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 and Agents.

LONDON
PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE
To be purchased directly from H.M. STATIONERY OFFICE at the following addresses
Adastral House, Kingsway, London, W.C.2; 120, George Street, Edinburgh 2
York Street, Manchester; 1, St. Andrew's Crescent, Cardiff
15, Donegall Square West, Belfast
or through any Bookseller

1933

Price 2*s.* 0*d. Net.*

70—31—14

PREFACE.

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 (on payment of a small fee and expenses) 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.

It is on the suggestion of the English Consultative Committee on Forestry that this publication has been prepared. Since their suggestion was made Mr. W. E. Hiley has brought out " Improvement of Woodlands " (Country Life, Ltd., London, price 10*s.* 6*d.*), which should be of great value to them, and to all who are concerned with woodlands. It should stimulate interest and deserves a wide circulation. But it covers a wider ground than is attempted here, and the two publications will not in any important respects take one another's place. This work, indeed, seems to fit in both with Mr. Hiley's book and with Mr. C. O. Hanson's " Forestry for Woodmen " (Clarendon Press, Oxford, price 6*s.* 6*d.*), which is primarily intended for working foresters.

One of the Commission's Divisional Officers, 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.

The Commissioners desire to express their gratitude to the members of the Land Agents' Society (and particularly to Mr. Leslie Wood), who have devoted great pains to providing the detailed information summarised in Part V, and to Mr. R. C. B. Gardner, Secretary of the British Wood Preserving Association, for providing the material embodied in the section on Timber Preservation.

FRANCIS D. ACLAND,
Commissioner.

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

February, 1933.

BULLETIN No. 14

FORESTRY PRACTICE

CONTENTS

PART I.

NURSERY WORK.

INTRODUCTION.

The first question to be decided is whether to have a 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. To maintain supplies of plants of the ages recommended on pages 28–37, 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 seed beds. In preparing it, 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.

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 seed. If it 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, and a piece of old coniferous woodland is often excellent, though the stumps present a formidable problem.

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 Bucco cultivator 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 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 19). 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 unwise to sow conifer seed in the first year or two. The ground should first be used for raising transplants and thus inoculated with the micro-organisms which are lacking in soils which have not previously been under trees.

Details of certain of the Forestry Commission's earlier investigations as regards nursery practice are published in Bulletin No. 11.

CHAPTER I.

THE GROWING OF SEEDLINGS.

1. The 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 (except oak) 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.

Species.	Spacing recommended.	Per acre of planting.			Remarks.
		Plants required.	Seed to be sown in nursery.	Plants to be lined-out.	*General Note.*—Closer spacing may be used where there are good markets for early thinnings, provided that the necessary thinning will actually be done.
		CONIFERS.			
	(feet.)		(oz.)		
Western Red Cedar (*Thuya*)	5 × 5	1,742	2½	2,200	
Lawson Cypress	5 × 5	1,742	3	2,200	
Douglas Fir ..	6 × 6	1,210	3¼	1,600	
Western Hemlock	5 × 5	1,742	3	2,300	
European or Common Larch	5 × 5	1,742	9½	2,500	Can be spaced 5½ × 5½ in good sites, if desired.
Japanese Larch	5½ × 5½	1,440	3½	1,800	Can be spaced 6 × 6 in good sites, if desired.
Austrian Pine ..	4½ × 4½	2,151	6	2,500	For windbreaks. Space wider for nurse-crops.
Corsican Pine ..	5 × 5	1,742	9¼	3,000	
Lodgepole Pine..	5 × 5	1,742	4	2,100	Space 4½ × 4½ on the worst sites.
Maritime or Cluster Pine	5½ × 5½	—	—	—	Establish by direct sowing of 3 to 4 lb. of seed per acre.
Monterey Pine ..	5½ × 5½	1,440	10	1,800	Can be spaced 6 × 6 in good sites, if desired.
Scots Pine ..	4½ × 4½	2,151	5	3,000	
Norway Spruce..	4½ × 4½	2,151	2½	2,700	Can be spaced 5 × 5 on better sites and for turf-planting.
Sitka Spruce ..	5½ × 5½	1,440	2¼	2,100	Can be spaced 6 × 6 on the better sites if desired; should be 5 × 5 on the poorer.

Table I—continued.

Species.	Spacing recommended.	Per acre of planting.			Remarks.
		Plants required.	Seed to be sown in nursery.	Plants to be lined-out.	
		HARDWOODS.			
Ash	4 × 4	2,722	4 lb.	3,400	Plant only in strips and groups. Wider spacing sometimes justified.
Beech	4 × 4	2,722	25 lb.	3,600	Wider spacings suitable when planted with nurses.
Birch ..	8 × 8 (as a nurse)	680	—	—	Plant only in very exceptional cases to shelter frost-tender species. 1 lb. of seed will give from 1,000 to 2,000 transplants.
Sweet Chestnut..	4½ × 4½	2,151	½ cwt.	2,700	
Oak	*See* page 38	About 2,700	½ cwt.	—	To provide seedlings for patch-planting (*see* page 39)

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 quite dry. 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 ; ash must be stored for a year mixed with sand in a box buried beneath the ground. 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 ; these are described in full in Bulletin No. 11. 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 2.

Species.	Sq. yds. per lb. of seed (average quality).		Depth of cover.
	Drills.	Broadcast.	
CONIFERS :—		Sel-Cr 75	(inches.)
Western Red Cedar (*Thuya*) ..	60	44	½
Lawson Cypress	55	40	¼
Douglas Fir	45 60	33 45	¼
Western Hemlock	90	60	½
European Larch	45 65	33 45	½
Japanese Larch	95	65 60	½
Austrian Pine	27	20	⅜
Corsican Pine	40	30 35	½
Lodgepole Pine	90	60 75	¼
Mountain Pine	20	15	¼
Monterey Pine	30	20	⅜
Scots Pine	35	25 55	¼
Norway Spruce	40 60	30 45	¼
Sitka Spruce	95 115	65 85	½

Species.	Yards of		Depth of cover.
	6-in. band.	3-ft. bed.	
HARDWOODS :—			(inches.)
Ash	25	12	½
Beech	10	4	¾
Birch	—	25	⅛
Sweet Chestnut	2½	½	1½
Oak	1½	½	1½

2. 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, and precautions must be taken against flooding in rainstorms. The ground should be divided up into seedbeds 3 feet to 3 feet 6 inches broad, which should run up and down the slope.

The beds should be divided by alleyways 14 to 18 inches wide, left to facilitate access for sowing, weeding, etc., and to help drainage in wet climates. The soil is firmed and brought to the finest possible tilth, in the same way as for onion beds. 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 2 above gives the number of square yards which will be required by 1 lb. of seed, and from this the area of the beds can be calculated.

3. Preparation of Seed for Sowing.

Seeds of European larch, Douglas fir and Sitka spruce germinate better if they are given preliminary soaking in water at ordinary temperatures. The seed, enclosed in canvas bags, is merely immersed in a bucket or other receptacle, or put between sacks which are kept wet. Larch should be soaked for one day, and Douglas fir and Sitka spruce for from five to seven days.

Before being sown seed should always 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, 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.

4. Sowing the Seed.

The chief points in the sowing of all seeds and particularly conifers are that they should be covered with the right thickness of soil (which is given in Table 2 above), and, more important still, that this covering of soil remains loose and friable and does not form a crust under the influence of weather. It is, in fact, safest to use pure sand for covering all the smaller seeds unless the nursery soil is exceptionally light and suitable. Compared with these points the dates of sowing are relatively unimportant, but the general principle as regards conifers should be to start with Douglas fir as soon as the ground can be got in order. Even the latter part of February is not too soon for this species, especially if the seed is old. The pines and Norway spruce should then be sown, and last of all Sitka spruce and the larches, in that order. Except where there is virtually no danger from spring frosts or the caking of the soil, it is unwise to sow Sitka spruce or larch earlier than April in the south and May in the north. Birch should be sown after the larches; other hardwoods may be sown as soon as possible after the end of January, and are useful for keeping the work going during intervals when the soil is not working well enough for conifers.

Many people sow conifers broadcast, but the simplest and best method for the fairly small-scale forester is in drills. Hardwood seeds are best sown in bands, but the bigger seeds such as chestnut may well be dibbled in.

(*a*) *Drill Sowing.*—Drills can quite easily be made with a piece of inch board, the edge being pressed down into the soil to the precise depth required for the particular sort of seed. When working on a small scale the best practice is for two men to use a piece of board rather longer than the width of the bed pressing it down at intervals of 4 inches—the board being clearly marked along the sides at the desired depth. 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 evenly 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 fine dry soil exactly up to the top so as to give a covering of the required depth. A riddle may be used, or shallow wooden troughs, 1 inch wide, which should be filled level with soil and then emptied into the drills, facilitate this process. 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.

(*b*) *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 1½ inches 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.

5. Care of Seedbeds.

Several sorts of coniferous seeds need to be sheltered during the first twelve months after sowing. Shelter is not necessary for the pines, and other seeds should be sheltered 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, and 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. For seed of broad-leaved trees, shade is never necessary. This shelter provides 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.

The first weeding, especially in broadcast beds, is an expensive and tricky business, as many of the annual weeds germinate before the tree seeds. 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 obtainable for this work (*see* page 74), 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.

During the winter, protection from frost must be given to beds of Sitka spruce and Douglas fir and to the larches where the soil retains much moisture and there is, therefore, danger of frost lifting. 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.

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

6. 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 prized 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. Grading is dealt with in subsequent chapters. Counting of plants, desirable as it may be, will not help them to grow, and will probably have the reverse effect if their roots are exposed in the process! A rough estimate at the time of lifting should suffice; this can be followed by an accurate count after lining-out is finished.

CHAPTER II.

THE PRODUCTION OF TRANSPLANTS FROM SEEDLINGS.

1. 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 warmly tucked up in a bed. 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. For 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 on 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 root system. Forest tree seedlings, however, should be treated like very young babies. They must, when naked, 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 these should be covered over while 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 it. Everything done must be subsidiary to the main purpose which should be 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.

2. The 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 page 9 gives the information required and allowance has been made in it for normal wastage and culling.

In accordance with the recommendations below as to lining-out the lines will accommodate 65 plants to the square yard, 1,966 to the rod, and 314,000 to the acre. 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 being covered with straw or bracken. The trenches should be in a shady place if possible.

3. Time of Transplant.

Nursery operations should be so ordered that larch seedlings can be lined out before the end of February, and Corsican during that month. The dates of lining-out other species are comparatively unimportant, provided they are moved during the rest period, and that if there is any sign of shoot activity especial care is taken in handling them.

4. Preparation of Ground for Transplant Lines.

The treatment must vary according to the nature of the ground selected. It should bring the ground to the condition required for an average garden crop such as cauliflowers or brussels sprouts.

5. Method of Grading.

General considerations as to the objects and advisability of grading both of seedlings and transplants are given later (page 18), 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 three grades should be put into the three spaces between the fingers of the left hand and the two grades which are being kept should have their roots covered with earth before a fresh handful is dealt with.

6. Lining-Out.

In setting out the plants the object must be to set them at the same depth as that which they occupied in the seedbeds, and that their roots should occupy their natural position. This can be most nearly assured in practice by opening out a straight-backed trench 9 inches deep (or more if necessary) to take the plants. A beginning should be made on the windward side of the ground, and a spit of earth should be taken out and wheeled to the other end of the ground where it will be wanted to fill up the last trench. Then the man who is lining-out moves along the trench with his left side towards the straight back and the wind, and his left knee in the trench. He takes a bundle of seedlings in the left hand, singles them with the fingers of that hand or, if less expert, with the right and then fixes them in position by drawing fresh soil up to their roots with the right hand. As he moves forward the pressure of the left knee firms the soil about their roots. After finishing the line, soil is turned into the trench with a spade, firmed round the plants by treading, and then levelled; the next straight back is dug in the firmed and levelled soil exactly 10 inches from the previous line, *the loose soil being well pulled back.* This is necessary not only in order to make sure that there is no doubling-in of the root ends of the seedlings, but because it will be found that for good and rapid work it is essential to maintain a proper trench throughout the operation.

Some people prefer to use transplanting boards (*see* page 74) for placing the plants in the trench. These are constructed so as to hold the seedlings at the right depth and spacing; they are "filled" under shelter, often by boys or women, and carried bodily to the trench when ready. The boards are not suitable for use in stony ground, and are not necessarily an economy, whilst there is always the risk that roots may be too much exposed in filling and carrying. It is largely a matter of personal opinion and local conditions as to whether the merits of the board outweigh its disadvantages.

7. Weeding.

The ground should be treated very much like that in which carrots 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.

8. 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 in four minutes undo all the good results of 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 they will be wanted. If they are not to be moved immediately after lifting, they must be protected from sun and wind by being properly heeled-in—as described for seedlings (page 16). 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.

9. Grading Policy.

The technique of grading has been described above (page 16). 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 seedbeds are there certain 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 seldom worth the trouble it gives, and 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 emphasized that surplus stocks, unless grown for resale, 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 should be used, and the seedlings should be cleanly cut a few at a time, and not when they are in bundles.

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.

10. 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 generally not 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.

1. Maintenance of Fertility.

Nursery land, no less than land for agricultural crops, has certain definite requirements both of lime—on physical and chemical grounds—and of nitrogen, phosphorus and potash, and any deficiency should be rectified in the manure given to the preparatory crop when the nursery is first prepared.

It must be realized, too, that every transplant which leaves the nursery takes with it some of the mineral content of the soil, and that this must be put back. The best procedure is to arrange that

not more than two-thirds of the nursery area should ever be under seedbeds or lines. The rest should be manured by one or other of the following methods: (*a*) a single-season crop, after applying the appropriate manure, of potatoes, or a green crop of lupins, mustard or vetches; (*b*) a two-season crop consisting of a summer crop, say, of lettuces, followed by an autumn-sown crop of rye and tares; (*c*) summer fallowing—if the ground has been allowed to get very dirty, with the subsequent application of leaf-mould and/or an artificial manure, such as bone-meal. Provided the ground is cropped or fallowed in rotation as suggested, there should be little need for further manuring, but the application of a little additional phosphate to the seedbeds may be found beneficial. A suitable dressing is 2 oz. of bone-meal per yard of bed when the seedbeds are being prepared.

Leaf-mould is usually better than farmyard manure for manuring seedbeds; it should be composted with lime, and when well broken down should be distributed over the ground before the final cultivation in preparation for sowing or lining-out.

2. 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 40), 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. The only treatment is to watch and to have a man who really knows how to set a mole trap.

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 larvæ 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, summer digging, 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. A heavy dressing of kainit (20 cwt. per acre) dug in before sowing a green crop has also proved successful, and 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 it seems possible that

lead arsenate (5 lb. per 1,000 square feet) may prove efficacious against the leather-jacket.

Of smaller insects, the most troublesome are probably the green-fly family (Chermesidae), 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 dealt with in Part II (*see* page 66), but in most cases the damage is unlikely to be serious. The most important exception to this is a disease which attacks the larches (*Meria laricis*), causing their needles to turn brown and drop off, with consequential reduction of the plants' vigour, so that they sometimes die after lining-out or planting. The damage done may be distinguished from that due to frost as follows:—*Meria* starts at the middle or the end of the needle and spreads down it, whereas frost kills the whole needle at once; *Meria* seldom attacks the needles at the extreme tip of the shoot, whereas that is the part most affected by frost; needles attacked by the fungus are less shrivelled than those killed by frost, even when completely browned. Infection spreads from cast needles lying on the ground, and stocks may become badly infected if allowed to stand in beds or lines for two years. A good treatment is to move the plants after one year, and to spray fortnightly from March to May inclusive with liver of sulphur solution (1 lb. well mixed *in* 14 gallons of water per 300 sq. yds.).

