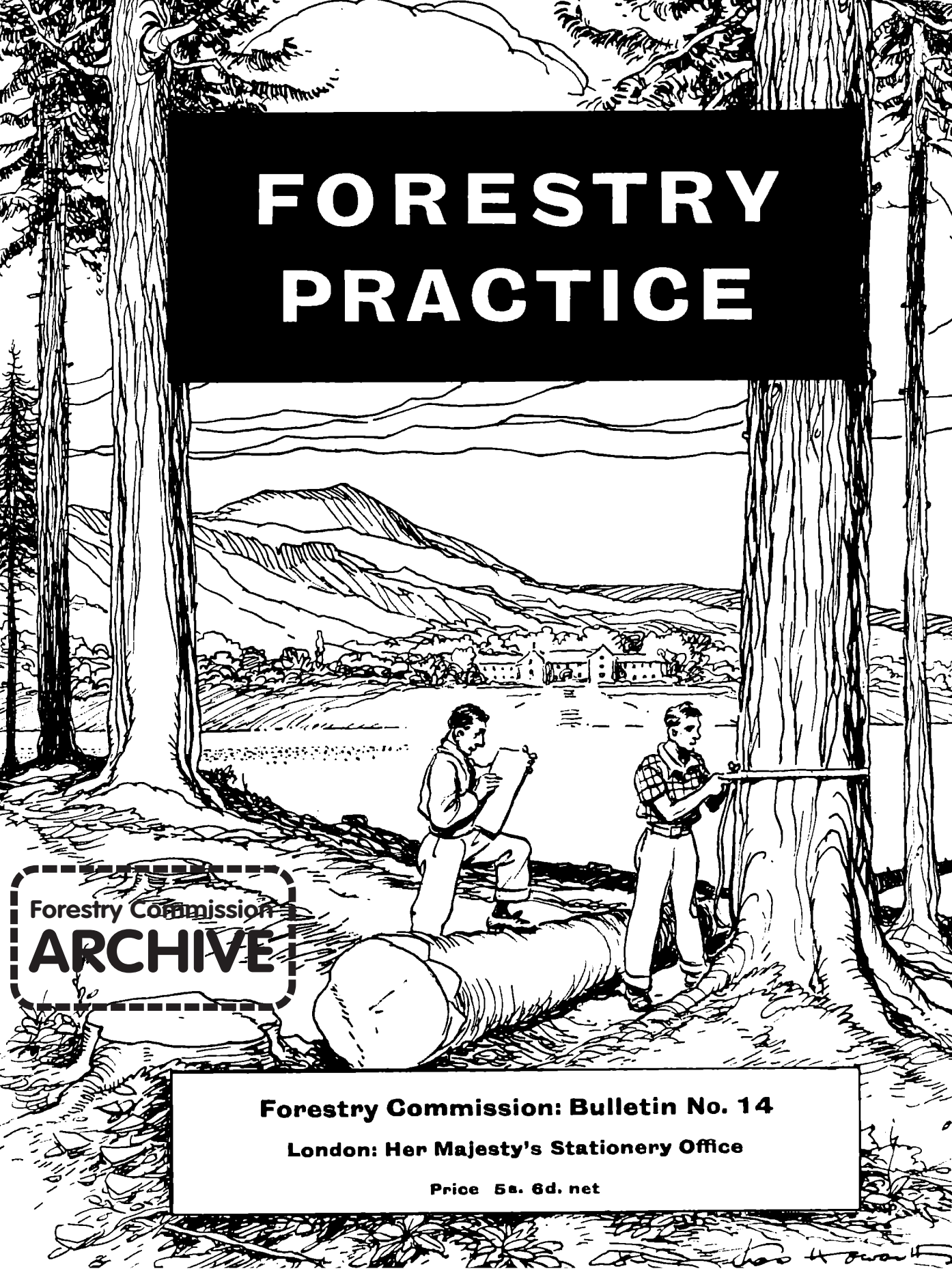
FORESTRY PRACTICE



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FORESTRY PRACTICE

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

Eighth Edition 1964

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Forestry Commission

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FOREWORD

THIS Bulletin was originally conceived in 1933 by the late Sir Francis Acland, who was then a Forestry Commissioner, with the object of making available to landowners and others concerned with private estates, the experience and knowledge gained by the Commission's staff. It does not purport to be a formal textbook covering the whole science of forestry, but rather a handbook of those operations that the average landowner, his agent, or his forester, have to tackle most frequently. As Acland pointed out, no printed account can provide a complete substitute for the information and advice that an owner may gain from an actual inspection of his woods by a professional consultant or by one of the Commission's staff concerned with advisory work. But much useful knowledge, and a host of facts required for reference, can be set down in print.

Over the past thirty years, seven editions of this Bulletin have been issued, and the necessity for a full revision, to take account of the many recent developments, had become apparent. This work was entrusted, in 1963, to a group of experienced Forestry Commission officers who augmented their own experience and knowledge with that held by other members of the Commission's staff. This present edition is, therefore, very much the outcome of team work, though certain people have been mainly responsible for particular sections. Mr. J. R. Aldous is the principal author of Part I, which deals with Nursery Work; he was assisted by Mr. J. Atterson. Mr. R. F. Wood is responsible for the revision of Chapters 8 to 12, on the Establishment of Plantations. Chapter 13, on Thinning, was overhauled by Mr. D. R. Johnston and Mr. J. W. L. Zehetmayr. Dr. D. H. Phillips saw to Chapter 14, on Diseases, Mr. D. Bevan to Chapter 15, on Insects, and Mr. C. A. Connell to Chapter 16 on Fire Protection. Chapters 17 to 19, on Utilisation, have been revised by Mr. E. G. Richards, while the notes on forest tools in Chapter 20 were contributed by Mr. J. W. L. Zehetmayr.

FORESTRY COMMISSION,
25 Savile Row,
London, W.1.
June 1964

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PART I
NURSERY WORK

Chapter 1
ESTABLISHING A FOREST NURSERY

IN this section of the Bulletin, the techniques currently used in Forestry Commission nurseries are outlined; they are not the only satisfactory techniques but most have been found successful over a period of years under many different conditions of soil and climate.

Before describing how to raise plants, mention must be made of the factors to be considered when deciding whether or not to have a nursery. The most important are skilled supervision and adequate labour, a suitable site and a sustained demand for plants. All of these are essential if the nursery is not to be run at a loss. Considerable financial loss can result from badly managed nurseries, and where there is only a small area to be planted the most satisfactory method of obtaining plants is usually by purchase. Both transplants and seedlings can be bought from forest tree nurserymen at reasonable prices, though they are best ordered at least one year ahead in order to be certain of having the plants when required.

If it is decided to run a nursery, it should be remembered that it is not always necessary to raise plants from seed. Raising seedlings suitable for transplanting requires a suitable site and skilled attention if good quality plants are to be obtained at a cost comparable with trade prices. Therefore, unless skilled direction and supervision by a trained forester or a thoroughly experienced workman is available for managing the nursery, it may be better to buy seedlings from a nurseryman, and line them out for use as transplants one year later.

SITE REQUIREMENTS

The most important requirements for a nursery site are a light soil which can be worked at most times of year, moderately acid conditions (pH 4·5—5·5), and freedom from weeds. The site should not be subject to late spring frosts; it should, if possible, be on a slight slope (to facilitate drainage of water and cold air) and should be accessible to wheeled vehicles in all weathers. A nearby water supply is desirable.

Soil texture is one of the most important factors, because it affects all cultural operations. Well-drained stone-free sandy loams or loamy sands are the most desirable because they are friable and can be worked in late autumn and early spring when heavier soils are unworkable. They also minimise the risk of 'frost-lift' of young seedlings. The soil should have a combined silt and clay content of not more than 25 per cent. If the soil is too sandy, there may be excessive leaching of plant nutrients; and where there is much fine sand there is the risk of losing top soil by wind during dry spring weather, or by heavy rain-storms. Nevertheless, there are several highly productive nurseries on pure sand soils.

Heavy soils should *not* be chosen for nursery sites. They are difficult if not impossible to work in the winter; they are often insufficiently acid for the best growth of several species of conifer, and frequently they are also heavily infested with weeds. Growth of conifers is slower on sites where the soil is neutral or only slightly acid, compared with growth on acid soil. On alkaline soil plants often become chlorotic, their foliage looks yellowish, and they grow very poorly in spite of heavy manuring.

For most hardwoods, best growth is obtained on acid or slightly acid soils. Poplars and ash however grow best on neutral or slightly acid soils.

Sites free from weeds are most desirable. The size of the weed population can by itself determine whether a nursery is profitable. A heavy weed infestation is most costly to remove or control, and it can cause far greater reduction in seedling numbers and in height growth of both seedlings and transplants than is generally recognised.

Suitable weed-free sites are often found on heathland or in existing woodland, amd their development is outlined below. Old kitchen gardens, though tempting as potential nursery sites, should be avoided; they are generally extremely weedy and the soil neutral or even slightly alkaline.

Since 1944 there has been a steady increase in

the use of heathland sites for nurseries because of the high yield of excellent quality plants which they produce, and the low cost of maintenance, due to their relative freedom from weeds. The majority of suitable heathland areas are found in the eastern and southern parts of the British Isles on light sandy soils derived from sandstones and unconsolidated sands. These soils usually support heather or ling (*Calluna vulgaris*), with some bracken and wavy-hair grass (*Deschampsia flexuosa*) in mixture. Sites in cleared pine plantations should not be used to raise young pines owing to the risk of the infection by *Lophodermium* fungus from the surrounding plantations.

SIZE

The size of the nursery, if it contains both seedbeds and transplant lines mainly of conifers, should be between one twentieth and one twenty-fifth the size of the estate's annual planting area. If all plants are raised from seed about one-fifth of the cropped nursery area will be taken up by seedbeds.

LAYOUT

Once the site for the new nursery has been selected and its size calculated, its shape and layout should be decided. A rectangular shape facilitates cultivation, whereas with irregular shapes it is very easy for odd corners to be neglected and to become refuges for weeds. The nearer the rectangle is to a square, the smaller the amount of fencing that will be required to enclose a given area.

Permanent roads, ten to twelve feet wide, should be planned as convenient within the area and around the perimeter. The perimeter tracks help to isolate the cultivated ground from surrounding vegetation; they also afford useful turning spaces for machinery. In a large nursery, some of these roads should be metalled so that they can carry a lorry in all weathers. This metalling should be done with gravel that is quite free from limestone or industrial waste materials, as these can have an adverse effect on the adjacent soil.

SITE PREPARATION

The next step is to clear away the ground vegetation and to cultivate the soil.

Heathland sites should if possible be at least 100 yards from any roadside, in order to decrease the risk of weed seeds entering. The heather or ling should be hand-pulled or cut mechanically and burned in piles away from the nursery area. Burning the heather on the site before or after pulling is not recommended, because fire destroys part of the valuable surface peat layer and because the sites may become colonised by the fungus *Rhizina inflata* which later may kill seedlings and transplants.

Having cleared the area it should then be either hand-dug or shallow-ploughed in autumn to a depth not exceeding five inches, and subsoiled if a pan of any type is present. Shallow ploughing will avoid turning up subsoil inimical to satisfactory seedling growth. The ground should be left in this condition over winter.

Grassy areas are best tackled by deep ploughing, followed alternately by discing and tine-harrowing at intervals of a few weeks through the summer.

FENCING THE NURSERY

Fencing of the whole nursery area against rabbits, sheep and cattle is essential. This can be done before the site is cultivated, but it is better to fence after cultivating, so that cultivation can come right up to and a little beyond the fence line. (For details of suitable fencing materials, see page 42).

If the site is exposed to strong winds, permanent hedges should be planted; Lawson cypress and *Cotoneaster simonsii* are very suitable species, though other species may be used if preferred. However, Western red cedar, *Thuja plicata*, should never be used because of the risk of the 'Keithia' fungus disease, *Didymascella thujina*, infecting the hedge and becoming a permanent source of infection for any *Thuja* species raised in the nursery. Similarly, beech can harbour aphis which can infest and check growth of beech transplants and seedlings. Where internal shelter hedges are desirable, the extent of ground enclosed in each section should not be less than one acre. Where much mechanisation is contemplated, long uninterrupted runs of 300-450 feet should be allowed; sections of ground should be long and thin, with hedges running parallel to the long axis of the section.

INITIAL FERTILIZING AND CORRECTION OF EXCESS ACIDITY

After cultivation, and fencing, the necessary fertilizers or manures are normally applied in the course of preparing for seedbeds or transplant lines. Exceptionally, on very acid soils (pH 4·5 or less) a dressing of ground limestone or ground chalk at no more than 5 hundredweight per acre should be applied immediately after the initial cultivation. On extremely light and acid sandy soils, Bessemer basic slag may be applied at the same rate in addition. In areas where dolomitic limestone is available, this may usefully be applied instead of ground chalk or limestone, particularly on heathland sites as these are often deficient in magnesium.

At one time, it was thought necessary in a newly broken-in nursery to put in a first crop of transplants so as to inoculate the soil with the fungi required for good plant growth. This has rarely been found necessary anywhere in Great Britain. It is preferable on any new, weed-free site to sow seed and raise seedlings on the site rather than risk introducing weeds with imported seedlings.

Chapter 2
THE GROWING OF SEEDLINGS

SUPPLY OF SEED

Seed requirements will depend upon the size of the areas to be planted, one, two, three or possibly four years ahead, and the age and species of the plant as well as upon the origin and quality of the seed, and the productivity of the nursery.

Seed should be purchased from seedsmen who are themselves collectors and importers, and if expensive seed is to be purchased, alternative quotations should be obtained. Seed may also be purchased from the Forestry Commission. Orders should be placed early, preferably by September for sowings in the following spring. It may be noted that many suppliers now belong to one of the Forest Tree Seed Associations and can supply seed certified to have been collected from known good quality parent stands in Britain.

Seed from stands certified to be of good quality will often be more expensive than uncertified seed. However, it is generally worth while to pay for the more expensive certified seed.

Tables 1 and 2, on pages 4 and 5, give the seed properties of the commonly used forest species, based on Forestry Commission laboratory and nursery records over many years. The figures given may be used as standard against which to judge seed offered for sale, or which may have been collected locally.

Details of the germination percentage, number of pure seed per pound, and number of viable seed per pound, are provided for all conifer seeds tested at the Forestry Commission's licensed seed testing station at Alice Holt Lodge, Wrecclesham, Farnham. This station only deals with seed collected or imported by the Forestry Commission, and with seed collected by members of Tree Seed Associations (for details see Appendix), who wish to use the seed themselves. Members' seed, and seed from other sources which is to be offered for sale, must under the Seeds Act of 1920 be sent for testing to the Ministry of Agriculture Seed Testing Station in Cambridge or to the Department of Agriculture Seed Testing Station at East Craigs, Edinburgh.

Where untested conifer seed has to be sown, a 'cut test' should be made on a hundred-seed sample to obtain a very rough figure for the viability of the seed. When making a 'cut test', it is important to get an unbiased sample of 100 seeds from the bulk of seed to be sown. Each of one hundred seeds is cut with a sharp knife or razor blade and the seeds that are full and have a white firm embryo and endosperm are counted. The number of full seeds gives a rather high estimate of the germination percentage and this figure should be reduced by 10%. The 'cut-test' is useful as a guide but one cannot by inspection distinguish full seeds which are alive and healthy, from full seeds that have been killed or damaged by heating or bruising during extraction. Thus there is always a risk that the 'cut-test' will mislead.

STORAGE OF SEED

(*See also:* Preparation of Seed for Sowing, page 6. *And also:* Autumn Sowing of Hardwoods, page 7).

Most conifer seed can be safely stored for two to three years if put into sealed airtight containers after extraction and kept in a *cool* dry place, e.g. a wine cellar.

Hardwood seed requires more care in storage. Oak and beech seed cannot be stored dry. From the time of collection until January, the seed has to be turned at weekly intervals to prevent moulds forming; thereafter, until sowing it may need to be moistened occasionally to prevent drying out. (See Forestry Commission Leaflet 28; *Collection and Storage of Acorns and Beech Mast*, for details.)

PREPARATION OF THE GROUND

Calculation of Area

Tables 1 and 2 below give the number of square yards of sowing area which will be required for 1 lb. of seed of average quality, and from this the area required for the beds can be calculated. If the beds are 3½ feet wide only the centre 3 feet should be sown; three inches must be left unsown along each side, as seedlings close to the bed edge are often damaged. Thus one running yard of bed is equivalent to one square yard sown.

Cultivations

The site for seed beds should be ploughed in the autumn. On light soils, which do not have to be left rough throughout the winter to enable frost to break up the clods and form a good working tilth, seedbeds may be thrown up in the autumn after ploughing. Otherwise the ground should be left ploughed through the winter and the beds be thrown up as soon as the ground is workable in the spring. On very heavy soils, instead of ploughing, the

ground may be ridged up with potato ridgers set deeply and 2½ feet apart. The ground should remain ridged over winter to allow the frost, water and sun to break up the soil into a suitable condition for final bed preparation in spring.

Throwing-up of Beds

Seedbeds should be made 3½ feet wide, allowing 18 inches for alleys between beds. Alleys should be dug out by hand, or by tractor and potato-ridger, set 5 feet apart to throw the soil on top of the seedbeds. The height of the newly thrown-up beds should vary according to the soil type and climate, e.g. in wet regions on heavy soils the beds at this stage may well be eight to ten inches above the alleys, whereas in dry areas the height will be four to six inches; this allows for the beds finally settling to depths of five, and two to three inches, respectively.

Spent hops and similar bulky organic manures should be spread just before seedbeds are thrown up, and be worked-in during bed preparation.

In spring, all seedbeds should be roughly cultivated and levelled (on ridged ground by pulling two ridges together with a rake and leaving alternate furrows for alley centres); this should be done when the soil is moist, neither very wet nor dry.

Inorganic fertilizers should be forked into the top 3 to 4 inches of soil before the final levelling (see Chapter 4, page 18, for rates). Afterwards the beds should be levelled, raked and consolidated by trampling or rolling.A suitable type of roller is a metal one weighing one or two hundredweight, measuring twelve to fifteen inches in diameter, and three feet six inches wide. After trampling, the surface of the beds should be smoothed with the back of a rake. Good consolidation is a prerequisite for high yields of seedlings. Under-consolidation of the soil causes a reduction in germination and also lengthens the period of germination. If firm pressure with a clenched fist on the seedbed leaves only the light impression of the knuckles, the bed is adequately consolidated.

Where a previous crop has to be cleared before seedbeds can be prepared, the procedure is the same as outlined above except that all operations follow each other quickly. It becomes important to work heavier soils when they are not too wet, otherwise they will lose structure. Particular attention must also be paid to consolidation.

TABLE 1

DATES FOR SEED COLLECTION, GENERAL SEED DATA AND SOWING PRESCRIPTIONS, FOR THE PRODUCTION OF CONIFER SEEDLINGS

Species	*Normal month of collection*	*Normal Seed Qualities*				*One-Year Seedling Production*		*Two-Year Seedling Production*	
		No. of Pure Seed per lb. (Thous.)	*Germination percentage*		*No. of Viable Seed per lb. (Thous.)*	*Recommended Density of Viable seed per sq. yd. (Thous.) (broadcast)*	*Normal Sowing Area† (sq. yd./lb.) (broadcast)*	*Recommended Density of Viable seed per sq. yd. (Thous.) (broadcast)*	*Normal Sowing Area† (sq. yd./lb.) (broadcast)*
			Normal	*Low*					
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Scots pine	January	75	90	50	67	1·2	55	1·0	65
Corsican pine	January	32	80	50	25	0·6	40	0·5	50
Lodgepole pine*	January	135	90	50	120	1·2	100	1·0	120
European larch	November	75	30	15	23	1·0	25	0·8	30
Japanese larch	September	115	40	20	46	0·8	60	0·6	75
Hybrid larch	September	110	30	15	33	1·0	35	0·8	40
Douglas fir*	September	40	80	50	32	1·0	30	0·8	40
Norway spruce	October	65	80	50	52	1·5	35	1·2	40
Sitka spruce	September	190	90	50	170	1·8	95	1·4	120
Grand fir*	Aug./Sept.	23	25	10	6	0·8	7	0·6	10
Noble fir*	Aug./Sept.	15	25	10	4	1·0	4	0·8	5
Western hemlock	September	290	60	30	175	2·5	70	2·0	90
Western red cedar	September	400	60	30	240	2·5	100	2·0	120
Lawson cypress	September	210	50	30	105	1·5	70	1·2	90

Notes: * Seed of these species benefits form stratification, see page 6.
† For drill sowing add 25 per cent to these figures.

TABLE 2

DATES FOR SEED COLLECTION, GENERAL SEED DATA AND SOWING PRESCRIPTIONS, FOR THE PRODUCTION OF HARDWOOD SEEDLINGS

Species (1)	Normal Month of collection (2)	No. Pure Seed per lb. (Thous.) (3)	Normal Sowing Area (Sq. yd./lb.) Broadcast** (4)	Remarks (5)
Oak	October	0·13	1	Because of variation in seed size, sowing seed. 3-in. apart is preferable to sowing by weight See F.C. leaflet 28
Beech	October	2·0	4	
Sycamore	Sept./Oct.	6·0	8	S w immediately or stratify for 4 months. See F.C. leaflet 33
Ash	Oct. (*)	6·0	12	Stratify for 18 months. See F.C. leaflet 33
Birch	Aug./Sept.	250	30	Very variable germination
Sweet Chestnut	Oct. (†)	0·11	0.6	Treat as for oak above
Wych Elm	May/Jn. (‡)	50	10	Very variable germination
Gean or Wild cherry	Jly./Aug.	2·5	5	Double the weight if seed is sown with pulp. Sow immediately or stratify for 4 months.

Notes:

(*) Collect July/August for immediate sowing; later collections must be stratified for 18 months.
(†) Does not normally set fertile seed in Scotland.
(‡) For immediate sowing.
(**) For drill sowing add 25 per cent to these figures.

Example:

The sowing area for one pound of Scots pine seed having 90,000 seeds per lb. and a germination of 40 per cent would be calculated as follows:

$$\text{No. of viable seeds} = \frac{90{,}000 \times 40}{100} = 36{,}000$$

$$\text{Sowing area} = \left\{ \frac{\text{No. of viable seeds per lb.}}{\text{Recommended No. of viable seeds per sq. yd.}} = \frac{36{,}000}{1{,}000} = 36 \text{ sq. yd. of seed bed, less } 20\% \text{ to compensate for low } \textit{germinative energy}. \right.$$

$$= 36 - \frac{36 \times 20}{100} = 28.8 \text{ sq. yd.}$$

$$= 29 \text{ sq. yd. (approx.)}$$

Soil Sterilisation

On old nurseries where the soil is not heavy and where seedling production and growth has declined over the years, it may be worth while to try formaldehyde as a soil sterilisation agent on beds to be used for spruce, Douglas fir or larch. A small trial of 10 or 20 square yards will be sufficient to tell whether the soil is responsive. One gallon of 38 per cent formaldehyde solution should be mixed with 15 or 25 gallons of water. The resulting solution should be applied at the rate of 1 or 1½ gallons of solution to each square yard of bed, using a watering can fitted with a rose. The solution should be applied *at least* 3 and preferably more than 6 weeks before sowing. It has been found that the solution penetrates the soil more quickly and deeply if the soil is hard with frost (*not* glazed frost). Sterilization during the early winter, or even late autumn, is preferable to sterilization in March or later. Ten days before sowing the soil should be turned by forking to a depth of 4 inches,

not more, to permit residual vapours to escape; at this time fertilizers can be applied, Rubber gloves should be worn and care should be taken both to avoid splashing exposed skin with formaldehyde and to avoid inhaling any vapours. Any splashed skin should be washed with water immediately.

PREPARATION OF SEED FOR SOWING

When sowing by hand, conifer seed should be mixed with red lead (1 lb. red lead to 10 lb. seed) to enable it to be seen more easily and so sown more uniformly. The seed should be put in a piece of muslin or similar cloth, and held in a bucket of water for a few minutes until all the seed is wet. The seed should then be taken out and spread thinly on a flat surface to dry until it is just damp, when it can be mixed with the red lead. If it is too wet when mixed, the individual seeds stick together and are difficult to handle. Red lead gives no protection against mice or fungi.

Stratification

For certain conifer species, either early sowing or stratification of seed for a period before sowing is desirable, while for certain hardwoods it is almost essential. Thus, stratification is advisable for Douglas fir (2 to 3 months); silver firs (*Abies* species) (3 months); birch (3 months); and Norway maple and sycamore (4 months). It is essential for ash (16 months), gean (4 months) and lime (12 to 16 months) if collected normally. Good results can occasionally be obtained by sowing seed of ash and gean when it is still green, but a greater yield of plants is obtained by collecting fully ripened seed and by stratifying gean for four months and ash for sixteen months before sowing.

