense seedbeds and transplant lines. Cold, dry air hinders its spread. It is generally worst also in nurseries made near old pine woods.

Pine Leaf Rust.—In April and May the leaves of Scots pine may show long and distinctly extruding yellow sacs, which when ruptured scatter large quantities of spores. The needles do not always die prematurely and this disease, which is caused by some species of *Coleosporium*, is not of serious consequence. The disease lives its complete life cycle on two hosts. One stage is on the pine. The other hosts most commonly found near a nursery are groundsel (*Senecio vulgaris*), eyebright (*Euphrasia officinalis*), coltsfoot (*Tussilago farfara*) and harebell (*Campanula* sp.). The presence of these, and particularly groundsel, in a nursery is to be avoided.

Pine Bark Rust.—Hemispherical, oblong, sausage-shaped, yellow vesicles may appear on the stems of young or old pines in May or June. These are spore-carrying bodies of a fungus which has been living in the wood and bark of the tree. Plants in nurseries may be affected and the disease may appear on trees up to 25 to 30 years old or more. The affected wood becomes strongly impregnated with resin, and at any time of the year the diseased part can be detected by this and by the stem being flattened. This disease can be very destructive since the tops of affected trees invariably die or are broken off by snow or wind. The cause of this disease is a species of *Cronartium*, a fungus which, like *Coleosporium*, may use two hosts for its development, or infection may be carried directly from one tree to another. Felling of diseased trees is recommended.

Leaf Cast of Larch. (F.C. Leaflet No. 21).—Seedlings and transplants in some nurseries suffer from severe casting of needles during summer. The needles assume a premature autumn colouring and soon fall off leaving only a

few near the tips of the shoots. This disease is caused by a fungus *Meria laricis*. Spraying with liver of sulphur, Sulsol or Amberol has been found to be effective (*see* under *Fungicides*, page 62). The disease also occurs on older trees.

Larch Canker. (F.C. Leaflet No. 16).—This dreaded disease of the larch is well known. The fungus causing it is *Dasyscypha calycina*. Cankers are produced on the stems of larches and while relatively few trees are killed by the fungus, those attacked are always more or less seriously crippled.

The disease does most damage amongst young trees growing in frosty sites or in a moist, stagnant atmosphere. The larch should not be planted where it will be subjected to these conditions. Free movement of air in the plantations is necessary if this disease is to be kept under control. Early thinnings are indicated.

Douglas Fir Canker. (F.C. Leaflet No. 14).—Cankers appear occasionally on the stems of Douglas fir which may be encircled and, in the case of small trees, death may result.

This fungus seems to gain entry through wounds in the bark and these should not be made. Men carrying out pruning operations ought to be warned against allowing the saw to break the bark. Clean-cut wounds made in removing branches do not seem to be liable to infection. The fungus may also enter through small dead twigs. The disease, therefore, tends to be worst among Douglas firs planted in frosty sites. A similar disease occurs on Japanese larch.

Die-Back of Corsican and Austrian Pines.—This disease is caused by *Brunchorstia destruens*. Needle and shoots at the tips of branches die. Generally the whole tree dies. The disease is met with most frequently at high elevations some distance from the sea, in districts having a high rainfall and where Corsican pine has been planted near to old Austrian pines. Selection of healthy sites for Corsican pine is the best way of preventing this disease. Trees that have been attacked by the fungus should be removed and the branches burned.

In conifer plantations that have been planted three to five years and over, single trees may become sickly and die. Later a group of trees round the first victim may die. This may be due to an attack by a fungus at the roots of the trees. The usual symptoms are a definite reduction in the rate of growth and a marked discoloration of the needles. If the attack is severe the tree may die very soon, but sometimes it may live, perhaps miserably, for years. Attacks of this kind may generally be laid to the charge of one of two fungi :—

The Honey Fungus, *Armillaria mellea*. (F.C. Leaflet No. 6).—This fungus is common everywhere, but it almost invariably occurs in places that had grown birch or other scrub and old hardwoods. Conifers in plantations of all ages are affected by it and an attack may spread rapidly. The honey fungus possesses a peculiar and, for the fungus, effective means of spreading underground. It produces long, black root-like strands of tissue which mycologists call " rhizomorphs ". These rhizomorphs travel from an affected tree to a healthy one and thus spread the fungus.

The honey fungus may be distinguished from the other root fungus which will be described, by these rhizomorphs, by the presence of a thickish white layer under the bark of the infected tree, by an accumulation of resin in the soil round the collar of the tree and occasionally by the appearance of toadstool fructifications.

While damage is done to conifers, some hardwoods, in particular some species of *Prunus*, may also be attacked; but damage to hardwoods is uncommon. Advantage of this is taken in treating diseased young conifer plantations where it is recommended that diseased trees should be rooted out and burned and, where practicable, replaced by shade-bearing hardwoods.

Conifer Heart-rot, *Fomes annosus.* (F.C. Leaflet No. 5).—This fungus is known to many foresters as *Trametes radiciperda.* It is common in conifer woods and its bracket-like fructifications may be found on the stools of some broadleaved trees. It does not spread underground by means of rhizomorphs but infected roots may transmit the fungus to sound ones by touching them. Under the bark of infected trees the fungus appears as a white, very thin felt. *Fomes* not only can kill trees but it may also attack the wood of most conifers so that this becomes rotten.

As in both of these fungi the main method of spreading appears to be underground it has been recommended that attacked groups of trees should be isolated by trenches 18 inches to 2 feet deep. Fructifications are then destroyed as they appear. This means of preventing the spread of the fungi is seldom practicable nor can it be guaranteed to be effective.

C. Fungi attacking Hardwoods

Oak Mildew.—Young oak plants in the nursery and in the forest frequently have their leaves, etc., covered by a white growth, in appearance not unlike that which is common on roses. When this occurs growth is checked. The white covering is the mycelium of a fungus *Oidium.* Attacks are worst in moist seasons and in places where the plants are subjected to much dampness in the air. The most effective cure is spraying with sulphur and indeed this must usually be done if healthy oaks are to be reared (*see* below). Spraying should be commenced as soon as the mildew appears and repeated twice at intervals of one month.

Fungicides

The object of a fungicide is to destroy a fungus without injuring the host plant. It is necessary, therefore, to take considerable care in the preparation of a fungicide in order that an excess of one ingredient may not occur.

Destruction of a fungus may be effected before it has had time to develop or the fungus itself may be destroyed. Fungicides are most generally used against fungi, *e.g.*, mildews, which occur on easily reached parts of plants. They are applied either as a liquid or powder. If a liquid is employed it ought to be sprayed on as a fine mist which will wet the stem and leaves thoroughly. It is useful to add some material such as soft soap, flour or calcium caseinate to the liquid to act as a " spreader ". If a powder form of fungicide is used it must be in a state of very fine division. It ought to be applied when the leaves are wet.

The following fungicides are recommended for use in forestry; most are obtainable ready-made from horticultural chemists, etc. :—

Liver of Sulphur.—1 lb. liver of sulphur mixed in 14 gallons of water with about half a pound of flour (previously made into a paste) added as a spreader.

For *Meria* on larch fortnightly sprayings from the beginning of March to the end of May are advocated. The above solution will spray 300 square yards of seedbed.

Sulphur.—A sulphur spray is used for oak mildew. Finely divided sulphur is difficult to wet but if previously moistened with a dilute solution of soft soap to which oleic acid has been added this difficulty is overcome. One pound of flowers of sulphur will make 50 gallons of spray which is sufficient for 500 square yards of seedbed. Alternatively proprietary sprays such as Amberene may be employed.

Cheshunt Compound.—This is used for the control of some damping-off fungi. It consists of 2 parts by weight of copper sulphate and 11 parts of ammonium carbonate. The materials are ground to a fine powder before mixing and the mixture is kept in a stoppered bottle for 24 hours before use. The solution is prepared by dissolving 1 oz. of the dry mixture in a little hot water, which is then added to 2 gallons of water. The solution is watered on to the seedbed.

Potassium Permanganate.—This is used to combat damping-off fungi. It is easily prepared and is generally effective. The seedbeds should be watered with a solution consisting of 1 oz. potassium permanganate in 2 gallons of water. If the seedbeds had not previously carried seedlings apply two gallons to 3 square yards using a fine rose. Ordinarily, half this quantity will suffice.

INSECT PESTS

A. On Conifers

Insects attacking the stems of young plants :—

Hylobius abietis (Pine Weevil). Forestry Commission Leaflets 1 and 25.

Hylastes species. (Black Pine Beetles). Forestry Commission Leaflets 4 and 25.

Pissodes species (Banded Pine Weevils).

Strophosomus coryli, Otiorrhynchus picipes. (Clay Weevils).

Although the Pine Weevil (*Hylobius*) is usually the most conspicuous of this group of small beetles and weevils that attack the stems of conifers shortly after planting, other kinds, particularly *Hylastes*, may prove much more important locally. The damage takes the form of the removal of bark in spots and patches, which show up as light-coloured marks on the surface of the stems and roots ; if these damaged areas completely ring the stem the tree dies. Trapping is effective in certain instances, but the only preventive measure that can be generally recommended is the postponement of replanting of felled coniferous areas until such time as the more damaging weevils and beetles have ceased to breed in large numbers in the stumps of the felled trees.

In practice this means that a clear three years should be allowed to elapse before planting conifers on the site of, or close to, any land on which a coniferous crop has been felled. Even then it is advisable to examine the stumps of the old trees to make sure that the insects are no longer breeding there. Methods of examining stumps, and trapping the adult insects, are given in Forestry Commission Leaflet No. 25.

Insects attacking young shoots of pines

(*a*) *Myelophilus* species (Pine shoot beetles). Forestry Commission Leaflet 3.

The adult forms of these beetles tunnel into the young shoots of pine trees to feed, usually selecting those around the leader. These shoots are killed and break off, so that the tree may assume a typical spire-like form, lacking branches near its tip, whilst its vigour of growth is much depressed. As the

beetles breed mainly in the bark of felled logs, a simple and effective method of control is to remove all felled coniferous timber from the woods without delay, particularly during the summer months. If for some reason pit props, poles or timber must remain there, they should be barked; the insect cannot breed successfully in barked material or in small brushwood.

(b) *Evetria* (*Tortrix*) species. (Pine Shoot Moths). Forestry Commission Bulletin 16.