Sometimes one-year seedlings in beds start to fall down as if they had been nipped at the ground level, or to die while still standing up, especially in damp weather, when neither drought nor frost can be the cause. This is due to damping-off fungi, and risks can be materially reduced by avoiding denser sowings than those given on page 11, and keeping seed beds in good fertility and tilth. A solution of 1 oz. of potassium permanganate in two gallons of water is an effective remedy. For a first application to ground being used as seedbeds for the first time, apply two gallons to three square yards, using a fine rose; for normal applications half this quantity applied at weekly intervals till the danger is over will suffice. The solution does no harm whatever either to seed or seedlings. The attacks come on extremely rapidly, and should be watched for and jumped-on at once. May and June are the most dangerous months.

Against oak mildew (*Oidium quercinum*) spraying is effective, and is essential to the raising of healthy stock. Seedlings should be sprayed as soon as the mildew appears, and twice more at intervals of one month. To make 50 gallons of spray, which is enough for 500 square yards of seedbed, mix 1 lb. of flowers of sulphur with 1 lb. of calcium caseinate, and enough water to make a paste; then add further water to make the 50 gallons.

PART II.

PLANTATION WORK.

CHAPTER IV.

PREPARATION.

1. 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. But 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 up 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 reasonably good 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.

The Forestry Commission have collected much information as to the rates of growth and yields of timber of existing plantations; details are contained in Bulletin No. 10. It must be remembered that it is dangerous 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 often 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 41–42 ; the following figures are calculated on the assumption that fencing (including rabbit netting) costs £1 per chain :—

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

A 2-acre strip 20 chains by one 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 96 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, not only so as to fit in as suits him best with his markets and with other operations, but so as to get a few years more timber growth, after it has been measured and a price agreed on, without paying for it. 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 strong coppice shoots and brambles. 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 and 4 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 £22, 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 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 not taken off for haymaking and harvest, or for weeding paths after rain, or for removing wind-fallen trees, 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

---

* As an average figure, this is rather a low rate. More detailed figures for different types of planting are given later, pages 54–55.

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.

2. 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 reafforesting 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. But 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. They also necessitate far deeper knowledge of forest technique than will generally be possessed by the ordinary owner and agent who have to occupy themselves with many and varied duties. 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 properly. 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, larch may be used to nurse oak, which gives a mixed crop at first, but leaves a final stand of pure oak, the larch 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, at one stage or another, mixtures tend to mean mess.

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 anyone who takes " safety first " as his planting motto. But experiment, if wisely conducted, 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.

Species.	Conditions justifying selection.	Unfavourable or unsuitable conditions.
Cedar—Western Red .. *Thuya plicata*	Suits a wide range of soils including fairly heavy clays. Stands shade well.	Does not thrive on sour peaty soils, and is liable to disease, especially in high rainfall districts—60 to 80 inches.
Cypress—Monterey .. *Cupressus macrocarpa*	Useful as a shelter-belt tree along the sea coast.	—
Cypress—Lawson .. *Cupressus Lawsoniana*	It requires a good deep fertile soil, and will stand shade well. Might be more extensively used.	Dislikes hot dry soils.
Douglas Fir (Oregon or Green form) *Pseudotsuga taxifolia (Douglasii)* Trade name of timber Oregon pine, but the use of "Douglas fir" is becoming more general.	The better types of soils, *i.e.*, deep, well drained and fertile, where for any reason it is not desired to use oak or larch. Prefers north and east aspects.	Definitely unsuitable for exposed situations, badly aerated or wet soils, shallow soils over chalk and limestone, areas subject to smoke or fumes and ground liable to late frosts. Very liable to wind-blow on damp and soft soils.
Hemlock—Western Hemlock *Tsuga heterophylla*	Will stand a large amount of shade, and is therefore good to plant under open crops of larch. It is a quick-growing tree of great beauty.	—
Larch—European .. *Larix decidua (europaea)*	For short rotations can be grown successfully on a wide range of sites provided they are airy, and the conditions given in the next column are avoided. For long rotations it also needs well-drained loamy soils and a sheltered situation. Bracken land is generally suitable.	Avoid: poor sands; late frost-hollows; shallow soils on chalk; peat soils; badly drained soils; exposed sites at high elevations; soil which has had a larch crop just previously.

INDIVIDUAL SPECIES.

CONIFERS.

Age to plant.	Notes on timber.	General remarks.
2 yr. + 1 yr. or 2 yr. + 2 yr., according to size and site.	When clean grown the wood splits readily into posts and rails. When of timber size the heartwood lasts well. It is light in weight and a beautiful colour, and is good for gates, ceiling and roof beam work. Used in Canada for telephone poles.	Should be grown in the estate nursery, as seedlings and transplants are dear. Despite risk of disease, is probably worthy of greater use. Useful for underplanting open crops of larch. Line-out or plant when just beginning to grow.
Uncertain.	Good timber, and useful when material of a durable nature is required.	Is difficult to establish; the best treatment is still uncertain.
2 yr. + 1 yr. or 2 yr. + 2 yr., according to size and site	As for *C. macrocarpa.*	As there is liability to windthrow it must be carefully and intelligently thinned.
2 yr. + 1 yr. In sheltered situations and heavy weed growth, 2 yr. + 2 yr. or 2 yr. + 1 yr. + 1 yr. may be used if carefully planted. Stock more than 4 years old should be used only in very exceptional cases.	Good for many purposes if it grows slowly enough, but for outside work even fast grown thinnings are very useful. As box- or crate-wood does not hold nails well. In contrast with the cypresses this timber should be treated with preservative when in contact with the ground. It makes good rough boarding for estate purposes such as concrete shuttering and staging.	Its chief recommendation is its very high volume production, which means that it is cheap to grow. But the fastest, *i.e.*, the most cheaply grown, is correspondingly less valuable, and generally speaking Douglas fir should be grown so as to have *not less than* five annual rings to the inch. It is very liable to *Chermes cooleyi*, which checks its growth. (*See also* Forestry Commission Bulletins Nos. 4 and 6 and Leaflets Nos. 8 and 18.)
2 yr. + 1 yr. or 2 yr. + 2 yr., according to size and site.	Probably it has not yet been sufficiently considered as timber. It has the same general character as Douglas fir, and holds nails better, though not so strong for structural purposes.	It is important to get a true strain of seed or plants grown from it. The seed should come from low elevations in British Columbia or Oregon. Grown from seed it must be sheltered in the nursery *for the whole of the first year.*
Optimum, 1 yr. + 1 yr. or 2 yr. + 1 yr.; maximum, 2 yr. + 2 yr. Strong 1 yr. + 1 yr. are excellent plants. Some growers prefer 1 yr. + 2 yr. to 2 yr. + 1 yr. Do not use 2 yr. + 2 yr. without some very good reason.	The volume yield per acre is not high, but it 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; its use for telephone poles is being investigated; results to date are promising.	Larch canker should not be troublesome if unsuitable sites are avoided, and the trees are well thinned. Quite small poles are usually saleable and larch may thus advantageously be used when a nurse is required for oak. (*See also* Forestry Commission Leaflets Nos. 11, 13 and 16.)

NOTES ON

A.—

Species.	Conditions justifying selection.	Unfavourable or unsuitable conditions.
Larches—continued.		
Larch—Japanese .. *Larix kaempferi* (*leptolepis*) Hybrid larch, *Larix eurolepis*.	Stands more exposure than European larch and is less affected by smoke and fumes. Good as a first crop on high-lying (over 800 feet) heathery or grassy slopes in the west. Promises to prove useful on shallow fibrous peat. May be planted on ground which has previously carried a crop of European.	Avoid :—Dry soils ; low rainfall districts (under 30 inches) ; badly-drained sites.
Pines.		
1. Austrian Pine.. .. *Pinus nigra* (*laricio* var. *austriaca*)	Wind-breaks and possibly as an advance crop, for example, to nurse beech on a chalk soil.	Not suitable for high rainfall areas.
2. Corsican Pine .. *Pinus nigra* var. *Calabrica* (*laricio* var. *Corsicana*)	Sand dunes and poor or dry soils in areas subject to smoke or fumes. A substitute for Scots pine where quicker volume-production is required.	Should not be used at high elevations in west or north or on soft ground.
3. Lodgepole Pine .. *Pinus contorta* var. *latifolia* (*Murrayana*)	It is worth trial as a substitute for Scots pine on heather - clad morainic knolls and poor quality heaths.	Not worth planting on the better soils.
4. Maritime or Cluster Pine *Pinus Pinaster*	The only place in which it may perhaps be justifiable to substitute it for Scots or Corsican pine is sand dunes in the warmer parts of the country.	All other sites.
5. Monterey Pine .. *Pinus radiata* (*insignis*)	Grows very fast but coarsely in the warmer parts of the country only. Suits light land.	Not recommended for use except in the south-west of England, and there only as a bulk-producer.

INDIVIDUAL SPECIES—*continued.*

CONIFERS—*continued.*

Age to plant.	Notes on timber.	General remarks.
As for European larch, but the maximum is 2 yr. + 1 yr. + 1 yr. A good 2 yr. + 1 yr. should be big enough for anything. If not, it should be retransplanted.	Produces more wood than European larch up to 30 yrs. old in the western half of the country, but the timber is generally regarded as inferior.	Is practically immune from larch canker. Should not be used as a substitute for European larch on good larch sites The Hybrid grows more rapidly than the Japanese, and is believed to have similar requirements.
2 yr. + 1 yr. or 2 yr. + 2 yr., according to size and site.	Timber poorer than Scots or Corsican pine.	Is of very dense habit ; stands smoke well ; liable to disease in the west, and in Scotland.
Optimum, 2 yr. + 1 yr. ; minimum, 1 yr. + 1 yr. ; maximum, 2 yr. + 1 yr. + 1 yr.	Produces saw-timber much more quickly and therefore much more cheaply than Scots pine, but such timber is of less good quality.	It is *essential* that the plants are transplanted in the nursery the year before planting, and that the roots are not exposed during handling. Should be planted before the middle of February if possible.
Optimum, 2 yr. + 1 yr. ; minimum, 2 yr. + 1 yr. ; maximum, 2 yr. + 2 yr. but not in soft ground or exposed situations.	Uncertain ; probably comparable to Scots pine, but more resinous.	An easy tree to handle and will grow over a wide range of conditions, but is still in the experimental stage. Inclined to be top-heavy on the better soils.
One of the few species easier to raise by direct sowing than by planting.	Timber poorer than Scots or Corsican pine.	—
Probably best as 1 yr. + 1 yr.	Inferior to Scots pine in quality.	For commercial planting should be confined to those places where bulk is the main essential. Is the most beautiful of the common pines as a specimen tree.

NOTES ON

A.—

Species.	Conditions justifying selection.	Unfavourable or unsuitable conditions.
Pines—continued.		
6. Scots Pine .. .. *Pinus sylvestris* The imported red or yellow deal is the same species	The easiest and often the only tree to plant on dry heather or bilberry soils. Very frost-hardy and so useful in frosty situations, both as a main crop and (on the better soils) as a nurse for other species.	Should not normally be used on the heavier and more fertile soils, or in exposed situations or at high elevations near the western seaboard. Unsuitable for grassy peats or areas subject to smoke and fumes.
7. Weymouth Pine .. *Pinus Strobus* Canadian "White Pine"	Is better avoided because of its liability to disease after its early years.	—
Spruces.		
1. Norway Spruce .. *Picea Abies (excelsa)* "White Deal"	Wettish grass or rushy land. Suitable for the better (*i.e.*, *Juncus* and *Molinia*) types of peat. Stands late frost better than Sitka spruce.	Dislikes dry or heathery land. Is liable to windthrow and consequently heavy damage may result if drains are not kept open after the crop is established. Dislikes smoke and fumes.
2. Sitka Spruce .. .. *Picea sitchensis*	In general a substitute for Norway spruce at high altitudes or wherever volume production is more important than quality of timber. Useful on sites exposed to prevailing winds, smoke or fumes or when types of peat not suitable for Norway spruce (*e.g.* those with considerable heather) have to be planted.	Birds like and beaters hate it; but patches are useful in woodland, the shooting on which has been let to certain classes of tenant, as they prevent them from entirely exterminating birds. Unsuitable for really dry sites or those which are liable to late or early frosts. Should not be used on the poorer types of heather peat.

Notes on

Pinus montana has not been dealt with above, as it is doubtful whether there Silver fir has grown magnificent timber in this country, but unfortunately cannot the Grand fir of the Pacific slopes (*Abies grandis*) fortunately may serve as a useful tree of the Pacific Coast is *Sequoia sempervirens*, or Californian redwood. It higher than that of any other conifer. It is a species which deserves further trial

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

Age to plant.	Notes on timber.	General remarks.
Optimum, 2 yr. + 1 yr.; minimum, 2-yr. seedling; maximum, 2 yr. + 2 yr. The latter should never be used except in shelter, and when there is a good reason for not using 2 yr. + 1 yr.	A good general utility timber if it is slowly grown. It is used for construction work, fencing, telephone poles, and wagon flooring. Thinnings are difficult to dispose of until big enough for pitprops and not of much use for estate purposes unless creosoted (*see* page 82).	Crops grown on soils which are too good, produce coarse timber of little value, hence the importance of restricting it to the poorer sites. This tree has many insect and other enemies.
—	—	—
Optimum, 2 yr. + 2 yr.; minimum, 2-yr. seedling; maximum, 3 yr. + 3 yr. The 2-yr. or 3-yr. seedlings are suitable only for turf planting. Older plants can be suited to the site, taking care to use the smallest suitable. Taller plants for frost-hollows	Will not take creosote well and is therefore unsuitable for many outside purposes. A good timber for indoor work and for certain specialized uses such as pulpwood and plywood. It is difficult to market small thinnings, but the tops may sometimes be sold as Christmas trees.	On heavy clay soils may sometimes be used as a nurse for oak. Sometimes pays to grow as Christmas trees.
Optimum, 2 yr. + 1 yr.; minimum, 2-yr. seedling; maximum, 2 yr. + 2 yr. The remarks above on Norway spruce apply equally to Sitka spruce	Probably not as good as Norway spruce, but should serve very much the same purposes if grown in reasonably close canopy.	Produces timber much more rapidly than Norway spruce and under a wider range of conditions; should not be used where a more valuable timber can be grown.

other Conifers.

are any conditions in ordinary practice in which some other pine is not better. now be recommended owing to disease (*see also* Forestry Commission Bulletin No. 7); substitute; it requires good, well-drained, loamy soil and stands shade well. Another requires good fertile soil and a high rainfall, but its timber production is probably in the west, but is frost tender when young.