The construction of a stratification pit is shown in Forestry Commission Leaflet 33, entitled *Collection and Storage of Ash, Sycamore and Maple Seed.* Large amounts of seed are mixed with two or three times their volume of sand and put in the pit. Small lots of seed should be mixed with two or three times their volume of sand and put into flower pots within the pit. Alternatively, wooden seed boxes can be made, their capacity being not more than one cubic foot, with bottoms of $\frac{1}{4}$ or $\frac{3}{8}$-inch mouseproof netting and detachable mouse-proof tops of the same material. These boxes can be sunk deep in well-drained soil, or put in a stratification pit. Good drainage is essential both in the pots and boxes and in the pit, as waterlogging kills the seed. When placed in the pit, the boxes or pots should not come to more than twelve inches from the top, and a layer of pure sand one foot deep should be used to top-off the contents of the pit to ground level. An alternative, suitable for small lots of seed, is to put the damp mixture of seed and sand into a *sealed* tin or polythene bag, which is then stored in a cool cellar.

Before mixing seed with sand, a careful note should be kept of the weight of actual seed going into each container (which must be clearly marked) so that sowing densities can be calculated at a later date.

The seed should be carefully examined at regular intervals from early March onwards, and when a few seeds begin to show signs of root emergence, the whole should be sown immediately.

Apart from the species just mentioned, seed should be sown dry. There is no advantage in soaking seed before sowing. Stratified seed may be harmed if it is left out of the ground awaiting suitable weather conditions for sowing.

SOWING AND COVERING THE SEED

Density of Sowing

Tables 1 and 2 on pages 4 and 5 give prescriptions for sowing densities based on Forestry Commission experience. The seed data is based on normal quality seed. If the numbers of seed per pound, or the germination percentage of the seed, differ by more than ten per cent. of the quoted normal figures, then a proportionate increase or decrease in the sowing density should be made. If, with conifers, the germination figures fall below the figures in Column 5 of the conifer table (1), then an additional increase of twenty per cent should be allowed in the sowing density. This broad increase is necessary to compensate for the reduction in *germinative energy* which occurs in seed of low viability.

Tables 1 and 2 have been prepared on the basis of good quality seedlings in broadcast-sown seedbeds. If seed is to be drill-sown, the sowing *area* required is twenty-five per cent greater than that recommended for the broadcast sowing of the same amount of seed.

Season of Sowing

The last two weeks in March and the first three weeks in April is the best period for sowing most forest tree seeds. The first sowings should be made at the beginning of this period in the South of England and two or three weeks later in Scotland. Spruces, Douglas fir, hemlock and Western red cedar should be sown before pines and larch. *Abies* species (Silver firs) have given excellent crops when sown, unstratified, in January or February.

If seedbeds have been roughly prepared in autumn, there are usually plenty of opportunities to complete sowing during the best period. Late sowings frequently result in small, poorly-rooted seedlings which are liable to frost-throw in the following

winter and which usually have to remain in the ground for two years. Sowing should *never* be delayed for part or all of a lining-out programme to be completed. The ill-effects of delayed sowing are far greater than those of delayed transplanting.

Autumn Sowing of Hardwoods

Oak, chestnut, elm, sycamore, Norway maple, and birch can also be sown immediately after collection. This saves the trouble and expense of storage, but if it is done, the beds require weeding and protection through the winter. Sowing of oak can be carried out by two methods. The first is to plough out a three-inch deep furrow and then space sound acorns along it at one pound per twelve feet of furrow, covering these with a nine-inch wide furrow slice of a second furrow, and repeating the process across the area. Two furrows can be used simultaneously, one for the outward journey of the plough and one for the inward journey. After completing the sowing, the ground can be harrowed to even off the surface.

The second method is to prepare the seedbed, and then, with a 'cuffing board' (a flat board on the end of a long wooden handle) to draw the top inch of soil to the outside of the bed. The acorns are sown broadcast and covered then with cuffed soil. If acorns are sown in the autumn, beds can be protected from damage by game birds by spreading a marker such as a thin cover of sawdust or a length of old telephone cable along the top: two to three inches of soil from the alleys is spread over, and is left until spring when the top layer of soil down to the marker layer of sawdust or cable can be pulled back into the alleys. This method reduces game and pigeon damage to the acorns during winter. A careful watch must, however, be kept for mice, and traps set if damage is seen.

Drill Sowing

Drill sowing of conifers and other hardwoods is simpler for unskilled workers than is broadcast sowing, and for this reason is often preferred in small nurseries. Drills can be easily made across the bed at four-inch intervals with a piece of inch-thick board, the edge being pressed down into the soil to the precise depth required for the particular kind of seed. The seed must of course be evenly distributed along each drill. This can be made easier if the required amount of seed is emptied into the drill from a calibrated tube or a narrow-necked bottle.

Alternatively, a *pressing board* may be used for marking the drills. This is a board two to three feet long and three feet wide, and has one-inch plaster laths nailed across it at four-inch intervals. Yet another method is to use a wooden roller with laths nailed on to it crosswise, or else a roller with quarter-inch by one-inch rubber bands round the periphery of the roller at regular intervals; such a roller will mark out the seed drills lengthwise *down* the beds, instead of across them. This pattern allows mechanical cultivation between drills.

Broadcast Sowing

The most usual sowing method for conifers and most small-seeded hardwoods, e.g. elm and birch, is to sprinkle the seed evenly by hand at a previously calculated density. Regular sowing is largely a matter of practice. The density should be checked occasionally by measuring the length of bed covered per pound of seed. Seed should be covered (see below) as soon as possible after sowing to avoid losses from birds and wind.

Never sow small seeds on windy days.

For larger seeds (usually over $\frac{3}{8}$-inch length), such as beech, oak or ash, the top soil from the bed is removed to the required depth with a cuffing board; the seed is then sown and promptly re-covered with soil.

Band Sowing

This is an alternative method for sowing large hardwood seeds and consists of 'cuffing' open, six-inch wide trenches of the required depth with six-inch spaces between the bands. Seed is sown evenly over the band, allowing about two square inches of soil per seed for beech and ash, with slightly more room for large seed such as oak. The bands are then covered over with soil.

Covering Depth and Materials

After sowing, *small* seeds of all species should always be covered with *grit* or *silt-free* coarse sand. This practice brings about more rapid and uniform germination than does covering with soil or leaf mould, and the total yield of useful seedlings is substantially higher. But for large seeds, such as acorns and beech nuts, soil is quite suitable.

Lime-free, light-coloured, washed, coarse sands or fine angular gravels passing a $\frac{1}{16}$-inch to $\frac{1}{8}$-inch mesh are the best materials for covering small conifer seeds.

If a sand is used it must not be too fine, otherwise it will be blown away by the wind; the seed will be exposed, and may vanish also. Soil or fine dusty or silty sands, or media containing a proportion of small flat pebbles, are all alike unsuitable for conifers, and can reduce the potential yield of seedlings by as much as 70 per cent. Before using any new sand or grit, some of the material should be stirred with a small quantity of strong vinegar or dilute hydrochloric acid. If small bubbles of carbon dioxide gas can be seen or heard, then the material *contains lime or chalk* and must not be used. The use of grits containing lime makes the soil less acid, resulting in fewer and poorer conifer seedlings.

The depth of cover is determined by the type of seed sown; a useful rule of thumb is to cover the seed to a depth equal to one and a half times the length of the seed. For instance ¼-inch cover is needed for Scots pine and Norway spruce, with ⅜-inch for Corsican pine and Douglas fir, and ½-inch for Sitka spruce and the larches. On average, one ton of grit covers about 100 square yards of sown seedbed.

CARE OF SEEDLINGS

A constant watch must be kept on the developing seedlings for signs of 'Damping-off' disease, during and shortly after germination, and for the *Botrytis* mould fungus in late summer and autumn. Diseases affecting seedlings are described, together with the appropriate counter-measures, in Chapter 14, page 61. A look-out for insect attacks should also be kept and in particular for cockchafers, cutworms and aphids. These insects, the damage they cause and the methods of control, are described in Chapter 15, page 67.

SHELTERING

(a) General Considerations

The provision of overhead shelter to seedbeds should only be done where local experience has shown it to be essential. It costs money, especially as the shelters must be removed and later replaced whenever a seedbed has to be weeded or sprayed with weedkiller. In many nurseries in Wales, the Midlands and North of England, and southern Scotland, shelters are now seldom used. Early sowing ensures that the seedlings become stout enough, and sufficiently well-rooted, to withstand hot summer sunshine, and also winter frosts, when these occur. But in the South of England sheltering against summer sun is advisable, while in exposed districts in the north of Britain, sheltering against winter frost is usual. Elsewhere, it is often the practice to shelter hemlock and silver fir seedbeds, but to leave other species unprotected.

(b) Shelter against Sun and Drought

In East Anglia, and roughly south of the line between the Thames and Severn estuaries, there are occasions in summer when overhead shelters are essential. These are when the sun raises the soil surface temperature to over 100° F, when there is a risk that recently germinated seedlings will be killed at the root collar. Beech, western hemlock, western red cedar and silver firs (*Abies* spp.) are species most commonly shaded, especially in nurseries on sandy soils.

Portable screens can be made by nailing plasterers' laths, half to threequarters of an inch apart, on to a light framework; or else by threading them between two sets of flexible wires, so as to form a long screen that can be rolled up for storage. These screens should be laid across wires supported by short posts, nine to twelve inches above the beds. Alternatively branches of broom or spruce stuck in the ground may be used. Screens should be removed when the weather is cloudy and air temperatures are less than 75° F, otherwise some species may produce over-developed shoots and underdeveloped roots.

(c) Shelter against Frost

Shelter against frost may in certain localities be desirable. But it must be realized that a shelter will give protection only against moderate and light frosts of short duration and will not protect crops against heavy, long-sustained, frosts. It is the more difficult to make recommendations because the degree of protection given varies according to type of shelter; with lath shelter, even the distance between laths can markedly affect the degree of protection. In general terms, however, the denser the shelter, the greater the protection.

It has been necessary in the northern part of Britain to protect Sitka spruce and larch against late autumn frosts. In the south, damaging autumn frosts are sufficiently infrequent to make it doubtful whether the erection of shelter to give protection solely against autumn frosts is justifiable. However, if the supports are already erected, shelters should of course be put on when there is the risk of early autumn frost. Frost protection is particularly important in frost pockets, and in years when there is a wet late summer so that seedlings have not hardened-off by late September. Once the seedlings have 'hardened-off' the protection can be removed.

Early-flushing species, e.g. larch and beech, beds of which are to stand over to a second year, and also beds of autumn-sown beech, must be sheltered against spring frosts.

On seedbeds on wet and heavy soils, and where the seedlings are small, the use of overhead screens helps to minimise the risk of 'frost-lift'. Shelters will *not* prevent the freezing of the soil in a really hard winter. But they do lessen the number of occasions on which alternate freezing and thawing—the real cause of 'frost lift'—occurs.

Sheltering of seedlings should not be necessary after the beginning of the second growing season.

WEED CONTROL ON SEEDBEDS

Weeds are extremely harmful to seedling growth. The plants that occur as weeds in forest nurseries grow much faster than young trees, and if allowed to develop they will smother and kill seedlings and reduce the vigour of any that survive by competing for water and nutrients. In controlling weeds the aim must therefore be to kill or remove them soon after they have germinated; or if this is not possible,

at least to kill or remove them before they have set seed.

Weeds can be controlled in seedbeds by hand removal, by mechanical cultivation, and by chemical means. Control by the first of these methods alone is time-consuming and costly; the second is possible only where seed has been sown in drills, and even so needs supplementing by hand work; the third, though fairly cheap, has certain limitations because of the sensitivity of the crop. In practice, the most satisfactory way of controlling weeds in broadcast seedbeds is by mineral oil sprays in combination with hand weeding.

Chemical Weed Control

Most of the chemicals in current use are *mineral oils*, a term which includes both *vaporising oils* and *white spirits*. Before considering the suitable substances, we must rule out the *unsafe* ones.

Selective weedkillers which contain 2, 4-D or 2, 4, 5-T, or MCPA, or their butyric homologues, or IPC or dalapon, or pre-emergence weedkillers which contain pentachlorphenol (PCP) or dalapon, *damage seedlings and transplants and are unsuitable for use in forest nurseries*, though some may have a place in the forest.

It is essential to distinguish two phases in seedbed weed control, namely weed control before any seedlings have emerged (pre-emergence), and weed control after seedlings have begun to emerge (post-emergence).

N.B. The rates set out below refer to *seedbeds* and should not be confused with the rates for *transplant lines* given in Table 5, page 17.

Pre-Emergence Spraying

For pre-emergence weed control, spray *vaporising oil* (See Note 2, page 17) at ten pints per 100 square yards (sixty gallons per acre). The best time to spray is three to four days before seedlings germinate—though any time before that is nearly as good, provided that the weed seeds are showing signs of sprouting. Spraying with vaporising oil *after* seedlings have begun to emerge often results in the death of those seedlings that are visible. To estimate when to spray, a few seeds should be uncovered in two or three places in the bed. If any seeds have roots ¼ to ½-inch long, full germination may be expected in three to four days time, and the pre-emergence spray should be given immediately.

Seedbeds of all species, whether hardwood or conifer, may safely be sprayed *before* seedlings have emerged. In practice, pre-emergence sprays using vaporising oil have usually reduced annual weeding costs by 25 to 40 per cent, and in extreme cases they have reduced weeding costs by 80 per cent. Any weeds which have survived the spray must be removed by hand, but though it is important to do this, the time taken is usually very little compared with normal weeding.

Seedbeds of oak, sweet chestnut or beech which are covered with an inch or more of soil, may safely be sprayed soon after sowing with Simazine at 4 lbs. of 50% powder in 40 to 60 gallons of water, per acre. This is the only instance where Simazine can be recommended for use on first-year seedbeds; in all other circumstances its use is risky.

Post-Emergence Spraying

Control of weeds *after* seedling emergence is very much more a matter of hand-weeding. Mineral oils cannot be used safely until four weeks *after* germination is complete, and a less phytotoxic (poisonous to plants) oil, namely *white spirit* (See Note 3, page 17) must be used, and at a lighter rate. Also, species differ in their sensitivity, hardwoods being so sensitive that they should never be sprayed while in leaf. For conifers, the rates for the different species are given below.

It must be clearly understood that, because this spirit is less phytotoxic, weeds are better able to survive and only the smallest weeds (those recently germinated and up to one inch in height) will be killed by white spirit applied at the recommended rates. If the weed population consists mostly of moderately big weeds, it is not worth while to spray. On the other hand, when a crop of weeds has recently germinated, as often happens when a few days rain follows a dry spell, a white spirit spray applied before the weeds are an inch high will kill them all. If spirit is applied at rates higher than those recommended, or at an earlier date, or in hot weather, there is a risk that the seedling crop will be damaged.

The recommended rates are:

For Douglas fir, larches and lodgepole pine, 2¼ pints of white spirit (Note 3, page 17) per 100 sq. yards net (15 gallons per acre).

For Norway spruce, 3¼ pints of white spirit per 100 sq. yards net (20 gallons per acre).

For Scots and Corsican pine, Sitka spruce, Lawson cypress and Western hemlock, 4 pints of white spirit per 100 sq. yards net (25 gallons per acre).

N.B. (i) *Vaporising oils must never be used for post-emergence spraying.*

(ii) *Do not spray in hot, dry weather or when it is very windy.*

The first spray should not be applied *until four weeks after* the emergence of the last of the seedling crop, i.e. when the first true leaves of all seedlings are well developed.

Subsequent sprays should be timed according to

the development of weeds, and may need to be at intervals of about three weeks or longer.

All weeds big enough to survive an oil spray must be removed by hand at the first opportunity.

Equipment and Methods of Application

Mineral oils can be applied either with a pressure-retaining knapsack sprayer, or else a tractor-mounted sprayer. Jets giving a fanspray are preferable to those giving a hollow cone of spray droplets. A working pressure of 30 to 40 lb. per sq. in. is suitable for pre-emergence sprays, and this must be maintained during the spraying. For this reason, a pressure-reduction valve should always be fitted, together with a pressure gauge to indicate the working pressure. For post-emergence sprays, a lower working pressure of 20-25 lb. per square inch is preferable, because it allows a longer time in which to apply the spray. Again it is essential that pressure should remain constant while spraying. The rate of delivery should be determined by measuring with a stop-watch the time taken to fill a one-pint measure using the actual spray material; all liquids and spray mixtures do *not* have the same viscosity, and hence have different delivery rates at an equal pressure—hence the above corrections. From this the time taken to cover the seedbed can be calculated.

It is wise to use water, or to spray a path in order to develop the correct rhythm of swing of the lance (if hand operated) and the speed of movement down the seedbed. After using water in the sprayer, the machine must be thoroughly emptied before refilling with vaporising oil. A calm period for spraying will reduce the risk of the spray drifting and causing damage to other seedbeds or transplants, or to hedges growing alongside. (Often the calmest times of day are just after daybreak and at dusk.)

Weeds which appear on paths and in alleys can be killed, or kept in check, by regular applications of vaporising oils applied at 10 pints per 100 sq. yd. (60 gallons per acre), or by Simazine at 4 lbs. of 50% powder per acre in 60 gallons of water. It is unwise to use strong chemical weedkillers, such as sodium chlorate or arsenical compounds, on nursery paths, as such substances eventually spread to the beds and check plant growth.

Weeds which are removed by hand should be put in heaps which should be removed daily and 'dumped' on a site *away from the nursery*. It is *impossible* in practice to compost weeds satisfactorily, because seeds of many species of weeds remain fertile for many years and are *not* killed in the process of composting. Spreading old heaps of weeds back on to the nursery is a fool-hardy and expensive practice.

LIFTING AND GRADING SEEDLINGS

Seedlings are normally considered large enough to be lifted for transplanting when sixty to seventy per cent or more in a seedbed are 1½ inches in height or over. Smaller seedlings have been transplanted successfully, but the operation is more expensive because of the extra time that is taken in handling small plants. Many seedlings grown on agricultural soils are not large enough to be lifted for lining-out until the end of the second year, but in good heathland nurseries, seedlings of all species, except the Silver firs (*Abies*) should be suitable for transplanting at the end of their first year. In lifting, great care should be exercised to minimise the amount of damage to the root system. Greater care is required with species which have long straggly roots, e.g. Corsican pine. A garden fork is usually the most suitable tool and should be inserted into the soil as deeply as possible before gently easing the handle back. Alternatively, a 'lifting bar' may be drawn by a tractor through the soil at a depth of six to seven inches below the seedbed surface. After loosening an area of seedlings, the tops of as many plants as possible should be seized in one hand and the soil very gently shaken free from the roots. The plants can then be kept moist by placing them in a box or basket ready for transplanting to the transplant lines.

If the seedbeds are uniformly stocked, several sample units should be marked off and the number of plants suitable for lining-out counted. From the information obtained, the number of under-sized or deformed plants can be assessed, and the seedbed area to be lifted, to meet any given lining-out programme, can be calculated. When there is a great deal of variation in size, the number of samples should be increased substantially. At the time of lifting, seedlings may be graded, but it is seldom worth while separating plants into bigger and smaller grades except where it is likely that the taller grade will produce plantable trees after one year, while the smaller plants may remain in the lines for two years. Whether grading is done or not, all plants which are weakly, diseased or deformed (i.e. culls) should be set aside and destroyed.

STORAGE, PACKING AND TRANSPORT

Whatever the period between lifting and transplanting, it is essential to keep the roots of the plants moist and to minimise drying out of plants. It is best if plants can be lined out immediately after lifting out, though often they have to be stored while awaiting transport to another nursery, or to free ground for the next crop.

If seedlings are to be lifted for immediate lining-out in the same nursery, the plants need only be 'heeled-in' temporarily (see below) or stored for a short time in polythene bags. It is not essential to count the seedlings at this time—the number lifted can be determined later from the number of plants

lined out; counting takes time and increases the risk of drying-out.

Use of Polythene Bags

If seedlings have to be stored for more than one or two days, or if they have to leave the nursery, they may either be stored in polythene bags or else be heeled-in while awaiting despatch. They may then be sent in polythene bags, hampers or bales to their destination. Polythene is now the most widely-used means of packing for transport or storage, and it gives excellent protection against drying-out.

Plants may be kept in polythene bags for some time (see Table 3) provided certain conditions are met. These are:

(i) At the time of lifting, plants must be fully dormant, the foliage must be dry and the whole plants free from damage or disease.

(ii) During storage in polythene, bags must be kept in a cooled, well-ventilated shed, out of the direct rays of the sun. At least one side of any bag must be exposed to the air, otherwise heating may occur.

TABLE 3

MAXIMUM RECOMMENDED STORAGE PERIODS FOR PLANTS IN POLYTHENE BAGS

Species	Date of Lifting of Stock		
	November-February	March (or up to the commencement of flushing)	April (or after flushing has commenced)
Norway spruce, Sitka spruce, Serbian spruce	Until mid-April	Until mid-April	Shortest possible time
Scots pine, lodgepole pine, European, Japanese and hybrid larch, oak, beech	Until mid-March	3-4 weeks from lifting	Shortest possible time
Douglas fir, Corsican pine, western hemlock, western red cedar, Abies *spp.* Lawson cypress, Sequoia *spp.*	6-8 weeks from lifting	3-4 weeks from lifting	Shortest possible time

Very satisfactory results have been obtained using shelves or sacks to hold bags in the storage shed. Bags should be stood up one layer to a shelf so that there is a small air space above each bag.

Plants are usually tied in bundles, though the string must not be too tight. However, if the bags are small and the plants fill them comfortably, this will not be necessary.

Plants transported by road or rail in polythene bags, on journeys that will take more than four hours, must also be packed in a way that ensures some air movement inside the load. Plants piled up in a heap in unventilated waggons will heat up quickly whether they are in bags or not.

Heeling-In

Where polythene bags are not available, plants should be tied in bundles (usually of 100) and placed in a well-prepared heeling-in trench (usually called a *sheugh* or a *bury*) on well-drained cultivated soil, until the time for transport. The shorter the period of time in the trench, the better it will be for the plants. Dig the trench the width of one spade, and one inch deeper than the length of the roots.

After standing a single line of bundled plants in the trench, loose soil should be carefully replaced and firmed round the roots, care being taken to ensure that no air-pockets are left. In covering the roots, a second trench will be opened to provide soil for covering; this trench will serve for a second row of plants. When plants may have to be removed from a trench in frosty weather, it is useful to lay a six-inch covering of loose straw over the tops of the plants when the weather is still mild. This will usually ensure that when the plants are required, they are not found to be frozen hard into the soil, though of course it is not effective against a really deep frost.

Seedlings from seedbeds may have to be lifted several weeks in advance of lining-out—particularly in heathland nurseries—so that seedbeds can be re-made for sowing in March. Such seedlings, if put into polythene bags or well-prepared trenches, will store satisfactorily over the winter, irrespective of whether the plants are bundled or not (but see Table 3). Spruce should be dealt with first, followed by pines and then larches. The operations can be started in mild weather in December, if absolutely

necessary. Seedlings have also been stored successfully when packed upright in boxes and kept in a cool, well-ventilated store, or on the floor of a dense plantation.

For short journeys from the nursery to the planting site, the plants may be sent by lorry without special packing. If so, the bundles must be stacked with their roots pointing inwards, and the load should be sheeted over to keep the foliage from drying out.

When young trees have to be sent by rail they should be sent by passenger train or *express* goods train to reduce the time in transit; it would be foolish to risk such valuable and perishable plants on slower trains. They should either be packed in polythene bags, each bag having one side exposed to the air, or else be packed in bales of hessian or wire netting, or in hampers, in sizes which are convenient to handle. All roots must be arranged so as to lie inwards, and with plenty of peat or sphagnum moss packed round their roots *only*. An adequate outer layer of dry straw or bracken packing must be placed all round the outside. With very large bundles, layers of packing should be placed through the centre to ensure adequate ventilation. All bundles should carry two strong labels marked 'Keep Away from Heat'. Every bundle should also carry the address of the consignee, who should be advised, by phone or telegram, as soon as the plants are despatched. Always avoid week-end travel for the plants. Loading should always be done by the consignor or his staff.

When receiving bundled plants, open the containers as soon as possible, release the ties on the plant bundles, and place the plants immediately into a carefully prepared trench. If, however, the plants are packed in polythene bags, and the safe storage period has not been exceeded, the bags should be set in a well-ventilated, shaded store.