In this case the damage is done by the grub or larva of the insect, which feeds in the young shoots of Scots pine or Lodge-pole pine. It has a preference for the leading shoot, which it may destroy or deform, causing the main stem of the tree to assume a fantastic curve that makes it virtually useless as timber. Extensive investigations have failed to reveal any practicable control measure. Fortunately severe attacks are generally confined to plantations aged about 6 years, and enough trees escape serious damage to give a satisfactory crop. Badly distorted trees should be removed in the early thinnings; those only slightly bent may straighten up as their trunks expand. Corsican pine is not seriously affected.

Insects attacking foliage:—

Lophyrus pini (Pine sawfly), *Lygaeonematus erichsonii* (Larch sawfly), *Coleophora laricella* (Larch mining-moth—F. C. Leaflet No. 11), *Adelges* (*Chermes*) *cooleyi* (Leaflet No. 2), *Adelges* (*Chermes*) *viridis* and *strobilobius* (Spruce-gall aphis—Leaflet No. 7) and *Adelges* (*Chermes*) *laricis* (Larch aphis), *Aphis abietina* (Spruce aphis).

Shoots of Scots pine and sometimes Corsican pine and larch may be completely defoliated by sawfly caterpillars. Larch needles are also attacked by the larvae of the larch mining-moth. These insects are nearly always present in woods, but are undiscovered except in the years when they make an invasion in force. In the case of both the sawflies, colonies of caterpillars will be found swarming on the attacked trees; these are about 1 inch long when full grown, and are yellowish grey with a black head, black spots underneath and three black rings in the middle. There is considerable variation in colour. No effective control measures are known. It is best to let the attack wear itself out—the loss will be less than the cost of preventive measures.

Leaf-shedding is often the indirect result of attacks by various species of aphids, especially plant lice. This type of attack can be recognised by the presence of the little scale-insects and sometimes by galls or false cones such as those of the spruce-gall aphis, which are not unlike small prickly pineapples, about an inch long and at first green in colour, later turning brown and persisting for some years. There will be small discoloured patches on the upper side of the needles, and sometimes, if the attack is bad, specks of white wool, which the insects spin to protect themselves, give a definitely silvery appearance to the whole tree when seen from underneath. This is more particularly the case with *Adelges* (*Chermes*) *cooleyi* which attacks Douglas fir, for the white wool is not such a feature in the identification of other types of aphis. Sitka spruce is sometimes completely stripped of its needles through the activities of another greenfly, *Aphis abietina*. No remedy for this pest has been discovered but fortunately the *Aphis* does not injure the buds; these produce new shoots and usually, if not invariably, the trees resume more or less normal growth in the following season. In the case of the larch-miner the outer leaves of the rosettes turn pale and adopt a curious kinked appearance which is characteristic; the minute larvae spin a thread

on which they dangle like a spider. Attacks both by the *Adelges* and by the miner work up to a maximum on a given tree, and then decrease, and the harm done is limited to slowing up the growth. The only control measure is spraying, which is rarely practicable in the field. Certain ladybirds are most helpful; they and their repellent-looking larvae, which creep about on the twigs like minute squat alligators, consume vast quantities of *Chermesidae*.

B. On Hardwoods

Insects attacking leaves :—

Tortrix viridana (Oak-leaf roller moth—F. C. Leaflet No. 10) and *Dasychira* (*Orgyia*) *pudibunda* (Pale tussock moth).

If the oak-leaf roller moth is present in epidemic form there is never any doubt about it. Foliage is devoured and caterpillars are seen on threads everywhere, going down to lower branches to find fresh feeding ground, and there are numbers of little green moths in the air. The caterpillars pupate by rolling themselves up in the remnants of the leaves. This scourge comes in cycles lasting three or four years, and nothing can be done to exterminate it short of dusting from aeroplanes or with powerful apparatus from the ground. Sessile oak is less subject to attack than pedunculate. The caterpillars never kill a healthy tree (although they restrict growth) as a second flush of leaves comes out after the first leaves have been eaten; but this is a severe strain to the tree, and the caterpillars may thus occasionally give the finishing touch to a tree which is already weak, or so weaken a strong tree that it succumbs to other enemies.

Beech is often defoliated in late summer by caterpillars of the pale tussock moth, but owing to the lateness of the attack the damage is relatively much less than in the case of oak attacked by tortrix.

Insects attacking trunk :—

Cryptococcus fagi (Felted beech coccus—F. C. Leaflet No. 15).

This is often associated with canker, and attacks the bark, which it covers in places with a mantle of small white felty spots, like the white wool of *Chermes cooleyi;* badly attacked trees may appear quite white over areas of 2 or 3 square feet. Healthy trees are rarely attacked, and by itself the disease is unlikely to cause death; the cost of treatment with soft soap and paraffin, or caustic washes, is thus rarely justifiable.

FIRE PROTECTION

From the time of planting onward, a mass of dead vegetation collects round the trees; this increases until some years later the trees close up, kill down the surface growth and encourage moister conditions. The first 15 years or so in the life of a plantation is thus a period of ever-increasing fire risk. However small and favourably situated a plantation may be, there is sure to be risk, and the fact that it is slight does not excuse the neglect of simple precautions.

Important as this subject is, it need not be treated at length here since on nine private estates out of ten the need for special precautions is confined to the margins of railways and main roads where experience will have shown how great the danger actually is; it varies greatly with the locality.

Where precautions have to be taken the following points should be kept in mind :—

(1) Open fire-breaks are worse than useless unless they are kept clear of grass and heather.

(2) The most economical fire-breaks can be obtained if belts of beech or other hardwoods can be retained when an area is felled.*

(3) However perfect the fire-break, patrols are necessary at danger points during periods of exceptional drought, especially in spring.

(4) Railway Companies are liable for damage caused by fires originating from the railway but unless negligence can be proved their liability is limited to £200. Owners have to consider how far, if at all, it is necessary to supplement the precautions taken by the Company.

(5) It is wise to insure young woods, say up to fifteen years of age. The risk becomes much less when the trees have closed up and lost their lower branches.

(6) The best tool for fighting a fire is a flattened birch broom after the style of a light besom, stiffened with wire or 1¼-inch mesh netting. These brooms should be used with a sweeping motion ; they can be made by any intelligent workman and should be stacked ready for use at known points. The Forestry Commission have adopted the practice of placing supplies of birch brooms at intervals along road sides in their plantations. It is hoped in this way to encourage passing motorists to use them in putting out small fires ; and they serve as a reminder to the public of fire danger.

(7) Counter firing (*i.e.*, burning an area in front of the fire to check its advance) is the only way of dealing with a fire which is out of control, but is so risky that it ought not to be attempted without responsible guidance and a large number of helpers.

(8) Fires often break out again after they seem to be extinguished, especially where stumps or peat smoulder underground. It is therefore desirable to leave one or more men on watch for some hours or even days after the others have left.

(9) For industrial or tourist districts a civilly worded notice asking visitors to avoid fire risks is more effective than a threat of prosecution for trespass which cannot, as the law stands, be carried out. If a safe site for picnics can be provided and visitors referred to it, the public will be less likely to start fires and more ready to help in putting them out if they do occur.

WORK OF THE FOREST GANG

The following refers primarily to England and Wales ; the spring work may often be five or six weeks later in Scotland.

October.—All draining and preparation of ground should be completed. Lifting of plants in the nursery and planting in the field should be started.

November to February.—Clear rides and clean fire lines. Continue lifting and planting. Dig over nursery ground as plants are lifted, especially the

* It is a fallacy to believe that by planting a strip of hardwoods next to a road, railway or path a fire-belt has been automatically established. If, however, they are cut-over or burnt, and coppice freely, hardwoods are a useful help during the season of full foliage and become a real protection when they have killed the inflammable ground cover, *but not till then*. Where a belt of trees is planted for the specific purpose of fire protection, the best species to use is a conifer—Japanese larch.

ground intended for seedbeds. Lift seedlings from the nursery and start lining them out. Also line-out plants brought in. In hard weather carry on with preparation of ground for next season or making fence stakes from the previous year's thinnings or fellings. Make additional drains where wet weather shows they are needed. The greater part of felling and thinning should be done in these months.

March.—Finish all lining-out and planting before the end of this month. Start sowing seed if tilth is suitable.

April.—Finish seed-sowing. Sow green crops in nursery. Continue preparation of ground for next season, including fencing and draining. Thin in woods where there is no danger of wind-throw and do cleaning.

May to September.—Weed plantations and nurseries. Kill rabbits off the piece for next season's planting. Finish all other preparatory work so that everything is ready by the end of September.

TOOLS AND APPLIANCES

It is always worth while to investigate new or improved tools ; it is doubly so in forestry, where labour costs are all-important ; it is essential when starting large-scale operations of a type new to the district, or previously of minor importance.

The agricultural or forest labourer soon loses patience if new and untried tools, some of them unsuitable, are continually thrust upon him. Before a new tool is issued it should be subjected to a searching test by an enlightened and impartial workman, or by the owner or agent himself, and the men must be thoroughly schooled in its use ; there is sure to be difficulty in overcoming their conservatism but ultimate success is assured if—and only if—the tool is really suited to local conditions.

A very wide range of makes and patterns of the more usual forestry tools, such as spades, axes, and bill-hooks, is stocked by the principal manufacturers and their agents. Various designs are preferred in certain districts, sometimes as a matter of custom, but frequently because local peculiarities of soil or plant growth call for particular shapes of tools, especially of spades and bill-hooks. When ordering new tools it is advisable to bear in mind such local preferences, and unless a change is desired for some definite reason, to make sure that the customary pattern is obtained.

A list of firms that manufacture a wide range of general forestry tools is given below. This is not to be taken as an unreserved recommendation of those named, nor as implying that good tools may not be supplied by other makers ; but it is of little use to recommend operations without indicating where the necessary tools may be obtained, and the firms listed are known to supply implements of a satisfactory standard.

SUPPLIERS OF GENERAL FORESTRY TOOLS

Thomas Black and Sons, Ltd., Sea View Works, Berwick-on-Tweed.
Edward Elwell, Ltd., The Forge, Wednesbury.
English Tools Ltd., 15, Wiend, Wigan.
Hardypick Ltd., Sheffield.
William Hunt & Sons Ltd., Brades Steel Works, Birmingham.
C. T. Skelton & Co., Ltd., Sheafbank Works, Sheffield, 2.
Spear and Jackson, Ltd., Aetna Works, Sheffield, Yorks.
Robert Sorby & Sons Ltd., Kangaroo Works, Sheffield, 8.
Cornelius Whitehouse & Sons Ltd., Cannock, Staffs.