NOTES ON

B.—

Species.	Conditions justifying selection.	Unfavourable or unsuitable conditions.
Ash .. .. .. *Fraxinus excelsior*	Likes deep moist fertile soil and shelter. Dog's mercury, nettle (in woodland), garlic and woodruff are often indications of an ash soil. Will stand a fairly heavy clay if well drained and other conditions are favourable.	Any conditions other than those given in the previous column.
Beech .. .. .. *Fagus sylvatica*	Chalk or limestone soils. Sometimes useful on other sites as a subsidiary species, *i.e.*, in mixture with other trees.	Except on chalk or limestone, some more profitable species should usually be grown as the main crop.
Birch—Silver and White *Betula alba verrucosa* and *pubescens*	Birch is mainly useful as a nurse for frost-tender conifers.	Should not be used on any site where it is not definitely wanted either for shelter or soil-improvement or beauty.
Chestnut — Sweet or Spanish *Castanea sativa* (*vesca*)	It 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.

INDIVIDUAL SPECIES—*continued.*

HARDWOODS.

Age to plant.	Notes on timber.	General remarks.
The optimum for the most suitable sites is 4 or 5 yrs' old transplants — twice transplanted.	It combines elasticity with strength better than any other timber. Small poles are specially used for sports goods; large (12 inches quarter-girth upwards) for coach work, and many other uses.	It is no use planting ash unless there is local evidence that first-rate stuff can be produced. It is extremely rare to find optimum conditions except in small patches and strips. It is best established in small areas, either by natural regeneration in groups among other trees, the advance growth being cut back to near the ground, or by careful pit-planting of groups of large transplants, 4 ft. apart, the crop being gradually opened out when about 20 yrs. old, and underplanted with beech, if large-sized timber is aimed at.
Under light shade 1-yr. or 2-yr. seedlings; 2 yr. + 1 yr. or 2 yr. + 2 yr. transplants must be used in the open, and even bigger stock where there is severe frost danger.	Coppice and thinnings are useless except for firewood. There is a limited demand for small trees which are preferred for bending—a quality for which beech is outstanding—and they are also used for turnery. Grown on a full rotation beech can seldom be a paying crop as, though it is a really good general utility timber, and has a special use for making cheap furniture, the price gives a poor return on a long rotation.	For mixing with, or underplanting, light-demanding species such as larch, oak and ash. It also makes good shelter-belts even on rather poor soils and at high elevations, as it is very wind-firm and stands exposure (*see also* Forestry Commission Leaflet No. 15).
Best to plant as 1 yr. + 1 yr. or 2 yr. + 1 yr. Frequently comes in naturally in more than sufficient quantity	It is excellent firewood, and has many other uses, but is generally not easy to dispose of. Remarkably durable for fencing, etc., if properly creosoted; makes good charcoal	Is not to be despised in mixture with conifers on poor soils, as its leaf-fall helps the decomposition of the needles; it may well be retained, provided it is not allowed to do too much damage to the crowns of the conifers.
2 yr. + 1 yr. or 2 yr. + 2 yr.	As big timber it is very similar to oak, but lacks its distinctive figure. Many "old oak" beams are really chestnut. Sound timber is in good demand in the furniture trade, and for coffin boards. As coppice it commands high prices in some districts, for purposes such as split fencing and walking sticks.	It is better not to start coppice unless there is a local demand or one can be worked up. For coppice purposes transplants should be planted fairly close, and cut back after 6 or 7 years.

NOTES ON

B.—

Species.	Conditions justifying selection.	Unfavourable or unsuitable conditions.
Oak .. .. .. *Quercus pedunculata* and *Quercus sessiliflora*	Should not normally be grown except on well-aerated deep fertile soil in lowland; it is perhaps the only species suitable for the true clays.	Not recommended for exposed sites, frosty hollows or any infertile soils.
Poplar .. .. .. Black Italian Poplar. (*Populus serotina*) *P. robusta* *P. regenerata* *P. generosa*	Alluvial lowland soil; will also grow, though more slowly, on stiff clay.	Should not be planted in exposed sites or on dry or infertile soils.
Cricket Bat Willow .. (*Salix caerulea*)	Margins of flowing streams or water courses with alluvial soil.	Will do no good anywhere else.

Notes on

Sycamore, maple, elm (*see also* Forestry Commission Leaflet No. 19), alder, reason, including definite evidence that they grow and pay well. This does not of rabbits, and is a cheap way in some places for making very good game coverts,

INDIVIDUAL SPECIES—*continued.*

HARDWOODS—*continued.*

Age to plant.	Notes on timber.	General remarks.
Recent investigations encourage the use of 1-yr. and 2-yr. seedlings, planted densely with or without prior digging of the ground (*see* p. 38 and bottom of p. 21).	The timber is very strong and does not easily warp. It has a beautiful grain, particularly if cut on the square. The heartwood lasts very well for all outdoor purposes, but seasons slowly. Good stuff is always in demand.	The sessile is less subject to defoliation by caterpillars and to mildew than the pedunculate, and is to be preferred, especially on the lighter soils. Oak is rather difficult and expensive to establish on heavy soils owing to its slow growth and long struggle with weeds. At the end of the tables there is a special note of methods which have been found easier and more successful than those generally followed in the past (*see also* Forestry Commission Leaflet No. 10).
To raise poplar in the nursery plant 9 inch cuttings in February, cut from one-year old wood of vigorous side branches of young plants. The soil should be deeply dug and well manured, and two buds left above ground. Lift after a year, prune roots and cut back shoots to an inch of old wood; line out at 2 to 3 ft. in fertile soil. Plant out 2 or 3 yrs. later not less than 20 ft. apart.	Good for crates and packing cases, and when creosoted for rails, weatherboarding, etc. Does not splinter, and is therefore specially useful for floors of warehouses and stores, cart bottoms and brake blocks.	Poplar produces volume quicker than almost any other forest tree; financially it is of doubtful utility unless really suitable land is available. *Serotina* is the safest. *Robusta* and *regenerata* are being severely damaged by canker on the Continent (*see also* Forestry Commission Bulletin No. 5).
—	Used for cricket bats and artificial limbs.	Growing of cricket bat willows is a highly specialised affair (*see also* Leaflet No. 20).

other Hardwoods.

hornbeam and hazel are species best left alone, unless an owner has some special apply to natural regeneration of sycamore, which often only needs ***absolute exclusion*** and growing timber for which there is sometimes quite a good demand.

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 such as those damaged by *Oidium* (*see* page 21) must be discarded.

To establish a pure stand of oak the spacing should be 4 ft. × 2 ft. (5,444 plants per acre); if there is danger from frost, nurses such as Norway spruce, Scots pine, alder or birch 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 in the long run, but first costs are high and a long time must elapse before there is any appreciable revenue.

On suitable sites the admixture of European larch is recommended, and may result in important financial returns long before the lapse of the 120 or more years required to grow large oak timber. Tree by tree or row by row mixtures must be avoided; the aim should rather be to establish pure strips or patches of oak, which can be properly looked after and are less likely to suffer damage by being overtopped by the larch.

In strip-planting the oak strips should be 27 feet apart, centre to centre, and each should comprise four rows planted 4 ft. × 2 ft. Between each pair of oak strips two rows of larch should be planted, spaced 5 ft. × 5 ft., and 5 feet from the nearest row of oak. The number of plants required per acre (4,150 oak and 830 larch) is 464 less than for pure planting, but as the larch should be transplants, and will also probably cost more to weed, there will be little

saving in costs of establishment. The benefits lie rather in subsequent revenue from the larch.

Patch or group-planting is definitely cheaper than strip-planting as regards first cost, and should yield better interim revenue, but the arrangement of the planting is rather more troublesome. Nevertheless, it is probably to be preferred for most places. Patches 6 feet square and 20 feet apart, centre to centre, planted with 25 oak seedlings each (at about 14 inches apart), are established throughout a matrix of larch planted 5 ft. × 5 ft., no larch tree being within 5 feet of an oak seedling. This arrangement gives 109 patches per acre, and each of these is relied upon to produce one good oak tree at maturity. The total number of plants required per acre is 2,725 oak (seedlings) and 1,307 larch (transplants). The best procedure is to start by locating and clearly marking the patches, then to plant the larch, and, finally, the oak.

The best planting 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 benefits from the competition of most kinds of weed-growth, and weeding must always be reduced to the minimum, but coarse grasses such as occur on clay, and dense growths of bramble or bracken, must be cut. It is best in all cases to weed at least once at the end of the first summer, in order to find the plants and assess beating-up requirements. Subsequently the absolute minimum of weeding should be done. However much the oak weeding is reduced, the larch or nurses must be weeded in the ordinary way.

When the plantation is about 8 feet high it must have special attention; weed-species, nurses or larch 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.

3. The Supply of Plants.

The procedure should be the same as given under the supply of plants for nursery work, on page 15.

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.

4. Fencing.

Sheep, deer and cattle must, of course, be excluded. If the position is such that deer-fencing is necesary, 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 which may be from 8*s*. to 18*s*. or so per chain, 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 completely effective. If the forester can use only small and odd-shaped bits of land, the only hope of economical planting is to exterminate. If there is serious trouble from old banks riddled with burrows, or from the sides of deep ditches or rocky places and screes, it may be necessary to use poison gas—a painless and simple process if something like Cyanogas (*see* page 76) is used. According to letters which have appeared in the Press, the more accessible burrows may also be dealt with by feeding motor-car exhaust fumes into them through a flexible pipe fixed to the exhaust-pipe of a car.

If 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, since 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 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.

The following table is based upon the assumption that netting, wire and staples will be bought through some purchasing agency (the greatest crime which an owner can commit against his own interests is to buy wire netting at the price per roll listed by the ordinary ironmonger), 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.	Remarks.
		s. d.	
1. Light rabbit-proof	42 in. × 1½ in. × 18 gauge netting, top strand twisted over	16 0	The spacing of the stobs may be varied. Top wire not always

FORESTRY COMMISSION.

BULLETIN No. 14. PAGE 41.

The statement regarding the price of wire netting was not intended to be derogatory to ironmongers as a class, but to emphasise the fact that it is never necessary to buy netting at the prices shown in what is called the " B.W.N.M.A. Standard List."

The Commissioners are informed by the Ironmongers' Federated Association that arrangements have now been made whereunder any retailer can, at a fair profit to himself, supply netting delivered to any railway station south of a line Oban–Aberdeen, at cash prices ranging from 46½ per cent. (for 50 rolls) down to 40 per cent. (for 1 roll) less than the " Standard List " prices. North of the line Oban–Aberdeen and for the Scottish Islands prices are necessarily higher.

February, 1934.

(12/4056) Wt. 274—757 500 5/34 H & S, Ltd. Gp. 12

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.

4. Fencing.

Sheep, deer and cattle must, of course, be excluded. If the position is such that deer-fencing is necesary, 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 which may be from 8*s*. to 18*s*. or so per chain, 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 [illegible] certain cases this has pro[illegible] and [illegible] is t[illegible] wit[illegible] and[illegible] sim[illegible] Ac[illegible] acc[illegible] exl[illegible] ex[illegible]

18[illegible] re[illegible] m[illegible] g[illegible] n[illegible] 6[illegible] A[illegible] v[illegible] v[illegible] c[illegible] 1[illegible] 1[illegible]

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 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.

The following table is based upon the assumption that netting, wire and staples will be bought through some purchasing agency (the greatest crime which an owner can commit against his own interests is to buy wire netting at the price per roll listed by the ordinary ironmonger), 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.	Remarks.
		s. d.	
1. Light rabbit-proof	42 in. × 1½ in. × 18 gauge netting, top strand twisted over barbs of one 2-ply × 4-point galvanised top wire; barbs at 6 in. Stobs spaced at 12 ft. Netting turned out 6 in. at bottom	16 0	The spacing of the stobs may be varied. Top wire not always necessary, or can be stapled 4 in. above netting and latter lashed to it with tie-wire. The last is good where hares are troublesome if top wire is barbed, but is bad for hounds.
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. Stobs at 9 ft. apart	19 6	Bad for hounds. Good, especially if top wire is barbed, against public, hares and occasional stock or sheep.
3. Sheep-netting ..	As Nos. 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. Likely to be much damaged by occasional horned-stock.

Type of fence.	Details.	Cost per chain erected.	Remarks.
		s. *d.*	
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. Stobs at 9 ft., strainers at not more than 150 yards	14 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. × 1½ 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. Galvanised iron posts at 20 ft., wooden droppers at 5 ft.	35 0	Rabbit-netting often also needed, or sheep netting—against roe deer—with reduction in number of wires, but enhanced total cost. Wooden posts can sometimes be used or/and galvanised iron droppers (staggered).

Where there is much trespass two top barbed wires at the same level, but on different sides of the stobs, is 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. If stobs have to be bought considerable saving may be made by increasing the distance between the stobs and employing droppers between them.

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 generally

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.

5. 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 extract the nourishment which the plant needs 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 neither fit to plant nor 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 back-bone, 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, and 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.

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 at 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.

6. Other Preparatory Work.

(*a*)—*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. But 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 advance trapping of weevil and beetle (*see* Forestry Commission Leaflets Nos. 1, 3 and 4), since it is much better to lock the stable door *before* the horse is stolen.

(*b*) *Scrub* should almost always be clear-felled and, with careful marketing and estate utilization (*see especially* page 82, Timber Preservation), much of the cost may often be recovered. The only exception is with birch or small oak, where the poles may be killed by ringing the bark, and left standing.

(*c*) *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. During hard weather when there is nothing else to do, it is a good plan to grub up old gorse and even broom, so as to avoid the dense mass of young regeneration which often springs up after burning.

The treatment of bracken depends upon whether, with the collection 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, and it is much easier to do this properly if, in the season before planting the new growth is whipped over with sticks before the fronds uncurl, and this whipping is repeated as the second and third flush come on. This, of course, also greatly weakens the growth in the first year after planting, when the bracken will be most likely to do harm. Whipping should not cost more than 3*s.* an acre each time. It must be noted that it will disturb nesting pheasants, and that it creates one of the main conflicts between forestry and game interests.

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 couchy areas (*Agropyrum 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.

(*d*) *Moors and Sandy Heaths.*—For the treatment of moors having

much peat, *see* Peat-planting (page 50). Other moors and heaths frequently lend themselves very well to preparation by ploughing if there is no danger of the land becoming water-logged. Shallow furrows are cut—one for each line of plants—in which they can be planted in the shelter of the intervening heather, or of 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, where on favourable sites it has allowed pine seedlings to be used.

Dense old heather 12 inches or more in height must usually be burnt to facilitate planting, but a very fierce fire may be definitely harmful. Shorter heather is generally best left, on account of the shelter it affords.

(*e*) *Pan Areas.*—The application of ploughing to a wet and peaty moor has great possibilities, but has not yet been thoroughly worked out, except on the areas on which " pan " occurs. Where the pan is within 12 inches of the surface, deep ploughing with powerful steam tackle or 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. Where the pan is more than 12 inches deep it may usually be neglected, but such conditions imply poor soil, slow growth and probable difficulties in establishing the crop.

(*f*) *Peat Areas* are dealt with under Peat-planting (page 50).

CHAPTER V.

ESTABLISHMENT OF PLANTATIONS.

1. 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 an acre a day, 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 planted 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. Anyone 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. But 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, but 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 farthing, were a 7*s.* 6*d.* magnolia!

It has been possible to indicate fairly definitely in the tables on pages 9, 10 and 28–37 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 mainly on the nature of the soil and its texture and humidity. Different methods of planting can be described, and also how planting should be organised, and the time it should take can 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.