Cold Storage

It has recently been found that seedlings can be kept in good condition in cold rooms or refrigerators at temperatures of 32 to 36°F. Seedlings are stored in polythene bags or shelves or in boxes, and the conditions must conform rigorously with the requirements given above for storage of seedlings in polythene bags, The main value of cold storage of seedlings has been to keep the plants dormant and to enable them to be lined-out safely very late in the spring, when they would otherwise have broken bud.

UNDERCUTTING SEEDBEDS

Undercutting seedbeds with a tractor-mounted undercutter is now widely applied to seedbeds of certain species. It is a most effective treatment on beds of rising two-year-old species which normally develop a strong tap root system, such as oaks, pines, and Douglas fir. Undercutting helps to produce a more balanced plant by *reducing* the amount of shoot growth which the plants would otherwise make in the seedbed, and by *increasing* the amount of root fibre. Hardwood species are the most responsive to undercutting, and if undercut in March in the second year, at a depth of three to four inches, will produce plants which are virtually as good as one-plus-one transplants.

More recently, good results have been obtained by undercutting repeatedly at 4 to 6-week intervals during the second season, at a depth of 4 to 6 inches. Some benefit has also been derived from side-cutting to sever long lateral roots.

The object of undercutting is the same as one object of transplanting; it obliges the plant to form more root fibre in relation to its growth of shoot. If it is intended to use this technique, it is advisable to sow the seed at one quarter the rate prescribed in Tables 1 and 2, as the plants will need more growing space in their second year.

Chapter 3

RAISING TRANSPLANTS FROM SEEDLINGS

THE object of transplanting, also called lining-out, is to check shoot development and to encourage the formation of a compact fibrous root system, thus producing a plant which is most suitable for planting in the forest.

SUPPLY OF SEEDLINGS FOR TRANSPLANTING

Supplies of seedlings which are to be imported into the nursery must be ordered well in advance, if possible one year ahead of requirements. Final tenders for the plants should not be accepted until samples of the plants labelled by the suppliers have been received. These samples should be carefully preserved so that one can make a check against the stocks actually supplied later. Certain nurserymen now have available seedlings of the common conifers grown from seed certified to have been collected from good quality parent stands. These plants are more expensive but have the advantage of having a known and good origin.

When planning the lining-out programme for a

heathland nursery, it is important to remember that the economic success of such nurseries depends on keeping them weed-free. On no account should plants which have been grown in an agricultural-soil nursery be lined-out in a weed-free heathland or woodland nursery. If plants are brought in, weeds will *inevitably* be brought in too. Indeed, it is highly desirable, in a clean nursery, to line-out only those plants raised in the same nursery and not to bring in any plants from outside.

In order to calculate the ground requirements, the spacing at which the plants are to be lined-out must be decided. Different species require different spacings, and a great deal also depends on whether the plants are to remain one or two years in the lines, and on the size of the plants to be lined-out. Table 4 sets out general recommendations for fertile good quality nurseries.

If mechanized methods of weed-control are to be used, a standard spacing between rows is essential; therefore only the spacing *between plants* can be varied, according to the age and species of plant to be lined-out. In addition, any alleys between lining-out strips and rows must allow for the passage of tractor wheels. If strip lining-out, employing boards six feet four inches in length, is used, eighteen-inch alleys should be allowed between strips; this width is also suitable for alleys left at intervals in 'long-line' lining-out.

TIME OF TRANSPLANTING

The normal nursery transplanting season extends from the beginning of October to the end of April, excluding as a rule both December and January. For most types of tree it does not greatly matter which month is chosen, provided periods of hard frost, snow or drought are avoided. Small seedlings should be lined-out in spring, as otherwise there is the risk of frost-lift, particularly on heavy soils. If choice allows, beech should be lined-out in autumn, and Corsican pine in November or February. The larches should be lined-out before the middle of March because these species are among the earliest to flush. Douglas fir should be lined-out in March or April. Otherwise the time of transplanting can be arranged to suit the general programme of nursery and forest work. It is a great advantage to have all lining-out completed by the end of March. However seed sowing must never be delayed while a lining-out programme is completed,

In Scotland, the lining-out in July of rising two-year-old Scots, Lodgepole and Corsican pines, Silver firs, and spruces, has been successful, provided the plants are lined-out almost immediately after lifting when the weather is both moist and cool. Such plants have produced better transplants than two-year seedlings lined-out in the following spring; but June and August lined-out plants have not been as successful as those lined-out in July. It must be emphasised that lining-out in the summer is very dependent on weather conditions; it would be risky to attempt it during a dry summer or to apply it in the south of Britain.

PREPARATION OF GROUND

Where as is usual, the crop of transplants is to follow either seedbeds or a previous crop of transplants, the ground should be ploughed or dug over at the first opportunity, and it should also be cultivated by rotovator or by hand just before lining-out takes place.

Most ground which has been bare-fallowed or green-cropped would normally be reserved for seedbeds, but where such ground is available for lines, it should be ploughed or dug over during the previous late summer or autumn and left to weather during winter. Alternatively, it can be deeply ridged at 2½-foot intervals, with a potato-ridger, after ploughing the previous autumn—a particular advantage in heavy soils. In spring, when the ground is not too wet, it can be cultivated with a rotary cultivator, or else by hand. Ridged ground has to be levelled-down with a disc harrow immediately before use, if the conventional system of long transplant lines is to be used.

At the time of final cultivation or lining-out, any manures and insecticides which may be required should be cultivated into the soil, if not done previously. If the ground is at all heavy, it is important to cultivate only the ground that is to be lined-out the same day; the benefit of the winter weathering will be lost if rain falls on the ground between the time of cultivating and that of lining-out.

PLANTS AWAITING LINING-OUT

Definite consigning instructions for plants should not be given until the ground has been prepared and is ready for transplanting, or unless it is quite certain that it can be made ready before the plants arrive. Plants despatched in polythene bags may be kept for a limited period in their bags. (See Chapter 2, page 11). Otherwise an adequate heeling-in trench (bury or sheugh), should be prepared on a dry site in advance, and covered over with loose straw or bracken to keep out any frost which may harden the ground before the plants arrive. When plants are to be heeled-in, the bundles should be untied, and the seedlings should be spread evenly along the bottom of the trench in an upright position. The roots should be covered over with friable soil and, if frost is expected, lightly covered over with straw or bracken.

LINING-OUT

This transplanting process consists of making a series of long or short trenches across the ground,

in which the seedlings are planted at their proper depth and at the predetermined distance apart (see Table 4), with or without the assistance of lining-out boards. The use of lining-out boards has now become the accepted practice and they can be used with or without the assistance of lining-out ploughs. Skilled labour, and light to medium stone-free loam soils in a moist friable condition, are essential for success if the 'boards' are to be dispensed with, and even where men can be found to do the work entirely by hand, its progress is very dependent on weather conditions.

TABLE 4

RECOMMENDED DISTANCES BETWEEN PLANTS

Expected average height when lifted from the lines	Spacing, in inches, at lining-out	No. of plants per 100 sq. yds.
Less than 9 inches	1½ × 8	10,800
9 to 18 inches	2 × 8	8,100
Over 18 inches	3 × 8	5,400

Note:

The spacing between rows recommended here, namely eight inches, is that most widely used. In theory, the spacing between rows should be adjusted to suit the size of plants being raised; but most nurserymen have some cultivating, spraying or lining-out equipment adjusted to a particular row spacing; it is found best in practice to stick to this spacing for all commonly required sizes of plant. Row spacings of seven inches are also common. It is best to keep to one spacing throughout any particular nursery.

Irrespective of method, two general rules apply. Firstly, seedling roots *must* be kept moist at all times and should be exposed as little as possible to sun and wind. On dry windy days, the roots should be moistened by dipping the plant roots in a bucket containing a little muddy water before inserting them in the boards or trenches. Seedlings should be heeled-in or kept in polythene bags in the shade close to the working point until required. The second rule is that the back of the lining-out trench must be vertical and the seedlings be set upright against it. It must also be deep enough to accommodate the roots and allow them to hang freely without bending them. Any roots that are exceptionally long and stout, e.g. two-year-old oak, should be pruned cleanly to six inches, no less, with a sharp knife.

Hand Methods, Using Lining-Out Boards

Long Lines—In most nurseries, a tractor is available to apply sprays or to carry tines or hoes to kill weeds. It is now general for transplants to be arranged in beds of five or six lines which can be straddled by a tractor. If the implements on or sprays from the tractor are not to damage the crop, it is essential that the spacing between rows is uniform and the same as that between spray jets, cultivating tines, etc. The required spacing can be obtained by careful use of a line to mark out the rows or by use of a spacing board. Both long (10 or 12 foot) or short (6ft. 4 ins.) boards may be used for transplanting in long lines. It is more important that space between the lines is correct than that the lines are absolutely straight.

When using the 'long' type of lining-out board, a gang of at least four and preferably five workers is advisable, two to do the spade work, two to fill the lining-out boards and one to act as a runner to carry the boards from the filling bench to the spademen. A pair of trestles is set up at a convenient point, along with a windbreak of sacking erected to screen the roots of the plants as they are placed into notches in the boards. Each seedling is set so that its level after transplanting (and allowing for soil settlement) will be the same as it was in the seedbed. The distance between plants is fixed by a notched spacing bar on the lining-out board. Each team of workers should have a set of six boards to allow the process of filling the boards, carrying, digging trenches, earthing-up and levelling to proceed continuously. Board filling is suitable work for boys, girls, or women, whose nimble fingers often enable them to work faster than men, while their lower wages help to keep down costs. A common size of board is ten feet long, with notches spaced two inches apart, and thus holding sixty plants.

The first line or row of plants, which is usually six to eight 'boards' in length (i.e. 60 to 80 feet), is marked out on the ground with a nursery line. A trench with one side vertical, the depth of the root systems, and six inches wide at the top, is then dug along the line with a spade. Boards filled with seedlings are set with the tree roots hanging freely and vertically against the back of the trench, after which they are temporarily pegged in place. The trench is then filled with loose earth, which is firmed by foot around the tree roots, and then levelled off with the back of the spade. The catches holding the two halves of the board tightly together and gripping the plants, are then released, and the board itself is then lifted clear to leave the seedlings standing erect in the line. After completing each row, the next one is cut, at the desired distance, in the earth thrown up and levelled from the preceding row.

Short boards may be used in the same way as long boards to give continuous rows of seedlings, or they may be used to line out by the strip method, described below.

Strip Method. In this method, most of the operations are similar to the lining-out procedure des-

cribed above, except that lining out is carried out in sections one board-length *wide*, with eighteen-inch alleys between sections. The Paterson board, usually employed, consists of two unhinged, unnotched parts, one of which fits snugly against a fixed notched member on the plant filling bench. Seedlings are put into the notches as in the case of the orthodox lining-out board. The second part of the Paterson board has one or two narrow sponge rubber strips glued to it lengthwise, and is placed over the first part and held in position by two spring-loaded swivel catches, thus holding the plants securely in position. The boards are ideally suited to plants with 1½ to 4 inch shoots. A spacing board fitted with two handles is used instead of a line for marking off the distances between lines. When using this method either a two-man gang or a single person can carry out all operations.

The main advantages of strip lining-out are: lines can be hoed and weeded from the ends of the line without trampling on the ground between lines; fewer people are needed for each squad; it is a fairer method of distributing piecework lining out. It has however the great disadvantage that spraying or cultivating machinery cannot, in practice, follow the lines of the transplants.

Working Without Boards

Where lining-out is done without boards, the worker takes a small bundle of plants in one hand and works along a prepared trench, setting each plant in turn in its place, judging depth and distance by eye. Each seedling is temporarily held in place with a handful of earth firmly pressed against the roots. Once a trench has been completed in this manner, earth is thrown in with the spade to complete the filling-in of the trench, and the earth is then firmed down and levelled.

Only a skilled man can match a lining-out board for accuracy of depth and spacing; and few skilled men will take on such tedious and cold, dirty work.

Machines to Aid Transplanting

Machines can only be satisfactorily and economically used in large sections on reasonably stone-free ground. Wide turning spaces for tractor and machine are necessary, particularly where this is trailed and not mounted on the tractor.

A.—Lining Out with Boards and an Agricultural Plough

In this method a tractor-drawn single-furrow plough is employed to do nearly all the heavy earth moving, so speeding up the work and lowering costs.

The sequence of operations is this:

(1) Men open first trench by hand, and set out the first row of trees in the lining-out boards.

(2) The tractor-drawn plough cuts a furrow alongside, throwing up the soil so as to bury the roots of the line of trees.

(3) The men firm up the earth thrown up by the plough, with their feet, and level it off with spades. They then remove the boards.

(4) The next trench is cut by hand in the soft earth previously cultivated and the cycle repeats.

Fast work is possible because, after the first row, the men only handle recently stirred soil and always move it downwards. Only long lines are feasible.

B.—Lining Out Ploughs

There are two machines used quite widely, namely the 'Ledmore Lining-out Plough' and the 'York Lining-out Plough'. Both ploughs are tractor-mounted and do all the digging of trenches and covering of roots. For both, boards have to be filled and put in position by hand. At least a dozen workers are required; these work in small teams, filling, carrying and placing lining-out boards on the edge of the prepared trench, and a balance has to be reached between the speed at which the plough covers the ground and the speed of filling the boards. In operation the plough travels first down one side of a rectangular section, and returns up the section on a line a short distance across the section and parallel to the first line; the process is repeated until the whole area has been lined-out.

The Ledmore plough is off-set so that the tractor runs on uncropped ground. The tractor and plough can be made to work so that all rows in a section are the same distance apart; alternatively every seventh row can be omitted to leave an alley-way so as to allow tractors to spray or cultivate between rows later on.

The York plough differs from the Ledmore plough in that the plough is mounted on a horizontal shaft on which it can be moved sideways. The tractor follows the same course for each row of a bed of lines, only the position of the plough being altered, and thereby minimising errors in spacing between lines. Otherwise the working is similar to the Ledmore plough.

The Ledmore plough is designed for transplant lines nine inches apart; the York plough lines are normally eight inches apart. Both makes may be drawn by either wheeled or half-tracked tractors.

C.—Machine Transplanters

There are also available several makes of machine transplanters, which all work on a similar principle. There is a rotating disc with rubber flaps or metal grips, in each of which a seedling is placed and held. The disc rotates and carries the seedling down into a V-trench until, when it is vertical, with its roots in

the soil, it is released. The V-trench is opened up by a share in front of the disc and is closed again by two consolidating wheels just as the seedlings are freed from the disc. There are various arrangements of machine transplanters; some go behind a tractor and some are self-powered. Operators ride on the machines and fill each flap or grip with a plant as it comes up.

Machine transplanters need a wheeled or half-tracked tractor which is able to give high tractive effort at ½ m.p.h.; for many tractors, this necessitates a second (reduction) gear box. These machines are mechanically efficient but require, in practice, more ground for any given number of trees than do other methods. They should only be considered where there is a very large programme in view and an ample area of light soil is available.

WEEDING TRANSPLANT LINES

Hand Methods

Dutch hoes and wheeled hoes are the commonest hand tools used for keeping weeds under control between lines and for aerating the soil, but they have to be supplemented with hand weeding between plants. Weeds which have been pulled up should be collected in baskets and placed in temporary piles on the main roads, where they can be later collected by tractor and disposed of on a dump right away from the nursery. Weedings should be carried out frequently, and always before the weeds are large enough to set seed.

Machine Methods

Tractor-mounted implement frames carrying light spring tines, cultivators or goose-foot hoes, are used quite extensively for cultivating between rows of transplants. A self-propelled cultivator has also been developed.

Chemical Methods

Two methods of control of weeds can be recommended, the first, using Simazine, has been used extensively in the last three years and has largely superseded the second, using mineral oils.

Simazine. This is a residual herbicide which interferes with processes in the leaf associated with photosynthesis, and it is not directly a root poison. It is now very widely used to control weeds in transplant lines. The product on sale is a wettable powder containing 50% Simazine which is applied as a spray at the rate of 4 lbs. per acre in 40—60 gallons of water. As far as evidence goes at present, Simazine slowly disappears from the soil, and does not accumulate. However, this latter possibility cannot yet be completely ruled out and the weed-killer should be used with discretion. Simazine is marketed under various trade names, including 'Bladex' and 'Guesatop'.

Rate of application: Four pounds of 50% powder per acre to all common forest species except poplar, ash, and European larch. Treat larch at *half rate. Do not spray* poplar or ash.

Time of application: Shortly after lining-put; good results are only obtained if Simazine is applied while the soil is clean.

Restrictions: Crop plants must be two inches or more in height when sprayed. Do not spray first-year seedbeds. Do not spray second-year spruce seedbeds. Leave undercut beds until the soil has settled down hard after undercutting, before you spray.

Mineral Oils. Mineral oils can be applied to conifer transplant lines by knapsack sprayer and lance, or, by tractor-mounted sprayer fitted with fan nozzles on the end of extension pipes screwed into the booms, so that the sprays are directed between plants, but *beneath* most of the foliage. Precautions are necessary to ensure that the correct dosage rates are applied. Oils should be applied in *dull calm* weather; during the growing season they should be *restricted to conifer species only*, and used when the weeds are small and less than half an inch across or high. Larger weeds and resistant weeds will have to be removed by hand. Transplant lines of broadleaved species can only be sprayed when the plants are leafless and buds closed, i.e. autumn, winter and early spring.

Table 5 sets out the maximum rates of application for *transplant lines.* (Rates for seedbeds appear under "Weed Control on Seedbeds", pp. 8–10).

LIFTING AND GRADING TRANSPLANTS

Lifting is preferably carried out by two men working on opposite sides of a row of transplants. Each man inserts a garden fork deeply into the soil at an angle of about 45 degrees, and both men press down on the fork handle together, in order to loosen and lift the plants. After loosening a whole row, the plants are lifted by hand and the soil is very carefully shaken free of the roots; the plants can then be graded.

In larger nurseries a tractor-mounted plant lifter can be used to loosen the soil and reduce the effort required in lifting. The lifter consists of a six-inch wide horizontal steel plate set with the trailing edge raised at an angle of thirty degrees. Fixed to the trailing edge are curved blades set in a plane perpendicular to the main plate, rising at an angle of about forty degrees and spaced at regular intervals equal to the distance between the transplant lines. When the blade is hauled below the surface, the blades break open the soil midway between rows, while the main plate disturbs the soil beneath the plants, making the hand lifting operation quite easy.

When lifting plants, all culls, i.e. dying, deformed, unbalanced and damaged plants, should be dis-

TABLE 5

SEASONAL MAXIMUM RATES OF APPLYING VAPORISING OILS AND WHITE SPIRITS FOR WEED CONTROL IN TRANSPLANT LINES OF CONIFERS, AND OF VAPORISING OILS TO HARDWOODS

Season	Species	Vaporising oils[2]		White spirit[2]	
		Rate per 100 square yards[1]	Rate per acre[1]	Rate per 100 square yards[1]	Rate per acre[1]
After flushing and before the end of June	Douglas fir and larches	unsafe		2½ pints	15 gall.
	Common pines and spruces	unsafe		4 pints	25 gall.
	Broadleaved species	unsafe		unsafe	
Early July to late September	Douglas fir and larches	unsafe		4 pints	25 gall.
	Common pines and spruces	4 pints[3]	25 gall.[3]	5 pints	30 gall.
	Broadleaved species	unsafe		unsafe	
Autumn, winter, and early spring	Douglas fir	unsafe		4 pints	25 gall.
	Pines, spruces	4 pints	25 gall.	5 pints	30 gall.
	Broadleaved species and larches	5 pints	30 gall.	Not recommended on account of expense	

Notes:

1. Heavier dosages than those recommended can be extremely harmful to the plants.
2. Both Vaporising oils and White Spirits are subject to change according to market developments. Oils currently (June, 1964) available which have been satisfactory in Forestry Commission nurseries are 'Shellspark' and 'Esso Green Oil', among vaporising oils, and 'Shell Weedkiller W', 'Shell White Spirit' and 'Esso White Spirit 100' among white spirits.
3. Vaporising oil should be used for inter-row spraying of transplants *only* if it is certain that the oil can be applied without striking plant foliage.

carded and burned. The good plants may be sorted into suitable height classes especially where plants are going to be used in weedy areas. Uniform plants are an advantage when weeding, since it is obviously impracticable to weed plants of varied sizes at exactly the right time of year for all of them; otherwise grading should be kept to a minimum. In practice, it is never necessary to distinguish more than two such height classes of planting stock; often no grading is needed, but culls should always be removed.

SURPLUS PLANTS

It cannot be too strongly emphasised that surplus stocks, unless grown for re-sale, and in particular inferior stocks, cost money every year they are retained in the nursery; immediately it has been decided they are not required for use they should be discarded. Relining plants year after year is an extravagant practice, unless the plants have some particular merit or are of species which are difficult to obtain.

PACKING, TRANSPORT AND STORAGE OF TRANSPLANTS

The principles for packing, transport and storage of transplants are similar to those previously described for seedlings (see page 10). It cannot be over-emphasised, however, that the plant roots must be kept moist at all times. and that the shorter the period plants remain in trenches after lifting, on the planting site, or in transit from nursery to planting site, the better it will be for the plants. Care taken in these operations will be well rewarded by greater success in the forest.

Chapter 4

MANURING AND MANAGEMENT

MANURING

If a nursery were repeatedly cropped without manuring whatsoever, the soil would eventually become impoverished to the point where it no longer produced any usable plants. The plants take up in their roots and shoots, considerable amounts of nitrogen, phosphorus and potassium, as well as many other elements, all of which have been extracted from the soil. The three elements named are taken from the soil in such quantities that their loss, when the plants are lifted, has to be made good by the regular addition of balanced fertilizers. The amount of fertilizer must be regulated because over-manuring can be just as harmful as under-manuring; over-manuring may lead to nutrient unbalance and consequent reduction in the uptake of essential nutrients, or may lead to toxic concentrations of salts in the soil water. Generally speaking, nitrogen, phosphorus and potassium are the only elements which may be in short enough supply to limit plant growth in most nurseries, although magnesium deficiency has been observed in a number of nurseries. Copper and calcium deficiencies have also been recorded but are very local.

Fertilisers can be applied either in organic or in inorganic form, and from numerous experiments it has been shown that much the cheaper inorganic fertilizers are quite as good a source of the major nutrients as the more expensive organic forms. Nevertheless, on light soils which are low in organic matter or humus (less than 4 per cent), and also on heavy soils or light sandy soils, it has been found a very sound practice to apply bulky organic manures in order to improve the physical qualities of the soil, i.e. to lighten the clays, or to improve the moisture and nutrient-retaining capacity of the sandy soils. This is best done by applying hopwaste, which can be obtained at low cost from local breweries in most districts. Composts of straw and hopwaste, or bracken and hopwaste, were used occasionally in the immediate post-war years, but the very high costs of preparation were out of all proportion to their value, and they are seldom seen today. Untreated hopwaste is cheaper than hop compost and is equally effective. Heathland nurseries are usually treated with hopwaste.

Farmyard manure, which is becoming increasingly expensive as well as scarce, is a most *unsuitable* organic supplement because of its high content of weed seed. The seeds cannot be eliminated even by careful composting. It may also contain amounts of lime which are dangerously high for forest nursery soils.

An alternative method of maintaining a high humus content is the introduction of a bulky green crop into the nursery rotation. This green crop is ploughed in (see page 19, last para.).

It is impossible to give an accurate manurial prescription for all nurseries without detailed knowledge and experience of each site. However, the following notes are a guide for fertilizer applications. The prescriptions are averages and should be increased slightly (by 10 to 20 per cent) in high rainfall areas (over 45 inches per year). Granular fertilizers are preferable to non-granular fertilizers because they are easier to handle and are generally more effective than powdered fertilizers. Compound fertilizers have the advantage of making possible the application of two or more nutrient elements in one operation, without the disadvantage of having to mix fertilizers beforehand.

The materials recommended are those available in August, 1963. They are likely to become more concentrated as methods of manufacture develop. The rate of application for such new materials should be that calculated to be nearest in the amount of the actual elements nitrogen, phosphorus, and potassium applied per acre to the present prescriptions.

Manures to be Applied before Sowing and Lining Out

The prescriptions given below are suitable for both conifers and broadleaved species:

12 lb. per 100 square yards (net) of granular potassic superphosphate (20% K_2O, 20% P_2O_5). Repeat the dressing for each crop of seedlings or transplants. This is equivalent to 5 cwt. per acre.

If straight fertilizers are preferred, 13 lb. of superphosphate (18 per cent P_2O_5) and 5 lb. of sulphate of potash (48 per cent K_2O) each per 100 square yards net, will be adequate. (5½ cwt. and 2 cwt. per acre respectively).