Certain tools of unusual importance in forestry are at present made by comparatively few manufacturers, as listed below.

NURSERY TOOLS

Nurserymen's equipment of many kinds, including spraying machinery, hot-bed and other thermometers, crates, labels, fencing materials, stencils, weighing machines, barrows, hessian, wheeled hoes, cultivators, and seed drills, sand distributors and spraying equipment, are obtainable from Messrs. George Monro Ltd., Waltham Cross, Herts, who have depots throughout the country. The same firm can also supply the principal insecticides, fungicides, fertilisers, and sundries such as peat and silver sand.

Lining-out Boards for transplanting seedlings. Benjamin Reid and Company, 20, Hadden Street, Aberdeen.

Blow Lamps for weeding seedbeds. Woodward Bros. & Copelin Ltd., Gem Works, Oakhill Road, Sutton, Surrey. "Primus" equipment is obtainable when import conditions permit, from Condrup Ltd., 66, Colebrooke Row, Islington, London, N.1.

Soil Injectors for combating cockchafer attacks on seedbeds. Cooper Pegler & Co., Ltd., "Delgenish", Chipstead, Surrey.

Sprayers for applying fungicides, etc. Four Oaks Spraying Machine Co., Ltd., Four Oaks, Birmingham; Messrs. Cooper Peglers as above; Ernest Hill Ltd., Beta Works, Sheffield.

Chemicals, such as fungicides, and other materials required for nursery use should be purchased from wholesalers wherever possible, as substantial savings can be made on the retail prices.

Power-Driven Cultivators.—Several makes are on the market, and one of the most effective and handiest for work in confined spaces such as nursery beds is the "Rotehoe", made by Messrs. Rotary Hoes Ltd., Station Road, East Horndon, Essex.

TOOLS FOR AFFORESTATION WORK

Fencing Tools for straining, manipulating or cutting wire; the Page Ironside Co., 1, Cheapside, Kilmarnock.

Draining Tools.—For heavy clays the strengthened clay spades or "grafts" as made by most of the tool manufacturers should be used.

The best tools for peat drains have been developed in Scotland and can be bought from firms such as James Rigg & Sons, Crawick Forge, Sanquhar; T. Black & Sons Ltd., Sea View Works, Berwick-on-Tweed; English Tools Ltd., 15, Wiend, Wigan, and J. Donald & Co., Barblues Forge, Airdrie.

The principal tools for peat draining include the *rutting spade*, resembling a large hay knife, used for cutting the sides of the drain; this is a one-sided tool supplied for use with either right or left foot. Once the sides have been cut, the peat may be broken into sections with the *cross-cutting spade*. These sections are then lifted from the drain with the *hack* or *drag*, a fork with its teeth at right-angles to its handle. The bottom of the drain is then cleaned out, if necessary, with *scoops*, which may be of either the "push" or "pull" pattern.

Planting Tools.—Schlich and similar types of tree-planting spade are made by Messrs. J. Rigg & Sons, Crawick Forge, Sanquhar, and Messrs. J. Donald & Co., Barblues Forge, Airdrie. They may also be obtained from Messrs. Benjamin Reid, 20, Hadden Street, Aberdeen.

Semi-circular spades are made by Thomas Black & Sons Ltd. of Berwick-on-Tweed.

Planting mattocks and picks are of many types, and some are better adapted than others to any particular set of local conditions. For general use, the hoe or adze end should be nearly at right angles to the haft and nearly straight, about 8 inches long and 4½ inches wide, carrying its full width as close as possible to the eye. The other end, whether axe or pick, is less important to the quality of the work, but makes all the difference to handiness and speed; a 12-inch pick or a 6-inch by 2½-inch cutter is suitable. Useful types are made by Hardypick, Ltd., Sheffield, 8, and William Hunt & Sons Ltd., Brades Steelworks, Birmingham, amongst other makers.

Machines for Gassing Rabbits.—The Burrun gas pump and the Cyanogas footpump may both be obtained from Messrs. George Monro, Ltd., Waltham Cross, Herts. The same firm also stocks Cyanogas "A" dust for use with the pump. This method of extermination is recommended by the Humane Societies for both rabbits and rats. It is also effective against moles.

FIRE PROTECTION

Hand-operated pumps are useful for fire fighting wherever water is available, and may also be used for controlling the burning of fire lines, or of heather, etc., prior to planting. One well-known make is the "Bantam", obtainable from E. H. Hill Ltd., Fitzwilliam Street, Sheffield, 1; in this design the bucket is carried in the hand, but others are available of the "knapsack" type. A canvas pack type for slinging on the shoulders, and therefore more easily carried across hilly country, is made by Melvin Bros., of Edinburgh. Other forms of knapsack sprayers may serve in an emergency.

Signalling horns and whistles for giving the alarm are made by J. Hudson & Co., Barr Street, Hockley, Birmingham, 19. Foghorns, operated mechanically by hand, are obtainable from George Wilson & Co. (London) Ltd., Seaway, Bevendean Avenue, Saltdean, Sussex.

Where protective burning is undertaken to clear fire-proof strips along the edges of plantations, a simple tool called a "heather burner" will be found very useful for lighting the controlled fires. This is obtainable from John Macpherson & Sons, Ltd., The Sporting Stores, Inglis St., Inverness.

PRUNING TOOLS

A useful type of saw for the "brashing" or moderately high pruning of conifer stands is the curved saw for use with strapped poles, made by Messrs. C. T. Skelton, Sheafbank Works, Sheffield, 2. The saw blade is listed under their catalogue reference 14314; the strapped pole handles, which have to be ordered separately under reference 14318, are available in lengths from 4 to 12 feet; a 4-foot pole is satisfactory for ordinary brashing. A similar type of saw, with a socketed handle, is made by R. Sorby & Sons Ltd., Kangaroo Works, Sheffield, 8 (Catalogue reference 49).

Short-handled pruning saws, both curved and straight, are made in various patterns by several makers. The "Dawyck" type is obtainable from Messrs. Spear and Jackson Ltd., Aetna Works, Sheffield. Pruning chisels are made by Cornelius Whitehouse and Sons, Ltd., Cannock, Staffs, who list them as "Cocoa Pruners" (Catalogue reference 544).

Safety belts for use in high pruning or tree-lopping are made by Messrs. Barrow, Hepburn and Gale, Ltd., of Grange Mills, Bermondsey, London, S.E.1.

Saws.—The firms listed above as general tool suppliers each have their own branded range of saws for most types of woods work. In addition,

Messrs. E. P. Barrus Ltd., of Brunel Road, Acton, London, W.3, import the Disston range from the U.S.A. (At present an import licence is necessary.) A point to note when ordering two-man cross-cut saws with detachable handles, is that they are normally supplied *without handles* unless those are specially asked for.

Bow saws have come into use to an increasing extent in recent years, especially for the preparation of pit-props. One such saw is the Spearfast E.38 made by Messrs. Spear and Jackson, Aetna Works, Sheffield. The blades are detachable, and spare ones should always be kept on hand.

MISCELLANEOUS EQUIPMENT FOR HANDLING TIMBER

Canthooks and timber carriers for manipulating logs are obtainable from Messrs. Canavon Partners Ltd., Avonmouth, Bristol. The same firm also supplies the Witte portable power saw for tree felling and conversion. Another such power saw is the Teles, made by Messrs. Teles Smith Ltd., Caxton House, Iddesleigh Street, London, S.W.1.

Monkey Jacks and Winches for tree felling and uprooting are supplied by Messrs. Trewhella Bros., Pty., Ltd., Rolfe Street, Smethwick, Birmingham.

Timber Marking Crayons are obtainable from W. F. Stanley & Co., Ltd., New Eltham, London, S.E.9.

Quarter-girth tapes for measuring timber in the round are manufactured by J. Rabone & Sons Ltd., Hockley Abbey Works, Birmingham.

Faggot tiers are obtainable from George Monro Ltd., Waltham Cross, Herts.

MAPPING AND SURVEYING EQUIPMENT

W. F. Stanley & Co., Ltd., New Eltham, London, S.E.9, supply a full range of requisites for drawing office work and field surveying, slide rules, calculators, etc., as well as hypsometers for measuring the heights of standing trees. Their " acre square " or area computor, a transparent celluloid plate marked off in rectangles each exactly equivalent to one acre on the six-inch-to-the-mile, or other suitable scale, is of considerable practical value. Used in conjunction with the six-inch Ordnance Survey map, it enables the area of plots of ground several acres in extent to be ascertained approximately with little or no measurement.

WATERPROOF CLOTHING

The provision of oilskins is well worth considering, particularly in the wetter areas. Firms manufacturing suitable suits, comprising jacket, leggings, and sou'westers, include Messrs. E. Macbean & Co., Ltd., Wellington Mills, Port Dundas, Glasgow; Messrs. J. Beara & Son, Appledore, Devon; and Messrs. Del Guerra Oilskin Co., Cardiff. (Whilst clothes rationing continues clothing coupons, or Coupon Equivalent Certificates, must be given up for these items; the Forestry Commission is empowered to issue such certificates in appropriate instances; other certificates are available for the supply of Thermos Flasks to Forestry Workers.)

Whilst forest workers may reasonably be expected to provide their own knee-length rubber boots or Wellingtons, the provision of thigh boots by the employer will often enable drainers to do enough extra work to save the cost several times over.

The provision of a few sheets of corrugated iron or other light temporary shelter on or very near the place where the men are working is another obvious

economy measure that is all too frequently overlooked. More permanent shelter provided at a place of constant employment, such as a nursery, will often enable men to do useful work under cover when heavy rain renders work out of doors impossible.

Labels.—Permanent indelible labels for recording date and details of planting, etc., are manufactured by the Serpent Label Co., Rockbeare, nr. Exeter. These are lead strips with imprinted lettering, suitable for nailing to creosoted posts, and have proved satisfactory for marking research plots.

When despatching bundles of trees by rail, it is advisable to use a sturdy type of temporary label, such as the paper-covered metal labels made by the Improved Metal Label Co., Ltd., 64, Port Street, Manchester, 1.