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. In the actual operation men should be assisted by a boy, one attending to two men. The man returns some of the soil to the hole, taking care in old grass-land to place the well broken-up turf at the bottom, and roughly shapes it to take the roots of the plant. The boy holds the plant in position until it is fixed, and leaves the man to complete and to firm the plant in; while he is holding for one man the other is completing the operation in one hole and getting ready the next. A boy can attend to three men if they are digging the holes at the time of planting. Even where holes are not dug some months in advance it often fits in well with nursery arrangements and plant supply, for men to spend a day or two digging holes, and then get up from the nursery just sufficient stock for a full day's planting. But naturally anything which involves covering the ground twice is more expensive than doing the whole job at a single operation.

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 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 planting 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. 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 prize the soil up so as to make a cleft. Into the cleft a plant is inserted with the tips of the roots below the prized-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 is made by an ordinary garden spade which has 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 75). 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 prized 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. It 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 are planted at their optimum size the roots should not be too big for notching, and on ordinary soils there should be no need for pit planting as experience shows the results do not justify the cost. It must be remembered that nursery stock very often has 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, only a few plants at a time being dealt with. Pit planting is necessary for poplar and large sizes of oak and ash and may be desirable for Douglas fir, which need special care to ensure a natural arrangement of the roots.

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 rush means relatively stagnant or more highly acid soil. The second-best peat carries purple molinia (*Molinia coerulea*, Bentham & Hooker, No. 1252) and other grasses, excluding Cotton-Grass and Deer-Grass (Scirpus). Private owners may often 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, and these associations are better left alone.

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 draining enough.* One of the most difficult things is to assess the sufficiency of the drainage. The main species to be employed are Norway and Sitka spruce; 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 silly 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 is often useful, as in pit planting, to have boys to hold up the two corners of the turf ready for the plant to be slipped in. 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 with the Belgian trowel spade. This tool cuts a hole the

size of a flower pot. In this the plant is placed, the hole being filled with the broken-up plug or, if the peat is of very low grade, with mineral soil. Unless the peat is exceptionally tough, the turf will subside in a few months to less than half its original thickness.

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 in 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.

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.

The application of about 2 oz. of basic slag, well scattered round the base of each plant, markedly assists growth on the *poorer* types of peat. The operation costs from 20*s*. to 30*s*. per acre, but any attempt to plant peat which is so poor that the slag will materially help, requires expert guidance. The slag is more effective if mixed with sand or other mineral soil and applied to the roots at the time of planting, but the preparation of the compost adds considerably to the cost.

The most efficient way of cutting turfs is to take them in long continuous strips; this saves one cut for each turf, and also 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.

The following method has been found useful at Corrour, Inverness-shire, in establishing plantations of Sitka spruce on poor soil at a high elevation:—Turfs are turned over in autumn in continuous rows and planted the following spring as in ordinary turf planting, thus forming a 'flying-nursery' in which every plant is set on a separate turf. Two years later the plants are distributed, turfs and all, to their permanent places. This method is only suitable for ground which requires little or no draining. On ground which requires draining it is better to use the turfs from the drains and place them at once in their final positions. But there is a type of ground where, though draining is unnecessary, pit-planted or notched plants are always checked, and may require cleaning for years. It is on this type of land that turf nurseries are specially useful. They admit of the use of two-year or three-year seedlings. If the number of plants in each nursery is limited to about 2,000 none will have to be carried more than 35 yards, and they can be moved *at any time of year*. The construction of the nurseries and planting with a compost of basic slag and sand costs at Corrour, £4 17*s*. 7*d*. per 1,000 plants. Planting at 6 feet and including the cost of setting out and occasional cut-off drains, the total cost works out at £8 per acre.

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 seedlings which has been already referred to. It must be emphasized that where spruces are to be planted, and in all but the driest sites for other species, screefing will do more harm than good, and if plants are not planted on the natural surface they should be placed on turfs or on top of 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 galvanized pail with a little 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 especially it is the position of the roots that matters most, and these must be properly 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. But in ordinary planting 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.

Organization 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 700 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 500. 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 1,400 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 1*s.* 3*d.* per 100 for cutting and spacing at 5 ft. × 5 ft. Thick turfs cost rather less when the texture and depth of the peat is such that they require less care in lifting.

2. 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 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. For all species other than Norway spruce and hardwoods this means that " beating-up " must be done a year after planting, and with trees no smaller than the originals, and that they are 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 under-crop such as beech later on if the ground is suitable.

Spruce is an exception to the rule of immediate beating-up because it has wonderful powers of recovery, and no tree is hopeless until it is absolutely dead, and if beating-up is necessary plants on turfs can be used and will pull their weight. As to beating-up hardwoods not much knowledge has yet been accumulated, but except for making good very heavy failures in oak, planted on the patch system, it is probably best to wait for some years, and then

to bring in beech. It should be remembered that where there is a natural crop of coppice or hardwood on the ground, which has been cut over before the planting, stool shoots can be accepted in lieu of failures, and will probably benefit a conifer plantation more than if a new conifer had been put in, provided they are prevented from doing actual damage.

It may be noted that in the case of larch many plants are wasted in beating-up because the trees look dead in the winter. The best way is to pull out all the dead ones that are met with in the summer weeding. It is a good plan, too, to mark the patch where you are going to beat-up with a stake in summer, so that men can go straight to it. But it should be remembered that larch, especially if eaten off by rabbits, will frequently shoot vigorously almost from the ground level.

Where deaths occur in well-defined patches it may be well to try a different species on these patches. Sometimes, as when trees have died because they are planted along a line of old hard-beaten wagon tracks on clay, it is merely a question of using a little more intelligence in selecting the right spot for the plant.

It should be needless to emphasize that the first duty of a beater-up is to report any trace of the presence of rabbits. If you are going to use plants as rabbit fodder it pays better to turn the animals into the nursery. They like the plants just as much there, and it saves you the cost of planting and them the trouble of running about.

3. Weeding and Cleaning.

Weeding means the removal of the growth naturally springing up round the young trees which would otherwise damage them. Cleaning means subsequent attention to the crop until it is ready for the next operation, namely, thinning ; it includes removing all elements both in the crop itself and in other growth which might otherwise do harm before the thinning stage proper is reached Both tasks must be faced up to, particularly the weeding in the years immediately following the planting of the crop, even if it means disturbing nesting pheasants or working short-handed in hay harvest. It is not necessary to treat all species alike, for some will stand shade, but even with them there must not be too great competition for nourishment and moisture, and in particular it must be realized that light and exposure are in some ways helpful, making for growth, checking the liability to mildew, and hardening off plants so as to prevent undue damage by early autumn frosts. As to tolerance of shade, there are among the conifers, on the one hand the larches and, to a lesser extent, the pines; these will not tolerate overhead shade and must, at latest, be weeded as soon as growth threatens to meet above them; on the other hand are Sitka spruce and shade bearers such as *Tsuga*, *Thuya* and the

silver firs ; these actually benefit from side shade, and will sometimes push through with no attention at all, although not then making their maximum growth or hardening off properly. Among the broad-leaved species there are the poplars, which will tolerate no shade at all, but most species come at the other end of the scale, and should probably never be weeded unless and until inspection shows that definite and specific damage is being done. Even oak and ash, which are light demanders in middle and old age, need shelter and active competition in youth.

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 generally sheer waste of money to cut the whole of the weed growth on an area, and it is 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.

Great economy can 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 is more expensive than that done in preparation for planting because of the care which has to be taken not to hit the plants, and may cost up to 4*s*. or 4*s*. 6*d*. per acre. Cutting lanes in bracken should not cost more than 7*s*. 6*d*., and clear cutting not more than 10*s*. 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 12*s*. 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 secure 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 the average workman is seldom capable of using his common sense in this respect.

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.

Cleaning.—This process is continuous with weeding, beginning from the time when it is unnecessary to give systematic attention to the vegetation round the young trees. It includes the removal of dead and dying trees and competitors, such as birch and strong coppice shoots, if they are tending to get too vigorous, also the cutting of plants such as honeysuckle, which are liable to do serious damage.

After a plantation reaches the thicket stage the lower branches begin to die; sooner or later these must be removed. This work is called brushing, and is done primarily to facilitate inspection, the marking of thinnings and the control of rabbits. If brushing is left too late, inspection will almost certainly be neglected; this is especially important since cleaning is a continuous process. It is only from inspection that one can know for certain that an area needs nothing doing to it or that rabbits are not multiplying, and only by *intelligent* inspection can one secure that money is not wasted, and actual harm done, by removing from a conifer wood those hardwoods which are doing no damage, or so little damage that they might better be retained. It is better to brush inspection strips through an area, so as to keep an eye on it all the time, than to neglect it pending the time when the whole job can be tackled.

4. Thinning.

In the ordinary type of even-aged forest the number of plants standing in a young crop in the thicket stage will vary from 1,000 to 2,000 or more per acre. When the wood has reached timber size and comes to be felled the number of trees harvested will rarely exceed 200 per acre, and may be as low as 50 (*see also* Forestry Commission Bulletin No. 10). It is thus apparent that from 80 per cent. to over 90 per cent. of the trees must disappear during the life of the stand. A certain number disappear owing to natural death, but the majority, in a well-managed plantation, are deliberately thinned out. Thinning has several objects to fulfil:—

(*a*) By reducing the number of the trees it gives those which remain more growing space both above and below ground. More growing space means quicker growth and so earlier maturity.

(*b*) By eliminating stems that are badly shaped and weakly, it provides an opportunity for favouring those that are better formed.

(*c*) Thinnings, where saleable, improve the financial return from the stand ;

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

But the primary object of thinning is the benefit of the final crop. However desirable an intermediate cash return may be, it must be a secondary consideration, and if a thinning is necessary it must be undertaken, even though no use whatever can be made of what is taken out. Neglect may lead, with Douglas fir or the spruces, to loss of the whole crop through wind-throw or snow damage and may therefore be very false economy. In the same way larch, no matter how heavily it may be thinned afterwards, will rarely recover its full vigour after one brief period of neglect in the extremely important adolescent state. It is sometimes thought that the accepted present custom of planting a good deal further apart than was the practice some years ago ought to have as one of its advantages that one need not thin until thinning will pay. But this is not so. Close planting was adopted in rather unintelligent imitation of what was at one time Continental practice, and wider planting does not mean that all plants can be left until they are of some use, though it may postpone the date of the first thinning. In fact, in the long run an owner will generally lose more than he gains if he postpones necessary thinnings until they will pay, even if it be only to cover their own cost.

Thinning should be done at definite intervals which should depend upon rate of growth, species of tree and the age of the crop. With young, very fast growing species such as 15 to 30-year old Japanese larch, Douglas fir and Sitka spruce on good soils, three years are quite sufficient to leave between successive thinnings, Scots pine and Norway spruce can usually be safely left for five years. Later in life, if woods are kept heavily thinned, the interval can be extended to 7 or even 10 years.

In thinning the following principles should be kept in mind :—

(1) The trees must be kept sufficiently dense in the early stages of a plantation to permit of adequate suppression of the lower branches.

(2) Once the thicket stage is reached in an even-aged plantation a segregation of the trees into three main classes is apparent. Class I, the dominant trees, are the tallest and usually the largest trees in the stand, they form

the upper canopy or crown layer and from among them the final crop trees must be selected. The lower canopy layer is subdivided into two classes, Class II, the subdominant trees, which are appreciably shorter than the dominants but have their leading shoots free, and Class III, suppressed trees, which are shorter still and stand directly under part of the branch system of taller trees. The dominant trees composing Class I, show usually a great range in development of crown and form of stem. In some the crowns are so shut in by competitors that the stems become weak and lanky, swaying about in the lightest wind and often damaging the crowns of their stronger neighbours; these are known as whips, and should be removed as soon as possible.

Another type is the wolf-tree; these are large dominant trees with spreading branches and crooked or deformed stems which can do great harm in a crop by suppressing more valuable trees. The sooner an injurious wolf-tree can be taken out the better, the first two thinnings should see the majority of them removed. It is a common error in thinning to leave wolf-trees in a young stand from a fear of breaking the canopy, but in a young stand an occasional hole in the canopy is quite harmless. At a later stage a much more serious gap is caused, and it may often be necessary to keep a tree which will never be good for anything but firewood, merely because it has been allowed to grow too big to remove safely.

(3) The main object should be to secure a uniform distribution of straight clean stems with well developed crowns. Often the better trees occur crowded together in groups which, if left will spoil each other. Such groups should be thinned out for the benefit of the trees with the best form and crown development.

(4) The subdominant, and, in the case of shade-bearing species such as silver fir and beech, even the suppressed trees may play an important part in protecting the soil from undue exposure. When marking a wood for thinning it is usually a mistake to mark first of all the small trees and then attend to the marking of the dominants. It often happens that for one reason or another a dominant requires to be marked, and in such cases smaller trees may often be usefully left to cover up the gap.

(5) Dead or dying trees should always be removed.

Three grades of thinning may be recognised, light, medium and

heavy. Light thinnings remove most of the subdominant and suppressed trees, also whips and (in the early stages) wolf-trees which are interfering with well-shaped dominants.

Medium thinnings will remove many of the weaker dominants as well as whips, injurious wolf-trees and those suppressed and subdominant trees not required to cover gaps.

Heavy thinnings will remove in course of time all injurious wolf-trees, most of the weaker dominants and such of the better dominants as are interfering with the best trees which it is intended especially to encourage. Subdominant and suppressed trees are left, if necessary, for soil cover. It should be observed that as thinning is (or should be) a continuous process, even in the heaviest type of thinning, it would never be desirable to take out in one thinning all the trees permitted by the grade. The trees must be kept sufficiently thick to maintain some degree of canopy, and so enable branch suppression and the selection of the best stems to continue.

The following notes are intended as a guide to the thinning treatment to be given to the major species. They are followed by a table which indicates the number of trees remaining at different stages of growth. It would be convenient if these stages could have been indicated by the trees' age, but it is not possible to do this usefully with any sort of accuracy. Height is a much better criterion. In the table, therefore, the number of stems which should be left per acre is related to height.

Corsican Pine.—This species is more responsive to thinning than Scots pine and thinning should not be delayed too long. The first thinning is usually required when the trees are about 25 feet high, and thinnings should be repeated every three to five years, but should not be heavy if clean timber is to be produced. *Appropriate Grade.*—Medium thinning.

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 is the general result. The first thinning should be made when the trees are 18 to 20 feet in height, all whips and weakly trees should be removed, and any dense group of dominants broken up. Larch responds very rapidly to thinning when young and quickly closes over gaps formed at this stage. Thinnings should be repeated at three to five-year intervals with the object of maintaining more than one-third of the stem length under crown. This is only possible when heavy thinning is applied. The commonest mistake in the treatment of larch is to neglect thinning in early youth. Experience has shown that heavy thinning in later life will not compensate for previous overcrowding. *Appropriate Grade.*—Heavy thinning.

Japanese Larch.—Japanese larch should be treated in the same way as European larch, *i.e.*, it should be freely thinned from the

thicket stage onwards. Owing to its rapid growth on good soils three years are a sufficient interval to leave between successive thinnings. *Appropriate Grade.*—Heavy thinning.