In heathland nurseries, raw hopwaste is applied at 500 lb. to 1,000 lb. (approx. 15-30 cubic feet) per 100 square yards for seedbeds, and 250 lb. (7½ cubic feet) per 100 square yards for transplant lines. (10-20 tons and 5 tons per acre respectively.)

Fertilizers should be applied to seedbeds at least one week before sowing. For transplants, fertilizers may be applied to the ground immediately before transplanting takes place. However, where it can be foreseen that transplanting will continue after

mid-April, it is desirable, at least on very sandy soils and with Norway spruce and Silver firs, to spread fertilizer before this time.

If the soil is known to be deficient in magnesium, magnesium sulphate (commercial Epsom salt) may be applied at 1½-3 cwt. per acre, at the same time as potassic superphosphate.

Hopwaste applications should be cultivated into the soil as early as possible, preferably during autumn cultivation work, so that the material has time to undergo partial decomposition before transplanting or sowing.

Nitrogen Top Dressings for Conifer Seedlings and Transplants

The timing, frequency and amount of nitrogen top dressings should be varied according to season and growth, and is best judged by the forester in the light of local experience and knowledge.

In general, the more nitrogen applied, the more the growth that will usually result. However, there are two important restrictions if the nitrogen fertilizers recommended here are to be used safely. Firstly, too much fertilizer put on at one time will kill plants, whether in seed beds or lines; two or three moderate applications (such as recommended here) are safer than one heavy one. Secondly, if a period of dry weather follows immediately after one nitrogen dressing, the rest should be withheld until there has been at least half an inch of rain.

With forest trees, late applications of nitrogen have made little difference to the ability of plants to withstand early autumn frosts.

Top dressings of nitrogenous fertilizers are best applied before rain is expected, but when the plants are still dry. After application, any fertilizer which may have lodged in the foliage of the plants must be brushed off with a light birch switch, or with a lath or a heavy sack. Any fertilizer which is allowed to remain will cause scorch and may lead to invasion by *Botrytis* fungus on weakened tissues.

If it is intended to produce one-year seedlings suitable for lining-out, such top dressings of nitrogen must be given.

Two to three dressings may be applied, between early June and August in the south of England, while in Scotland and the north of England they may be up to a month later. In acid nurseries (pH less than 5·5), 'Nitrochalk' (21% N) at 4 lb. per 100 square yards (1¾ cwt. per acre) for each dressing will be suitable for the less vigorous species, e.g. spruces and pines. Larches and Douglas fir should be treated with half the amount.

On soils where the pH is over 5·5, ammonium sulphate at 4 lb. per 100 square yards (1¾ cwt. per acre) at each application is to be preferred, using half rates or less for larches and Douglas fir. These would otherwise grow too big.

When the object is to produce two-year seedlings, applications of 'Nitrochalk' or ammonium sulphate should be spread over the two years by giving only one top dressing in July *the first year*, and a second dressing in July for all species excepting pines *in the second* year. Pines in their second year should receive the nitrogen in June.

Transplants should be given either 'Nitrochalk' or sulphate of ammonia at half the rates prescribed for seedbeds. The first dressing should be applied in late April or early May, or three to four weeks after lining out, whichever is later, with a second dressing in mid-July.

Nitrogen Top Dressings for Broadleaved Trees

For most broadleaved species, top dressings of 'Nitrochalk' (21% N) should be given at 4 lb. per 100 square yards, but very vigorous species, e.g. birch and alder, should only be given half this amount.

LIME REQUIREMENTS AND SOIL ACIDITY (pH)

The majority of common conifers grow best on acid soil, with a pH value between 4·5 and 5·5. If the pH is outside this range, and in particular if the soil is neutral or alkaline (pH 6·5—7·5), many species will grow badly.

If the pH value is found to be below 4·6, or if the readily soluble lime content is under 0·08 per cent, then a dressing of 5 cwt. per acre of ground mineral limestone or chalk (10 lb. per 100 square yards) should be broadcast over the area in autumn. This dressing may have to be repeated every three to five years. A soil analysis is essential to determine the lime content and pH value. In England and Wales the local County Agricultural Adviser will usually undertake the sampling, but where conifers are to be grown he must be warned *not* to prescribe the lime requirement necessary for an agricultural crop, but one for maintaining the readily soluble lime content at a level between 0·08 and 0·12 per cent. In Scotland, the Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen, will analyse soil and advise on lime requirement, if necessary.

Broadleaved trees tolerate soils with much higher lime content than do conifers, and will grow well in soils with pH values up to 7·0. For poplars, a soil with a pH over 5·5 is essential.

MANAGEMENT AND ROTATION OF CROPS

Some *heathland* nurseries which have been manured as prescribed above, are still in production after continuous cropping for over twelve years, without any reduction in plant quality. However, on agricultural soils it has been found necessary to operate

a three-year or four-year rotation, in which a third or quarter of the nursery is rested from tree crops each year.

In the majority of nurseries, particularly in low rainfall regions, the resting year is used for bare fallowing with repeated cultivations to reduce the weed population. In some nurseries in Scotland, principally in wetter areas (35 to 40 inches of rainfall and over), the rested portion is usually bare fallowed and cultivated until early July, when a greencrop of either pure oats, oats and tares, or blue lupins is sown. (Where the soil is acid, i.e. where the pH is below 5·0, tares are likely to fail and should be omitted).

The greencrop is believed to prevent loss of nutrients by leaching; if it is dense, it also suppresses weeds and prevents most of them from seeding. If pure oats are sown, a subsequent spraying with MCPA will control any susceptible broadleaf weeds present. (Such spraying must only be undertaken on a *calm* day; a high-volume sprayer should be used to put on a solution at 100 gallons per acre to reduce the risk of spray-drift on to adjoining sections of transplants, seedbeds or adjoining agricultural crops.) Suitable sowing rates are: (a) pure oat crops —four bushels of oats per acre (Yielder or Castleton Potato oats); (b) mixed oats and tares—two bushels of oats with 1¼ cwt. of Swedish Scotch tares per acre; (c) Blue Lupins—3 cwt. per acre. Before sowing, tares should be put into an equal volume of almost boiling water and allowed to cool in it—this speeds up the germination of the tares and produces a more uniform crop. The greencrops are ploughed under as soon as flowers or ears can be seen. Luxuriant green crops have to be rolled first.

Ground to be sown with a greencrop should be dressed shortly before sowing with potassic superphosphate at 13 lb. per square yard, combined with sulphate of ammonia at 6 lb. per 100 square yards. Alternatively, an equivalent NPK compound fertilizer can be used. A nitrogen top-dressing, at a similar rate, should also be applied four to six weeks after sowing (this should be omitted for lupins).

Seedbeds normally follow greencropped or bare fallowed ground, in order to get the benefit of the incorporated organic matter and the less weedy conditions, and they should always receive full fertilizer dressings at the rates previously recommended.

NURSERY PLANS AND RECORDS

For efficient management, an outline plan of the nursery grounds, showing paths, beds, etc., is *essential.* Otherwise areas cannot be calculated, nor stocks ascertained. A convenient scale is 1 inch to 100 feet.

Once such a plan has been drawn up, in black Indian ink on white paper, photoprinted copies can easily and cheaply be made. These can be filled in as required, using appropriate symbols or coloured crayons, to show the areas receiving various treatments—manuring, seed sowing, lining out, lifting, etc.

Systematic records of all work done must be made, and kept for a number of years. Even after the plants concerned have been lifted, it is often necessary to check their history, or that of the ground on which they stood.

Every batch of seed sown, or trees lined out, must have its separate entry, and it is particularly important to record its origin, whether it is a 'certified stock' or otherwise.

STOCKTAKING OF PLANTS

An annual stocktaking of all plants available in the nursery, by species, age, size, and identification number, is absolutely essential as a guide to supplies available for export, and as a check on the nursery productivity. This is usually done in August, as the previous summer's growth is coming to an end. Arrangements for the disposal, by use in nursery or forest, or by sale, are finalized in September, so that movements can start in October.

Where large numbers of plants are involved, and growth is reasonably even, a sample stocktaking is often adequate. For example, one may count every fifth square yard of a seedbed, and multiply the answer by five; or every tenth line of a transplant bed, and multiply the answer by ten. In all such sampling, it is essential to follow an objective scheme, neither selecting nor rejecting patches that look exceptionally good or unsatisfactory.

FORWARD PLANNING

Every nursery manager must have in view definite objectives of production. He must base his work on requirements, so far as they can be foreseen, for trees of various ages, sizes, and species. If there is a shortfall in stocks available, then he may have to 'buy in' seedlings, or even transplants, from trade nurseries; conversely, if there is a surplus, he may have plants to sell.

In like manner, his requirements of ground must also be worked out ahead. The use of each bed must be thought out for two or three seasons ahead, and areas must be calculated and adjusted to meet the desired programme of plant production.

Chapter 5
RAISING POPLARS AND WILLOWS

THE site for raising poplars and willows should be fertile and sheltered, with a pH of over 5·5. These soil requirements are not compatible with those of conifers. Poplars and willow nurseries are normally sited on land selected for these species alone.

The ground should be well manured with hop-waste at 1,000 lb. per 100 square yards, (if the soil is very humose, the organic manure can be dispensed with) and a complete NPK compound fertilizer applied at 20 lb. per 100 square yards.

Cuttings of well-ripened, one-year old wood, eight to nine inches in length, are required. Poplar cuttings must be at least the thickness of a pencil but willow cuttings may be more slender. Succulent material and 'blind' cuttings (i.e. those lacking buds), should be discarded. The cuttings can be taken any time after mid-October and should either be heeled-in in lines, with only the tips of the cuttings protruding above the ground, or else be completely buried in moist sand. At any time from early January to March, the cuttings should be inserted into cultivated ground so that the tops are flush with the soil surface, leaving 12 to 15 inches between cuttings and 15 to 18 inches between rows. The shoots which arise from the cuttings in spring should be reduced to one per cutting when they have reached a length of nine inches, leaving the strongest shoot in each case.

At the end of the first year, the rooted cuttings should be stumped, i.e. cut back to leave a one-inch stump above the ground, leaving at least one bud on the current growth. This can be done before or during transplanting, which should be carried out at a spacing of two feet by three feet if plants are to be lifted after one year, or three feet by three feet if they are to remain two years. Shoots on stumped plants are singled as in the case of cuttings. When lifting the trees for planting, the roots need special care. Normally the roots are extensive and the longer roots may need pruning with a sharp knife or secateurs.

If poplars are to be produced regularly, it will pay to establish a stool bed for the production of regular supplies of cuttings. These beds are made by planting cuttings or plants in spring at four feet by four feet, and cutting back to one bud. There is usually no need to thin the resulting shoots, which are cut back to ground level each winter to provide more cutting material. Stool bed areas require frequent cultivation and heavy manuring, but even so, the stools lose vigour and require replacing every four to five years.

For more detailed information on poplars see Forestry Commission Leaflets Nos. 27—*Poplar Cultivation* and 39—*The Quality of Poplar Plants.*

Chapter 6
NURSERY PROTECTION

HERE we are concerned with protection against mammals, birds, and flooding. Protection against fungal and other diseases is dealt with in Chapter 14, page 61; while protection against insects is discussed in Chapter 15, page 67.

Rabbits

It is essential to fence the nursery securely against rabbits, using a fence constructed to the specification given on page 42. Gates leading into the nursery should also be rabbit-proof and must be kept closed when not in use. At weekends and at night it may be necessary to lock them and to provide admission by means of stiles. A single rabbit can cause a large amount of damage in one night; in large nurseries, a rabbit can find sufficient cover to remain hidden for a considerable time.

Moles

These animals from time to time cause considerable damage to seedbeds on loamy soils by burrowing through the soil and damaging seedling roots in the process, or burying seedlings underneath their spoil heaps. The animals can be exterminated by trapping, using 'pincer', 'barrel', or 'half barrel' type traps, or by poisoning with worms dusted with strychnine hydrochloride or strychnine sulphate and placed in the mole runs. Full details of these methods are contained in the Ministry of Agriculture Advisory Leaflet No. 318—*Moles.* A third method which has proved satisfactory is by gassing, using 'Cymag' introduced into the mole runs.

Mice and Voles

These pests occasionally cause damage to both

seed and seedbeds. Where damage is noted, baited spring-back traps should be used for control. Small areas of valuable seedbeds may be enclosed in mouseproof netting.

Birds

Finches can cause considerable damage to ungerminated and recently germinated conifer seed. The only remedy that can be recommended is to cover the beds with netting. This is expensive but is often worthwhile on species such as Corsican pine which are often regularly attacked, and where up to 80% of the crop may be lost.

Rooks, pigeons, and game birds occasionally cause damage to newly sown seedbeds, particularly oak and beech and also to green crops. Scarecrows, gibbets, wind-mills and banging devices, etc. are usually ineffective after a few days, as are many of the proprietary non-poisonous seed-dressing repellents. On the whole, however, attacks by birds are infrequent and spasmodic.

Flooding

In the average forest nursery, a large area of bare soil is exposed to the full force of summer rainstorms, and the rapid erosion that sometimes results can be a real source of loss. The seedbeds themselves are raised above the general level, but it is still necessary to provide and maintain adequate channels for storm water to escape along a path where it will do no harm.

Chapter 7
NURSERY EQUIPMENT

FEW forest nurseries today are worked without mechanical aid, which means at least one tractor. For economic results, it is essential to build up equipment for as many tasks as possible, around one type of power unit. A standard agricultural tractor, with a three-point linkage and a power take-off, must first be selected. Several standard agricultural tools that serve equally well in a forest nursery, can then be obtained and used with little or no modification.

The specialized items of equipment, designed for forest trees, must of course be planned to fit a standard farm tractor of the type concerned. The Forestry Commission now has extensive experience gained by equipping its own nurseries, and its advice is available to anyone undertaking the mechanisation of forest tree nurseries.

A full set of equipment to cover all likely jobs is as follows:

(a) **Power Unit**

Wheeled tractor. 35 horse power, with three-point linkage and power take-off

(b) **Standard Agricultural Appliances**

Two-wheeled trailer, to enable tractor to move plants, fertilizers, sand, etc.
Two-furrow plough, for general cultivation.
Single-furrow plough, for lining out (without aid of lining-out plough).
Ridging plough, for throwing-up beds
Spring-tine cultivator
Tine harrow
Power sprayer, operated by tractor's power take-off
Rotavator, operated by tractor's power take-off
Fertilizer distributor
Roller; smooth, of suitable width and weight

(c) **Specially designed Forest Nursery Appliances**

Roller for forming seed drills
Sand distributor
Seed drill
Undercutting blade
Plant lifting blade
Lining-out plough

(d) **Hand Tools for use with above**

(i) *For all members of the gang:*

Garden spades
Dutch hoes
Rakes
Digging forks

(ii) *In lesser numbers:*

Lining-out boards, with stands and screens
Garden lines, with reels
Measuring sticks
Sand shovels
Watering cans

Buckets
Weed baskets
Plant boxes for plant transport
Polythene bags, „ „
Twine for tying bundles of plants
Hand sprayers of knapsack type

(e) **Special Equipment** (where required)

Lath shelter, with supporting wires and posts, for sheltering seedbeds
Irrigation outfit, including gravity feed or powered pump, and hose and spray pipes

(f) **Maintenance Equipment**

A full set of carpenter's tools, including hammers, saws, axes, pliers, pincers, brace-and-bit, etc., must always be on hand for adjustments and repairs involving woodwork.
A set of mechanical engineer's tools, including spanners, wrenches, oil cans, grease guns, etc., is absolutely essential for maintenance and adjustment of mechanical plant.
Sharpening stones and oilcans for maintaining hand tools

(g) **First Aid Outfit** (See page 93).

All this equipment represents a substantial investment of capital, and it is essential to store it in properly designed sheds, with adequate security provisions, and to keep accurate stock records.

PART II
PLANTATION WORK

Chapter 8
CHOOSING THE LAND AND THE CROP

SELECTION OF LAND FOR PLANTING

ANYONE setting out to make a plantation will usually have decided in advance where he wants to plant. In fact it will probably have been the unsuitability of a piece of land for other purposes which has turned him to forestry as a means of using the land well. The most obvious example of this is an old woodland site. The land may be covered with scrub, trees or bushes, or even just with stumps, which make a change of land use difficult; or the soil may be unsuitable for improvement for agricultural use. Ground heavily infested with bracken and too steep or rocky to make mechanical weakening or eradication practicable, is another type of land more suitable for forestry than for other uses. However, there are occasions when the choice between one piece of land and another has to be made; the choice may, for example, lie between whether to form a plantation on one part of a hillside or on a different part. In cases of this kind there are some general points which should be considered.

Obviously, first of all we must be sure that the land is capable of carrying a crop of trees. In most cases there will be little doubt that trees will grow, although the choice of the most suitable species may present a problem. However, all the factors which go to make up the particular environment chosen must be considered, the most important of these being the climate, both general and local, and the soil. The evidence of existing woods on the area and on similar sites nearby should never be neglected.

Secondly, there is the question of fencing. All plantations have to be stock proof and as the cost of fencing is high, the shorter the length of fence necessary the better. This means that the shape of the proposed plantation is of great importance if the cost of fencing is to be kept down. Narrow strips or awkwardly-shaped areas have a high proportion of perimeter to area and consequently show a high fencing cost per acre; the case of narrow shelterbelts is, of course, quite a different one, and there, a higher cost must be accepted.

The following examples of the effect of shape on fencing costs are of interest (a cost of £4 per chain of stock proof fence is assumed): a 10-acre strip 50 chains long by 2 chains wide will cost £416 to fence, or £41. 12s. per acre; but if the width is doubled to give dimensions of 25 chains by 4 chains, the cost will be £232, or only £23. 4s. per acre; if the area is made square, 10 chains by 10 chains, the cost will come down to £160, or £16 per acre.

Size also has a great effect on fencing cost. As shown above, a 10-acre plantation, square in shape, costs £160 to fence, that is, £16 per acre; but a square 100-acre plantation costs only £5 per acre. We can say, therefore, that we want as economical a fence line as practicable, but that many other factors other than cost influence the boundary lines. Certainly the plantation must be fitted to the ground, and saving in fencing costs must not be made at the expense of a good topographical boundary.

A third consideration is access. There is little point in growing excellent timber at a low cost if the extraction of produce, both thinnings and final crop, is to be very expensive. There is no doubt that in the long run a good road system pays its way. Inspection is easy, men can get on to the job without spending a long time walking to and from work (in some cases this saving alone can pay for the road), access for fire protection is good, and most important of all, getting the timber out is easy. With timber of low value, or when only a small quantity of timber is being offered for sale, the presence of a road giving easy access may make the difference between obtaining competitive offers for the timber from merchants and getting no offer at all. Obviously, making a road to a new plantation need not be done when the wood is planted; the important point when planning the site is to see that the question of access to the plantation is not forgotten; wherever possible, a suitable track should be marked out and left unplanted.

SELECTION OF SPECIES TO PLANT

Of all the work which the forester has to perform, there is none which has a more lasting effect than the choice he makes of the species to plant. It may

be easily imagined that a choice once made is not easily altered; and there is the complication that a mistake may not become evident until a number of years after planting. Obviously therefore, choosing the species, or mixture of species, is a difficult task, and it may be performed confidently only with experience, and especially local experience.

In this country we have a long planting tradition. In fact, we have as wide an experience of establishing new woods as any country in the world. In particular, because of a dearth of native coniferous trees, we have built up a great deal of knowledge about the use of species introduced from abroad. Therefore we can take heart from the fact that there is a considerable body of experience and knowledge to draw on.

There can be no doubt that the only safe way to choose the species, is to make a choice based on ecological grounds. This means that an attempt must be made to plant the species which is best suited to the planting area. This means considering all the influences—soil, topography, climate, etc., which act together in a complicated way to make up any particular site. On many occasions it may be found that the site is suited to the needs of a number of species, and in this case the choice between these species might be decided by the species most likely to satisfy any particular need, for example, producing a certain type of material for which there is a good local demand, or producing the largest volume, or the material of highest value.

Where the value of wood produced is not expected to differ among the possible species, it is known that the return on capital, as well as the net annual income over a crop's life, are higher the greater the rate of volume growth. With broadleaved species, the economic advantages of mixture with conifers are substantial, and by this means a good return per acre, and per £100 invested, is achieved, while still securing a final crop of the broadleaved species.

But it must be understood that these economic advantages can be secured only within the framework of an ecological choice.

If the matching of the most suitable species with the site is taken as the basis of selection, what points then must be considered? That the variety of sites in Britain is very great is obvious to all those who travel through the country, and therefore there are many factors which must be considered before the choice of species is made. Here we can only mention the main factors which influence the choice; these are:

Climate, both general and local,

Underlying geological formation,

Surface drift and soil, which may differ markedly from underlying rock,

Elevation, aspect and exposure,

Local topography,

Special influences (for example, liability to damage by animals, insects, or fungal diseases).

The greatest help in deciding the species to plant may be obtained from an examination of existing woods either on the area to be planted or on a comparable site close at hand. It is worth while going to a great amount of trouble to visit and examine any such woods. Even if the plantation has not grown well, the reasons for the comparative failure may be deduced and a repetition of the mistake avoided.

There is one further piece of evidence which is of the first importance in choosing species for afforestation—the surface vegetation. There is no doubt that the ground vegetation provides a most valuable guide to the choice of species, since the plant communities reflect the soil, moisture, and other conditions. But it is only one of several factors, all of which should be considered before a choice is made.

Plant Indicators

It may be worth while to consider in detail the indications given to us by various plants. The first point to note is that a single plant species rarely grows by itself, but is usually found with a number of others; and it is these associations of plants with which we are concerned. Next, we must be able to identify the commoner plant communities. When we have done this, we must relate tree species to the ground, using the different plant associations as indicators. The following table gives some of the commoner vegetation types and the indications they provide for us about suitable tree species:

TABLE 6
PLANT INDICATORS

Plant Associations	Site Conditions indicated	Tree species indicated	Remarks
Grass/herb	Moist and fertile soils. Often on lower slopes of hills and in valleys. If rushes are present, there may be a shallow layer of peat.	Beech, if soil is dry and calcareous. Generally hardwood soils. Ash, sycamore, wych elm. Douglas fir, European larch and Norway spruce, the last-named if peat is present.	Wood sanicle, wild garlic and dog's mercury are sometimes present and often indicate suitable conditions for ash.

TABLE 6 (*Continued*)

PLANT INDICATORS (*Continued*)

Plant Associations	Site Conditions indicated	Tree species indicated	Remarks
Fern/grass	Steep, moist slopes.	Japanese and European larches, Douglas fir, Norway spruce. Hardwoods, if really fertile; oak, beech, wych elm, sweet chestnut.	
Bracken	Slopes with fairly deep well-drained soil. Frequent on former woodland.	European larch, Japanese larch, Douglas fir.	Bracken grows on a wide range of sites, and should be treated with reserve as an indicator.
Grass/heath	Dry slopes and knolls.	Scots pine, European larch and Japanese larch; Sessile oak, if really fertile. Corsican pine in south.	The grasses are usually fine; typical grasses are *Deschampsia flexuosa* *Festuca* spp. and *Agrostis* spp. Bell heather (*Erica cinerea*) is sometimes present.
Rush/grass	Heavy clay soils.	Scots pine, Norway and Sitka spruce, Lawson cypress. Corsican pine in South.	Mosses are usually present.
Purple Moor grass (*Molinia caerulea*)	Usually heavy clay soils often with a layer of shallow peat. Drainage is usually poor.	Norway and Sitka spruce, but avoid the latter in frosty hollows.	The Purple moor grass is often found pure over large areas.
Heather or Ling (*Calluna vulgaris*)	Usually a leached and compacted soil of low fertility in an area of fairly low rainfall.	Scots pine, Japanese larch and Lodgepole pine. Corsican pine on southern heaths.	Typical of the 'grouse moor' in the North. Ling or heather is usually an indicator of unsuitable conditions for establishing spruces, but the destruction of the ling may render the ground suitable, provided the tree crop is soon established and so checks the ling's return.
Heather or Ling mixed with Purple Moor grass	Usually in the wetter regions of the west and north. The soil may vary but peat is always present and may be deep.	Scots pine and Lodgepole pine, if mainly heather. If mainly grass, Sitka spruce may be used in mixture with either Scots or Lodgepole pine.	Unsuitable for Norway spruce. On the poorest sites, there may be Cross-leaved heath (*Erica tetralix*) and Deer grass (*Trichophorum caespitosus*); on these sites only Lodgepole pine should be planted.