PART III

CHAPTER VIII

UTILISATION

Markets*

The success which an owner achieves in marketing is generally a pretty accurate measure of the amount of trouble he takes. If he follows the line of least resistance and sells everything, standing, to the nearest timber merchant, he is extremely lucky if he gets the best price or if the produce is removed on time, and luckier still if the ground is left in a tidy state, fit for planting—and by the time he wants it.

The average local timber merchant deals primarily with certain classes of produce for which he has steady markets; when he buys a parcel of standing timber it generally includes material which he does not really want and which he proposes to re-sell in the round or which, after sawing, he has not the trade connection to market advantageously. He generally says he is doing you a favour by taking this material, which puts you under an obligation to sell him your next lot at a low price, and he allows a very low price for it, or frankly expects to get it for nothing, and consequently, makes a big reduction in the average price for the whole. If the owner is prepared to do some real hard work to find out the different markets and their exact requirements, and will "lot" the produce accordingly or, better still, if he is prepared to fell and grade it and offer the right stuff in the right places, to the right buyers, he not only escapes being under any obligation to any one, but should also find a surprising improvement in the average price secured. For real efficiency, besides felling, grading and measuring, the estate may have to haul to the road side or even deliver to the purchaser's yard, and it is possible to arrange this economically if everything is done by piecework or contract under really competent supervision. In such cases the increased price is not the only advantage; the owner avoids all argument as to the upkeep of extraction roads, and the whole job is controlled; the felling area can be cleared by the time it is required and the ground can be tidied up as felling proceeds, before it becomes a tangle of brambles and coppice shoots and a breeding place for insects. There is often also an important advantage in selling by measure, after felling, instead of by estimated contents, standing; estimates will certainly vary in accuracy, but (as when a farmer sells to a butcher) any error is unlikely to be to the advantage of the seller!

* At the present time (September, 1946) all felling, sale, and purchase of growing trees or round timber in the log is governed by *The Control of Growing Trees and Home Grown Round Timber in the Log (No. 1) Order 1944.* (Statutory Rules and Orders 1944, No. 269.) H.M. Stationery Office. Price 3d.

There will often be one grade or class of produce for which there seems no satisfactory market; but the gain on the rest should more than compensate for this unsaleable stuff, and it is good business to accept a low figure for it or, better still, to run it through the estate sawmill to provide rough lumber and to reduce purchases of sawn material. There is also often a chance of selling sawn produce to other estates, farmers and others; the price may be low but, obviously, there should be a minimum profit equalling what it would have cost to haul to the merchant's mill and back. The owners of small estates should benefit by co-operation in the sale and exchange of produce, getting in touch, if necessary, through such channels as the Land Agents' or Forestry Societies.

Timber will generally be the product of clear-felling or taking the standards out of coppice areas. If the crop is sold standing an endeavour should be made to agree a price per cubic foot felled and trimmed-out, but a clear understanding is necessary as to top diameter, measurement, bark allowance, and the disposal of the tops. There must also be definite arrangements as to time of clearance, liability for road repairs and, in clear-fellings, as to the cutting of underwood and unmerchantable trees, and the burning of lop and top. When dealing with large areas it is desirable to specify the order in which sections shall be felled and to secure that the earlier fellings must be satisfactorily cleared before work commences on new ones.

If the owner is to fell he must consider if, and to what extent, it will pay him to make separate lots for different species, sizes and qualities, and must give particular attention to the trimming-out and cross-cutting of the stems. Bad trimming-out can spoil many a good log, and there is no greater pitfall than the temptation to cross-cut a log too high or to omit to "sound" a rotted or shaky butt (by cutting off sections till one gets back to sound timber). By cross-cutting too high large knots may be included in the butt log, the top may be left too short and rough to be really useful and, owing to taper, the total measured volume may be actually decreased; a really prime, if shorter, butt, and a useful second length giving together a full measured volume are obviously preferable. Omitting to sound the butt leaves the buyer no option but to estimate how far the rot or shake extends; he may have a very shrewd idea, but he is likely to safeguard himself well against an underestimate.

Poles and Pitwood.—Every effort should be made to sell or utilise profitably the small sizes of trees which normally come from thinnings. Thinnings are essential for the proper development of tree crops, and if the operation can be made profitable also it has a very favourable effect on the final financial return. Well-grown poles of Scots pine can often be sold at much more than pitwood price for telephone poles and electric transmission lines, and may be a product of either clear-felling or thinning. The owner who wishes to benefit by this must familiarise himself with the detailed specifications of possible purchasers, and must have a sufficient quantity to justify a sale direct or to a special merchant unless the one who takes the pitwood is also in a general way of business. Apart from this and a few other special markets, such as Dutch barn posts, copper-poles, crate or turnery poles, birch for the bobbin-mills, ash for turnery and sports goods, or sycamore for dairy utensils, the coal-mines are the main outlet for oak and conifers below timber size, whether from clear-felling or thinning. It is well worth while to take real care about material sold to collieries, for instance, *pitprops* must be sold separately from *pitwood*; the former must be cut to the sizes and lengths required, and thoroughly seasoned before despatch (see F. C. Leaflet No. 23).

The chief problem is how to dispose of the other broadleaved species; it is, as yet, unsolved, and provides scope for unlimited ingenuity and resource

except where local conditions are exceptionally favourable. The creosoting tank probably offers the solution, as the species for which there is least demand take creosote well, and then show remarkable durability (*see* Timber Preservation, page 75).

If the poles or pitwood are from a thinning it is almost essential to fell and extract them with the estate staff; if from a clear-felling the procedure must depend largely upon circumstances and it may often pay to sell standing. This should be avoided if possible, especially if the estate workmen have previous experience in cutting pitwood, and if haulage to rail and the merchant's prior inspection of the converted pitwood can be arranged for. In such case the estate should fell and convert and sell either by the 100 lineal feet or by the ton, but a clear understanding is necessary as to rate of delivery, rejections and the acceptance of railway or colliery weights as the basis of payment. If the produce is sold standing the same general precautions as suggested in dealing with timber are necessary; it is generally better to accept a lump sum rather than to arrange any price per unit of quantity.

Minor Produce is a convenient if somewhat misleading name generally used to describe all material too small or too rough for pitwood. In some localities such as the chestnut areas of Kent the " minor produce " becomes of major importance for chestnut fencing and hurdles but, generally speaking, it provides an opportunity *par excellence* for showing what can be done by an enterprising salesman, especially if he has a creosoting tank available and facilities for delivery in retail quantities.

There can be few more fascinating jobs than the search for markets, and there will be many surprises, often with more than a hint of romance, if one refuses to be content with the more ordinary sales of firewood, pergola poles, bean-rods, pea-sticks and the like. If a steady supply of suitable material is assured it is often worth while to nurse expiring local industries or to start new ones—turnery work, hurdles, chair-backs, besoms, ladder-rungs, wheel-spokes and so on through the list. No forester can serve his employer better than by finding or creating markets for this minor produce. It is not unusual on neighbouring estates to find that while one is able to dispose of the whole of this produce, the other can sell none.

If an owner is really going to make the most of these markets it will pay him, especially if he sells the timber standing, to cut or make a special sale of his underwood first. Underwood is not the only source of minor produce, however; there is still a sale for knees and bends for boat-building, alder for clog-making, and cordwood for charcoal burning; rustic work consumes much medium-sized crooked stuff from branchwood, the more twisted the better, and birch twigs, though not now in much demand by schools, are used for such different purposes as besoms, steel-making and steeplechase jumps.

Rods for making salmon traps; faggots; fascines for embankments, road making or dock construction; brush for stack-bottoms; oak bark; spile rods (for making spigots); turnery poles; materials for hoop-making, for dock fenders, chip baskets, hurdles or rustic work; even heather for thatching summer-houses or for packing crockery; moss for artificial floral decorations; walking-sticks; stakes for hedging or for tree guards and for staking fruit trees in nursery gardens; Christmas trees; these and many others, even if they are not strictly what is known as forest produce, are all grist to the mill. There are very few localities that offer no market for any of them, but it may take hard work to find it.

Timber Conversion at Whiligh

The following memorandum on methods of conversion, and prices obtained on his estate at Whiligh has been supplied by Lord Courthope, one of the

Forestry Commissioners. He adds this note: "By utilising small stuff in considerable quantities for wheelwright purposes, gate-making, etc., wastage is reduced to a very small figure. Most of the ash is sold in plank, cut through and through. In other words, the whole of the true volume, less sawdust, goes to market. In the case of oak, from 80 per cent. to 85 per cent. of quarter-girth measure finds its way into actual commercial utilisation. All the prices which I quote have been obtained here recently (1933), and are *ex* yard. In many cases I put on rail, but an extra charge is made for this. A great deal depends upon the skill of the foreman sawyer. All the primary conversion is done on a big rack bench taking a 72-inch saw, the secondary conversion on a push bench taking a 4-feet saw and with a boring table attached, and a small vertical band saw which is used for the felloes and other curved purposes."

Big park grown oak usually has good figure—the older the tree the better the figure—and is cut on the quarter for high-class work such as staircases, doors, window-ledges and frames, and floorboards.

A short butt length is frequently cleft into panels, spokes and shingles—the panels from the full radial face, the spokes and shingles from the wedge-shaped waste cut from the back of the panels.

Such trees are also used for beams and planks of exceptional size. Unusual sizes recently supplied include tie beams 28 ft. × 18 in. × 16 in.; hammer beams, 14½ ft. × 33 in. × 33 in.; panels, 3 ft. 9 in. wide; altar tables, 3 ft. 3 in. wide, etc. Such timber fetches up to 18s. 6d. per cubic foot.

Clean standards grown in coppice are usually converted as follows:—

First length.—Roof timbers and planks.
Second length.—Arris and cant rails, gate timbers.
Third length.—Posts, spurs, etc.

Oak wheel naves fetch 7*d*. per inch of diameter.

Smaller standards of 80 to 90 years cleave well. Butt lengths into shingles, park palings, and spokes. Slabs and odd pieces are cut into telegraph arms 3 in. × 2 in. or 2 in. × 2 in.; collars, 6 in. × 1¼ in.; slate battens, 2 in. × 1 in., and tile battens 1 in. × ¾ in. Building timbers range as follows:—

Rafters, 4 in. × 2 in. up to 8 in. × 6 in.; plates, 6 in. × 4 in.; purlins, 4 in. × 3 in. Prices obtained, 6*s*. to 8*s*. per cubic foot. 1-inch boards of varying lengths and 6 in. to 9 in. wide, are sold in squares of 100 superficial feet, varying according to quality from 33*s*. to 55*s*. per square.