Scots Pine.—This is a species which does not repond rapidly to thinning, and consequently light but fairly frequent (every five years) thinning should be the rule. In slow-growing crops and in areas where small thinnings are unsaleable the first thinning may even be delayed until the crop is about 30 feet in height, but in such cases the risk from insect attack and crooked stems is considerable. Scots pine being a light demander, subdominant and suppressed trees do not play an important part in the stand and should be removed at each thinning. Wolf-trees are often troublesome in Scots pine and should be removed in the earliest thinnings. *Appropriate Grade.*—Light thinning until the trees are about 50 feet in height, medium thinning thereafter.

Douglas Fir.—The very rapid growth of Douglas fir on good soils makes this a particularly tricky species to handle. *Early thinning is essential especially in closely planted stands.* Failure to thin in time often leads to disaster in the shape of wholesale snow-break or windthrow. This is due to the fact that young closely grown Douglas fir have a very poorly developed root system and so offer only the feeblest resistance to snow or wind. Thinning should start as soon as there is evidence that the weaker trees are being suppressed and should aim at eliminating all coarse-grown dominants which approximate to wolf-trees and in breaking up groups of dominants. In no species is attention to form more essential. The trees to encourage are the smaller but straight stemmed dominants with well-shaped not over-large crowns. Suppressed and subdominant trees may be left to cover gaps. In young fast-growing stands, thinnings should be repeated every three years. *Appropriate Grade.*—Medium to heavy thinning in early youth, affecting mainly the dominant crop ; medium thinning after the trees are, say, 50 to 60 feet in height.

Norway Spruce.—Owing to the retentive branch system of Norway spruce early thinnings should be kept moderately light. After the trees reach from 30 to 40 feet in height thinning should be heavier with the endeavour to free gradually the crowns of the final crop trees. Suppressed and subdominant trees should be removed at each thinning to admit light to the soil and so promote decomposition of the humus. In exposed sites, where there is danger from windthrow, medium to heavy thinnings are desirable from the start to encourage root development and so make the crop more stable. *Appropriate Grade.*—Light thinning in youth in sheltered localities, medium to heavy in exposed sites. When the trees have reached a height of 45 to 50 feet, gradually increase the grade to heavy.

Sitka Spruce.—This species grows very fast on good soils and the branches are somewhat less persistent than those of Norway spruce. Thinning should normally start when the trees are 20 to 25 feet in height and be repeated at three-year intervals. *Appropriate Grade.*—Medium thinning.

Other Conifers.—Shade bearing conifers such as *Thuya, Tsuga, Sequoia sempervirens, Cupressus Lawsoniana, Cupressus macrocarpa, Abies grandis*, etc., should all be lightly thinned until the trees are from 40 to 50 feet in height. After that stage, if branch suppression is satisfactory, heavier thinnings can be introduced.

Oak.—When grown pure at close spacing, light thinnings should be carried out, removing mainly suppressed and subdominant trees until the crop is from 40 to 50 feet in height. Heavier thinnings should then begin and the better trees should gradually be given free growing space.

When grown in mixed woods special care is necessary to prevent the young oak being overtopped by faster growing neighbours. Subdominant nurse trees should be retained to control the lower side branches of the oak, and any dominants threatening to suppress the oak should be cut away. *Appropriate Grade.*—Light thinning in early youth in pure crops; medium to heavy thinning later.

Ash.—This is a difficult species to thin successfully owing to the prevalence of forking in the leading shoots. Light frequent thinning combined with pruning provides the best method of dealing with young crops of ash. As soon as a sufficient length of clean bole is obtained, thinning should be gradually intensified, and it is important that the final crop trees be freed as soon as possible to develop full crowns, but any sudden opening of the canopy may cause a serious check in growth. *Appropriate Grade.*—Light thinning until clean boles of 20 to 30 feet in length are formed. Thereafter heavy thinning to free the selected trees.

Beech.—A heavy stocking is desirable in youth because the proportion of straight clean trees is always low, and therefore a large number of stems are required from which to select the final crop. The trees respond readily to thinning in later life. *Appropriate Grade.*—Light thinning until the trees are 40 to 50 feet in height. Heavy thinning thereafter.

Number of Stems in Relation to Height.—The table on page 64 gives the number of main crop stems per acre for different heights of each species and for a given quality class. The numbers represent the main crop stems *after* a light thinning has been carried out. The data are taken from the British Yield Tables published in Forestry Commission Bulletin No. 10, and are based on close-planted and lightly thinned woods. In the case of certain species, notably the larches and Douglas fir, the numbers are certainly too

high because the plantations were thinned less heavily than is now considered desirable. The figures should, therefore, be regarded as a maximum.

Mean height of trees in feet.	Scots pine (England). Q.C. II.	European larch. Q.C. II.	Japanese larch. Q.C. I.	Norway spruce. Q.C. II.	Sitka spruce. Q.C. II.	Corsican pine. Q.C. II.	Douglas fir. Q.C. II.
		Number of trees per acre after thinning.					
40	720	870	920	1,070	1,020	880	1,090
50	480	600	600	670	730	550	750
60	300	430	460	470	560	370	530
70	200	310	—	330	420	—	380
80	150	220	—	230	310	—	280
90	—	—	—	180	230	—	200
100	—	—	—	—	—	—	150

The term Quality Class needs some explanation. It refers to the site and not necessarily to the timber. The classes are determined by the rate of height growth, which has a fairly constant relation to volume. For rapidly growing species such as Douglas fir and Sitka spruce the growth on Q.C. I sites may be too rapid to make good timber. The annual rings can be controlled to some extent by cautious thinning but, as explained above, the danger of snow-break and windfall limit the possibilities of this control.

5. Pruning.

The quality of timber, and so the price which can be obtained for it, depend more upon its freedom from knots than upon any other factor. This is especially the case with fast-growing species such as Douglas fir and Sitka spruce which reach timber size comparatively quickly but produce knotty timber of low value because there has not been time for the side branches to fall off.

By pruning when the trees are small, clean serviceable timber can be produced. The questions, when to prune, which stems to prune, and how far up the tree it is necessary to go are all controversial at the present time, and little or no actual experience is available.

Pruning, as distinct from the brushing, will generally have been necessary to get in among the crop for the purposes of inspection; it should start when the trees are quite young, *i.e.*, at the first thinning, when the better shaped dominants should be pruned up as high as the dead branches extend. At the next two thinnings further pruning should be carried out yielding eventually a clean length of from 20 to 30 feet in the selected trees.

In practice it will often be desirable to wait until a length of 15 to 20 feet can be pruned in one operation. There is no objection to removing, in addition to dead branches, the lowest whorl or two which are partially dead. It is clearly waste of money to prune inferior stems or, as a rule, those which will soon be removed in thinnings; pruning should, therefore, be confined to well-shaped trees of the dominant class, and, for further economy, some such spacing as 10 to 12 feet might be adopted in selecting these stems.

Pruning can be done at any time during the winter or spring. 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. The curved pruning-saw mounted on a pole is satisfactory for branches which cannot be reached unaided, provided the height does not exceed 15 feet. Most special tools for work above this height are cumbersome, and a handsaw is recommended. The workmen climb the trees and work downwards, standing on the branches; each man should have a safety belt. Costs should not exceed 3*d*. per tree; for average coniferous crops this represents at maturity, allowing 4 per cent. compound interest, an increased cost per cubic foot of less than a halfpenny for Douglas fir, three farthings for spruce and Corsican pine and 1*d*. to 2*d*. for Scots pine, according to age.

CHAPTER VI.

GENERAL.

1. Pests.

The best way to deal with pests is not to have to, and the best way not to have to deal with them is to remember that the conditions needed to maintain health are very much the same for trees as for human beings. If they are to flourish both need, first and foremost, an environment and dietary which are suited to their best development. Both need fresh air and sunlight and a proper system of water supply and drainage and the avoidance of overcrowding. In the case of both, too, definitely unhealthy and, still more, dead individuals should be promptly removed. In both, if these conditions are complied with, there will still be diseases, and in both, under these conditions, diseases ought not to do much harm. The following notes, which are given first for fungi and then for insects, and deal with both conifers and hardwoods, are intended mainly to help the identification of those most frequently met with or most important. It is seldom that cure is possible, and seldom, if cure were possible, would it be worth while to apply it. In general, if diseases do very much harm to trees, it shows that

the crop is not suitable for the locality, or that it is being badly treated. If treatment is put right and serious damage still continues the sooner an owner cuts his losses and replaces the species affected with something more suitable the better.

A. *Fungi on Conifers.*

(i) Diseases attacking foliage :—

Meria laricis (Larch needle-cast—Leaflet now in preparation).

This is found mainly in nurseries and is dealt with on page 21.

Brunchorstia destruens (Die-back).

If Corsican and Austrian pines have been planted at too high elevations, and/or in areas of too high rainfall, they may take on a pale browny yellow tinge at the tip of the branchlets, where needles and buds have died from this fungus. The die-back will extend gradually downwards, frequently killing the tree. If this happens it is an indication that the wrong site has been chosen. Some good may be done if diseased trees are removed, but the disease probably will not spread to plantations which are on suitable sites.

Keithia thuyina.

It is this fungus which generally causes the defoliation of Thuya. The attacks are probably due to unsuitable conditions (*e.g.* the locality being too wet or too dry) and sometimes cause serious damage. No control measures can be taken.

Lophodermium pinastri (Leaf-shedding disease).

This disease first becomes prominently noticeable in spring, making the needles of Scots pine turn pale brown and show rows of tiny black spots. It especially attacks young nursery stock or recently planted trees, and no direct physical causc is known. The fungus will have started the year before the discoloration of the needles is noticed, in the form of a speckling of small brownish red spots on the needles towards the end of summer. The only control measure is to sow seed thinly and to keep stock vigorous and properly transplanted. Even well-grown stuff may, however, be attacked in mild damp seasons, and attacks are likely to be especially severe in nurseries which are perpetually damp, and which may therefore have to be abandoned. Plants seem to be specially liable to attack if grown from Continental seed. Affected stock is rarely killed, and need not *necessarily* be destroyed, although it is naturally better not to use it. Great numbers of slightly attacked seedlings or transplants have been successfully used, and the attacks rarely go on after the plants are five or six years old.

(ii) Diseases attacking butts.

If plants start to sicken after being two or three years in the plantations, and there is no clear evidence of insect attack or other damage, nor obvious unsuitability of site, the following diseases may be suspected:—

Armillaria mellea (Honey-fungus—Forestry Commission Leaflet No. 6).

This fungus is almost invariably present in hardwood areas and survives, after felling, in the stumps. It spreads through the ground by means of "rhizomorphs," rather like thin black leather boot-laces, and attacks young conifers, destroying the cambium or inner bark and replacing it by a white felt-like tissue. The attacked plants soon die, but if the trees are really suited to the site the plantation as a whole will not suffer much harm. Any groups of dead conifers should be removed and replanted with hardwoods, unless there is natural coppice to fill the gap.

Fomes annosus (Red-rot—Forestry Commission Leaflet No. 5).

This disease also kills young conifers, as well as being the common cause of hollowness in older larch, Scots pine and spruce. It is most to be feared where old coniferous woods have been replanted with conifers. When it attacks young trees it replaces the cambium by a thin papery tissue and quickly kills them; older trees seldom die from the disease, but their value is greatly reduced, and plantations should be felled as soon as practicable if thinnings disclose the presence of much of the rot.

(iii) Diseases attacking branches and stems:—

Dasyscypha calycina (Larch canker—Forestry Commission Leaflet No. 16) and *Phomopsis pseudotsugae* (Leaflet No. 14).

In almost every larch plantation there will be on a certain number of trees a patch with resin exuding and distortion of the surrounding bark, from a square inch in size to elongated wounds several inches long. This is due to larch canker. If there is a lot of it the larch is on the wrong site, the ground being possibly not sufficiently drained, or the site too damp or frosty, and if it is very bad it may be best to start again. If there is only a little and thinning is properly attended to, trees will make good in spite of it. There is some evidence that frost damage gives this disease its start on a tree. Even in the worst cases trees will pull through after a fashion; they respond especially to thinning, and will often make quite respectable stems in a final crop.

Somewhat similar cankers on the Douglas fir and occasionally Japanese larch and other conifers are caused by *Phomopsis*. This disease also makes the young shoots die back rather as though

they have been frosted. Sometimes it gives rise to a constriction of a young shoot near where a side branch enters; this constriction is characteristic and appears almost as though caused by a tight bandage. Control measures are described in the leaflet.

B. *Fungi on Hardwoods.*

Disease attacking bark:—

Nectria ditissima.

Cankers appear on the trunk and branches and even young twigs of ash, and sometimes beech and other species. They may be of any size and are rather like split blisters with ragged edges. The damage may be due to frost. If not, and if there are many dark red specks like large pin heads, which are really the fructification of the fungus, the disease is *Nectria*. It causes black-heart in ash, and is liable to attack most other hardwoods. No control is possible, but healthy trees on suitable sites rarely suffer severely, except in the case of ash which is sometimes attacked in places where all the conditions seem to be favourable.

C. *Insect Pests on Conifers.*

(i) Insect attacking the stems of young plants:—

Hylobius abietis (Pine weevil).

Attacks of the pine weevil must always be expected when replanting felled conifers, especially pine woods or areas adjacent thereto. It is essential to take preventive measures during the season *before* planting. The weevil can be quite successfully trapped, and the method is described in Forestry Commission Leaflet No. 1. An attack is perfectly easy to identify and a forester who does not identify it and take immediate measures is not worth his position. One sees little white shrunken spots, grooves and patches on the stems of the plants which are places where the weevil has eaten through the bark and exposed the wood. If the bark is completely ringed the plant will die, and if not it will look sickly. In trapping it is necessary to try traps in many different positions to see which most attract the weevils, and as many as 12 traps to the acre may be needed. Children make very good collectors of weevils, either from the traps or straight off the trees, and may conveniently be paid by measure—so much a gill.

(ii) Insects attacking shoots:—

Myelophilus piniperda (Pine-shoot beetle) and *Evetria* (*Tortrix*) *buoliana* and *resinella* (Pine-shoot tortrix).

The leading shoots and the side branches of the Scots pine are frequently damaged by two types of insects. The pine-shoot beetle bores into the tops of the youngest shoots, making an

entrance hole the size of a pin head which is generally surrounded by resin ; it works its way down in the pith until it reaches the previous year's wood, where the exit hole will be found. The shoot is weakened and breaks off. The beetle breeds in the bark of the trunk and root collar and the twig is its feeding place.

In the case of the tortrix, a small reddish brown moth which flies in July evenings lays its eggs in the buds in that month ; the grubs live in the bud over the winter, making it hollow and unable to develop ; their presence can be detected by the occurrence of resin on the affected buds, a web also may be found.

The beetle can be dealt with by promptly removing all logs felled during the winter, and thus diminishing breeding places, or by leaving decoy logs as breeding places and stripping off and burning the bark in the early summer to destroy the pupae (*see* Forestry Commission Leaflet No. 3). The tortrix can be dealt with only by collecting and burning the buds which contain the larvae, but it is rather doubtful whether action of this kind is justified, as although many of the thinnings will have been spoilt they are always of low value and enough useful trees will get through to make a crop.

(iii) Insects attacking foliage :—

Lophyrus pini (Pine saw-fly), *Nematus Ericksonii* (Larch saw-fly), *Coleophora laricella* (Larch mining-moth—Forestry Commission Leaflet No. 11), *Chermes cooleyi* (Leaflet No. 7), *Chermes viridis* and *strobilobius* (Spruce-gall aphis—Leaflet No. 7) and *Chermes laricis* (Larch aphis).