SEED SOURCES AND PROVENANCE

The provenance or geographical origin of seed is most important, and choice of the wrong provenance can have a marked effect on the health and yield of the resulting crop; in extreme cases it may mean the difference between success and failure of the plantation. Species which have a wide natural range usually show the greatest variation between provenances; e.g., Sitka spruce ranges from Alaska to California, though it is seldom found far from the Pacific Ocean. Lodgepole pine has an even wider distribution, as it ascends high into the Rocky Mountains, as well as growing at sea level along the Pacific Coast. Both of these trees show such a wide variation in rate of growth, that the poorer provenances may produce only two-thirds the volume of the best ones. Japanese larch and Serbian spruce, on the other hand, have restricted natural distribution, and have not, so far, shown important provenance differences.

Natural resistance to pests and diseases also varies with provenance. Different seed origins of European larch vary greatly in their resistance to canker and die-back; on sites where canker is likely to occur, great care must be taken to choose suitable provenances; High Alpine origins are almost certain to fail. Similarly, Douglas fir provenances from the interior of British Columbia tend to be more resistant to the aphid *Adelges cooleyi* than those of the green type from the coastal regions, but the inland trees often suffer later on from needle-cast diseases, and so the former are to be preferred in most circumstances.

With many species, the most vigorous provenances also have an inferior stem form, and it is necessary to consider whether the planting site is a testing one, in which case inherent growth vigour must be paramount. Increased vigour can often be obtained by using provenances from latitudes further south than those of Britain, though this usually carries the risk of increased danger from frost.

In general, the principle that there should be an approximate match between the climate at the site of the parent stand and the climate of the site where the progeny will be used in Britain is sound, but experience has shown that this concept must not be treated rigidly. On the one hand, climatic matching is no easy matter, and on the other, the existing pattern of distribution of a species may be the result of disintegration of a uniform distribution during the glacial period; e.g., Norway spruce from a continental climate in south-east Europe grows better in Britain than spruce from a more maritime climate in Norway.

For home-collected seed, there is a certification scheme operated by the Forest Tree Seed Association of England and Wales, and the Scottish Forest Tree Seed Association, which enables their members to obtain seed or plants from Registered Seed Sources. By recording where each lot of certified plants is planted, and watching their development, it is possible to discover which origin is best for local use. Normally it is safest to use seed from a Seed Source in the same region and on a comparable site. Within Britain, there is little evidence that taking seed from stands in the south leads to increased vigour when planted further north, but there does seem to be a natural division into eastern and western sectors. With Scots pine, in particular, any planting near the west coast should be done with provenances from north-west Scotland.

IMPORTED SEED

Grand fir. *Abies grandis:* Little is known about provenances. Vancouver Island and the northern foothills of the Cascade Mountains are generally suitable.

Noble fir. *Abies procera:* The behaviour in Britain of imported provenances has not been studied. Satisfactory results have been obtained with seed from the Cascade Mountains of Washington.

Douglas fir: Three regional divisions of the natural range of this species are usually recognized, viz. the Green or Coastal Douglas fir, the Grey or Intermediate Douglas fir, and the Blue or Colorado Douglas fir. The majority of British plantations have been raised with seed from the Cascade Mountains in Washington and Oregon, and the Lower Fraser River of British Columbia. It is now considered that the coastal belt of Washington and the Northern Cascade foothills are the best seed sources.

European larch: As a second choice to seed from good Scottish sources, the Carpathian area (Sudeten, Tatra or Polish) is the most promising source. On fertile sites these may grow very fast with poor stem form, but they are usually resistant to die-back, whereas Scottish larch is intermediate in susceptibility between the Carpathian and Alpine provenances. Seed from over 1,000 metres in the Alps should not be used.

Japanese larch: Most seed comes from the Nagano Prefecture on Honshu Island and is collected at medium elevations. Seed from plantations on the Northern island of Hokkaido has also given good results. Seed from good British sources should be used if available; this often yields hybrids between Japanese and European larch, which grow vigorously.

Lodgepole pine: Extreme inland (i.e. Rocky Mountains or interior Oregon) provenances are unsuitable. A selection should be made from the coastal and coastal mountain regions from Alaska

to Oregon. The most promising provenances, combining good form and health, are from the drainages of the Skeena and Bulkley rivers, but seed from Queen Charlotte Islands in British Columbia and the Coast of Washington gives best results under marginal conditions of exposure and poor acid soils.

Corsican pine: It is important to obtain plants of true Corsican provenance, i.e., plants raised from seed collected in Corsica, or their progeny from home stands.

Norway spruce: There are indications that South-east Europe origins are best, that German and Alpine origins are intermediate and that Scandinavian origins (particularly the northernmost origins) are unsuitable for use in Britain.

Sitka spruce: Seed from Queen Charlotte Islands of British Columbia is commonly used in Britain and is considered fully suitable. Southern provenances e.g. Washington, grow faster but are more frost-tender in early years. It is possible that seed from Alaska will prove more suitable in the far North of Scotland.

Western hemlock: As a second choice to seed from British sources, seed from the coast of British Columbia is commonly used.

Western red cedar: Seed is available from home sources, and from British Columbia.

Beech: There are fine stands in Belgium, Holland, Denmark and Germany which are regularly used for seed collection and whose seed is very suitable for use in Britain. When home-grown seed is used, a very careful choice of parent stand is essential. In practice, imports are frequently made, because years of ample seed production (mast years) are infrequent in Britain, and the seed is hard to store for more than one winter.

TABULAR NOTES ON INDIVIDUAL SPECIES

The main characteristics of the best known species are summarised in Table 7 to 10 which follow. It should be noted that the uses of the timbers, and their preservative treatment, are further discussed in Chapters 18 and 19.

* The figures quoted for the *yield* of various species are the *mean annual increments* (total production/age) for the range of sites on which the species are usually planted. Mean annual increment rises with age to a peak value, then declines. It is these maximum values which are given for major species in the right-hand column of each table.

TABLE 7

NOTES ON INDIVIDUAL SPECIES: MOST COMMONLY USED CONIFERS

Species and Native Country	Conditions justifying Selection	Unsuitable Conditions	Notes on Timber	General Remarks and Yield (H. ft./acre/annum)*
Scots pine, *Pinus sylvestris* L. British Isles and Northern Europe.	An adaptable tree which succeeds over a wide range of conditions. The easiest tree to plant on dry heather sites. Thrives on light or sandy soils and at low or moderate elevations. Very frost hardy. A strong light demander. Does well in low rainfall areas. A useful nurse species.	Avoid soft ground and sites exposed to sea wind. Not easy to establish on moorland country under high rainfall. Unsuitable for chalk or limestone soils except as a nurse for beech. Not a tree for high elevations, except in north-east Scotland, where it thrives up to 1,500 feet in glens.	A general purpose timber with good strength properties. It works, nails, and finishes well. Takes preservatives readily so is easily treated for outdoor use. Its wide range of uses include fencing, joinery, building, flooring, box and packing case manufacture, pitwood, fibreboard, wood-wool and chipboard manufacture, pulpwood, railway sleepers and telegraph poles. The 'redwood' of the imported timber trade.	Although growth is rather slow and volume production is not high compared with more exacting species, generally it is a 'safe' tree to plant. 60—160

TABLE 7 (*Continued*)

NOTES ON INDIVIDUAL SPECIES: MOST COMMONLY USED CONIFERS (*Continued*)

Species and Native Country	Conditions justifying Selection	Unsuitable Conditions	Notes on Timber	General Remarks and Yield (H. ft./acre/annum)
Corsican pine, *Pinus nigra* var. *calabrica* Schneid. (Syn. *P. nigra* var. *maritima* Melville) Corsica	Low elevations, particularly sandy areas near the sea. Light sandy soils and also heavy clays in south and east England; low rainfall areas. More successful on chalky soils than Scots pine. Tolerates smoke better than other conifers.	Avoid high elevations. Not suitable for the northern and western uplands of Britain.	The timber resembles that of Scots pine, but is somewhat coarser in texture, has a higher proportion of sapwood, and has slightly lower strength properties. Readily treated with preservatives. Its other uses include box manufacture, pitwood, fencing, fibreboard manufacture, chipboard manufacture, pulpwood and wood, wool. Selected material is suitable for joinery.	It is important to obtain plants of true Corsican provenance, that is, plants raised from seed collected in Corsica, or their descendants. Produces timber faster than Scots pine. Shows some resistance to smoke. 80—220
Lodgepole pine, *Pinus contorta* Dougl. Western North America	Flourishes on the poorest heaths and peats, where no other tree will grow, after suitable ground preparation. Stands exposure better than any other tree.	—	Home-grown timber is used in the round for pitprops and fencing. The sawn timber has similar properties to Scots pine and can be used for the same purposes.	Is probably the best pioneer species in Britain and is now being widely planted, especially in the west and north. 60—110
European larch *Larix decidua* Mill. Mountains of Central Europe	Site requirements are exacting. Does best on moist but well-drained moderately fertile loams. A strong light demander. A good nurse tree.	Avoid damp, badly drained or very dry sites, frosty places, shallow soils over chalk, poor sands, peat soils, leached soils, exposed sites at high elevations or near the sea, areas carrying a dense growth of heather.	The timber is heavier and stronger than most other softwoods. The heartwood is naturally durable but any sapwood needs preservatives for outdoor use. It is widely used for fencing, gates, estate work and pitwood. Other uses include telegraph poles, rustic work, garden furniture, waggon construction and chipboard; but it is not generally acceptable for fibreboard or pulp manufacture. Selected material is in demand for vat making and boat-building.	Canker is a danger and it is essential to select really suitable sites for planting. Choice of origin of seed for plants is most important; home-collected seed (particularly Scottish), from a good stand, is the most reliable; seed from the high Alps (over 3,500 ft.) must be avoided. Sudeten and Polish provenances are promising. Not a high yielding species. 40—120

TABLE 7 (*Continued*)

NOTES ON INDIVIDUAL SPECIES: MOST COMMONLY USED CONIFERS (*Continued*)

Species and Native Country	Conditions justifying Selection	Unsuitable Conditions	Notes on Timber	General Remarks and Yield (H. ft./acre/annum)
Japanese larch, *Larix leptolepis* Murr. Japan	Thrives over a wide range of conditions including the high rainfall districts of the west and north. Suitable for upland sites including grassy and heathery slopes. Of great value on coppice areas as it quickly outgrows and suppresses coppice shoots. A valuable pioneer species and a useful nurse.	Avoid dry sites and areas where the annual rainfall is low (under 30 inches); also badly drained sites, frost hollows and very exposed situations.	The timber is strong and resembles that of European larch. Grade for grade it can be used for the same purposes.	Resistant to larch canker. Gives a higher yield, up to middle age, than European larch or Scots pine. 60—140
Hybrid larch, *Larix eurolepis* Henry First raised in Scotland	Of special value on sites which are at the limits for the use of European or Japanese larch. Hardier and more resistant to pests and disease. On good sites can grow even more quickly than Japanese larch.	—	Resembles the timber of European larch and grade for grade can be used for much the same purposes.	Characteristics are intermediate between European and Japanese larch, but depend on the particular parents of the hybrid. First generation hybrid from selected parents is outstanding; second generation hybrid is also valuable, but third generation is poor. 60—160
Douglas fir, *Pseudotsuga taxifolia* Rehd. (Syn: P. *menziesii* Franco) Western North America	Likes a well-drained soil of good depth and of moderate fertility. A tree for valley slopes. Particular care is needed in site selection.	Unsuitable for exposed situations, heather ground, wet soils and shallow soils. Liable to windblow on soft ground except where drains are well maintained.	An excellent constructional timber with a high strength to weight ratio in compression and bending. Takes preservatives reasonably well. It is used for fencing, pitwood, flooring, joinery, building, packing case manufacture, telegraph poles, flag poles, chipboard, fibreboard and pulpwood.	On suitable sites Douglas fir grows rapidly and produces a high volume of timber. Thinning at too late a date can render crop unduly susceptible to windblow. Good drainage is important. 120—260

TABLE 7 (*Continued*)
NOTES ON INDIVIDUAL SPECIES: MOST COMMONLY USED CONIFERS (*Continued*)

Species and Native Country	Conditions justifying Selection	Unsuitable Conditions	Notes on Timber	General Remarks and Yield (H. ft./acre/annum)
Norway spruce, *Picea abies* Karst. Europe	Moist grassy or rushy land, and shallow, less-acid peats. Succeeds on old woodland sites and most soils of moderate fertility including heavy clays.	Fails on heather land and does poorly on dry sites, particularly on the eastern side of Britain. Often checked by frost in hollows, but eventually wins through.	A good general purpose timber with a clean white colour, It works and nails well, and has a wide range of uses. It is stable during changing conditions of humidity, and is therefore particularly suitable for building. Its other uses include joinery, kitchen furniture, boxes and packing cases, pulpwood, chipboard, pitwood, fencing, fibreboard, wood-wool, ladder poles and scaffold poles. The 'whitewood' of the imported timber trade. Seldom used out of doors as the heartwood is hard to treat with preservative, but small poles take enough preservative in their sap-wood to fit them for fencing.	Where it is really at home, Norway spruce produces a high volume of timber. Good drainage is essential if windblow is to be avoided. The young trees, and often tops of thinnings, can be sold as Christmas trees, but only in November/December. 100—220
Sitka spruce, *Picea sitchensis* Carr. Western North America	Damp sites, generally, including exposed high land. Stands exposure better than any other common conifer, very suitable for high rainfall districts especially on the west coast.	Avoid all dry sites. Honey fungus is a risk in some scrub and coppice areas. Not a tree for the dry east nor for southern and midland England.	Properties and uses are the same as those of Norway spruce. A first class pulp wood and readily accepted for chipboard, box boards and many building jobs.	A faster grower than Norway spruce and a very large volume producer. Useless as a Christmas tree. 140—280
Western hemlock, *Tsuga heterophylla* Sarg. Western North America	No well marked climate preferences. Does well in the west. May be highly productive at quite low rainfalls. Acid mineral soils and the better peats. A strong shade bearer and excellent for under planting.	Very difficult to establish pure on exposed bare ground, so needs a nurse. Dislikes heather competition and is slow to establish on heaths, where it may eventually grow well. Sites where previous conifer crops have suffered from *Fomes annosus* should be avoided, as hemlock is prone to butt rot from this fungus.	Home-grown hemlock has good prospects as a building timber and—if graded for the purpose—as a joinery timber. Also for pitprops and general estate work. A good pulp-wood.	Is easily established under a light shade, for example of birch. 160—280

Other Conifers

The species described in Table 8 below have been planted as forest trees only on a comparatively small scale so far. They should be limited to small areas on carefully chosen sites unless clear evidence of their successful growth is available locally.

TABLE 8

NOTES ON INDIVIDUAL SPECIES: OTHER CONIFERS

Species and Native Country	Conditions justifying Selection	Unsuitable Conditions	Notes on Timber	General Remarks and Yield (H. ft./acre/annum)
Lawson cypress, *Chamaecyparis lawsoniana* Parl. Western North America	Soil requirements are not exacting, but does best on a deep fertile soil preferably in a sheltered situation. Stands shade well and is fairly frost hardy.	Avoid heather ground.	There is too little home-grown timber of this species on the market for it to be considered for any special purposes. It finds an outlet as a general-purpose softwood.	Of limited value; has a tendency to fork and is liable to suffer from snow break. Foliage is valued by florists. 140—280
Austrian pine *Pinus nigra* var. *austriaca* Asch. and Graeb. Austria	Limestone sites in exposed areas. Useful for shelter-belts near the sea. Tolerates smoke better than other conifers.	Not suitable for wet soils, or for planting in the north and west generally.	Very knotty owing to large branches.	Only worth planting where sea, limestone, or smoke rule out other conifers, and then only as a shelterbelt. —
Californian redwood, *Sequoia sempervirens* Endl. California	Deep, fertile soils in high rainfall areas. Sheltered situations. Tolerates a great amount of shade.	Avoid infertile soils, dry areas, exposed situations and frosty places.	Has mainly been used for fencing owing to its high natural durability. A valuable timber in its homeland.	Usually slow in establishing itself. Best planted under tall cover. 180—300
Wellingtonia, *Sequoiadendron giganteum* Buch. California	Deep, moist, fertile soils in sheltered situations. Tolerates drier and more acid soils than the Californian Redwood.	—	Timber is similar to Californian Redwood.	Windfirm. A hardy tree. 180—300
European silver fir, *Abies alba* Mill. Central Europe	Not safe to plant owing to damage caused by the insect *Adelges nüsslini*. A strong shade bearer.	—	The timber has generally the same appearance and texture as Norway spruce, or 'whitewood', and is used for the same purposes under the same trade name of 'whitewood'.	— 160—260

TABLE 8 (*Continued*)

NOTES ON INDIVIDUAL SPECIES: OTHER CONIFERS (*Continued*)

Species and Native Country	Conditions justifying Selection	Unsuitable Conditions	Notes on Timber	General Remarks and Yield (H. ft./acre/annum)
Grand fir, *Abies grandis* Lindl. Western North America	Well-drained, moist deep soils. Useful for underplanting.	Avoid frost hollows and poor soils, particularly really acid ones.	Similar to spruce.	In favourable situations, produces a large volume of timber rapidly. 180—300
Noble fir, *Abies procera.* Rehd. Western North America	Flourishes on well-drained, deep, moist soils. Tolerates fairly acid soils and is less frost tender than other silver firs. Stands exposure well.	Avoid poor soils and dry sites.	Similar to spruce.	Has proved a useful shelter-belt tree under west coast conditions, particularly in Scotland. A high volume producer. 140—240
Serbian spruce, *Picea omorika* Pan. Yugoslavia	Similar to Norway spruce, but tolerates poor soils.	Similar to Norway spruce, but is frost hardy.	Similar to Norway spruce.	Useful in frost hollows where other spruces fail. 120—220
Western Red cedar, *Thuja plicata* D. Don. Western North America	Moderately fertile soils, even if rather shallow, and fairly heavy clays. Stands shade well; succeeds on chalk.	Avoid poor or very acid soils and exposed sites.	A lightweight timber with heartwood of good natural durability, and so suitable for exterior work. Its uses include roofing shingles, ladder poles, weather boarding, greenhouse construction and seed boxes.	Liable to attack by the 'Keithia' disease, caused by the fungus *Didymascella thujina* in nursery seedbeds (See F.C. Leaflet No. 43). Foliage is valued by florists. 140—260
Mountain pine, *Pinus mugo* Turra. Mountains of Central Europe.	Will grow on the poorest sites and will stand great exposure. Not a timber tree but can be valuable as a margin to very exposed shelterbelts.	Not worth planting on other than the very worst sites.	Not a timber tree.	No timber yield.
Maritime pine, *Pinus pinaster* Ait. Mediterranean	Thrives on sandy soils, especially in the south and west of England.	Not recommended elsewhere.	Resembles Scots pine. Much is imported as pitwood and some for box making.	Windfirm, and a useful shelterbelt tree in exposed places in the south-west.
Monterey pine, *Pinus radiata* D. Don. California	Sandy soils; light fertile soils, in the south and west of England. Only hardy near the south and west coasts.	Not hardy elsewhere.	Resembles Scots pine, but is usually coarsegrained owing to rapid growth.	Windfirm, and useful for shelterbelts. Grows very quickly where conditions suit it.

The Principal Hardwoods

In general, hardwoods should be restricted to the best sites and most fertile soils. Good results are unlikely on poor land or in exposed situations.

TABLE 9

NOTES ON INDIVIDUAL SPECIES: PRINCIPAL HARDWOODS

Species and Native Country	Conditions justifying Selection	Unsuitable Conditions	Notes on Timber	General Remarks and (H. ft./acre/annum)
Oaks: Pedunculate oak, *Quercus robur* L. and Sessile Oak, *Quercus petraea* Lieb. British Isles and Europe	Well-aerated deep fertile loams. Grow well on fertile heavy soils and marls. Strong light demanders. Sessile oak tolerates less rich soils than does Pedunculate oak.	Avoid all shallow, ill drained or infertile soils, and exposed areas.	Oak is both strong and resistant to abrasion. It has a naturally durable heartwood, but the sapwood needs preservative treatments when small poles are used out of doors. Prime clean oak is used for veneers, furniture, gates, flooring and barrel staves for tight cooperage. Lower grades of oak are used for fencing, weather-boarding, engineering, waggon construction and repair, sawn mining timber. Round oak is used for hardwood pulpwood. Small poles are valued for cleft or round fence stakes.	Both species are very windfirm. 20—60 As coppice, 20—30. Bark is still harvested as tan-bark in southern England.
Beech, *Fagus sylvatica* L. Southern England, South Wales, and Europe	Chalk and limestone soils. Good loams of all types if well drained. Likes a mild sunny climate. A heavy shade-bearer.	Avoid frost hollows, heavy soils on badly-drained sites, and leached soils.	Beech has a wider range of uses than any other home-grown hardwood; it is strong, works well and stains well. Uses include furniture, turnery, flooring, veneers, charcoal, bentwood and pulpwood. A good firewood.	Benefits from a nurse on exposed areas; Scots pine is a suitable species. Useful for underplanting. Grey squirrels can be very destructive to young beech. 40—100
Ash, *Fraxinus exelsior* L. British Isles and Europe	A most exacting species which demands good soil conditions. Likes sheltered situations and deep calcareous loams, moist but well drained. Thrives on chalk and limestone but only where soil is deep. Benefits from shelter in youth.	Not a suitable species for large scale planting or for use on open ground. Avoid dry or shallow soils, grassland, heath or moorland, ill-drained ground, heavy clays. Frost hollows and exposed situations are also unsuitable.	Ash has a high resistance to shock and is thus used for oars, hockey sticks, vehicle framing, tool handles and turnery and furniture. Also for pulpwood.	It is no use planting ash unless there is local evidence that first-class timber can be produced. It is rare to find suitable conditions except in small patches, and it is necessary to choose these sites with great care. 40—80

TABLE 9 (*Continued*)

NOTES ON INDIVIDUAL SPECIES: PRINCIPAL HARDWOODS (*Continued*)

Species and Native Country	Conditions justifying Selection	Unsuitable Conditions	Notes on Timber	General Remarks and Yield (H. ft./acre/annum)
Sycamore, *Acer pseudoplatanus* L. Central Europe	Fairly frost hardy. Stands exposure well.	As for ash but stands exposure.	A white timber especially suitable for use in contact with food (kitchen utensils, butchers' blocks, bread boards, etc.). A good turnery timber; used for textile rollers. Figured sycamore is much sought after for veneer and furniture manufacture. Also for pulpwood.	A useful tree as a windfirm mixture for conifers in shelterbelts. Grey squirrels can be very harmful. 40—100
Sweet chestnut, *Castanea sativa* Miller. Mediterranean	Needs a deep fertile soil, and it does best in a mild climate. Profitable as coppice in the South of England.	Unsuitable for the less fertile soils, frosty or exposed sites, badly drained ground or heavy clays.	Coppice grown material is used for cleft fencing and hop poles. Large material is used for furniture and coffin boards.	Treatment as coppice is discussed in Chapter 11. When grown for timber, should not be left to reach large size, owing to risk of shake. As coppice, 60.
Poplars: **Black hybrids** (*Populus* x *euramericana* (Dode) Guinier) *P.* '*Eugenei*' *P.* '*Gelrica*' *P.* '*Laevigata*' *P.* '*Robusta*' *P.* '*Serotina*' Europe, etc.	Very exacting; suitable sites are limited. Loamy soils in sheltered situations. Rich alluvial or fen soils, both well-drained and well-watered. Banks of streams.	Avoid high elevations, exposed sites and shallow soils. Stagnant water is fatal but occasional floods do no harm. Avoid acid peats and heathland.	Large clean poplar is peeled for matches and veneer packages (chip baskets). Used for waggon and barrow bottoms because of its high resistance to abrasion. Good pulpwood.	Poplar growing is a specialised job and is dealt with in Forestry Commission Leaflet No. 27, *Poplar Cultivation.* 60—120
Balsam poplars: *P. trichocarpa* Torr. & Gray. *P. tacamahaca* x *trichocarpa* hybrids North America	Often susceptible to bacterial canker and only clones generally resistant in practice should be used. They withstand slightly more acid soils than the Black hybrids and are more suited to the cooler and wetter parts of Britain than those.	As above.	As above.	As above. 60—140

Hardwoods of Limited Forest Value

Many of the species listed, while of little value for forest planting have valuable silvicultural virtues, which may make their retention worth while. Others have a place amid the farms.