Oak weather board fetches 30*s*. to 35*s*. per square.

Park paling is sold at a price per yard run to include posts, rails, gravel board and capping, as well as pales. The price varies with the height up to a maximum of about 19*s*. per yard run for a 7-feet fence, or the pales are sold separately; 6-feet pales fetch 42*s*. per 100; 3-feet pales, 21*s*. per 100.

Gate posts up to 6 in. × 6 in. 3*s*. 6*d*. per cubic foot; larger posts, 6*s*. per cubic foot.

A 10 feet oak field gate containing about 2¾ cubic feet of timber fetches 30*s*. and a 9-feet heave gate containing 1½ cubic feet, 20*s*.

Oak spokes fetch about 10*d*. each.

Oak or ash plank with a curved grain up to 12*s*. per cubic foot.

Straight ash plank of good quality, 6*s*. to 8*s*. per cubic foot.

Ash felloes, 4 inches, 1*s*. 10*d*. each; 5 inches, 2*s*. 4*d*. each; 6 inches, 3*s*. each. Beech felloes, 4 inches, 1*s*. 8*d*.; 5 inches, 2*s*. 2*d*. each; 6 inches, 2*s*. 9*d*. each.

Ash grown on heavy clay is usually white and of good quality. Trees up to 60 years, cut through and through, sell well for tennis racquets and aircraft, though the demand for aeroplane ash is decreasing. Older trees go for motor-coach work.

Smaller sizes, slabs and crooked lengths, are utilised for felloes, axle beds, swimmers and bosters for farm wagons (about 6*s*. per cubic foot). Tops into plough handles (4*s*. 6*d*. a pair), shim handles (3*s*. 6*d*. a pair), etc.

Both oak and ash planks with a good curve fetch good prices, about 12*s*. per cubic foot, for cart rods and the forebodies of wagons.

Very little elm is available on this estate. It is used for the floors of farm wagons and carts, or for wheel naves. Boards fetch 6*d*. per foot super. Elm naves 4*d*. per inch of diameter.

A small quantity of Spanish chestnut of sawing size is available, and is used for floor boards, staircases, window-frames, etc., on estate, 6*s*. 8*d*. to 7*s*. per cubic foot. Too little is sold to quote reliable prices.

Spanish chestnut coppice is grown on eleven years' rotation. The best fetches £20 to £30 an acre standing.

Cleft chestnut spiles—uncreosoted—fetch 16*s*. per 100.

Beech is used for the undercarriage of farm wagons, 4*s*. to 4*s*. 6*d*. per cubic foot. Beech axles, 4*s*. 6*d*. each.

There is a good, but limited, market for hornbeam. A recent sale of plank to a millwright has been at 7*s*. per cubic foot. The timber is cut into cogs, and is also used for the screws of carpenters' benches, electric bell pushes and switches, and the slats in electric dynamos. I have sold hornbeam for the latter purpose at 10*s*. per cubic foot.

There is a limited local use for poplar in oasthouses, where the "hairs", or drying floors upon which the hops are dried, are usually supported on poplar owing to its fire-resisting qualities.

TIMBER PRESERVATION

It is very well worth while to treat inferior timbers with creosote to make them available for fencing and other purposes. Many of these timbers as, for example, birch, alder, elm, sycamore and beech, take creosote readily, and can be reckoned on to give a life in service better than untreated timber of even such naturally durable species as oak and larch, and quite the equal of those species creosoted. Scots pine, too, takes creosote readily in the sapwood, but some woods take creosote very sparingly, and among these are spruce, Douglas fir, and the heartwood of oak and larch. The sapwoods of the two latter, however, creosote so well that on the score of durability there is no need, if the gates are to be properly creosoted, to reject sappy timber when sawing gate-sets.

There are four methods of applying preservatives to timber, namely, brush application, cold dip, hot-and-cold steeping and pressure. For external work in contact with the ground, brush application is little better than no treatment at all, and is to be condemned. For interior work and such external work as weather boarding, it may be quite suitable, but must be repeated every two or three years. It gives only a skin-deep penetration, and for satisfactory results it is essential that a reasonable depth of impregnation be obtained. The second method, cold dip, has given good results on several estates, but most species must remain in the steeping tank two or three weeks before enough creosote enters the timber, the method thus not being suitable for large quantities.

In the third method, where the hot-and-cold process in the open tank is followed, excellent results can be obtained, and in the more absorbent timbers enough creosote can be put into a post in 24 hours' treatment to give it a life of 25, 30, or more years. The tank can be either a horizontal one, long enough to take a fence rail and wide and deep enough to take a gate, heated by steam coils or by flue, or it may be merely a drum of about 90 gallons capacity mounted on a rough-and-ready fireplace of bricks, and with a length of piping to act as chimney to give a good draught. In a drum only the butt-ends of the posts are soaked but this is quite satisfactory if the soaking extends 6 inches or so above the future ground level, and if the tops are well brushed over with hot creosote. Drums can be purchased for about £1 each from firms dealing in road-dressing materials. Whatever be the type of open tank, it is very necessary that the following directions be adhered to.

The posts should be thoroughly peeled, both the inner and outer bark being removed, for a strip of bark will prevent penetration of the preservative. The posts should be allowed to season, being stacked in such a way that air circulates thoroughly through the pile, the lower tier of which should be raised well above the ground on stout supports. Generally speaking, the posts should not be treated until seasoned for, say, six months in the open. Some recent experiments, however, with the butt-tank appear to indicate that small posts of spruce, Douglas fir and larch may absorb creosote more readily when treated green. In treatment the posts are immersed in creosote, which is then heated to about 200°F., or just below the boiling point of water, and maintained at that temperature for about one hour, when, and this is the very essence of the open tank process—the creosote with the posts in it is allowed to cool down, the timber being removed from the creosote when it is cold. *Absorption of the creosote takes place during the cooling period.* If the number of posts to be treated is great it is a good plan to have a battery of small tanks, in one only of which the creosote is heated, the rest holding cold creosote. At the end of one hour's heating the load of posts is removed from the hot tank and placed in one of the cold tanks for 24 hours, another load of posts being put in the hot tank, and so on.

For satisfactory treatment it is desirable to obtain an absorption of ¾ to 1 gallon of creosote per cubic foot of timber. The cooling time required to obtain this absorption naturally varies with the species and degree of seasoning, and whilst with absorbent timbers such as beech and alder it may only require two or three hours' cooling, the more refractory timbers such as spruce and Douglas fir may require 24 hours or more. An estate owner will soon find by actual trial what length of cooling time is required to give satisfactory penetration for his own timbers. The cost of creosote varies from 1*s.* per gallon when bought in very small quantities, to about 7*d.* per gallon when bought in 20 barrel lots, *i.e.*, 800 gallons. It should be purchased, if possible, direct from a tar distillery or gas-works. (1939 prices.)

There are numerous recorded cases of excellent service from posts treated by this open tank method, and the British Wood Preserving Association have collected a number of posts from estates in the British Isles, showing that lives of 24 years have been given to alder, birch, poplar, elm and beech, even in gravelly soils and in districts with a 48-inch rainfall. The condition of these posts was such as to warrant another long lease of life, whereas untreated posts of the same species, and from the same sites, had decayed in from 5–7 years. Among this collection are posts of Norway spruce treated in the open tank 24 years ago, and today quite sound.

Even posts of larch and oak should be treated if they contain any proportion of sapwood. The heart will not take creosote, but the sap will; it will be given a life equal to the heart, and thus prevent the post becoming, years hence,

a mere stick of heart surrounded by void where the sap used to be. Such posts are common enough on estates where too great reliance has been placed upon the natural durability of oak and larch. Records obtained by the Association show many cases of larch, grown in warm, damp districts, decaying in under seven years when used untreated as fence posts.

On estates where there is a very large quantity of timber to be treated a pressure plant may, in the long run, prove an economy, especially as with it the more refractory timbers may be treated more easily and satisfactorily than in the open tank, and a better job made, for instance, of creosoting a gate which has already been assembled. Generally, however, for estate work, the open tank will be found sufficient, provided the timber be given a fair chance by being peeled and seasoned, and the creosote treated equally fairly by being allowed to enter the timber while it is cooling, and not expected to do so only when boiling hot.

On many estates the open tank, even when quite a large one, is a home-made affair, constructed from a second-hand rectangular tank with an old boiler shell for storage of the creosote and a semi-rotary pump to keep the rectangular tank supplied, or the steeping tank itself may be made from an old boiler. A good cast-iron sectional tank 20 ft. × 5 ft. × 5 ft., should be obtainable second-hand for about £40, and with luck, one may often be secured much cheaper ; the costs of erection and equipment will vary with local conditions. On more than one estate the tank is heated by steam coils supplied with waste steam from the saw-mill engine or the farm threshing tackle ; in such cases a wooden tank is both cheap and satisfactory. In a horizontal metal tank, a grid or some form of grating shou.d be put on the floor of the tank for the timber to rest on, so as to allow free circulation of the creosote. If the timber lies on the floor of the tank, and creosote does not circulate properly, there is a risk of the tank burning through.

On some estates alternative methods have been tried with water-soluble salts such as zinc chloride. These methods, however, have not been tried long enough to justify either recommendation or condemnation. In face of the recorded lives of posts treated with creosote the 12–14-year lives secured by alternative methods have not, in themselves, sufficient value as yet. Tar has been used extensively in the past, but it is not recommended for fence posts, because it provides merely a surface protection, and does not penetrate the wood so well as does creosote, nor is it as toxic to fungi and insects. Charring is equally unsatisfactory.

PART IV

CHAPTER IX

FINANCIAL QUESTIONS

The Working Plan, Reports and Records

An ordered scheme of management is as necessary to the working of a woodland property as to a farm. In the latter case the sequence of crops, manuring and so forth, in fact the whole cycle of operations, may be repeated twice in a decade ; for woodlands it may not be completed once in a lifetime. The length of time and importance of the issues involved require that the scheme for woodland management be committed to writing—this scheme is called a " Working Plan ".