Shoots of Scots pine and sometimes Corsican pine and larch may be completely defoliated by saw-fly 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 saw-flies, 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. It is a messy and expensive job to pick them off or crush them by hand and spraying is ineffective. 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 the genus *Conitidae* (plant lice). This type of attack can be recognised by the presence of 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 *Chermes cooleyi* which attacks Douglas fir, for the white wool is not such a feature in the identification of other types of *Chermes*. 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 *Chermes* 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; their repellant-looking larvae, which creep about on the twigs like minute squat alligators, consume vast quantities of Chermesidae.

D. *Insects on Hardwoods.*

(i) Insects attacking leaves:—

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

If the oak-leaf roller moth is present 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 really 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 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.

(ii) Insects attacking trunk :—

Cryptococcus fagi (Felted beech coccus—Forestry Commission 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.

2. 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 are 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.

The experience of the Forestry Commission during the bad fire season of 1929 was to the effect that the general public were responsible for starting 43 per cent. of the 409 fires reported ; probably the major part of a further 11 per cent. classed as of unknown origin should also be laid at their door. Railways started 35 per cent., and road engines a further 5 per cent. In this country the risk from lightning is negligible, and it is doubtful if there is even one well-authenticated case of a fire started by the action of the sun's rays through a piece of broken glass.

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 hardwood can be retained when an area is felled.*

*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.*

(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) The spark problem can be best studied at night.

(6) It is wise to insure young woods, say up to five years of age. The lowest premiums are about 2*s.* 6*d.* per £100. The risk becomes much less when the trees have closed up and lost their lower branches.

(7) 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.

(8) Back 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.

(9) 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.

(10) 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.

3. 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 ground intended for seed-beds. 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-stobs 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 soiling 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.

4. Tools and Appliances.

The generally accepted maxim that men work best with the type of tool they have used all their lives is often the excuse for a disastrous policy of *laissez faire*. 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 initiating 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, most of them unsuitable, are continually thrust upon him, and the last state then becomes worse than the first. Before a new tool is issued it must be subjected to a searching practical 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 the conditions.

It is not proposed to deal here with the almost innumerable types of the simple everyday tools such as spades, bill-hooks and axes, but a few notes are given below regarding tools not generally known or types which the Forestry Commission have found exceptionally useful.

The mention of the names of firms who supply certain tools or appliances does not mean that there may not be other firms who supply them, but it is of no use to recommend tools without indicating where they can be obtained, and, of course, the mention of a firm does not mean that it will always supply good articles at a reasonable cost, but only that it does so at present.

Nursery Tools.—Transplanting boards can be used in free-working, even ground without many stones. They may be an economy if boys or women are available for filling them. A satisfactory type is listed by Messrs. Ben. Reid & Co., Aberdeen, and costs about 20*s*. This firm will also supply details as to their use.

Soil injectors for using carbon bisulphide against chafer grubs can be purchased from firms such as Cooper, Pegler & Co., 24, Christopher Street, Finsbury Square, London, E.C.2, and cost about 75*s*.

Blow lamps for burning weeds in seedbeds are listed by some of the principal nurserymen, or particulars can be obtained direct from Messrs. Condrup, Ltd., of 77 and 78, Fore Street, London, E.C.2, the agents for the Primus lamps. A suitable type costs from £8 to £9.

Sprayers suitable for seedbeds or transplants are obtainable from many firms, including the Four Oaks Co., of Sutton Coldfield. An elaborate and expensive type of machine is unnecessary in a small nursery provided it has a nozzle which will give a really fine spray and can be directed to the under surface of the leaves. It should generally be possible to borrow the potato or orchard sprayer for use in the nursery when required.

Carbon bisulphide and other chemicals such as for sprays, should be bought from manufacturing chemists and not at retail prices from the local druggists.

Fencing Tools.—A very handy tool is the light wire-strainer known as the Page-Ironside Automatic Lever Wire Strainer; this is a pattern originally developed for fencing the large Australian sheep-stations; it is sold by Ironside, Son & Co., 39, Grosvenor Place, London, S.W.1, at 25*s*. The same firm also supply a complete fencing tool, which, if accompanied by a few staples and a yard or two of wire, is never out of place in the pocket of the man who is looking round a fence. A strainer designed to take the place of the ratchet type and deserving of attention is the Whiting patent wire strainer; this is sold by the Gloucester Foundry, Ltd., Emlyn Works, Gloucester, at 42*s*. to 72*s*. per gross, according to size.

Draining Tools.—For heavy clays the strengthened clay spades 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. A sort of glorified hay knife called a rutting spade is used for cutting along each side of the drain, the turfs are then cut into convenient lengths with a tool variously described as a sheep-drain, hill-drain or raising spade which is also used to loosen them so that they can be pulled out with a hack or drag. The bottom of the drain is then finished off, if necessary, with a bottoming or cleaning spade or a scoop.

Rutters and raising spades appear clumsy and cost 20*s.* to 30*s.* each, but they are remarkably efficient when once the knack of using them has been acquired. Rutters are made for both right and left foot so that the cut can be made in either direction. For small-scale operations in good peat a hay knife is quite a passable substitute for a rutter.

Planting Tools.—Because a tool is listed as a " planting mattock " it will not necessarily be the best for any particular set of conditions. The hoe- or adze-end must be nearly at right angles to the haft and nearly straight, about 8 inches long and 4¼ inches wide, and it must carry its full width as close as possible to the eye. The other end, whether axe or pick, is less important to the quality of work, but makes all the difference to handiness and speed; a 12-inch pick or a 6-inch by 2½-inch cutter will generally be found best. Messrs. Wm. Hunt & Sons, Brades Steelworks, Birmingham, have made several useful patterns specially for the Commission.

Semicircular spades (Belgian pattern) can be obtained from Messrs. Thos. Black & Son, Ltd., Sea View Works, Berwick-on-Tweed, or P. & R. Fleming & Co., 29, Argyll Street, Glasgow, price about 10*s.* 6*d.* each.

Schlich spades are sold by nurserymen, such as Ben Reid, of Aberdeen, or by Thos. Black & Son; a really strong, fully-strapped type is essential, and should cost about 10*s.* 6*d.*

Fire Protection.—Shunters' horns are better than whistles for giving the alarm. A suitable pattern is No. 175½, sold at 3*s.* 1½*d.* each by Messrs. J. Hudson & Co., 244, Barr Street, Hockley, Birmingham.

Knapsack water-pumps are useful when burning fire-lines for fire-fighting if water is available and a proper system of supply organized, and for damping-down a burnt area after the flames have been put out. The two English-made types used by the Commission have similar hand-pumps, and each can carry about 4 gallons of water; the one made by the Four Oaks Spraying Machine Co., of Sutton Coldfield, has a canvas water-container, whereas the cheaper pattern made by Ernest H. Hill, Ltd., of 66, Fitzwilliam Street, Sheffield, has a lead-coated metal container, so that with the addition of a detachable spray-nozzle and lance it is suitable for spraying in the nursery or garden. Messrs. E. H. Price & Co., of 33, Mark Lane, London, E.C.4, also make a knapsack or " Water-pack " at a very reasonable figure, but do not sell it complete with pump.

Miscellaneous.—A great help in the handling of round timber, which should be much better known, is the American pattern of canthook such as No. DC 5194, sold by J. Yates & Co., Ltd., of Scholefield Street, Birmingham, but men are slow to take to it.

It is often difficult to get barking irons or strippers and good timber-marking crayons. The former (if not made by the local blacksmith) can be supplied by Thos. Black & Son, and the crayons by Berrick Bros., 13, Camomile Street, London, E.C.3.

The provision of oilskins is well worth considering in wet areas; men can then work in light rain—the best weather for planting.

If drainers are provided with thigh boots they will generally 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 men are working is such an extremely obvious economy measure that it is all too frequently overlooked.

A transparent celluloid computing scale is a great help in measuring acreages off a map. Messrs. W. F. Stanley, of 286, High Holborn, London, W.C.1, make various patterns; that which is on the scale of 6 inches to the mile, and is marked with numbered squares four chains by two and a half (*i.e.*, 1 acre each) is recommended.

Particulars of machines for gassing rabbits can be obtained from Messrs. Geo. Monro, Ltd., of Hertford Road, Waltham Cross, Herts. Pumps cost from 17*s.* 6*d.* to 42*s.*, and are used with a special powder known as Cyanogas "A," which is highly poisonous. It is important to observe due precautions both as regards men and dogs, when using this simple and useful appliance.

Pruning investigations carried out recently in the Forest of Dean have necessitated the design of improved patterns of safety-belts and climbing-irons; these have been made locally and can be obtained from the following firms:—Climbing-irons from Messrs. Herbert & Young, Cannop Foundry, Coleford, Glos., at about 5*s.* the pair; leather-work for the irons (about 16*s.* 6*d.* the pair) and safety-belts (about 26*s.* 6*d.* each) from W. H. Newnham, Newerne Street, Lydney, Glos. Pole-saws for pruning from the ground up to a height not exceeding 15 feet can be obtained from Messrs. Mathieson, 23, Cockburn Street, Edinburgh. The type used by the Forestry Commission is known as the Lyford Pike pattern; this is a curved saw with teeth set to cut on the downward stroke.

PART III.

CHAPTER VII.

UTILIZATION.

1. 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 resell 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 anyone, 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 roadside or even deliver to the purchaser's yard, and it is possible to arrange this economically if everything be done by piece-work 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 !

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.—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 familiarize 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* should be sold separately from *pitwood*; the former should be cut to the sizes and lengths required and peeled before sale.

The chief problem is how to dispose of the other broad-leaved 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 82).

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 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 is backed by a creosoting tank and has 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. But underwood is not the only source of minor produce; 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 steeple-chase 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 be 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 Sir George Courthope, Bt., one of the Forestry Commissioners. He adds the following note: "By utilizing 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 utilization. All the prices which I quote have been obtained here recently, 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, and 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, floor-boards, etc.

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 18*s.* 6*d.* 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 6*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 28*s.* per square.

Park paling is either 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 18*s.* 6*d.* per yard run for a 7-feet fence, or the pales are sold separately; 6-feet pales fetch 36*s.* per 100; 3-feet pales, 20*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 9-feet heave gate containing 1½ cubic feet, 20*s.*

Oak spokes fetch about 9*d.* each.

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

Straight ash plank of good quality, 7*s.* 6*d.* to 9*s.* per cubic foot.

Ash felloes, 4 inches, 1*s.* 8*d.* each; 5 inches, 2*s.* each; 6 inches, 2*s.* 6*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 rackets and aircraft, though the demand for aeroplane ash is decreasing. Older trees go for motor-coach work.

Smaller sizes, slabs and crooked lengths, are utilized for felloes (1*s.* 8*d.* to 2*s.* 6*d.* each), axle beds, swimmers and bosters for farm

waggons (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 waggons.

Very little elm is available. It is used for the floors of farm waggons 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 waggons, 4*s*. to 4*s*. 6*d*. per cubic foot.

Beech axles, 4*s*. 6*d*. each, and felloes 3*d*. less than ash.

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 for use 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.

2. Timber Preservation.

A hint has already been thrown out that it is well worth treating the 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 proper 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 esse nce ofthe 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 5*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 gasworks.

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 to-day 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. But generally, 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.

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.

The British Wood Preserving Association, whose offices are at 166, Piccadilly, London, W.1, will be glad to supply to anyone interested the names of firms manufacturing the pressure or open tank apparatus, and those supplying the 90-gallon butt treatment tanks. They will also send, on request, leaflets describing the open tank method in more detail than has been possible here, and particulars which they have collected as to durability.

PART IV.

CHAPTER VIII.

FINANCIAL QUESTIONS.

1. 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 life-time. 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 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.*—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 the revision of 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 in.

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); and 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, page 12).

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, etc.

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 are taken off for short spells of other work, such as beating, hay-making, etc., 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, etc.), 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

must 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, and this is the whole basis of economic forestry.

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 nurserymen'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, since, 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. An example of the form of statement which may usefully be prepared is given on page 98.

2. Forestry and the State: Income Tax, Death Duties and Grants.

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.

Under the Local Government Act, 1929, woodlands have been de-rated, though in Scotland rates are still paid on 25 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. And here arises the first important point. Forestry land is seldom let, and, therefore, it has been customary for the Commissioners of Inland Revenue 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. And 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 entitled 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. And 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 are still permitted to 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," on it the Schedule A charge is based, but the tax is not levied until one-eighth, and in some cases more, has been deducted (*see* Note (i), page 96, with regard to further relief by way of a ' maintenance claim ') ; tithe paid is also deducted. Tithes are not payable on woodland unless it has been converted to forest use since 1836. In Scotland " stipend," which corresponds to 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—are assumed as equalling one-third of the estimated annual value of ownership, *i.e.*, one-third of the gross annual value, including tithe. 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, 7½*d.* per acre per annum, or, during a rotation of 60 years, 36*s.* 3*d.* 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 all 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 April 5th of the year immediately preceding that of assessment (*see* Note (ii), page 96), or on such other date in that year as the woodland accounts are normally made up to. This option 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 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 of 2*s.* 2*d.* Thus the owner 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. And 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 a concession which may have to be resorted to by a successor who is forced to raise large sums from woodland to pay the death duties on the rest of the estate.

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 will not be payable under Schedule A as the rent of the land, at the Schedule A *assessment*, is allowed as an outgoing in the Maintenance Claim, *i.e.*, tax remitted balances tax paid. Government Grants given for planting are, of course, deducted from the expenses of planting, when making out the Schedule D balance sheet, just as any other receipts would be.

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 are deductible 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. But 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.

That good friend of all landowners, Lord Selborne, has pointed out an interesting consequence of 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. But 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.

Afforestation Grants.

The following State grants are available :—

(1) Conifers.—Up to £2 per acre for every acre planted and thereafter maintained as a forest crop.

(2) Hardwoods.—For every acre planted with oak, ash, beech, sycamore, chestnut or other approved species, and thereafter maintained as an area for the production of hardwoods—Up to (*a*) £4 per acre for oak or ash ; (*b*) £3 per acre for beech, sycamore or chestnut ; and (*c*) £2 per acre for other approved species.

The grants will normally be limited to schemes dealing with not less than 5 acres ; the rates are liable to revision.

Forms of application for grants and the relative regulations may be obtained from the Forestry Commission, 55, Whitehall, London, or 25, Drumsheugh Gardens, Edinburgh.

The regulations are of a simple character. Applications must be lodged by the 1st January and approved before operations are begun. Applications may relate to work to be done during one season only, or to be extended over a period of years.

When the season's work has been satisfactorily completed and inspected, 75 per cent. of the grant is paid, the balance being paid four years later provided any necessary beating up has been done and the plantation has been properly established and maintained.

When woodlands are under Schedule D, grants come in on the credit side of the expenses claim, but if they are under Schedule B no question of tax on grants arises.

The facts given in this section are presented in summary form, with rather more exact detail, in the Forestry Commission's Leaflet No. 12.