TABLE 10

NOTES ON INDIVIDUAL SPECIES: HARDWOODS OF LIMITED FOREST VALUE

Species and Native Country	Conditions justifying Selection	Unsuitable Conditions	Notes on Timber	General Remarks and Yield (H. ft./acre/annum)
Birches: Silver birch, *Betula pendula* Roth. White birch, *Betula pubescens* Ehrh. British Isles and Europe	Not worth planting for their own sakes but often useful as nurses for frost-tender conifers or for beech or oak. Prefer light soils in the drier parts of the country, but these species are ubiquitous as natural growth on felled woodlands.	Should not be planted on any site where they are not clearly wanted for silvicultural reasons or for beauty.	Mainly used in turnery work, e.g. for bobbins, toys, tool handles and brush backs. Have good strength properties and could find a wider range of uses if grown to saw-log size. Pulpwood.	Natural growth is often worth keeping as shelter for a new crop. Must be cut out before it damages the crowns or the leaders of more valuable trees. Makes useful fire-brooms.
Field elm, *Ulmus procera* Salis. England	Fertile, deep, moist, light loams. Frost hardy. Resists sea winds	All infertile soils.	Field elm is our most valuable hedgerow timber. Uses include coffin boards, weatherboarding, box ends, packing case manufacture, furniture, dock piles and fenders. Pulpwood.	Field elm is usually grown only as a hedgerow tree.
Wych elm, *Ulmus glabra* Huds. Britain and Europe	As for Field elm. Stands town smoke well.	As for Field elm.	As for Field elm. Also in boat building	Wych elm thrives under forest conditions, particularly in northern and western valleys.
Grey poplar, *Populus canescens* Sm. Britain and Europe.	Grey poplar merits retention in woodlands.	—	As above.	—
Aspen, *Populus tremula* L. British Isles and Europe	Seldom a good tree in the British Isles.	—	As above.	—

TABLE 10 (*Continued*)

NOTES ON INDIVIDUAL SPECIES: HARDWOODS OF LIMITED FOREST VALUE (*Continued*)

Species and Native Country	Conditions justifying Selection	Unsuitable Conditions	Notes on Timber	General Remarks and Yield (H. ft./acre/annum)
Alder, *Alnus glutinosa* L. British Isles and Europe	A very hardy and accommodating species, but prefers wet soils to dry ones. Can stand flooding.	Not suitable for very acid peats or badly aerated soils.	Used for hat-blocks, clog soles, and general turnery, also as pulpwood.	Will grow in conditions of wetness of soil which no tree, other than willow, will tolerate.
Limes: *Tilia cordata* Mill. *Tilia platyphyllos* Scop. *Tilia vulgaris* Hayne. Britain and Europe	Fertile soils.	All infertile soils.	Good for turnery, and is a favourite timber for wood-carving and as pulpwood.	Of limited value. Wind-firm. Viable seed is produced only rarely.
Cricket Bat Willow, *Salix alba* var. *caerulea* Sm. England	Margins of flowing streams or water-courses with alluvial soil; or similar highly fertile land.	No good anywhere else.	Used for cricket bats, artificial limbs, chip baskets. Pulpwood.	Growing cricket bat willows is a highly specialised business. For details see Forestry Commission Bulletin No. 17 *Cultivation of the Cricket Bat Willow.*
Gean, or Wild cherry, *Prunus avium* L. Britain and Europe	Fertile woodland soils, particularly over the chalk.	All infertile soils.	A useful turnery and furniture wood.	One of the few trees to produce both good timber and showy blossoms.
Red Oak, *Quercus borealis* Michx. Eastern North America	Fertile sandy soils.	Infertile soils.	A general-purpose hardwood with good strength properties.	Valued as an amenity tree because of its autumn colour. Grows rapidly. Nursery treatment resembles common oak.
Horse Chestnut, *Aesculus hippocastanum* L. Asia Minor	Fertile soils.	All infertile soils.	A soft white timber of fine texture used to a limited extent in turnery work and in making moulders' patterns and fruit trays and as pulpwood.	Valued for amenity because of its showy white flowers.

PURE CROPS AND MIXTURES

The problem of whether it is better to grow pure woods, that is, woods with only one species, or to form mixed woods, has been a talking point among foresters for a very long time, for each method has its advantages and its disadvantages. Undoubtedly the main advantage of pure woods is simplicity; they are easier to plant, they are easier to thin, and when mature, the produce is of roughly the same sort, in size of log and in quality, and thus may be easier to sell. Against this most important point must be placed certain disadvantages. First of all, there is some evidence, from European forests, of deterioration in soil fertility taking place in pure woods of conifers; it must be said, however, that where deterioration has occurred, the methods of management adopted may have been at fault. But the risk remains, especially where crops of the same coniferous species are repeated on the same site. A further disadvantage of pure woods, especially on a large scale, is that the chances of an insect pest or fungal disease increasing in numbers until it becomes a menace to the health of the woods, are greatly enhanced. There have been examples of this on the Continent, although so far our equable climate has probably played a main part in reducing the risks. A third disadvantage is that the thinnings of some species, in particular hardwoods, are of very low value, and with pure crops of these species there is a long wait for any financial returns.

In considering the advantages of mixed woods we must remember the basic principle of matching suitable species with the site. It is useless to plant a mixture of species, the silvicultural requirements of some of which are not satisfied by the local conditions. There is, however, a considerable range of sites which can support a number of different species, and it is mainly in such circumstances that we have the chance of planting mixtures.

On certain sites the establishment of some valuable species in pure stands is an unsure, slow, and uneconomic business; but if they are planted along with another species, usually called a nurse, the establishment process can become more certain and quick. In these circumstances, if all goes according to plan, the first few thinnings would concentrate on the removal of the nurse species, and a pure crop of the nursed trees would be left. In practice, however, it is likely that the crop would remain a mixed one for a long time, perhaps until maturity.

One advantage of mixtures is that the risk of soil deterioration is diminished, particularly where hardwoods are associated with conifers, or a thin-foliaged light demander is mixed with a denser-foliaged shade bearer. Another advantage is that by mixing deep rooting species with shallow rooters, the chances of windblow are lessened. The amenity value of mixtures is also worth consideration. Lastly, mixtures give greater opportunities of regenerating the plantation by some means other than clear felling, for example by one of the many forms of selection working.

Against these advantages must be set the major disadvantage of increased difficulty of management, as mixtures require much more skill and judgement, and often more tending, than pure plantations. But with this extra attention undoubtedly goes greater pleasure and satisfaction. A consideration that has influenced many planters is the simple one of not having all their eggs in one basket.

Methods of Mixing

If we decide to plant a mixture, say of two species, the method of laying out the mixture remains to be decided. The most obvious way is to plant alternate trees of each species, but this is rarely found satisfactory; the two species hardly ever grow at the same rate or have the same tolerance of shade; the result is often that the slower species is suppressed, and we are left with a pure wood of branchy specimens of the more vigorous tree. Alternate lines of the different species is another rather similar method, which is easier to plant; but it too suffers from the same danger of suppression of one of the species. This disadvantage can be overcome by widening the lines into bands consisting of three or more lines of each species. When this is done, even if the side rows of the slower species are suppressed, the middle ones should remain free and come into the canopy. This method is a simple one to plant and has the merit of being suitable for mixing more than two species, and also for use with species of widely differing rates of growth, since the width of the bands, that is their number of lines, can easily be varied. With a mixture of hardwoods and conifers, the distance between the rows of hardwoods can be made smaller than between the conifer rows. If the ground had been prepared by ploughing furrows at intervals, the planting distance between rows cannot of course be altered, but the spacing within the rows can be made closer. If bands are planted on hillsides, it should not be forgotten that they will become apparent in the view, and broad ones will be regarded as unsightly.

Another method is to plant groups of one species in a matrix of another, for example, groups of hardwoods in a matrix of conifers. This method has a great deal to commend it; the groups may be adjusted in size to be suitable for different species and conditions, as may the distances between groups; nine to twenty-five plants per group, with plants closely spaced within the group in the case of hardwoods, and with groups spaced twenty to thirty-five feet apart centre to centre, are practicable. If we

consider the case of hardwood groups, then we can expect finally only one mature tree to arise from each group (a much larger number of trees must of course be planted in order to be sure that one will come through, and to secure natural pruning); thus the distance between groups might be decided by the space which one mature tree would be expected to occupy, after most of the conifers have been removed in thinnings.

All mixtures are difficult to manage and few develop exactly as planned, but their use is so important that the thought and care needed in planting and tending them must become a part of the forester's skill. Complex mixtures, involving several species or intricate planting patterns, should be avoided; they never develop in the forest according to the plans that are so easily drawn up on paper.

Chapter 9
PREPARING LAND FOR PLANTING

IN this chapter we start with the preparation of bare land for planting, and go on to a discussion of draining and fencing methods which are also applicable to former woodland. The planting methods described in Chapter 10 likewise apply to both new ground and former woodland. The special problems associated with the restocking of old woodland areas are discussed later in Chapters 11 and 12.

Until about 1932, very little preparation of the ground before planting was done, other than clearing away any scrub or the remnants of an old tree crop. In general, the custom was to notch the young trees directly into the surface of the ground, or to use the elaborate method of pit planting, and sites where these methods would not be successful in establishing the young trees, were not usually planted. Some present-day planting is still done by direct notching without any sort of prior preparation, but we do now realise that some preliminary work can have great advantages on most types of ground.

The effect of ground preparation lies in altering the site locally, and perhaps only temporarily, where the young tree will be planted, in such a way that it can become established more easily. Let us look now at a few of the types of ground where some kind of preparatory work before planting is usually worthwhile.

BARE LAND

By bare land we mean land which has not carried trees, as distinct from stump-covered old woodland or land carrying scrub growth. The simplest form of work is probably screefing, which consists merely of removing the surface vegetation from the planting spot with a spade or a mattock, and this method has been practised for many years, the planting being usually carried out at the same time as the screefing. In this case, the removal of the vegetation gives the young plant, for a time, a small area free of weed-growth, with which otherwise it would be competing for moisture and soil nutrients. Screefing is a simple operation and almost always repays, in better initial growth, the extra time it takes; but it must not be done on wet ground.

Ploughing of Bare Land

One of the most striking features of most Forestry Commission hill planting areas is the ploughing of the ground at close intervals; for the first few years, the ridges and furrows show up very clearly. Why does the Commission go to the trouble and expense of ploughing? To answer that question we must go back a little. When large-scale afforestation of poor quality hill land began, it was found that on many sites the trees did not grow well (and in some cases, did not grow at all) where they were notched directly into the surface of the ground.

On the less fertile sites available for afforestation, particularly those with a heath or bog vegetation, it is found that notch planting is not sufficient to enable the plant to become quickly established even if screefing is done first. This is because trees planted with their roots a few inches into such soils must usually develop a new root system almost on the ground surface, where air is available and where nutrients are released by the decaying vegetation, before growth can be resumed. The total volume of readily rootable soil available per tree is thus very small, so establishment will be slow and subsequent growth poor. If the trees are planted on upturned turves on a peat bog, or on mounds of excavated soil on a heath, their roots have sufficient air and also an increased supply of nutrients from the buried vegetation, so that their early growth is greatly improved.

The provision of 'turfs' and 'mounds' is nowadays done mechanically by ploughs hauled by crawler tractors. These provide a furrow and a ridge of turf or soil for each line of trees, and a choice of planting position is thus available according to whether the shelter and moisture-retaining conditions in the furrow, or the well-drained conditions on the ridge, are most important on the particular

site. The use of ploughs enables other operations to be combined with the provision of planting turves, such as shallow drainage to remove surface water until the forest canopy develops, or deep cultivation of hard soils.

The benefits of ploughing can be summarised as follows: First, reduction of early losses. Second, but hardly less important, faster and more uniform early growth; this shortens the time spent by the young trees in a stage susceptible to frost and weed competition. Third, increased timber yield for a given rotation, as a result of the quicker early growth. also, probably, greater total production for *any* length of rotation. Fourth, younger—and therefore cheaper—plants can be used. Fifth, planting is easier and quicker—therefore cheaper. Sixth, weeding is often unnecessary. Seventh, fire hazard is reduced for some years. Eighth, the effective application of any fertilizers needed is cheapened and simplified. Finally, on the worst sites ploughing can make all the difference between successful establishment and no growth at all.

Against these advantages must be placed the increased difficulties of hauling out poles and timber later on, over the ridges and furrows, (though the modern double-drum winch will make light work of this), and the higher initial costs. On balance, however, it is found that any disadvantages are far outweighed by the benefits of surface drainage, soil loosening and weed suppression which result from ploughing.

There are three main types of land on which ploughing is normally done; wet (often peat-covered) sites, dry heaths and grassy sites.

On wet sites the benefits derive from the local drainage provided by the furrow, together with the suppressive effect of the turf ridge on the weeds. Where slopes are gradual the furrows should run up-and-down the slope so that the surface water they collect flows in to permanent, contour drains (see DRAINING, below) and does not lie for long on the ground. The most suitable plough for this work is the Cuthbertson double-mouldboard plough, which provides two ribbons of turf from each fairly shallow furrow.

On ground which is too rocky or irregular to plough at regular five or six feet spacing it will be necessary to plough all the practicable parts and to cut the turf into thick slices for spreading at the desired spacing between the furrows; for this the Cuthbertson single-mouldboard plough is the most suitable.

On dry heaths the objects of ploughing are to remove the weed growth at the position of planting, break up and partly incorporate the surface layer of tough, raw humus, and reduce the compaction in the underlying mineral soil, breaking the iron-pan where one exists. Such work can be done with relatively simple but necessarily robust ploughs. The commonest model in use on Forestry Commission lands is the 'Tine' plough, which has a sub-soiler point which penetrates to 12-15 inches and a share and mouldboard which cut a furrow about nine inches deep beside the sub-soiler channel. The direction of ploughing should be along the contour if it is desired to conserve summer rainfall, or where there is risk of erosion, but if the soil is subject to winter waterlogging, even after ploughing, the furrows should be directed more nearly down the slope into permanent drains, running only slightly across the contours of the hill face.

The third main type of ground requiring ploughing has been called the 'grassy site' type but the areas concerned might be more generally defined as sites where it is important to secure freedom from competing weed growth. Examples are old farm land and chalk downlands. Ploughing is usually at five feet spacing but occasionally complete surface cultivation is provided. Various types of plough are used, including strengthened agricultural ploughs.

Ploughing of ground for afforestation requires a powerful crawler tractor. Commission practice has been to use standard agricultural makes of between thirty and sixty horse-power. On soft peat-land, models with extra-wide (and sometimes lengthened) tracks are required.

Up to the present, most ploughing has been carried out by the Forestry Commission. In upland districts, notably in Scotland and Wales, many private owners have already followed the Commission's example on a large scale. Elsewhere, few private owners have used this method of ground preparation, partly because the types of ground on which ploughing gives the greatest benefits are not found, partly owing to lack of suitable equipment, and partly because of the extra initial expense. There is no doubt that, on many sites, great advantages are to be gained by ploughing, and careful consideration of the problem of whether or not to plough, is well worth while; some contractors now possess the proper tools. As the technique and equipment vary so much from one district to another, it is advisable to seek the advice of local Forestry Commission staff before embarking on any extensive ploughing work.

DRAINING

Trees require a considerable amount of moisture if they are to grow well. This we all know, but we sometimes forget that they cannot thrive if the ground is waterlogged. Although roots will stand

temporary submersion they cannot remain alive if the water lies for long; in addition roots cannot get proper anchorage in soft ground and without this anchorage, the trees sooner or later blow over. Therefore, land which is permanently waterlogged, or on which water lies for long periods after rain, must be drained if roots are to live and the plants to prosper. If for any reason it is not possible to give effective drainage, then such land is not worth planting.

Soils differ very greatly in their natural drainage characteristics; gravels, sands and the lighter loams may present no problems however high the rainfall. On the other hand, clays, even in the drier parts of the country, are frequently subject to winter waterlogging.

Except in the higher rainfall areas, most of the difficulties arise from water which flows into the area from higher ground above, either on the surface of the ground or in the upper layers of the soil, or which comes from springs. The best method of draining is to deal first of all with the water running on to the area, and it is worth a great deal of trouble to find out exactly where the water is coming from. Generally, this kind of water can be dealt with by means of long 'cut-off' or 'trap' drains to intercept the water near its source, and to lead it away into a stream or main ditch. These 'cut-off' drains should be as nearly as possible at right angles to the flow of the water, that is, they should be almost 'contour' drains, with only a small fall for the water collected. This system of contour draining can be seen in many of our older woods, but the art of making the drains seems to have been lost with the understanding of their importance, and in too many plantations there may be seen badly-designed drains. Drains can be found even running directly up and down a slope, and these can drain practically nothing except water which actually falls in them. In general the slope of the drains should be as gentle as is consistent with a free flow, and obviously in a 'contour' drain there can be no sharp corners or sudden changes in gradient. With wet pockets, caused for example by springs, or by the collection of seepage water in a hollow, a few very carefully aligned drains may be sufficient to lead the water away.

When drains to deal with the water coming on to the area from above, and from any wet pockets, have been made, then we must consider dealing with excessive rain falling on the area. Most of this water will run along the surface of the ground, and again may be best collected in contour drains which intercept the flow.

In the higher rainfall areas in the hills, where peat has formed on the surface, a carefully laid out system of drains is of special importance. Again, the principle should be to intercept the water as it runs down the slope, and this as before may be done by a series of drains almost at right angles to the flow of water to be caught, with each drain leading eventually into some form of main outlet such as a small stream. Danger from scouring, choking, and overflow must be expected if the result of the drainage system is to add appreciably to the volume of water which the outlet has to take; thus we must choose an outlet which is capable of taking a considerably increased flow.

The spacing of drains varies with the type of soil, the slope and the rainfall, and there can be no definite rules. On wet peat hill-land, ploughing has now superseded hand draining and turfing. The plough ridges to provide turf are spaced as closely as possible, usually 5½ to 6½ feet apart, with the permanent drains ploughed in more deeply at a much wider spacing. The permanent drains, must of course, be laid out with close regard to the contours. On the more usual lowland sites, the spacing will depend entirely on the nature of the ground and no regular pattern will be possible or necessary.

The size of drains is a further problem. It is as big a mistake to have a drain too large as it is to have it too small; too deep a drain tends to silt up and one too shallow chokes and overflows in a flood. The best size will depend on the nature of the ground, but a drain 12 to 18 inches deep, with a width at the top of 24 inches and a width of 9 inches at the bottom, is a common size. In areas of shallow peat, overlying clay, deeper draining is probably essential in order to permit the mineral soil to dry out and fissure so that roots can penetrate it.

Drainage is still an operation which has to be carried out by hand on most estates, and a skilled drainer, a man who can judge the best alignment as well as cut a clean channel of the right size, is a valuable workman. But great advances have been made in the last decade or so with the development of hill draining ploughs—the Cuthbertson is probably the best known and most widely used—and almost the whole pattern of drains made in Forestry Commission hill plantations in the higher rainfall areas, is made by the Cuthbertson single mould-board plough, which gives a smooth, level drain about 18 inches deep, 30 inches wide at the top and 8 inches wide at the bottom. The plough is pulled by a crawler tractor, and as the whole outfit moves at a good speed, usually that of a slow walk, the pattern which the drains are to follow needs to be thought out and decided well in advance. Even with the most skilled ploughman, it is impossible to lay out a complete pattern by machine, and there always remains sorting up of ends and some tidying up to be done by hand.

For especially large drainage channels there are

other machines, working on an endless bucket principle or on the grab principle, which can operate in the most difficult soils, for example, stiff clays, but it is as yet uncertain on what sites they can be economically employed.

FENCING

It is, of course, essential that all browsing animals which might damage the young trees are excluded from a plantation; this means sheep, cattle, deer and rabbits. For generations, the rabbit has been the forester's worst enemy, and a large part of the cost of fencing, which as we saw earlier is a major item in the total bill for establishing a plantation, has been caused by the need to keep out this pest. With the coming of myxomatosis, we have had an opportunity which may never come again, to exterminate the rabbit, by turning all the weapons we possess—guns, traps and gas—on to the survivors of the disease. Anyone who has any interest in forestry and especially anyone who means to do some planting, should regard it as a bounden duty to have all the land he owns completely free of rabbits, and to do all in his power to persuade his neighbours to do likewise.

As fencing is such a heavy cost to bear, there is a temptation to try to get away with a lighter and less secure fence than is in fact possible, but there is little doubt that a fence designed to a specification meant for the job it must do, and well erected, will be the most economical in the end. The use of creosoted scots pine posts instead of uncreosoted posts, is a good example of spending a little extra to begin with and saving a great deal in the end, in the very much longer life of the posts.

Table 11 below gives some general specifications of different types of fences; these specifications will of course vary with local conditions and customs.

TABLE 11
FENCING SPECIFICATIONS

Type	Straining Posts	Intermediate Posts	Wire	Wire Netting	Erection
Rabbit Fence	Round 6–7 in. top diam. × 7 ft. At all definite changes in direction and sudden changes in gradient; also at intervals of about 100 yds. if the fence is straight.	Round 3 in. top dia. × 5 ft., or cleft with 4 in. face. Spaced 9–12 ft. apart.	2 × No. 8 gauge plain wires, 1 at top of netting and one near the bottom. A third wire half way up the post may be used if required for additional strength.	42 in. × 1¼ in. mesh × 18 gauge.	The bottom 6 in. of the netting should be turned outwards and either buried in a shallow trench or covered with sods.
Sheep Fence, Type 1. (Wires only)	Round6-7in.top diam. (or squared 6 in. × 6 in.) × 7–8 ft. At all definite changes in direction and sudden changes in gradient; also at intervals of about 100 yds. if the fence is straight. Stays 5 in. × 3 in. × 6 ft. will usually be necessary.	Round 3 in. top diam. (or squared 3 in. × 3 in.) × 5 ft. 6 ins. or cleft with 4 in. face. Spaced 6–9 ft. apart.	5 – 6 × No. 8 gauge plain wires.	—	—
Sheep Fence, Type 2. (Wire and sheep netting).	As for Type 1.	As for Type 1.	(*a*) 3 × No. 8 gauge plain wires *or* (*b*) 2 × No. 8 gauge plain wires.	(*a*) 36 in. × 4 in. mesh × 14 gauge (without centre strand) *or* (*b*) 36 in. × 4 in. mesh × 14 gauge (with centre strand).	The netting should not be buried.

TABLE 11 (*Continued*)

FENCING SPECIFICATIONS (*Continued*)

Type	Straining Posts	Intermediate Posts	Wire	Wire Netting	Erection
Cattle (or Sheep and Cattle) Fence.	As for Sheep Fence, Type 1.	As for Sheep Fence, Type 1.	As for Sheep Fence, Type 1, but the top and/or second top plain wire should be replaced by a 2 ply 4 point barbed wire, with barbs 6 in. apart.	—	As for Sheep Fence Type 1.
Sheep and Rabbit Fence.	As for Sheep Fence, Type 1.	As for Sheep Fence, Type 1.	4 × No. 8 gauge plain wires.	As for Rabbit Fence.	As for Rabbit Fence.
Sheep, Cattle and Rabbit Fence.	As for Sheep Fence, Type 1.	As for Sheep Fence, Type 1.	As for Sheep Fence, Type 1. The top plain wire may be replaced with a barbed wire, or a barbed wire may be run along the top of the posts.	As for Rabbit Fence.	As for Rabbit Fence, except that the netting must be on the inside of the fence and the bottom 6 in. buried straight down.
Deer Fence.	—	Round 6 in. top dia. × 8 ft. spaced at 18–24 ft. Droppers 1 in. × 1½ in. × 3 ft. 6 in. spaced at 5–6 ft. staggered on top and bottom halves of fence. Stays may be necessary.	4–5 × No. 6 or 8 gauge plain wires. 3–5 × 2 ply, 4 point barb 6 in. apart.	Sheep netting may be required up to 3–4 ft., (fewer plain wires are then needed).	The fence should be 6 ft. high. The barbed wires should be placed about the height of the head of a deer.

Where trespass is troublesome, two barbed wires on the same level on the top, but on different sides of the posts, are a useful deterrent, but nothing will keep out people—not forgetting shooting parties and estate workmen—who are really determined to get over the fence, and the final result of the preventive measures may be merely more damage to the fence. Where this may happen it is often better to provide a simple stile, or even just a light smooth pole which is easy to get over, along the top of the fence and between two posts. On regular foot paths, stiles are usually to be preferred to gates which can so easily be left open; but gates must of course be provided on legal bridle paths.

In hunting counties a close liaison with the hunt is essential and it will be best to provide a number of gates into the plantation rides; if this is not done, damage to fences is inevitable. Remember also that it is usually necessary to check at the end of the day that the gates have been closed behind the field.

Chapter 10
ESTABLISHMENT OF PLANTATIONS

PLANTING METHODS

AT the outset let us state clearly what we must aim at in all our work connected with planting; it is this—to plant a live and vigorous young tree with healthy roots, themselves still moist, firmly in a moist soil. That may seem obvious but it is not as easy to carry out as may at first appear.