A Working Plan must be dated; it must be drawn up for a defined period, usually 5 or 10 years, bearing in mind the much longer period required for the tree crops to complete their rotation; it should be signed by the person who prepares it, and countersigned by the owner or his representative; it need not be an elaborate document; the following will suffice:—

(*a*) **Description of Area.**—A brief description of the ground to be covered, stating its situation, total extent, ownership, geology, soil, climate, vegetation, animal life, and any other factors likely to influence the practice of forestry. This description can be done in the most general terms though this does not mean that a more detailed account would not be useful. There should follow details of the acreages of, and existing crops on, the areas to which the Plan applies; to include fields, etc., which it is proposed to plant.

(*b*) **Objects of Management.**—A statement of the aims in view, with an indication as to whether crops are being grown for sale or to provide estate requirements, and of the weight to be given to considerations of sporting and amenity.

(*c*) **Programme of Work.**—Proposals as to felling, thinning and planting operations to be carried out during the next five or ten years; to include instructions as to the choice of species. This part of the Plan should either be well spaced out, room being left on an opposite page for the record of what is actually done in each year and reasons for any modifications which have been made, or at the end of the document there should be a brief summary under each year of the work to be done, with space left for recording what work actually *is* done and reasons of variation.

(*d*) **Revision and Variation.**—Provision for revising the Plan at the end of the period, together with a statement of the latitude permitted to persons other than the owner in varying the proposals.

(*e*) **Maps.**—A map, scale 6 inches to the mile, illustrating the Plan and giving the names, acreages and boundaries of the various areas referred to therein. It will often be useful to supplement this with a 25-inch map on which the boundaries of species, rides, drainage system, etc., can be marked.

Circumstances will often prevent close observance of the programme of work, and may even require changes in the objects of management, but changes should only be made with good and sufficient reason, and with the owner's consent to important alterations. On the other hand, the strength of private planting is its power and willingness to launch out in new directions, and to take advantage of opportunities, and the Working Plan must not be regarded as a Draconian Law.

An owner is often inclined to regard some new departure as the result of considered enterprise when really it is only following the line of least resistance; for instance, the area and species planted are apt to be determined by what one has ready to go out from the nursery! The object of the Working Plan is to bring one face to face with temptations such as this, so that the necessity of having to record one's falling from grace, for the reproving eye of posterity, may save one from the fall.

Records

For efficient management one needs detailed information as to work done, expenditure and receipts. Such records can be kept in very great detail if desired; for ordinary purposes it should suffice to take the area planted in any one season as the unit and to be satisfied with information as to work done and expenditure up to the point at which the crop may be regarded as "established" (*i.e.*, requiring, as a whole, no more beating-up or weeding). Details of expenditure and receipts from thinning and final exploitation are necessary, but it is not so important to have them separately for each unit area.

The information is best recorded in a large book with two or more pages for each unit area and entered up as at 30th September each year. The details to be given include the name (or number), and a brief general description of each area, with work done, expenditure and receipts, as follows :—

(i) Preparatory work, such as draining and cutting of heather and scrub, including the cleaning up of debris left from the felling of a previous crop.

(ii) Dates of planting, species, spacing, age and origin of plants.

(iii) Dates of beating-up and weeding (with details of plants used).

If possible :—

(iv) Thinning operations, dates and yields.

(v) Final exploitation.

If the areas for planting in different years are entirely separate it should be also possible to allot fencing costs to the individual unit concerned, but some of the units are generally contiguous, and this makes allocation so difficult that fencing can best be regarded as a separate item. For this purpose a special section should be allotted to it, and details as to type of fence, length, acreage enclosed and cost per unit length and per acre of new enclosure, entered annually. There are other classes of work and items of expenditure which cannot be put against one particular year's planting area, and yet others which are not worth the trouble ; for these there will be a separate section headed " General Maintenance ".

The total expenditure to date of any one year's planting is got by taking the total on its record sheet and adding any appropriate figures for fencing and general maintenance. Interest charges, rent of land, etc., can be added if desired, but if anything of this sort is contemplated the owner should consult some advanced text-book on forest management and finance, and arrange accordingly.

Accounting System

The bare essentials are a system that will permit the effective control of operations, and will also provide data for the records described above. It is to be noted that something in the nature of the system now to be described will be necessary for making up the accounts of the expenditure on plantations which have been put under Schedule " D " for Income Tax (*see* Forestry Commission Leaflet No. 12), and also for woods Dedicated on Basis 1. (*See* page 86.)

1. **From day to day** the work done by each man should be recorded on a time-sheet under the following heads :—

(i) *Nursery Work.*—

(*a*) *Seedbeds, First Year.*—Preparation, sowing and weeding, etc.

(*b*) *Seedbeds, Second Year.*—Weeding, etc.

(*c*) *Lifting Seedlings.*—Including grading and packing.

(*d*) *Transplant Lines, First Year.*—Preparation, lining-out and weeding.

(*e*) *Transplant Lines, Second Year.*—Weeding.

(*f*) *Lifting Transplants.*—Including grading and packing.

(*g*) *General.*—Fallow and green crops, weeding paths, composting weeds, trimming hedges and other general work.

If simplification is desired (*a*) and (*b*) or (*d*) and (*e*) may be put together, or even (*a*) (*b*) and (*c*) and (*d*) (*e*) and (*f*).

(ii) *New Plantations.*—Separately for each year's planting area where beating-up or weeding is still in progress, and which is thus not regarded as established :—

(*a*) *Preparatory Work.*—Including the cutting of bracken, scrub, heather, gorse, etc., and the clearing-up of debris from the exploitation of a previous crop.

(*b*) *Draining.*

(*c*) *Planting and Beating-up.*

(*d*) *Weeding.*

(*e*) *Special Work.*

(iii) *Maintenance.*—

(*a*) *Fence Repairs.*—Including replacements.

(*b*) *Protection.*—Including rabbit-trapping, weevil-trapping, patrol for exclusion of trespassers, and fire protection.

(*c*) *General, i.e.,* small-scale weeding or beating-up operations on areas regarded, as a whole, as established ; upkeep of roads, store-sheds, etc.

(iv) *Thinning.*—To include all preliminary work and such other expenses as the proprietor is liable for under the conditions of sale *e.g.*, haulage, preparation for use or market (other than saw-milling), repairs to roads.

This information may conveniently be kept separately for :—

(*a*) Each year's planting for which earlier records are complete.

(*b*) Other woods and plantations as a whole.

(v) *Felling.*—As for " Thinning ", and including all operations associated with the disposal and clearing of the crop, *i.e.,* until the area is handed over for fencing, draining and planting.

The time-sheet is prepared in such a way that vertical tots give the total time worked by each man and thus provide information for the preparation of the pay-list ; cross tots give the total time spent and thence the expenditure on each nature of work. Owing to the unfortunate frequency with which woodmen may be taken off for short spells of other estate work, such as haymaking, it is especially necessary to provide for suitable entries on the time-sheet.

2. **Each pay-day** the man in charge of the forestry gang must fill in a report on work done. The simplest and best plan is that this should not be a written description, but an entry of the units of work done (*e.g.* plants planted, chains of drain cut or fencing erected), under the same headings as appear on the time-sheet. This is all he need do, but either he or the clerk in the estate office may add further details before the report can go on to the owner or agent. The essential is the entry, opposite each item of work done, of the labour costs (taken from the time-sheet) ; each report becomes complete in itself, and reference to a file unnecessary, if there are two extra vertical columns, one giving costs carried forward and the other total costs. This report will enable immediate action to be taken if work seems to be proceeding unsatisfactorily as regards quantity or unit cost, which is very desirable for economy in working.

3. **Total expenditures for the year** as shown on the reports will have to be carried into an annual statement of accounts. In this there must also be entered cost of plants, tools and other materials bought, and the values of produce sold or used on the estate. Receipts such as revenue from, or value of, rabbits and firewood must not be overlooked.

4. **At the end of the forest year** it is essential also to enter the requisite information in the Working Plan and in the Records for each unit of area, as has already been mentioned. It is also very useful if the forester, agent

or owner will write a report of the year's work, based on its cost, but containing also notes of the special features of the year as regards weather, the general character of the season (with a copy of the monthly rainfall record), the lessons of the year's work and the points which require special attention in the following year as the result of experiments tried, treatment given, or neglect in the year under review.

Note on Nursery Costings

Most people will wish to have some idea as to whether the nursery is being worked profitably. Anything in the nature of detailed accounting or costing involves a great deal of work, but if operations continue from year to year on a stable basis, it is very useful to get out a simple statement showing, on the one side, the year's expenditure on seed, seedlings, labour, materials and other outgoings, and on the other side, the prices of plants used from the nursery on the basis of the average nurseryman's catalogue figures. Any difference (if it is on the right side) will represent profit, and can be apportioned over the different lots of plants used and deducted from their costs, to get the figures for entering in the records as the value of stock used in the woods. This is better than charging the woods full price and showing a profit on the nursery, as, after all, it is for the benefit of the woods that the latter is maintained.

Where operations are not on a steady basis or the owner is not satisfied with this very rough and ready method, it is necessary to make allowance for the value of stocks in the nursery at the beginning and end of each year, and to make up some simple form of trading account by adding also to the one side the value of commencing stocks and to the other side the concluding stocks; in this method the profit arrived at is applied in the same way as in the previous one.

It is readily apparent that much greater detail can be entered into if necessary; for instance, by costing seedlings separately from transplants and even dealing individually with the different ages, but all such methods become highly complicated and hardly suitable for the small estate nursery.

FORESTRY AND THE STATE

Income Tax

Of all those who follow the varied trades and occupations carried on in this country the forester is the most favourably treated by the State. When, therefore, it is argued that the chief deterrent to forestry on private estates is taxation, either the argument is based on an imperfect understanding of the facts or, as is more likely, the taxation referred to is not what falls directly on woods, but what the owner of the land has to bear in some other capacity than as a forester. Forestry Commission Leaflet No. 12 sets out the facts in a concise and useful manner.