Mr. Hiley in his " Improvement of Woodlands " summarizes the position as it appears to him in the following paragraph :—

" The general conclusion that must be drawn from this examination of taxation is that, although death duties have made it very difficult for large estates to be kept intact, there has never been a time when forestry has been so favoured. The willing forester receives every kind of encouragement and conditions are so

propitious that forestry pays better than ever before, and yet the area which is annually replanted by private owners is little more than half what it was before the war. It is no excuse to say that landowners are poorer, for poverty drives a man to attend more closely to his business. We may expect that in time Death Duties will weed out the stupid and inefficient, and leave the land for those who can make good use of it, but, unfortunately, the processes of natural selection are tediously slow, and there is a danger that the stupid and inefficient will leave nothing but scrub for the forester of the future to work on."

Notes :—(i). In making the 'Maintenance Claim' for the estate, the owner should claim, in respect of woodlands under Schedule B, landlords' 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 as they will have already appeared in the Schedule D account.

(ii). 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 scale to operate. If he wishes to put new plantations only under Schedule D he must give notice before April 5th for the tax to operate in respect of the work done during the Income Tax year which terminates on that date.

(12/4724)Q Wt. 518—223 500 7/34 H & S Ltd. **Gp. 12.**

PART V.

PRACTICAL EXPERIENCE OF PRIVATE OWNERS.

The Land Agents Society most kindly circulated to some of their members particularly interested in forestry, copies of a questionnaire which dealt in detail with many questions which are of interest to those who plant timber. Eighteen sets of answers were returned, and a summary of the answers to each question is given below. In most cases the answer is likely to have been influenced by the part of the country in which the work has been carried out and the experience gained, and, therefore, in connection with each answer the county of the estate which is reported upon is given. Some of the writers, notably those reporting on estates in S. Hants, E. Sussex and Durham, write from an experience gained on several estates in different counties, but the context and questions will show, where this is of importance, whether the answers given are local or general. The estates dealt with are very fairly well distributed both over Scotland and England. Two fall in Dumfriesshire, of which one is called Eskdale to distinguish it from the other. Two are in Hants, one in the north and one in the south of the county, and two in Sussex, one east one west. The Yorkshire estate is in the southern part of the N. Riding of that county.

All but two of the estates have nurseries, eight growing seedlings and transplants, seven transplants only, and one the largest, of 14 acres growing " transplants chiefly." The average size is about $2\frac{1}{2}$ acres, the smallest—half an acre—growing both seedlings and transplants.

The cost per thousand plants produced is given as follows :— 15*s.*, 2 yr. + 2 yr., N.W. Durham ; larch, 2 yr. + 1 yr., 40*s.* ; Scots pine, 2 yr. + 1 yr., 20*s.*, Morayshire ; 20*s.* to 25*s.*, 2 yr. + 2 yr., Dumfries ; 25*s.*, 2 yr. + 2 yr., Cornwall ; 28*s.* 6*d.*, 2 yr. + 1 yr. and 2 yr. + 2 yr., Eskdale ; £2 approximately for plants bought in as seedlings, N. Hants.

The following questions were asked : *" Can you say whether you think the nursery pays ? "* and *" If it pays, is it directly, i.e., because plants are raised cheaper or indirectly, e.g., because your plants do better or having them at hand gives you greater liberty in planting, or because nursery work can be economically arranged to fit in with other forestry or estate work, etc. ? "*

There was fairly general agreement that the nursery paid directly and entire agreement that it paid indirectly. The following answers are typical :—" The plants are actually cheaper than if purchased and plants do better than if purchased " (Eskdale). " Yes. The plants are raised cheaper and do very much better " (N. Hants). " The reason the nursery pays is because we buy seedlings and

with having the plants at hand it gives us greater liberty for planting, and the nursery work is economically arranged to fit in with other estate work " (N. Derby). " I consider they pay indirectly because the plants are at hand when required for planting, and risk of damage in transit by drying and heating is very largely diminished " (S. Hants.). " Certainly, indirectly, I have tried larch home-grown against bought plants in alternate rows, and the home-grown ones have thriven much better " (E. Suffolk). " Indirectly, no one can doubt the superiority of home-grown transplants, and I have had serious difficulty owing to weather and transport delays from northern nurserymen " (E. Suffolk).

The following is a particularly interesting answer :—" I have run two or three nurseries at different times, but only on a small scale, and I find that financially it is not directly a paying proposition. This is largely due, I think, to the fact that our soil has not got into condition, and we do not get the growth that the nurseryman gets. But it *does* pay in that the trees from the nursery when planted out start away better than the trees from a nurseryman " (E. Sussex).

The only answer dissimilar from those quoted is " No. We only keep nurseries so as to have trees ready at hand for making good failures in plantations. When any other planting takes place we buy the necessary trees " (Glamorgan).

The following interesting nursery balance sheet for a year is from Montgomery :—

EXPENDITURE.

	£	s.	d.	£	s.	d.
Lining out seedlings	25	11	0			
Clearing, weeding, and scuffling ..	19	9	11			
Digging	4	7	6			
Raising plants	9	4	4			
Rent, ·577 acres	0	15	0			
Proportion of Head Forester's salary ..	10	0	0			
				69	7	9
Seedlings purchased				15	14	0
To Balance being net profit				29	6	0
				£114	7	9

RECEIPTS.

Plants used on Estate :—	£	s.	d.	£	s.	d.
Larch .. 2,900 at 40*s.* per 1,000	5	16	0			
Beech .. 3,105 at 50*s.* ,,	7	15	0			
Sitka .. .. 1,150 at 35*s.* ,,	2	0	3			
Oak .. .. 2,850 at 55*s.* ,,	7	16	9			
Douglas .. 900 at 40*s.* ,,	1	16	0			
Poplar .. 525 at 30*s.* ,,	0	15	9			
11,430 plants, value ..				25	19	9
Plants sold				88	8	0
				£114	7	9

The next question was : *" Do you find any species particularly difficult or easy as (i) seedlings (ii) transplants ? "*

Most replies mentioned difficulties as follows:—" Larch seedlings " —Montgomery; " Corsican pine transplants particularly difficult "—S. Hants ; " Corsican pine very difficult, Sitka spruce very easy "—Cornwall ; " Scots pine easy, the weed of soil ; Corsican difficult for the chalk soils "—E. Dorset ; " Corsican pine difficult to transplant, Scots pine and spruce easiest to raise as seedlings "—E. Suffolk ; " Corsican difficult as seedlings "—Monmouth ; " Corsican pine as transplants "—N. Lincs ; " Larch raised from seed usually fails "—N. Hants ; " Difficulties, European larch, both seedlings and transplants ; Sitka spruce is sometimes difficult to bring through the winter as one-year seedlings "—Eskdale ; " Douglas fir will not do at all on account of the smoke in this industrial area ; Corsican pine are difficult to transplant, common and Sitka spruce easiest to grow "—Glamorgan.

To the question : *" Have you found that any particular methods give good results as regards (i) preparation of seed : (ii) shelter : (iii) weed problems : (iv) pests : (v) other "* there was no great number or variety of answers. Red leading of seed was several times mentioned ; shelter was referred to as follows :—" from early morning sun, against N.E. winds, for larch in spring "—Morayshire, and " by green branches in hot weather "—W. Sussex. "Against weed a blow lamp is used "—Morayshire, and the Montgomery estate is considering the possibility of getting one, and constant hoeing is several times commended. A few estates find mice very troublesome when oak is sown, and have to use small mesh netting or mouse traps. The following is a useful note :—" Sow ash seed last two weeks in August, when 90 per cent. will germinate in the following spring, thereby saving a year. All other hardwoods if mice and other vermin are exterminated are better sown when ripe "—S. Hants.

" What area of average annual planting do you think would justify having a nursery : (a) For transplants only : (b) for seedlings and transplants ? " Rather more answers named small than large areas, for instance :—" (*a*) 2 acres, (*b*) 5 acres. Three acres for transplants. Five acres and upwards would justify buying seedlings. About 6 acres per annum. Not less than 5 acres in either case. Provided the planting programme is continuous I would have a nursery even if yearly programmes did not exceed 5 acres." On the other hand :— " (*a*) 25 acres, (*b*) 50 acres—Dumfriesshire ; 30 acres—N. Lincs. From 30 acres upwards for both—Morayshire ; 20 acres—Sussex and Yorks." From E. Dorset came the sound point :—" The chief of many factors is not area but regular planting."

" Have you been much inconvenienced by heating or freezing of plants in transit ? " Heating is mentioned several times, and in a few cases the drying of roots when there has been delay on rail. The two most specific answers were :—" Heating, chiefly with two-year Scots pine, particularly in close woven mats "—E. Dorset, and

"It was a consignment of heated plants which caused me to start home and forest nurseries"—Yorks.

In the question as to *costs of planting* it was requested that a general description might be given of the areas dealt with and the figures are most interesting where this is done :—

Rough hill ground, Dumfries.—Fencing, £1 11*s.* 9*d.*; drainage, 6*s.* 4*d.*; planting, £2 6*s.* 4*d.*; plants, £6 1*s.* 6*d.* Total, £10 5*s.* 11*d.* Scots pine and spruce, 4 feet apart, Japanese larch, 5 feet apart.

Oak plantation, N. Hants.—Preparing ground, 50*s.*; fencing, £14; cost of 2,500 oak at 80*s.*, £10; planting, £6 5*s.*; beating up and cleaning, 30*s.* Total per acre, £34 5*s.* "We should probably use oak from the nursery which had only cost us £2."

Mid-Cornwall.—Cut and burn rubbish, £3; three days loosen soil with mattock, 16*s.* 6*d.*; 6 days' plant, £1 13*s.*; 2,250 plants, £2 16*s.*; 3 days' clearing, 16*s.* 6*d.* Total £9 2*s.*

Sussex.—"We find that the men plant about 450 trees each a day normally, but when they get used to it up to 600. We generally plant four feet apart, which gives, say, 2,500 trees per acre, allowing for rides, etc. Reckoning for setting out the work, etc., a man plants almost exactly an acre a week. The cost of the fencing varies according to the size and shape, and preparation varies according to whether it is agricultural land or planted after conifers or after coppice with standards. The following is an example :—

	Per acre.					
	£	*s.*	*d.*	£	*s.*	*d.*
Clearing up rubbish	4	0	0			
Planting, one man at 34*s.*	1	14	0			
Plants, 2,500 at 35*s.*	4	7	6			
Fencing	3	0	0			
				13	1	6

Cleaning after the first year again varies according to whether the land is agricultural or coppice or bracken land. It may be taken at £4 per acre."

E. Dorset.—"I have incurred costs ranging from 76*s.* to £30 per acre, according to area and plants used. Both figures include fencing, the lower figure is for mattock planting of two-year seedlings on new ground, at 1*s.* per 100, no day work."

Suffolk.—"I think it costs here about £13 per acre to prepare fence (including rabbit netting), pit plant at 4 feet 6 inches apart, and buy plants at 40*s.* per 1,000."

Under "*Costs of particular operations,*" some useful figures were given.

"Fencing, 16*s.* per chain, planting, 6*s.* 9*d.* per 1,000 by notching 2 yr. + 1 yr."—Morayshire. "Every man planting 2 yr. + 1 yr. by the notching system should plant 600 trees per day."—Yorks. "Cost of planting per 1,000 approximately 14*s.*; method T or L; size 12 inches to 18 inches"—N.W. Durham. "Devon two-bill mattock planting 2 yr. and 2 yr. + 1 yr. plants, 1*s.* per 100."—E. Dorset. "Cost of planting about 30*s.* per acre for 2 yr. + 1 yr. plants, notch planting."—Glamorgan. "Planting costs, 18*s.* to 20*s.* per 1,000 plants, 1½ to 2 feet holed in."—N. Lincs. "Labour pit planting, 1½ to 2 feet transplants, 40*s.* per 1,000."—S. Hants. "Cost of material and labour for erecting a fence against rabbits, 10*d.* per yard."—N. Derby. "Cost of fencing with rough stakes and wire-netting 42 inches wide, 1¼ inch mesh and 18 gauge works out at 1*s.* per yard run, or 22*s.* per chain."—Wilts. "Labour erecting, 42-inch wire netting fence, with one strand of wire on top, with piles 12 feet apart, and all necessary straining posts and struts, wire being bent over at bottom and pegged to ground, all materials being provided on site, 4*s.* per chain."—S. Hants.

The following from Yorkshire is an interesting practical point:—

> "Fencing against Stock. The cheapest effective fence is single strand wire and either oak or larch posts. The posts should be all pitted and well rammed, if pointed and driven into the ground the tops are damaged, rain penetrates, and in the course of a few years the top staples are either pulled or fall out."

"*Can you give any average figure of the proportion of plants planted which have to be replaced and the reason?*"

The fullest answer came from Eskdale:—"Beating up from nil to 50 per cent., average about 15 per cent. The usual causes of deaths among plants put out are: (1) weevil damage; (2) frost; (3) cold east winds in spring; (4) insufficient drainage; (5) sourness or acidity in soil not fully known until after planting; (6) less commonly, hares, rabbits, roe deer." Other answers were:—"5-10 per cent. due to drought and frost"—Dumfries. "Five per cent. according to season and damage by trespass, people and sheep"—Glamorgan. "Average losses pit planting 10 per cent."—S. Hants. "Corsican, 5 per cent., poorly rooting transplants"—Cornwall. "A good many beech owing to N.E. winds during a frost"—Chiltern Hills. "30–50 per cent. after a drought in the gravel soil part of this estate"—E. Suffolk.

The effect of difference of conditions on choice of species is markedly brought out in answer to: "*Have you been particularly (a) successful (b) unsuccessful with any species, with probable reasons?*" Many careful answers were given:—

" Japanese larch and sitka very successful. Common larch less successful owing to their being killed by excessive weed growth due to their slower growth when young. Douglas start off well, but are soon uprooted by wind, and have proved unsuccessful owing to the large amount of smoke in this industrial district "—Glamorgan.

" Successful—Sitka spruce, eminently suited to the locality. Unsuccessful—larch. Climate probably too damp causing larch disease."—Mid-Cornwall.

" Larch have given best results, the situation is particularly suitable and well sheltered."—N.W. Durham.

" Good—Sitka spruce, Corsican and Scots pine, oak, beech, chestnut. Bad, Douglas fir, larch (clay soil)."—Monmouth.

" Difficult to establish a crop. Scots pine will succeed and have been used on light land to replace dead trees of this species. Corsican pine has done well after some difficulty in establishing."—E. Suffolk.

" Most successful with Japanese larch. We find it difficult to get all hardwoods to start, especially sycamore."—E. Sussex.

" Douglas fir and European larch has grown very well if in right soil and situation which has not always been the case. The two best species are oak and Scots pine, probably due to their having been raised by natural regeneration."—Wilts.

" On the whole successful with all species, which I put down to pit planting ; experience over large part of the South of England ; 14,000 acres of woodland managed."

" The soil and situation of the plantation have more to do with the success of the operations than any other factor excepting perhaps a very dry spring."—N. Lincs.

The two reports from Dumfriesshire are on similar lines except as to experience with Scots pine : " Most successful, hybrid larch, Sitka spruce, Norway spruce, poplar. Fairly successful, Japanese larch, *Abies grandis*, *Tsuga heterophylla*, alder, beech, sycamore. Least successful, Douglas fir, Scots and Corsican pine, European larch, oak, ash."—Eskdale. " Three species have proved to be best for the estate :—Scots pine, Sitka spruce, Japanese larch. It is impossible to grow the common larch here as it soon succumbs to the fungus canker disease (*Peziza Willkommii*)."