Possibly the commonest method of planting is the simple old one of notching the trees directly into the ground. Basically, this consists of making a slit in the ground with a spade and holding it open just long enough for the roots of the plant to be inserted.

There are a number of different ways of making the notch, the most widely used of which is probably the L notch. In this method, the first cut of the planting spade is made with the edge of the blade towards the planter, and the spade is pushed about 6 inches into the ground; the second cut is made at right angles to the first so as to form an L. The spade is forced straight down and then pulled towards the planter so that a triangular piece of turf is levered up, thus opening the line of the first cut for the insertion of the plant roots, which are kept in the deepest part of the cleft, that is, the part nearest the planter. The spade is then removed, and as the soil falls back, the plant is pulled slightly up with the hand to an upright position at the correct depth, and the surface of the ground is firmed with the heel.

There are many varieties of this notch such as the T, in which the second cut is made across the first, like the top of a T; and the H, in which the soil is lifted with a third stroke placed across the base of the T. All these notches employ the same principle, and which to use depends mainly on individual preference; the results of all appear uniformly good.

Several kinds of spades can be used for notching, including the Schlich and Mansfield tree planting spades which have tapered blades set in a straight line with the handle. A very satisfactory tool is an ordinary garden spade which has become worn down, provided that the blade is not at too great an angle to the shaft. But on very stony ground a pointed spade such as the Schlich proves better.

A variation of notching can be made with a mattock instead of a spade. A double-ended mattock is essential, with an axe-end as well as a hoe-end, although a pick-end instead of an axe-end may be necessary in very stony ground. An L notch is used, and the first stroke is made with the pick-end (or axe-end) so as to tear a slit in the soil towards the planter; the second stroke is made by embedding the hoe-end just to the side of the far end of the first cut; the soil is then prised up, the plant inserted and the tool removed. The mattock is a useful tool in stony areas, especially on steep hillsides, and where screefing of the surface vegetation is necessary.

Pit planting, which consists of placing the plant in a hole dug sufficiently wide and deep to allow the roots to take up their natural shape, is rarely used nowadays as a forestry operation. It may, however, have a limited use with exceptionally large plants on very weedy sites, for example partly-cleared scrub areas.

Planting on Ploughed Land

In the last chapter we saw that land suitable for ploughing might be divided into three categories—wet sites, dry heaths, and grassy sites where relief from vegetation competition is important—and planting ploughed land on each of these site types presents different problems.

Planting on Peat. On the wet sites, usually peat, the plants are put into the plough ridge, and the object must be to place the tips of the roots of the plants in the rotting vegetation below the upturned ridge; the roots should be the 'meat in the sandwich' formed by the layers of rotting vegetation beneath the ridge and on the surface of the ground (it is most important, however, that the roots are not notched into the ground itself below the plough ridge). To do this the plant is notched into the top of the ridge, or if the ridge is a very high one, the top of the ridge is sliced off and the plant is notched into the lower ridge thus made. A planting spade of one of the various patterns is the tool normally used, and the notch is usually just a single slit; the roots of the plant are inserted behind the spade, which is then withdrawn and the plant firmed with the heel in the usual way.

Another method is to cut a V-shaped wedge of turf out of the side of the ridge with two strokes of the spade, and to place the plant in the apex of the hole made and then replace the wedge, ensuring that the roots are held firmly in the damp peat. As with notch planting, if the ridge is too high, it must be cut down so that the roots of the plants can get down to the layers of rotting vegetation.

Where ploughing has been done at intervals of 12 feet or more, turfs must be cut from the plough ridges and spread over the surface of the ground so that the plants may be planted on them. These turfs should not be less than 15 inches square, larger if possible, and about 6 to 9 inches deep. Usually, their

size will depend on the size of the plough ridge from which they are cut. If the slice cut from the ridge is laid on its side, then the depth of the turf will depend on the thickness of the slice cut. It is a mistake to make turfs too small; quicker growth is secured by using large turfs.

Usually the turf is split with a spade from the middle to the outside, the plant inserted through the notch, and the roots spread out beneath the turf. It is a good plan to keep the notch side away from the prevailing wind. With this method of planting there is a danger of the turfs drying out in summer, the notches opening and exposing the roots of the plants; putting in the plants more deeply than normal helps to reduce this risk.

As an alternative to notching, a special semi-circular spade may be used to extract a cone-shaped piece of soil and turf. The plant is inserted in the hollow and the peat cone replaced.

One further point concerning planting on plough ridges or on spread turfs needs stressing. Although it is advisable to leave the ploughing and turfs to consolidate for a few months before planting, it is vital that the planting is not delayed for more than one year; planting on old plough ridges, and on old turfs which have begun to amalgamate with the ground below, gives very poor results.

Planting on Dry Heaths. After ploughing on the dry heaths, the planting problems are different, and the best position for planting varies from one site to another; usually, however, the best position for the survival of the plant is low down in the furrow, where the plant obtains moisture and is unlikely to be troubled by the reinvasion of vegetation in the earliest years. On very hard soils however, a plant in the furrow may not be able to get its roots down, in which case it may be loosened by wind when it is a few feet high. Although early growth may be slower, trees planted on the ridge (preferably to the sheltered side), do not suffer from this early instability. If there is a danger of water lying in the furrows, planting may need to be done on the side of the plough ridge itself, which is usually only an indeterminate mound on the heaths and quite different from the distinct ridge turned out on wet peat moorland. The usual tool for planting on heathland is the spade, and some form of notch should be used, but often a clear-cut notch will not be possible owing to the stoniness of the ground.

On the sites where freedom from weeds is the most important aim of ploughing, the planting position will vary, as on the heaths, with local conditions. The main object should be to place the plant where it will remain free of weed competition for as long as possible, and this may vary from the top of the ridge to the bottom of the furrow. Once again a notch made by a spade is the normal planting method.

TIME OF PLANTING

Theoretically, planting should be carried out when growth is dormant, or at least not going on vigorously, that is during the period of winter rest from early October to the end of April. Our climate is a such a favourable one that if bad spells of weather are avoided, planting can go on throughout the winter and spring with reasonable success. In general, however, it has been found that planting in the spring is more satisfactory than in the late autumn and early winter, and it is usually worthwhile to make the effort of concentrating planting in this way. The merit usually claimed for autumn planting is that the young trees have a chance to become accustomed to their new environment during the winter and are thus better able to begin growth in the spring without any check. This view does not appear to be borne out in practice, however, and the early spring seems to give the best results, judged over a number of years. There are, of course, exceptional seasons which upset all calculations, but on the average, it would appear that autumn planting is a little more apt to do badly in a year of bad winter weather, than is spring planting. Hardwoods are a possible exception and it is a common practice to plant these in the late autumn.

The larches, which flush early, should be one of the first conifers to be planted in the spring; spruces can usually be left to the last if necessary, and on moist ground in the hills they are frequently not planted until late April.

Finally, there are two good rules to remember—never plant during frost or in a very cold wind—and be sure that the plants are in fact alive!

AGE AND TYPE OF PLANT

The best plants to use for planting in the forest are nearly always spoken of as 'sturdy transplants'. And this description is a good one as it implies a plant which is neither too small not too large and which has a good stout stem, or put in a more technical way, has a high ratio of root collar diameter (and therefore of total fibrous roots) to shoot length. There is no doubt that a plant of this type generally gives the most satisfactory results. With conifers, this usually means a two-year-plus-one-year or one-year-plus-one-year transplant about 12 to 15 inches tall. Smaller plants, 6 to 10 inches in size, are to be preferred for planting on spaced ridge-and-furrow ploughing on wet moorland or on dry heathland sites where there is little shelter, and where weed competition is negligible during the first few years. For fertile sheltered sites, and places

where a strong growth of weeds can be expected, larger and perhaps older plants, up to 24 inches tall, are often advisable.

Trade nurseries often quote prices by size rather than by age, and in such cases it is wise to ask for further information. Better still, ask them to supply sample plants before placing an order, and also inspect the beds at the nursery.

The following list gives the common ages of plants suitable for planting; it should be remembered, however, that size and general sturdiness are better criteria than age alone.

Scots pine:	1 yr.+1 yr.; 2 yr.+1 yr.; 2 yr.+2 yr.
Corsican pine, Lodgepole pine, Austrian pine, Mountain pine, larches and Douglas fir:	1 yr.+1 yr.; 2 yr.+1 yr.
Sitka spruce:	1 yr.+1 yr.; 2 yr.+1 yr.
Norway spruce, Western red cedar, Lawson cypress, Western hemlock, Grand fir and Noble fir:	2 yr.+1 yr.; 2 yr.+2 yr.
Californian redwood, Wellingtonia, European silver fir, Serbian spruce:	2 yr.+2 yr.
Oak and Red oak:	1 yr. or 2 yr. seedling.* 1 yr.+1 yr. transplant.
Beech, ash, sycamore, birch and elm:	1 yr.+1 yr,; 2 yr.+1 yr.
Sweet chestnut:	2 yr. seedlings; 2 yr.+1 yr.
Poplar and willow:	Rooted cuttings or sets. (See page 21.)
Common alder:	1 yr.+1 yr. /often best to be cut back after planting).
Lime, Wych elm and Wild cherry:	2 yr.+1 yr.

Note: *If two-year seedlings of hardwoods are to be used, they should be undercut in the nursery bed after one year's growth.

HANDLING OF PLANTS

Here we must consider what happens to the plant from the time it leaves the nursery until it is planted in the forest. This is a critical period for the young tree and it is probable that more planting failures are due to bad handling of plants before planting, so that the roots are in fact dead when the plants are set out in the forest, than to natural causes after planting.

Transport

First of all the plants must start off from the nursery in good condition. This means that after lifting they must be heeled in or sheughed carefully; they must be bundled properly and the bundles be well protected, for example with damp moss or straw, in grass mats or sacking, or in polythene bags, for transporting to the planting site. The two main dangers when transporting plants are first, that the roots will dry out; and second, that the damp bundles will become heated if there is no circulation of air; in either case, the plants may die. The protection of plants for a journey by lorry, which is of short duration, is not difficult, but with rail transport, with the greater distances and much longer times involved, the protection of the bundles needs much care. Where plants are to be sent by rail, the extra cost of passenger train or express goods transport is fully justified by the lower risk of losses after planting.

Polythene Bags

The use of the polythene bag, which is rapidly becoming general, is proving of great assistance at all stages in the movement of the plant to the actual planting site. One of the advantages of this form of packing is that plants can often be brought to the actual planting site in the same packs in which they were inserted on lifting in the nursery, without the troublesome breaking down of large consignments into smaller ones at various stages. Little extra need be said about polythene bags at the forest end of the line. The most important cautionary point is that they *must not* be exposed to direct sunshine, and on the bare hill-side some means of sheltering temporary stores of bagged plants must be devised. Often of course young plantations will be available. Ideally, the plant does not leave the bag till the planter is ready for it and 'sheughing' or 'heeling-in' as described below is obviated.

Heeling-in

If plants are not packed in polythene bags, whenever the plants are received they must be heeled-in or sheughed in a properly prepared trench, which is usually termed a sheugh in Scotland or a bury in the south. The time to prepare this is not when the plants have arrived but beforehand, so that there is

no delay between removing the packing and getting the roots covered with moist earth. The trench should be in good fresh moist soil, and should not be either in soil which is liable to dry out quickly or which may become water-logged; and the ground must be well dug over. The bundles of plants should be placed side by side in trenches, and if they are to remain in the trench for more than a few days, the bundles must be opened out. Earth should be well packed round the plants so that frost or drying winds cannot reach the roots. If the weather is very frosty the plants should be covered with straw or bracken.

When the planting is due to begin, the plants must be transferred to the planting site and there put into a temporary trench. Usually it will not be possible to have this in such a good soil, but the same principle holds of having it well prepared in advance. Drains should not be used as trenches. If the plants are to be planted almost immediately, they may of course be taken direct to the trench on the planting area.

Movement to Planting Site

Moving the plants to the planting site is another time of risk. Usually, they will be taken by tractor and trailer or by lorry, and the main point to watch is that the roots are exposed to the air for the shortest possible time. The bundles should be stacked on the trailer or lorry so that the roots point inwards, and the loaded lorry looks like a 'hedgehog' of plant shoots pointing outwards and upwards; finally a tarpaulin should be put over the load.

Now we come to the actual operation of planting. We have brought a plant with live roots to the planting site, and we have to ensure that the roots do not dry between the temporary trench and the plant's final position in the ground. Much depends on the organisation of the planting operation. Generally, however, a small number of plants—the number will depend on the species and the size—should be carried by the planter in a proper container, and each should be removed from the container one at a time and put straight into the ground. It is well worth while to equip each planter with a bag that can be slung over his shoulder, leaving both hands free for planting. This should have a waterproof base or lining, both to keep the roots moist and to prevent the planter's clothes getting wet and dirty. In the absence of a bag, a sack with a loop of rope will serve.

ORGANISATION OF PLANTING

With only two or three men engaged in planting, organisation of the work should present no difficulty, but with a larger planting squad, forethought is essential, not merely because it will make the work quicker and therefore cheaper, but because it will reduce the danger of the plants drying out. With more than one wood or compartment to plant, we must decide whether to give each separate area to say, two men, and allow them to work through their allotted compartment, or to concentrate all the men into one area, and then move on to the next when that one is completed. Both methods are satisfactory but with the method of concentrated working, supervision becomes easier. A point for consideration is whether it is worth while to have a man (or a boy) whose sole job is to keep the planters supplied with fresh plants from the heeling-in trench.

The planting of more than one species needs further arrangement. Where there are a number of different ground types within a planting area, and it has been decided that each requires a different species, then the man in charge must either have a sketch map showing where each species should be planted or he must be quite clear in his own mind where the species changes should be made. A few stakes put in the ground may be used as an aid to define the areas for the planters.

Intimate mixtures are another problem; if an alternate plant mixture is to be used, then either each man can carry two planting bags with one species in each and take a plant alternately from each bag, or two men can work in one row, each planting only one species. A third method is to plant the whole area with one species at twice the required spacing within the rows, and then to plant the second species in the gaps. With bands of different species the work is easier, but stakes are usually necessary to indicate the width of the bands. With group mixtures, for example groups of one species in a matrix of another, it is best to mark the centre of each group with a stake, then to plant the groups around the stakes, and finally to plant the matrix species.

Planting on piecework can be a satisfactory system, but only provided there is good supervision. With this method, it is best to keep the planters concentrated in one area and to have a central trench from which the issue of plants can be easily controlled, and number of trees planted can be checked.

USE OF FERTILIZERS IN THE YEAR OF PLANTING

There are few *commonly* planted soils on which the use of fertilizers is necessary to establish a tree crop. However, on the poor, wet, peaty moorlands

characterised by Deer grass, and on the poorer dry heaths, a phosphatic fertilizer applied in the first season is *essential* for satisfactory growth. Ground mineral phosphate is the most commonly used form, but superphosphate and even triple superphosphate are becoming more widely used, and have advantages in that the higher concentration of the phosphorus reduces the weight of fertilizer to be carried. Phosphatic manures are applied as powders or granules round about the plant. It is desirable not to apply for a few weeks after planting, and to avoid placing the fertilizer too close to the young tree—it should be kept a few inches away. Dosages vary from 2 to 4 ozs. of the fertilizer, or very occasionally more, according to the form of the phosphatic manure used and the particular requirements of the site. Very rarely, potash may be required on establishing plantations, but other nutrients need not be considered at this stage.

Plantations on exceptionally poor sites may exhibit nutritional troubles at later stages in their growth, but these are special cases which call for expert diagnosis.

SPACING

For many years close planting of conifers at spacings of three to four feet was the common practice in Britain, but within the last twenty years, there has been a tendency to use increased distances. Nowadays, the slower-growing conifers such as the pines and Norway spruce are planted at 4½ to 5 feet, and for the faster-growing conifers a spacing of 5½ to 6 feet is used. Although 6 feet may be regarded as the widest normal spacing, with species like Douglas fir and Japanese and Hybrid larch, on the best sites, spacings of 7 feet are sometimes used. On ploughed land, the plough furrows are commonly spaced at the desired distance between the rows of plants.

Hardwoods, and particularly oak, differ from conifers in that they rarely show quick early upward growth unless set close together; consequently the traditional close spacings of 3 to 4 feet are still the normal.

Contrary to popular belief, height growth in conifers is not affected by spacing, except on very exposed or weedy sites where close spacing has been found beneficial. As a general rule it may be said that the poorer and more exposed the site, the closer the spacing should be.

Table 12 below shows suitable spacings for the common species and gives the maximum spacings which might still be expected to give a crop, on the best sites.

TABLE 12

SPACING DISTANCES FOR FOREST PLANTING

Species	Normal Spacing in feet	Maximum Spacing in feet	Number per acre
Scots pine	5	5	1,750
Corsican pine	5	6	1,210
European larch	5½	6	1,440
Japanese larch	5½	6	1,440
Hybrid larch	6	6	1,210
Douglas fir	5	6	1,210
Norway spruce	5	6	1,210
Sitka spruce	5	6	1,210
Western hemlock	5	6	1,210
Lodgepole pine	5	5	1,750
Grand fir	5	6	1,210
Other conifers	5	—	1,750
Oak	4	5	2,720
Beech	4	5	2,720
Ash	4	6	2,720
Sycamore	4	6	2,720
Poplar	20	30	48
Willow	30	40	48
Other hardwoods	4	5	2,720

BEATING UP

Beating up (or filling up) is the name given to the replacement of dead plants in a newly planted wood. The aim in all our planting should be, of course, to have no beating up to do, but inevitably there are some failures, due for example to drought or severe frost, in almost all plantings. Before we set out to replace the failures, we must be sure that the plantation if left alone does not contain sufficient trees to make a satisfactory crop. This means that it is rarely worth while to beat up a young wood which has less than 20 per cent of failed trees, unless these occur in groups. Certainly, single dead plants should not be replaced, and a good rule might be to put in one stout tree where three have failed together.

To be successful, beating up must be done the year after planting, and very rarely should it be done for more than one further year, as after two or three years the new plants have practically no chance of catching up with those of the first planting. Consequently, it is most important to do the job of beating up with great care and with the best quality plants, and these should be at least as large as the originals, A faster growing species can sometimes be used. Where beating up is unavoidably delayed, it is better to leave the plantation alone, unless we can be quite sure that the plants introduced will become a part of the crop. Finally, let us remember that it is

very easy and very costly to do too much beating up, but that which is necessary should be done promptly and with care.

WEEDING

Weeding consists of the cutting back of the vegetation which has grown up around a young plant, and which might smother it if not so cut down. The main danger comes in the autumn when the heavy, and usually wet, dying vegetation, which has overtopped the small plant, collapses. The principal weeds which cause damage in this way are rank grasses and bracken, as both these types of vegetation can form dense mats over the young trees. In the summer, these, and other similar forms of weed growth, do little damage, and on exposed sites may even be helpful by giving some shelter from sun and drying winds.

Weeding is usually carried out by a man working down a line of plants (one of the main advantages of having plants in carefully spaced lines is that they can be found so much more easily during weeding) and cutting the vegetation for a sufficient distance around the plant to ensure that it cannot be smothered. An ordinary hand sickle or reaping hook is the normal tool used, but in some parts of the country a long-handled type (a staff hook) is preferred by experienced men. Before beginning any cutting strokes, the man must find the plant, or else damage to the tender leader is almost inevitable. For this purpose it is best to carry a hooked stick, and if this is made the same length as the usual planting distance, it also serves as a measuring rod and makes it easier to find the next plant in the row. The tramping down of grassy vegetation around the plant is occasionally done instead of cutting.

Woody weeds like bramble and gorse are unpleasant and difficult to deal with, and it is very easy for them to get out of hand. A bill hook or a slasher is required as well as a sickle, and gloves are essential.

On most sites which have been ploughed, little if any weeding is usually required, and the elimination or reduction of the need for this laborious and costly operation is an important feature of ploughing.

The modern herbicides are beginning to find applications in the control of weeds in forest plantations. So far they have had most impact on forest operations in old woodland sites (the subject of the following chapter) and some of the more important considerations in the use of herbicides are mentioned there. The subject is however rather too large to deal with adequately in a general text. See Forestry Commission leaflet No. 51. *Chemical Control of Weeds in the Forest.*

DRAIN MAINTENANCE

We have already discussed the importance of having a well laid out system of drains, particularly in hill areas of high rainfall. In order to keep the system functioning, it must have regular maintenance. Blockages must be cleared and overflows stopped, and any patches which show up as particularly wet must be given extra attention. This is of the greatest importance, as there can be no doubt that practically all windblow, other than in a rare catastrophic storm, begins in the wet patches. Early attention to drainage may prevent the trouble. Cleaning of drains and the deepening of selected channels must be done occasionally; just before the crop forms thicket is a good time, and again immediately after each thinning to clear the drains of slash.

Chapter 11

TREATMENT OF FORMER WOODLAND

HERE we consider ground preparation and replanting on former woodland areas. These can present a wide variety of conditions and there is probably no aspect of forestry in which it is more essential to consider every move well in advance, and to seek the best local advice available before actually starting work; mistakes can prove very expensive.

A few general considerations come first. Since the ground has already carried at least one tree crop, we can rest assured that it is basically suitable for planting up again. We may of course wish to plant a more exacting or more profitable species, and before doing so we must satisfy ourselves that the site is good enough, or can be made so by adequate preparation. In particular we must make quite sure that drainage is satisfactory; the drainage system found in many old woodlands is quite essential to their well-being, but it tends to become obscured during the long period of growth to timber size, and to be further obliterated by felling and timber hauling operations; so before we replant we must restore it to full efficiency. Next, fencing must be just as good as on new afforestation areas, for rabbits can become just as troublesome in old woods as in open country; moreover, they are harder to detect and to get rid of in woodlands.

WOODS ALREADY CLEARED

The simplest case of former woodland suitable for replanting is found where the previous crop was cleared many years ago, the stumps have virtually rotted away, and no regrowth has occurred. Such sites are more common in Scotland and northern

England than they are in the south, where regrowth from cut-over stumps and natural seedlings is generally prevalent. On such clear ground, attention to drains and the restoration of the fences is all that is required. But, where a sufficiently large area is available and equipment is at hand, it may prove worth-while to use the plough; experiments have shown that tine ploughing often results in the quicker and more certain establishment of the young trees.

Where any substantial area of coniferous, or mainly coniferous, woodland has been clear felled, the risk of young conifers being seriously attacked by the pine weevil, *Hylobius abietis*, soon after replanting, must be borne in mind. This subject is further discussed in Chapter 15, page 67. Where there is evidence of serious infestation, replanting may have to be delayed for two, or perhaps even four, years after felling, unless insecticidal protection is applied to the young trees. Otherwise the replanting of former conifer woods is usually a straightforward business.

WOODS INVADED BY COPPICE, SCRUB OR YOUNG SEEDLING TREES

The situation in former broadleaved woodlands can be much more complicated, for unless replanting is put in hand in the season after the felling, the ground is apt, particularly in the south, to become covered by a tangled regrowth of coppice shoots from the old stumps, and by natural seedlings or sucker shoots of birch and other intrusive species, together with brambles, bracken, and a rich variety of herbaceous weeds. If the lop-and-top of the old crop has been left to encumber the ground, and if the drains have been blocked and the rides torn up by timber hauliers, then at first sight the ground may appear hopelessly expensive to clear and replant. Careful forethought, however, will usually reveal some way to mend matters at reasonable cost. The modern herbicides can be extremely useful to the forester in controlling weed growth of one sort or another, especially on old woodland sites. A short note on the best ways to use chemicals on old woodlands is given later in this chapter. They are best considered as *aids* to silviculture—not as *alternatives* to it, and we can consider the methods of replanting old woodland sites before indicating in what ways herbicides can help us in achieving our objectives.

First of all we must assess the regrowth which is on the ground:—the species which are represented; their prospects on the particular site; and their stage of growth. Unless the previous woodland has been managed to that end, it will be rare to find sufficient regeneration of useful species to make a full and satisfactory crop. There may however be some useful material, and even if there is nothing which we wish to retain in the crop, the regrowth may serve a useful purpose as a temporary cover to the species which we wish to establish. The stage of growth is perhaps the most important point here, since very young thickets of regrowth are difficult to handle by any other method than complete clearance.

However, assuming that regrowth has reached a stage where it is possible to get about underneath it, we have the important decision to make whether or not to keep some of the material as cover to the new crop. Cover is of special value (i) on frosty sites, (ii) on heavy soils where its removal results in waterlogging of the surface soils, and (iii) on all sites where exposure is an important factor. Under all these conditions it should *always* be retained if it is suitable. Where these considerations do not apply to any important degree, as on well drained soils on sites with no special frost hazard or exposure factor, there may still be advantages in retaining cover, but that will depend largely on the species which is being planted. One would not retain it for larch or Scots pine for instance, and on favourable sites it is not essential for Douglas fir.