Under the Local Government Act, 1929, woodlands have been de-rated, though in Scotland rates are still paid on 12½ per cent. of their " gross annual value ". Income tax is charged on land on the estimated rent that an owner might receive from it under Schedule A, and on the estimated profits from the occupation of the land under Schedule B. Here arises the first important point. Forestry land is seldom let, and it has been customary for the Income Tax Commissioners to accept as the basis for assessment under Schedule A (and this governs Schedule B) the value at which the land has been assessed for local rates. This was, or should have been, not its value for forestry, but its unimproved or prairie value. If, for instance, an owner has afforested part of a rough heath, which has only a grazing value of 6*d*. an acre, he has been able to have this forestry land also assessed at 6*d*. an acre, however much

more it might be worth for forestry, and this assessment for rates would have governed his Schedule A and B assessment for income tax. Many owners have not in the past pressed their claims to have their forestry land assessed in this way beyond a certain point, and assessment committees have been sometimes inclined to assess on the basis of extracting all they could. The result has been a sort of compromise, woodland having been very frequently assessed at somewhere about 4*s.* per acre, of which about half was sporting value. In spite of de-rating, Inspectors of Taxes still take as a guide for Schedule A purposes this former poor-rate assessment, and where this was the unimproved value of the land, or approximated to it, rather than its value for forestry purposes, the owner of the land has gained.

This assessment based on the rating assessment is the "Gross Annual Value", and on it the Schedule A charge is usually based, but the tax is not levied until one-eighth, and in some cases more, has been deducted (*see* Note below, with regard to further relief by way of a "maintenance claim"); the interest portion (five-sixths) of the tithe redemption annuity is also deducted. In Scotland "stipend", which corresponded to the former tithe in England and Wales, is not deducted from annual value, but the tax appropriate thereto is deducted on payment of the stipend.

Schedule B—the estimated profits of occupation—is assumed as equalling one-third of the estimated annual value of ownership, *i.e.*, one-third of the gross annual value, including tithe redemption annuity. There are no deductions in this case. Thus if gross annual value (for forestry purposes) is 2*s.* per acre, a woodland owner who pays under Schedules A and B will pay on 1*s.* 9*d.* + 8*d.* = 2*s.* 5*d.* or, with tax at 5*s.* in the pound (a pre-war rate, subject to variation) 7¼*d.* per acre per annum.

It is not easy to write of probable profits from planting without bringing in the vexed question of simple or compound interest, but if it can be assumed roughly that one should get at least £10 more for an acre of timber than it has cost to establish, the income tax will not work out at a heavy rate; but there is an interesting alternative to Schedule B. An owner may place his estates under Schedule D* instead of Schedule B. Under Schedule D he is assessed on the profit for the year, *i.e.*, the year ending either 5th April of the year immediately preceding that of assessment or on such other date in that preceding year as the woodland accounts are normally made up to. This option for assessment under Schedule D has certain conditions: (1) It has to be proved that the woodland is managed on a commercial basis. (2) The option may extend to all woodland on the estate, or any planted since 1916 may be treated as a separate estate (and assessed under Schedule D), the rest remaining under Schedule B, if notice is given within ten years of planting them. Thus as old woodland is clear-felled and replanted it may be brought under Schedule D piece by piece. (3) The option once made

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Note:—In making the "Maintenance Claim" for the estate, the owner should claim, in respect of woodlands under Schedule B, landlord's expenses, namely:—

(*a*) Repair and renewal of gates and fences.

(*b*) Cleaning of ditches and repair and upkeep of roads and rides. Expenses incurred in the growing of timber, however, such as keeping open the drains in plantations, clearly cannot be charged; and the expenses mentioned under "*a*" and "*b*" above cannot be entered in the case of woodlands under Schedule D where they have already appeared in the Schedule D account.

* If an owner wishes to put the whole of his woods under Schedule D he must give notice within two months of the beginning of the financial year in which he wishes the Schedule D basis to operate. If he wishes to put new plantations only under Schedule D he must give notice before 5th April for the tax to operate in respect of the work done during the Income Tax year which terminates on that date.

must remain in force so long as the woodland is occupied by the person who makes it, but on change of ownership it reverts to Schedule B. The most favourable part of this arrangement is that during the early years of planting and establishment, when there is no profit, income tax is *repayable* on the cost of establishing and maintaining the plantations and may be *deducted* from other income tax payable by the owner.*

An illustration may be given of the working of the re-transfer to Schedule B. Suppose that an owner lives for 30 years after he has planted new plantations, which he has put under Schedule D. If establishing the plantation cost £12 per acre and maintenance an average of 6*s.* per acre for 15 years (the sale of thinnings covering maintenance for the rest of the 30 years) the owner will have recovered income tax on £16 10*s.* or at 5*s.* in the pound, £4 2*s.* 6*d.* per acre. If under his successor (whether by purchase or succession) the woods revert to Schedule B, and are sold five years later, he will, on the basis of a Schedule B assessment at 8*d.* (as in the illustration previously taken) have paid tax on 3*s.* 4*d.* or at 5*s.* in the pound, 10*d.* per acre. Schedule A income tax will have been paid on 1*s.* 9*d.* for 5 years, or on 8*s.* 9*d.* which entails tax for 2*s.* 2*d.* Thus the owners during the rotation will have *received* on account of income tax, £4 2*s.* 6*d.* less 3*s.* = £3 19*s.* 6*d.* per acre.

This is a fancy picture, because it is taken for one plantation only, the owner of which sells or dies very conveniently, whereas an owner does not plant a single plantation and then stop, or even plant for a few years only, nor if he did could he arrange to die just in between the time that his plantations ceased to be a liability and became an asset. If a proper forestry policy of steady planting and felling is adopted there will, in fact, normally be little advantage in the transfer back from Schedule D to B.

This is, in effect, the true position :—One pays a very moderate amount under Schedule A, whether one actually makes profits or not. One pays a smaller amount under Schedule B whether one makes profits or not. One pays under Schedule D on profits made, and recovers on the excess of costs over income, with this advantage, that there is a sensible relief during the expensive years of establishing plantations and therefore a real encouragement to an owner who is setting out on forestry on a business basis for the first time. The re-transfer to Schedule B should not be regarded, and normally cannot be used, as a way of dodging fair taxation, but only as an alternative method which may benefit a successor who is forced to raise large sums from woodland to pay the death duties on the rest of the estate.

In the year of assessment 1947/48 and subsequent years, the owner or tenant of forestry land assessed to Income Tax under Schedule D who has incurred capital expenditure after 5th April, 1944, on the construction, reconstruction, extension or adaptation of forestry buildings, cottages, fences or other works for the purposes of forestry on the land he owns or occupies, will be able to claim relief in the form of annual allowances of one-tenth of the expenditure each year for ten years.

A few further points should be noted as to the Schedule D assessment. Where new plantations as they are established are placed under Schedule D, the cost of clearing up (not felling) the old crop is an admissible expense in establishing the new one. Tax payable under Schedule A is balanced by the allowance of the amount of the net Schedule A assessment as an outgoing in the woodland accounts. Government Grants given for planting or maintenance, are, of course, deducted from the expenses of planting when making out the Schedule D balance sheet, just as any other receipts would be.

* Where the owner has earned income from other sources the repayment may fall to be restricted by reference to earned income relief.

DEATH DUTIES

The arrangements as to Death Duties (*i.e.*, Estate Duty and Succession Duty) are an even more striking instance of the favour shown to forestry.

In brief, whereas Death Duties are payable on nearly all property once in a generation, timber is exempt from duty unless and until it is sold. Also the graduated rates of estate duty may be lower for woodlands (unless they have a latent value, *e.g.*, for building) than in respect of other property. Also the value of timber is *not* taken into account in estimating the principal value of the estate or in determining the rate of estate duty chargeable on the whole estate. Also the duty on timber is actually payable (estate duty at the rate mentioned above) only as and when the timber is sold, and in the case of the sale of timber felled or cut there may be deducted from the proceeds of sale " necessary outgoings since the death " in arriving at the net proceeds upon which the particular payment of duty is calculated; this is further explained below. Also if at any time the timber or any part thereof is sold unfelled, either with or apart from the land, estate duty is payable on the principal value as at the date of death, of the whole or on a proportionate part thereof. Also duty is not payable on underwood sold, or on any timber cut for the use of the estate. Also in practice the principal value of the timber at the owner's death is treated as the maximum amount on which duty is to be charged in respect of all sales of timber felled and/or unfelled. If the successor dies before that limit is reached no further duty has to be paid in respect of the predecessor's death.

The " necessary outgoings " which can be deducted in arriving at the net amount on which duty is payable may, generally speaking, be taken to include (1) expenses of sale; (2) expenses of felling and drawing out the timber, and of restoring the fences, ditches, roads, and gates damaged in the process, so far as these expenses are borne by the vendor; (3) *expenses of replanting* ground on which timber has been felled or thinned; (4) expenses of management so far as intrinsically necessary.

An illustration, which for the sake of simplicity deals with estate duty only and assumes that all sales are of felled timber, may make the point clearer. Suppose that the value of the timber on an estate at the time of death is agreed with the Inland Revenue at £10,000 and that the rate of estate duty applicable to the rest of the estate is 10 per cent. The maximum estate duty payable will be £1,000. Actual payments of duty will not aggregate £1,000 unless and until the successor lives to realise £10,000 net from timber sales, *i.e.*, after deducting " necessary outgoings " as mentioned above. Suppose that these deductions have amounted to £2,000 he will have realised £12,000 gross before the duty reaches £1,000. Whatever further sums the timber may thereafter realise, no more duty is payable unless the sales were so soon after the death and at such prices as to indicate that the agreed value was too low. On the other hand, if the successor dies when the timber sales have realised £6,000 gross and £5,000 net, then the duty paid will have been £500 and no more is payable in respect of the predecessor's death.

An interesting consequence arises from the special consideration given to timber for death duty purposes. If an owner, wishing to help his successor to pay Death Duties, insures his life, the amount for which he has insured it is added to the value of the property in determining the rate of duty payable, and may well bring it under a higher rate of duty than would have applied to the estate alone. If he puts the amount which he would be paying in life insurance premiums into growing timber, the value of the timber on his death will in no way affect the rate of duty charged on his estate.

DEDICATION OF WOODLANDS

Purpose of the Scheme

The purpose of the Scheme is to encourage the application of systematic management to private woodlands. This step has become necessary, in the interests of national security, because the reserves of standing timber have been again greatly depleted during the late war, and also because the area of land suitable and available for timber production in Great Britain is limited.

Action is desirable also because of the waste of national resources when woodlands are neglected. By increasing the yield from home woodlands Britain can be made less dependent on overseas supplies of timber in peace as well as in war.