The next question was the first which came under the heading " Yield and Costs." It was : " *Do you go through your young plantations for removing dead or malformed trees or for pruning, before they get to the stage at which thinnings pay for themselves ? If so can you give costs of this per acre for different species ?* "

From N. Hants, Mid-Cornwall, N.W. Durham, and Monmouth the answer was " No," and from Wilts, " Sometimes, as a rule the larch is not beaten up [first-thinned] before the thinnings pay. If it was beaten up [first-thinned] earlier there would probably not be so much canker."

The following answers are representative of the remainder :—

"Yes, cost 25*s.* to 40*s.*, larch lowest. Douglas fir, highest."—Eskdale.

" If possible the hardwoods are pruned when they can be done with a pocket knife, in any case we try to go through before the area is ready for brushing."—N. Lincs.

" As soon as the trees reach a pole stage we go through the plantations and cut out all the dead trees and the badly suppressed, and all rubbish ; the main object being to enable us to see what we have got. Then four or five years later we go through again and mark the trees that are to be cut."—E. Sussex.

" Yes, but no pruning, only knocking off larch branches."—E. Dorset.

" Yes, in larch plantations suppressed branches are knocked off before trees are marked for initial thinning."—E. Suffolk.

The next question was, " *At what age with different species do you think that a crop begins to pay, either* (*a*) *for estate purposes* (*if so, what ?*) *or* (*b*) *for sale ?* " All the answers received are quoted :—

" I have found the thinnings from the Garden City Plantation pay for the labour after trees—chiefly larch—were only 10 years planted."

" The abnormal demand for rustic poles raised the price. Larch poles for wireless sold at 4*s.* per cubic foot, and at 3*d.* per linear foot. I have also sold larch poles averaging 6 cubit foot at 6*d.* per foot, 10 miles from the nearest station."—Yorks.

" Larch at 15 years for rails."—Monmouth.

" (*a*) Larch, 25 years, posts and rails ; (*b*) larch, 20 years, pitprops ; Scots pine, 25 years, pitprops."—Morayshire.

" Depends on soil, but broadly, larch, 25 ; Scots pine, 20, and spruce, 25, for pergola work."—E. Dorset.

" Larch is useful for estate purposes at 15–20 years old. Other conifer not till 30–40 years."—N.W. Durham.

" One cannot discriminate between estate and sale. Larch (European and Japanese) begin to pay at 15 years, sometimes even at 12. Douglas fir are just being appreciated and will pay at 15 years. Others pay at about 20 years."—E. Sussex.

" For sale at 18 years. Sitka spruce sells well for pitprops, fencing, scaffold poles, etc."—Mid-Cornwall.

" Larch will begin to pay at 12–15 years, that is, as soon as it is large enough for rustic work."—N. Lincs.

" Larch at 20 years old begins to pay with thinnings for hedging stakes, posts and fencing rails for estate use and for sale."—Glamorgan.

" Fifteen years (*a*) conifers, rustic stuff and bean poles for sale."—N. Derby.

" European larch (*a*) 15 years, poles ; (*b*) 15 years. Scots pine : (*a*) 20–15 years, fencing poles ; (*b*) 30 years. Oak : (*a*) at 40 years for fencing poles ; (*b*) 70–80 years."—Wilts.

" European larch begins to pay at 14 years for either estate work or sale. Douglas fir, Japanese larch, Sitka spruce, for fencing material (if creosoted), 20–25 years; (*b*) at 40–50 years."—Dumfriesshire.

" The age depends entirely on soil and elevation. Under most favourable circumstances, 15–20 years (hybrid and Japanese larch); other species, 20–30 years. These sizes are for estate purposes."—Eskdale.

The next question was as to *the age when plantations gave the best return* (*a*) *for estate purposes;* (*b*) *for sale.* The following answers are representative:—Larch and Douglas fir, 20–25, for sale; 15–20, for estate work.—N. Hants. Conifers such as larch, Scots pine and spruce, 50–70, according to soil and elevation.—N. Derby. All should be cut before maturity.—S. Hants. Larch, 18–20, Douglas fir, 20, if they can be sold, ash 40, chestnut 40–50.—E. Sussex. Conifers: (*a*) 25 and onwards; (*b*) 80–100; broad-leaved (*b*) 150.—N.W. Durham. The demand for thinnings does not warrant any short rotations.—E. Dorset. Larch, 20–25, for pitwood.—Monmouth. (*a*) Spruce, 50–60, larch, 70; (*b*) Sitka spruce, 20, larch, 70.—Mid-Cornwall. Conifers: (*a*) 50–60; (*b*) 60–80.—Dumfriesshire.

Then came this:—" *Does the timber on the estate make it self-supporting in the matter of timber? If not what do you have to buy from outside?* " All the answers were to the effect that foreign timber had to be bought for doors, door frames, floor boards, match-boarding, etc., but that otherwise estates were self-supporting, except two, where there was no saw-bench.

The following were the most interesting answers to the question: " *What sorts of timber that you use for estate purposes do you think you can grow cheaper than you can buy?* " Oak, ash, chestnut, larch, Scots pine.—W. Sussex. Oak, ash, elm, sycamore, larch, Scots pine, spruce.—N. Derby. Oak, ash, larch, Scots pine, Douglas fir.—N. Hants. Oak, ash, beech, larch, Scots pine, spruce.—Morayshire. All.—Wilts. None at to-day's prices.—S. Hants.

The general purport of the reply to the next question:—" *If you use bought timber is it because you do not grow similar timber or because what you grow is not of sufficiently good quality?* " was that our timber was not of sufficiently good quality for certain purposes. The following answer gave an individual view: " Because I can buy of similar quality cheaper than I can grow; there is no better timber grown than British of similar sorts."—S. Hants. The following answer from E. Sussex expresses the view of several other estates:—" Because we cannot convert nor can we creosote, and it does not pay to have a saw-mill on a small estate."

There was one answer, from Eskdale, to the question:—" *What area of timber would make the estate self-supporting.*" " Four hundred acres would produce ample timber for estate requirements, 85 per cent. conifer, 15 per cent. hardwoods."

It was interesting to find how many estates had *timber crops which pay best on quite short rotations.* Only one estate, Wilts, said " None " without any qualification, though this came near it from N. Lincs : " No crops on short rotations, probably black Italian poplar on suitable soil would give the best result." This also was similar :—" I think larch felled at 25 years might be profitable for use as estate fencing."—E. Suffolk. Other answers were as follows :—Larch, mixed coppice.—Monmouth. Larch and spruce.—Morayshire. Larch, possibly Sitka spruce, Douglas fir, ash (at 40).—E. Sussex. Sitka spruce.—Mid-Cornwall. Larch.—S. Hants. Alder and birch.—Yorks. So far larch, Douglas fir and chestnut coppice.—W. Sussex. Japanese larch and Sitka spruce pay best for pitwood at about 30 years.—Glamorgan. Larch, Scots pine, spruce, Douglas fir.—N. Derby. Hybrid and Japanese larch and Sitka and Norway spruce, possibly Douglas fir in specially favourable situations.—Eskdale.

The answers to the question :—" *At what age would you clear-fell ; (a) conifer ; (b) broadleaved species ?* " seemed almost to conflict with the answers to the preceding question which had given so many instances of crops paying best on short rotations. The only indications of fairly short periods for clear-felling were from E. Suffolk : Larch at 35, Scots pine at 60, ash at 50, oak at 90 if market was good, and from Glamorgan : (*a*) 30 years and upwards for sale, 60 years for estate use ; (*b*) 70–80. All the other answers were fairly represented by (*a*) 60–80 ; (*b*) 80–120, though N. Wilts gave 50 for conifer.

The answers were very various to the question : " *What area have you which is not giving or likely to give a reasonable return ?* " Dumfriesshire and S. Hants said : " None " ; Glamorgan, " None, except perhaps hardwood plantations kept for sentimental reasons." But in N.W. Durham an economical return was not expected from any area, and this tale of woe came from Yorkshire : " On the estates where I planted most extensively not one of the woods will ever pay for the outlay. Ground-game damage was the cause, and I do not think they can ever be made to pay the initial expense with interest. They are simply game preserves." Other estates gave areas as follows : 1,100 understocked and over-mature out of over 4,000 acres ; 330 acres of coppice with standards which was the total of the broadleaved plantations ; about 2,000 acres out of 5,000 ; 210 acres oak coppice, out of 272 broadleaved.

Equally various are the answers to the questions :—" *Would it pay to clear fell and replant the areas not giving a reasonable return ? If not, why not ?* " All the answers are quoted :—" Yes, only the very poorest crops would realize less than the cost of replanting."—Eskdale. " No, because the standards are mainly oak of a very good quality which should be preserved."—Wilts. " Yes," Dumfriesshire. " No, amenity or park timber is never grown clean, and is there for purposes of amenity only."—N. Derby.

" Yes."—N. Hants. " It would not pay at the present time owing to the low price of imported timber."—Glamorgan. " Clear-fell."—W. Sussex. " Would not pay present owner. No one can tell what timber is likely to be worth in the future, and I have very little faith in prophecy."—N. Lincs. " I think it would pay to replant the oak coppice to high forest if the owner could find capital and be prepared to wait."—Mid-Cornwall. " No, the cost of labour and restoration of damage caused is prohibitive."—N.W. Durham. " Yes, it would, and we are already seeing a very good result from the planting done in the past 24 years."—E. Sussex. " No, the owners regard replanting as a patriotic duty."

(To the question, " *If not, why not ?* ") :—" Unrestricted imports from virgin forests and competition by the Forestry Commission on larger units."—E. Dorset. " Yes."—Morayshire. " Not all at once as the shooting would be adversely affected."—E. Suffolk. And again Yorkshire laments, " No use now. The cost of clearing and replanting, fencing and netting might be covered by the sale of the timber left, but unless silvicultural methods are carried out I would never recommend replanting."

The next two questions may be taken together, they asked :— " *Whether there were good local markets for material under plank size and whether it had been possible to work up any such markets.*" There was no special indication of markets having been worked up, but there was very considerable evidence of the existence of local markets. The following answers are outstanding :—" A good local demand for rustic larch, and until the present agricultural depression hedge stakes, thatch pegs and tray ties met with a ready sale. Even now there is a sale for *good* oak, ash, sycamore and beech."—N. Lincs. " We can market everything locally including thinnings at quite reasonable prices, and the thinnings at good prices ; we sell the thinnings for pergola and rustic work, hedge stakes, bean sticks, posts for chicken runs, wireless and scaffold poles, etc."—E. Sussex. " Ash, alder, birch, larch and clean spruce find ready buyers."—Yorks. " No small sizes are wanted in hardwoods except beech, birch and alder for bobbins ; coniferous timber any size above 10 cubic feet per tree."—Eskdale.

Many interesting answers were given to the next question :— " *In the light of this (the existence of markets) would you, if you could start again, plant any of the plantations on the estate which have been planted (a) since the war, or (b) previously with different species ?* "

" We have planted extensively since 1920 with Scots pine, Sitka spruce, Japanese larch, Douglas fir. We have given up planting Norway spruce, as it will not stand the strong S.W. winds, and we are now in doubt about the Douglas fir, as even in sheltered situations severe damage is being done to promising plantations."—Dumfriesshire.

" No Douglas fir since it grows too fast to please the timber merchants. Probably no Japanese larch or Norway spruce. I

should plant some Sitka spruce, also a mixture of ash with European larch ; but Scots fir would be the chief conifer."—Wilts.

" I would have substituted Japanese larch for Corsican and Scots pine, as the thinnings are more saleable."—Glamorgan.

" We are planting what, in our opinion, the land will grow best, and that is the only rule to follow in all planting operations. If the history of some areas that now carry a poor or unsuitable crop was known, it would often show that it was the result of rabbit damage some time in the life of the wood."—N. Lincs.

" I should drop our Douglas fir. They are not suited to a poor grey sand and they are so very apt to be blown down, and we get far better results with Japanese larch. The Japanese outgrow the Douglas fir in mixture. I should also be much more careful about European larch on the land that has any heather on it."—E. Sussex.

" I have tried Douglas fir, but the soil is not suitable. I should replace European by Japanese larch. Possibly *Pinaster* vice Scots pine, I'm not quite sure."—E. Dorset.

" I think I should introduce more hardwoods into larch plantation, especially on the heavier soil so as to have a final crop of hardwood."—E. Suffolk.

Optimism comes out very strong in answering the next question : " *If you were put in charge of an estate in your district of* (*i*) 2,000, (*ii*) 5,000 *and* (*iii*) 10,000 *acres, on which no systematic planting had been done in this century, would you start it ?* " Given that there is on the estate ground not suitable for agriculture there is a general affirmative chorus even as regards the smaller sized estates. Exceptions are N.W. Durham : " No, not unless planting were required for shelter, sporting or ornament," and N. Lincs. : " The political outlook and the high rate of taxation is such that owners may well hesitate before starting a large and continuing outlay in planting trees, which, under the most favourable conditions, will yield little, if any, financial return in the lifetime of the planters. Besides, no one can say who the land will belong to 50 years hence. In certain districts there appears to be a growing demand for shelter belts for sporting purposes. But this is not ' Forestry ' pure and simple. A word of caution might be offered to those persons who are very keen to plant new and comparatively untried varieties of trees. Experiments are to be commended and encouraged, but do not throw over well-known sorts of trees from another country and climate for those which may or may not succeed."

The usual individual and interesting answer comes from Yorkshire :—" If interest and compound interest were to be charged certainly not. However, if there was as much timber left as would pay for reafforesting on silvicultural lines I would. I look upon timber as a crop from the same standpoint as a farmer does upon sowing seed to get a crop. No compound interest ! "

The last question : " *Can you mention any other technical points*

which you have not referred to above which you think might usefully (i) discourage an estate owner from planting or (ii) encourage him to plant? gave great scope, and the following interesting replies may be quoted ?—

From Glamorgan : " Exceptional cost of upkeep in an industrial area owing to high wages payable, wilful damage to trees and fences by trespass and danger of fires. A large number of separate small areas are more expensive to maintain than one large area owing to the greatly increased cost of fencing. Against this can be set the fact that demand for timber should be greater as the markets are closer."

From E. Suffolk : " The cost is rather discouraging. There must be some value for amenity apart from actual value of timber which should make planting attractive to an owner of land. In East Anglia the effect of the large Government plantations of pine must be considered. In 60 years or so the State will have to find a market for this timber and the landowner now planting should be able to share in this market. Another point of view is that with the large amount of State timber coming on the market the small landowner will have no chance."

From S. Hants : " The great deterrents to forestry operations generally are : (i) A sentimental attachment of landowners to their timber which prevents its being cut and sold as and when it becomes mature, or a suitable opportunity occurs ; (ii) the difficulty of finance ; (iii) the incidence of Death Duties."

From W. Sussex : " (i) Death Duties ; (ii) modification of death duties on woodlands that are not amenity woods."

From E. Dorset : " The certainty that prices will rise and of a scarcity of ash."

And again from Yorkshire : " First the Death Duties, high wages, shorter hours worked by men now, and any ground game saving. The only thing is that most landowners like to see and have trees, and freed from national and local burdens planting would be done."

Printed under the authority of HIS MAJESTY'S STATIONERY OFFICE
By Harrison and Sons, Ltd., 44–47, St. Martin's Lane, W.C.2.

(B 12/3426)Q Wt. 8325–665 1500 2/33 H & S, Ltd. Gp. 12