Outline of the Scheme

The origin of the Scheme is explained in the Forestry Commissioners' Report on Post-War Forest Policy (Cmd. 6447), Chapter III, dealing with Private Woodlands. A Supplementary Report entitled "Post-War Forest Policy, Private Woodlands" (Cmd. 6500) records agreement on principles reached between the Commissioners and Representatives of bodies interested in Private Woodlands. The Scheme as adopted by the Government is in strict accordance with that agreement.

The fundamental principles underlying the Scheme are as follows :—

(1) That the rehabilitation of the Woodlands must proceed with both certainty and rapidity.

(2) That all planting, and natural regeneration acceptable instead of replanting, must be properly looked after up to the stage of satisfactory "establishment."

(3) In every case the Owner must reach an early decision as to whether he is prepared to proceed with the work of rehabilitation.

(4) If an Owner is so prepared and can give satisfactory assurances he is deserving of financial assistance from the State.

(5) Where no satisfactory assurances are forthcoming within a stated period the State should acquire the land.

(6) That the wartime system of felling licences must continue until the reserve of standing timber can be adjudged satisfactory.

(7) That some degree of control of the silviculture of private woodlands is necessary.

The basis of the Scheme is that all woodlands judged to be suitable and necessary for timber production should either be dedicated to that purpose by the Owner or acquired by the State. Dedication would run with the land and would be unaffected by changes of ownership.

A covenant of dedication will be entered into by which both the State and the Owner undertake the respective obligations stated below. The Covenant would provide for arbitration in the event of disagreement.

Owner's obligations.—The Owner to undertake :—

(1) To use the land in such a way that timber production is the main object.

(2) To work to a plan, to be approved by the Forestry Commission, laying down the main operations to be undertaken.

(3) To employ skilled supervision.

(4) To keep adequate accounts.

The State's Obligations.—The Forestry Commission as the Agent of Government will undertake to provide financial assistance to the Owner on one of two bases at the Owner's option (the basis having been selected will not be changed subsequently) :—

Basis 1.—To repay the Owner 25 per cent. of the approved net annual expenditure on the dedicated woodlands.

Loans to be made available as for Basis 2.

Basis 2.—To make payments to the Owner as follows :—

(1) A Planting Grant of £7 10s. per acre for every acre planted or replanted whether hardwoods or softwoods.

(2) Loans (in addition to (1)) up to an amount to be fixed with reference to individual circumstances ; the rate of interest is still under consideration.

(3) A Maintenance Grant for 15 years of 2s. 6d. per acre per annum on every acre planted and properly maintained.

(4) A Maintenance Grant for 15 years of 2s. 6d. per acre per annum from the date of dedication on all productive woodlands other than new plantations (which are already covered by (3) above).

(5) Grants to be revised after 5 years on the basis of ascertained costs.

Proviso.—It will be an essential part of the Covenant that in the event of dedication tending to break down, so that the State has to assume management, any financial assistance which has been afforded should be taken fully into account in the terms of settlement.

Requirements under the Scheme

The Owner's undertakings.—It should be explained, generally, that it is not the intention of the Commissioners to require an Owner to undertake works which, because of extraneous or temporary circumstances, such as shortage of labour or skilled supervision, are in practice unreasonable. At the same time it is urgent to get on with the work of rehabilitation and a beginning must be made commensurate with the available means.

(1) **Use of the land.**—The primary objective is timber growing. That does not mean the exclusion of sport and amenity, but their reconciliation with the needs of good silviculture.

(2) **The Plan of Operations.**—This may be quite a short document defining the woodlands and laying down the quantities of essential work to be done annually over a stated period, which would normally be 10 years. By essential work is meant planting, thinning and felling. It is proposed to make the plan elastic, and the forecast of annual quantities will therefore be subject to reasonable variations to meet unforeseen circumstances. In determining the felling programme special attention will be paid to timber required for estate purposes. The choice of species for planting may be stated in general terms, leaving reasonable freedom for variations of soil conditions, encouragement of natural regeneration, etc. In general, all subsidiary operations such as drainage, beating up, weeding, protection against ground game, etc., will have to be conducted according to sound silvicultural practice.

A necessary part of the plan will be a schedule of areas qualifying for maintenance grants (Basis 2).

Forestry Commission officers will assist, if so requested, in the preparation of the plan.

(3) **Skilled supervision.**—Normally a trained forester is desirable, but it is realised that in the early stages at least it may be difficult to secure fully qualified supervisors. In such case the Commission will be prepared to help through its own servants. Should the Owner or his Agent possess the requisite silvicultural knowledge and time it may be possible to dispense with further supervision.

Owners whose woodlands do not justify the full-time employment of a skilled supervisor are recommended to explore the possibility of sharing one with neighbours who are in a like position.

(4) **Accounts.**—If Basis (1) is adopted the keeping of accurate accounts is essential, but with either Basis accounts are invaluable as a means of securing economical working. Account keeping need not be a bugbear. The data required for keeping accounts in the appended form are well within the capacity of an intelligent foreman. Forestry Commission officials will help with advice if so desired.

The Commission's undertakings.—Generally, it will be necessary to ensure that payments claimed have been earned. An annual inspection of work will be necessary, but it is hoped that this may also prove an occasion for the exchange of technical information and the discussion of problems.

(1) **Net Expenditure** (Basis 1).—The net expenditure will be ascertained by deducting woodland receipts from gross expenditure. There will be brought to account all items which the Commissioners themselves apply in developing woodlands. (See also appended Form of Account.)

(2) **Planting Grant** (Basis 2).—Successful natural regeneration will qualify for the Grant. Partial planting will be assessed *pro rata*, according to the number of plants used per acre.

(3) **Loans.**—It is hoped to issue a further note on this subject at a later date.

(4) **Maintenance Grants.**—In the case of new plantings, maintenance will include such items as weeding and upkeep of drains. As regards productive woodlands, the qualifying test will be the capacity of the crop to grow on to useful timber of reasonable dimensions and quality.

Coppice and coppice-with-standards properly managed as such will qualify for planting grants (*pro rata*) and maintenance grants.[1]

(5) **Revision of Grants.**—It is proposed to seek the co-operation of a number of Estates, suitably distributed as to silvicultural conditions, in securing the required data.

Procedure

It is proposed that all woodlands shall be surveyed and their suitability for dedication assessed. Owners will be informed as soon as possible of the result and invited to express their points of view.

A complete survey will take some time. In the meantime it is known that many Owners desire to dedicate their woodlands, and it is hoped that they will communicate their intention to the Commission without delay. The attached form may be used for the purpose. Inspections will be made and

discussions initiated as soon as possible. Letters on this subject should preferably not be addressed to the Commission Headquarters, but as follows :—

ENGLAND : The Director of Forestry for England,
Camp House,
Promenade,
Bristol, 8.

SCOTLAND : The Director of Forestry for Scotland,
25 Drumsheugh Gardens,
Edinburgh, 3.

WALES : The Director of Forestry for Wales,
Camp House,
Promenade,
Bristol, 8.
(Temporary address.)

Woods not suitable for Dedication

All the foregoing remarks relate to woodlands which are suitable for dedication. Planting grants at the rate of £7 10s. an acre (but no maintenance grant) will be available for other woodlands on the understanding that the timber may be felled in a national emergency.

Leaflet on Taxation of Woodlands

Forestry Commission Leaflet No. 12, dealing with Taxation of Woodlands, may be obtained free on application to the Secretary of the Forestry Commission, at 25 Savile Row, London, W.1.

FORM OF ACCOUNT

.....ESTATE (Dedicated Area.....acres)

Account of Forestry Operations for year ended.....19.....

(Annual Programme to be as prescribed in the Agreed Working Plan and items of Capital Expenditure to be subject to prior approval)

PAYMENTS	£	s.	d.
1. Annual Value of Land for forestry purposes and Rates thereon (if any)			
2. Labour			
3. Seeds, Plants and Materials purchased			
4. Supervision and Management			
5. Insurances (Fire, National Health, Unemployment, Workmen's Compensation)			
6. Tools, Plant and Equipment—			
(*a*) New			
(*b*) Repairs and renewals ...			
7. Hire of Transport and Implements			
8. Workers' Housing—			
(*a*) Rents			
(*b*) Allowances			
(*c*) Rates			
(*d*) Repairs			
9. New Works (housing, roads, etc.), viz. :—			
....			
....			
10. Other Expenses, viz. :—			
....			

RECEIPTS	£	s.	d.
1. Sales of Nursery Produce			
2. ,, Timber			
3. ,, Thinnings, poles, etc.			
4. ,, Minor Forest produce, e.g., bark, underwood, faggots and firewood			
5. Other Receipts, viz. :—			
...			
....			
6. Timber and other Forest and Nursery Produce used on estate and non-dedicated woods			
Balance, being net payments			

NOTES—

(*a*) *Work done.*

Preparation of ground .....acres
New fences (permanent) .....chains
New drains (permanent) .....chains
Planting, Underplanting and Direct Sowing .....acres
Plants used for Planting and Underplanting .....thousands
Beating up 1st.....acres ; 2nd.....acres
Plants used for beating up .....thousands
Weeding and cleaning 1st year.....acres ;
2nd year.....acres ; 3rd year.....acres
Brashing and Pruning .....acres
Thinnings 1st.....acres ; 2nd.....acres;
3rd.....acres
Felling .....cu. ft.
New Works (Description) :—
Other Work (Description) :—

(*b*) *Explanation of any exceptional costs and items.*

For Inland Revenue purposes.

Net Schedule A Assessment... ... ...£
Land Tax ... ...£
Tithe Rent Charge Annuity or Stipend ...£
Cost of new fences (permanent) ... ...£
Cost of new drains (permanent) ... ...£

I declare the foregoing to be a full and true account, to the best of my judgment and belief.

Signature .....

Address .....

DEDICATION OF WOODLANDS

Name of Estate.....

Parish..... *County* .....

Name and Address of Owner.....

Name and Address of Agent.....

Approximate area of Woodlands .....acres.

I am prepared to consider placing the above woodlands under the Forestry Commissioners' Dedication Scheme.

As at present advised I prefer :—

(*a*) Basis 1.

(*b*) Basis 2.

(Signed) .....Owner.

.....Date.

Application forms as above are obtainable from : The Secretary, Forestry Commission, 25 Savile Row, London, W.1.

(51349) Wt. 3063—1457 10/46 D.L. G. 344

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The Secretary,
H.M. Forestry Commission,
25 Savile Row, London, W.1

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