Complete Clearance and Replanting

Let us consider this, the simplest solution, first. One advantage is that we can probably keep the net cost low, since in most districts there will be some sale—albeit at low prices—for firewood, poles, and small posts, etc., that can be obtained from the cleared scrub; contractors or purchasers will be the more ready to take these if we can make them all available at one time.

Disadvantages are that much labour will be needed at one time, and that by opening up the whole of the ground to sun and light, we invite a vigorous regrowth of coppice shoots and weeds of all kinds, resulting in high weeding costs, and many species will suffer setbacks from late spring frosts. Herbicides, however, will certainly help in the weeding problem. Also the survival of plants in the first season is apt to be poor. This is largely a matter of drought accentuated by the vigorous weedgrowth on old woodland sites, but again the species used has a great deal to do with it, as also has the type of plant. It is a great mistake to use very small plants on cleared old woodland sites, but equally important that larger plants should be well balanced transplants, and not merely large stocks which have stood several years in the lines. A few types of scrub, however, are of such a character that clear cutting prior to replanting is the only reasonable course; rhododendron, dense briar and thorn are examples. Almost every other

type of weed regrowth can be dealt with as described below, with considerably reduced costs in establishment of the new crop.

Where the scrub has had to be completely cleared, the species used for replanting should be those that start growth quickly and soon suppress weeds and coppice shoots; Japanese larch and Douglas fir are particularly useful, but on rhododendron areas only a quick-growing species which casts intense shade will succeed in keeping the regrowth in check. Western hemlock appears to show most promise for this purpose.

A good deal of experimental work has been done on mechanical methods of scrub clearance, using such implements as bulldozers and rotary cultivators. Locally, machine clearance has been successful and relatively cheap, but the capital cost of power-driven equipment is high, and unless there is a fairly large area, say thirty acres or more, to be tackled at one time, it will seldom pay to assemble the necessary plant and organize its skilled operation.

Retention of Natural Seedlings, Coppice Shoots, etc., for the Future Crop

Should we decide to retain some of the existing trees for our future crop, we must satisfy ourselves that they are of a kind, an age and a character that will yield worth-while and profitable timber. Here local experience, aided perhaps by an examination of tree stumps of the same species on the same ground, will prove a helpful guide. It is seldom satisfactory to keep small groups or single specimens, but where reasonably large groups, of one-tenth of an acre or over, are found, they may be worth demarcating and preserving, even though the intervening spaces require clearing and planting up. There is often a temptation to hold on to large solitary broadleaved trees, to preserve the woodland aspect of the scene, in the hope that they will eventually develop into valuable big-boled timber by the end of the first rotation of the new crop planted around them. This step is rarely justified by results; all too often the over-age specimens form a gap in the canopy—and a loss in value of the new crop—out of all proportion to their individual worth. Far better to cut them out at once for what they will fetch—once down they will seldom be missed.

Young stems need not necessarily be rejected because they are of coppice origin. Provided they are vigorous and reasonably straight, they may form useful components of the new stand. But it is essential to reduce the number of shoots from each coppice stool to one; or exceptionally to two or three, as a temporary measure until the best of a clump can be chosen.

Retention of Existing Growth for Temporary Cover

Should we decide that the existing growth of natural seedlings or coppice shoots does not merit attention to form part of the new crop, the alternative to its complete immediate clearance is its retention, after suitable thinning, as temporary overhead cover for our new crop. The advantages that result from this method of establishment of the new crop are these:

(a) Weeding is very much reduced, the planting being on a clean forest floor, and the continuing shade suppressing most common weeds and coppice shoots.

(b) Seedlings or small transplants can be planted in such conditions with resulting economy.

(c) Establishment is generally easier, as the overhead shade protects the young trees from extremes of heat and cold, and from drying winds. Losses from frost and drought are generally much less than in the open.

(d) Beating-up is therefore eliminated, or reduced to a very small percentage.

(e) Planting can be carried on well into the spring in such conditions, as the plants are not exposed to full sun and drying winds.

The most suitable type of cover is a dense pole crop, fifteen to twenty feet high; birch, with its light crown, is the best species. But many other species can be used—ash, oak, hazel, hornbeam, or chestnut coppice, or mixed coppice, scrub and regrowth. If the cover consists of a thicket of some fast-growing species such as birch, it may be worth-while waiting for a few seasons until it has reached the desired height; but if this is not possible, lower cover can be accepted—the principle being that any suitable cover is better than none. Trees of timber size are, however, not suitable to use as cover.

When thinning out the cover prior to planting, the aim is to let in enough light to create a dappled shade on the forest floor in summer—admission of about 30 per cent light, or roughly the equivalent effect of a light first thinning in a Scots pine plantation. The trees removed in this initial thinning of the cover should be the low-branched and heavy-branched types which may do mechanical damage to the young trees later if allowed to remain and grow, leaving the thin-stemmed, high-crowned tree to provide the shade. All trees left should be brushed-up to about five feet.

In following this method we are making use of the principle that most forest trees are tolerant, in their younger stages, of some degree of shade, even though, once established, some must be classified as light demanders. Strong shade-bearers

such as beech, Western hemlock, Western red cedar, and Silver firs, tolerate a dense shade for several years after planting. Douglas fir, Norway spruce, sycamore, oak, and Norway maple, will stand dense shade for two or three seasons after planting, but then require more light. Once trees are established, overhead cover is only of benefit in reducing frost damage, and to a less extent perhaps in keeping down grass and herbaceous weed growth. The cover is itself competing with the young plants for moisture, and however much shade a particular kind of tree will stand, none actually benefits from a reduction of light. Hence the rate of removal of cover is a compromise. Too quick: risk of frost and increased weeding cost. Too slow: reduction of growth of the plants and higher costs later when the cover is removed.

It is difficult to give a rule of thumb guide that will apply to all circumstances. Cover has frequently been removed in two stages, about half after two growing seasons and the remainder after the fourth growing season. With the most shade-tolerant species such as beech, Western hemlock, Lawson cypress and Grand fir, it can be kept on longer than this without harm, but it is doubtful whether its retention for more than six years is ever justified.

In thinning the cover, the larger trees should be removed in thinning, leaving the more slender and lighter-crowned ones to maintain the shade. This minimises the danger, which is in fact more imagined than real, of the overhead cover damaging the young crop below it when felled. Provided reasonable care and skill are exercised, surprisingly little harm results to the young crop.

In lightening the cover, it is possible to kill the cover trees 'on their feet' either by ring barking or by the use of herbicides (see below, Use of Herbicides, basal bark spraying). There are two main arguments for doing this, firstly the material may be unsaleable, and not worth the cost of removal, and secondly the gradual lightening of the cover is better than its sudden removal. Even dead trees provide some frost protection. Against it however is the extreme ugliness of skeleton trees, which may take years to fall to pieces. The practice of ring barking (or basal bark spraying to the same end) must be confined to sites which are not in the view of the public, and firmly eschewed on hillsides in full view of roads.

Existing growth maintained for temporary cover may yield some useful produce, but it is doubtful whether this can often be harvested except at a cash loss. It is, of course, possible that good young stems retained rather longer than necessary for the sake of the new crop below, may become more readily saleable. Some may even be left for the whole or a considerable proportion of the life of the new crop. No rule can be given, but if this is to be profitable, the gains from these retained stems (which will probably be increasingly difficult to harvest without damage) must outweigh the harm they will do in reducing the growth of the young crop. It is worth observing that trees singled out from originally dense stands, however promising they appear, often develop disappointingly on isolation.

Two distinct advantages of this general method are the amenity and sporting aspects. A tree canopy is retained while the new crop is in the very young stage, which not only enhances the appearance of a wood as compared with complete clearance, but retains cover and shelter and roosting places for pheasants until the new crop has formed thicket.

Group and Strip Methods

As an alternative to the retention of cover uniformly over the whole area, it is possible to clear strips of varying widths, or groups of varying sizes, within the crop, and to plant up these. The general experience of working such methods has been, however, that they are very much easier to think out in theory than they are to apply in practice. The growth of the cover crop on the edges of the strip or group is commonly so vigorous that the young trees beside it stand in continual danger of being smothered. The group method calls for continuous close supervision of workmen, while both methods have the disadvantage that the planting must be done in two stages—first on the cleared sections, later on the sections previously left as cover.

The object of such methods is to reduce the cost of initial clearance or uniform thinning of the cover, whilst retaining some of the advantages of shelter. These partial cutting methods are usually designed to ensure that there is a full stocking at maturity, but intermediate yields are sacrificed in the interests of initial economy in preparation. As intermediate yields from thinnings are usually necessary to obtain a profit from a plantation, such partial cutting methods are dubious propositions, economically speaking, from the outset. Even where there is a sound argument for reducing initial costs, irrespective of the ultimate profitability of the plantations, for example where it is desired to rehabilitate as much ground as possible with a small labour outlay, it is only in rather special cases that groups and strips *have* proved to be cheap methods of establishing a crop.

In practice such methods have succeeded in what may be described as 'elderly shrubs', for instance old hazel, rhododendron or laurel scrub, which has completed its potentiality for height growth. The usual trouble with groups and strips is the regrowth

from the edges, particularly of vigorous tree-forming species such as ash, sycamore, field maple, etc. However, where these are absent and the growth is more or less static, there is much less trouble in maintenance. An owner who is able to give continual personal supervision to these treatments can often secure good results; but in other circumstances they show no advantages over continuous uniform cover.

NATURAL REGENERATION

This term is best applied only to a deliberate process of restocking a wood by means of natural seedlings. Deliberate natural regeneration has been practised in Britain on only a small scale and with a few species, such as Scots pine, oak and beech, although the regeneration of practically all species, both native and introduced, has taken place by chance in many places. Failure to make use of the method may be attributed to many causes, including our failure in the past to control rabbits and other vermin, and to our climate which does not favour regular and abundant seed years. Setting out deliberately to restock a wood by natural regeneration has proved very difficult and uncertain, and it is unlikely that the method will oust the much surer and quicker method of planting. There is the case, however, of a scrub wood with a good sprinkling of seedlings through it, or of scattered groups of regeneration arising from mother trees on an adjacent area. Usually it will be worth-while to keep these seedlings, especially if they are in groups.

In general, we might say that natural regeneration should not be specifically hoped for and certainly not waited for. But if it appears we should foster it and use it to supplement our planting, always provided that the species concerned is well suited to the site.

THE USE OF HERBICIDES

The modern herbicides are a boon to the farmer, and they are now quickly finding themselves applications in the forest. The subject is rather too large to be treated in detail in a general text such as this. See Forestry Commission Leaflet 51, *Chemical Control of Weeds in the Forest.*

Most of the substances which are of use to the forester belong to the broad class of growth-regulating chemicals, often referred to as 'hormone' or 'auxin type' weed killers. The most familiar application of this class of substance is, of course, the selective weedkiller which removes the daisies and other broadleaved weeds from the lawn and leaves the grass. In fact this good example of selectivity is more applicable to the garden and the farm than the forest, since we are not yet in the position of being able to select between the trees we want to grow, and all the other vegetation. However, we are not so very far from this position, though whether it can be reached economically in forests, or whether indeed we *want* to reach it, are both matters which remain uncertain.

The two chief substances in use in forestry are the compounds and formulations of the phenoxyacetic acids 2,4-D and 2,4,5-T. Neither of these are poisons in the strict sense, i.e. they are not scheduled under the Agriculture (Poisonous substances) Regulations. They operate by disrupting the plant's metabolism. There are three main uses of these materials which are now fairly well established in practice.

(*i*) *Killing stumps.* Here the object is to kill stools resulting from the clearance of unwanted woody growth and coppice in preparation for replanting. Very considerable savings can be made especially where the stools are of vigorously coppicing species such as Sweet chestnut. The substance used is usually an ester of 2,4,5-T applied in an oil carrier. Not all species are susceptible to 2,4,5-T. Those that are not, including rhododendron, laurel, privet and hawthorn, can be killed by ammonium sulphamate. This is not a growth-regulating substance, but a soluble chemical which, though very toxic to plants, has no other harmful properties.

(*ii*) *Killing standing trees.* 2,4,5-T in oil is also used in this way. It is sprayed over the bark of smallish trees from about twelve inches up the stems to ground level. Larger trees are often given a rough 'frill' girdle before applying the herbicide. The method is preferable to the older practice of ring barking as the outgrowth of coppice shoots is frequently stopped also. It has, of course, the same disadvantage of leaving ugly skeleton trees, which are sure to fall later on, standing about the area.

(*iii*) *Foliar sprays.* Low regrowth of many woody and herbaceous weed species (other than grasses) can be controlled using 2,4,5-T (sometimes with 2, 4-D in mixture). This may be profitable where the site to be planted is *extremely* weedy, when it is carried out prior to planting. It is however also possible to use foliar sprays selectively on sites which have already been planted, since many conifers are not highly sensitive to growth-regulating herbicides when they have hardened off their buds. As the woody and herbaceous vegetation may still be very active after this, we have a condition in

which the 'weeds' are in a more susceptible condition than the 'crop'. Useful applications of this method have been found with pines in dense gorse and with pines and other conifers languishing in heather.

Other applications of herbicides are being found. Grasses can be killed selectively with the herbicide *dalapon*, and this may prove to be of value on sites where dense grass competition is the main weed problem.

Here only a brief outline of the subject has been given. While so far as is known the herbicides at present in use in forestry give little cause for anxiety as regards harmful side effects, and while they are not themselves especially dangerous substances to handle, this is no field for amateur experimentation. They should be used strictly in accordance with the advice given in official publications and with careful attention to the makers' instructions.

In addition to the Forestry Commission Leaflet about these specific uses of herbicides, much valuable information on the use of herbicides is to be found in the 'Weed Control Handbook' issued by the British Weed Control Council (Blackwell, Oxford). The leaflet entitled 'The Safe Use of Poisonous Chemicals on the Farm' issued by the Ministry of Agriculture, Fisheries and Food; Whitehall Place, London, S.W.1, should certainly be read by all concerned with chemical control.

Chapter 12
TREATMENT OF COPPICE

COPPICE is woodland regenerated by shoots arising from dormant and adventitious buds at or near ground level after felling. Most broadleaved trees will coppice under suitable conditions. The vigour of coppicing depends on the species, on the age of the stem when cut (the younger the better), and also on the fertility of the site. Several species in Britain have been managed as coppice by long established tradition, the most important having been hazel, sweet chestnut, oak and hornbeam. The poles and small roundwood produced by coppice have had an important place in the economy, but during the last half century or so, there has been a considerable drop in the demands for products of coppice woodlands, so that now there is a legacy of such woods which can no longer be managed at a profit.

Coppice woodland may be divided into *simple coppice*, which is managed entirely for the production of coppice shoots, and *coppice-with-standards*, where timber is also grown on trees widely dispersed over the coppice, and harvested on a much longer rotation. Coppice-with-standards was a highly evolved and silviculturally sound system in certain districts of England, but its breakdown under current economic conditions has contributed to the considerable area of uneconomic broadleaved forest in the country, now requiring attention.

Chestnut Coppice

Sweet or Spanish chestnut, *Castanea sativa*, is grown principally in the south east and south of England where it thrives as coppice on a wide range of soils but especially on loamy or sandy soils with a slightly acid reaction; it does not do well on chalk soils, and tends to be short-lived on heavy clays. It has been estimated that about 30,000 acres of chestnut coppice, regularly managed, are needed to maintain the British cleft chestnut paling industry at its present size, quite apart from the considerable areas cut by estates for their own use. The total acreage of this species in Britain is about 49,000 acres so that there does not seem to be any large discrepancy between the supply and demand for this type of produce.

When planting new areas of coppice, well grown transplants, aged one-plus-two years should be planted at seven to eight foot spacing; these may be cut back as soon as they are established (say, two years after planting) and allowed to make coppice shoots. The coppice arising from this and subsequent cuts is not usually touched or thinned in any way but is allowed to grow without being tended until the majority of the poles are sixteen to eighteen feet long, measured to a two-inch to six-inch top, the specifications depending upon the uses to which the poles are to be put. The time taken to grow a satisfactory pole is generally between twelve and seventeen years, depending on the size required and the vigour of the crop, and during this period, the production of usable material down to a top diameter of 2½ inches over bark is about two tons (green weight), equivalent to about 60 hoppus feet, per acre per annum on an average site.

Coppice areas should be clear cut during the dormant season, all lop and top burned, and the poles carried off the site before the new coppice shoots appear, otherwise damage may be done to the young stems. Where coppice is grown for sale, it is usual to demarcate parcels which may vary in size from less than one acre to several acres; these are normally sold standing by public auction. Apart from the quality of the coppice, the price will depend to a considerable extent on the ease of access and nearness to a hard ride or road.

The principal uses today for chestnut coppice are for hop-poles and cleft fencing. For the former purpose the poles are peeled and may be used at once, while for fencing they are roughly peeled, cross cut to length, cleft and put into bundles which are tied tightly with wires to prevent warping and to straighten individual pales. These bundles should be set aside and allowed to season before being used. The proportion of naturally durable heartwood is very high, but thrifty users, particularly in Kent, creosote the poles and pales to give the sapwood an equal length of life.

Hazel Coppice

Stems of hazel, *Corylus avellana*, coppice have provided an important source of raw materials for a variety of rural purposes since the early days of civilisation, for when about seven to ten years old they are of a length, diameter, and suppleness to be worked conveniently by hand in conjunction with simple tools. Thus over a long period of time hazel coppice was much in demand and a large acreage in Britain was devoted to this crop. However, during the last half century the changing pattern of country and farming practices has led to a sharp fall in the demand for hazel so that a high proportion of hazel coppice woodlands are no longer cut regularly. Once hazel has been allowed to grow for twenty years or more the stems become too thick and brittle for traditional usage and woods made up largely of such material must be classified as derelict or scrub areas. A review conducted between 1951 and 1953 by the Rural Industries Bureau (the findings of which were published in the Forestry Commission's Bulletin No. 27) indicated that of 167,000 acres in Britain carrying hazel coppice of one form or another, only some 12,000 were being regularly worked. Since then the acreage under management has declined still further. Where the tradition of hazel coppice working remains alive, and this depends very largely on the existence of the skilled labour accustomed to the work, it is to be hoped that this elegant system will continue. But there seems no likelihood that hazel coppice will ever regain importance. At present, most hazel coppice presents a problem of conversion to high forest.

The management and utilization of hazel coppice are fully described in Forestry Commission Bulletin No. 27, 'Utilisation of Hazel Coppice' (H.M.S.O. 10s. 0d.)

Oak Coppice

Oak was managed as coppice for centuries in Britain, and today oak coppice is seen principally on the western seaboard from Cornwall to the north of Scotland, and less commonly in other parts of the country. The traditional products of these woodlands were bark for tanning, charcoal wood, mining timber, and fuel. Where production was chiefly for bark, the rotation was normally fifteen to twenty-five years, after which time the bark becomes corky and less valuable, but where the chief demand was for wood, rotations were commonly forty to fifty years, giving a total yield of about forty-five tons per acre from a site of average fertility equivalent to only 30 hoppus feet per acre per annum.

Current market conditions do not favour this type of silviculture, and today it is rare to find an oak coppice that is still managed for profit. In some districts there is still a small demand for oak bark, but any sale of the timber is very dependent upon local circumstances and the returns are small compared with those which would be expected from a high forest crop of some different species growing on the same site. For these reasons oak coppices are generally considered to be something of a financial liability, best treated by conversion to a more profitable high forest, usually of a coniferous species.

Other Species of Coppice

Locally small areas of coppice of other species may be found, which are still capable of being profitably worked. Examples are ash, sycamore, birch, and alder for the wood-turning industry, birch for crate-headings, and alder for clog soles. Where such an outlet exists, and is likely to continue, it may be worth while to retain the coppice crop; but in other circumstances its conversion to high forest, of these or some other species, is often the only sensible course.

COPPICE FOR PAPER PULP AND FIBREBOARD

Much the most important recent development in markets for small hardwood round material is the establishment in the south of England of factories partly or wholly dependent on supplies of such wood. This has already had a beneficial effect on the economics of conversion of coppices and poor broadleaved woodland to high forest, but it is more difficult to say whether the *management* of coppice for this market will prove attractive. It is however an outlet to be considered when thinking about the future management of vigorous, well-stocked coppice, pure or mixed, of species such as sycamore, ash, lime, alder, birch, etc. Haulage distance is plainly an important point, the nearer to a factory the better of course, but beyond fifty miles the haulage costs become rather serious and may be prohibitive unless return loads are available. The attraction of managing coppice for pulp is the low investment, but owing to the low volume

yields the profits are also likely to be low. This form of management is not likely to stand high protection or fencing costs, for instance. Hardwood pulpwood requires to be pretty straight, and there can be serious losses in conversion from poorly grown and crooked poles.

CONVERSION OF COPPICE TO HIGH FOREST

Many old coppices occupy valuable forest land, and if it has been decided to convert them to high forest there are several methods which can be adopted. A traditional system, applicable to coppices of tree-forming species only (e.g. not hazel), is to 'store' the better poles by thinning out the stools gradually, thus leaving a proportion of stems to grow on to timber dimensions. This has often been combined with the fostering of natural regeneration of desirable species. The method is extremely slow and is probably wasteful of good ground, but it may have a place where for one reason or another it is desirable to make the conversion with the least disturbance.

Most coppice conversion requires replanting, and is carried out according to the methods described in the previous chapter, for coppice only presents the forester with a special case of regrowth of unwanted woody species on the ground. As mentioned in Chapter 11, the primary choice is between clearance and the maintenance of cover, and the latter is generally considered the sounder course.

Chapter 13

THINNING

TREES in plantations are planted close together, generally somewhere between five and six feet apart giving 1,750 down to 1,210 trees per acre. The reasons for planting so many trees are to suppress the ground vegetation, to provide mutual shelter, to encourage straight growth and, after allowing for casual losses, to leave the forester a large choice from which to select his final crop trees. The number of trees is successively reduced by a series of thinnings throughout the life of the crop, so that the growth of the stand is concentrated progressively into a smaller number of more vigorous and better formed trees. Quite a large proportion of the total production—something like 50%—60% by volume or 80%—90% by number of trees—can be removed as thinnings during the life of the crop without reducing total volume production. The ultimate object of thinning is to obtain the largest possible financial return from the crop, but the financial result of one particular thinning cannot be judged in isolation. A thinning may yield very little profit immediately, although its effect on the ultimate profitability of the crop may be quite considerable. In general, however, one would hesitate to do any thinning which yielded a net loss on the operation.

As a general rule the most profitable way to thin a crop is to remove as much volume as possible in the form of thinnings without reducing the total volume production. If at any stage a greater volume than this is removed, the productive capacity of the crop, taking thinnings and final crop together, will be reduced; the volume standing on the ground at any one time will be smaller, although the average size of the standing trees will be larger.

If a smaller volume is removed the volume standing at any one time will be greater and the average size of the tree will be less, but the productive capacity will be unchanged.

Thinning has little or no effect upon the height growth of coniferous trees.

Wind stability depends primarily upon rooting depth but is also influenced considerably by thinning. On any given site, the most windfirm stands are those which are not thinned at all, *or* those which are thinned frequently and fairly intensively from an early age. A stand is predisposed to windblow *immediately* after a thinning, especially if it has not been thinned for a long time and the thinning is a heavy one, but later on this risk decreases.

Definitions

Several terms commonly used when discussing thinning are defined below:

Intensity (High, low)—the periodic annual thinning yield, or the volume removed in a particular thinning, divided by the intended cycle. Intensity may be thought of as the proportion of the increment removed in the form of thinnings over a period of one or more thinning cycles.

Marginal Intensity—the highest intensity which can be sustained without diminishing total production.

Weight (Heavy, light)—The total volume removed in any one thinning operation.

Cycle (Long, short)—the number of years between successive thinning operations.

Type—The type of thinning determines stand structure. One type of thinning may tend to remove the larger trees in a crop while another may tend to remove the same volume in the

form of smaller trees. The spatial relationship of larger and smaller trees is also determined by the type of thinning.

The term '*Regime*' is used to describe a particular combination of the factors mentioned above over a period of time and usually assuming, in addition, a particular initial spacing, and age *or* height, at the time of first thinning.

GENERAL CONSIDERATIONS

Thinning Intensity

The aspect of thinning which has the greatest influence on profitability is intensity. For practical purposes, removal of 300 hoppus feet every three years represents the same intensity as the removal of 500 hoppus feet every five years. Guidance on thinning intensity is given for each species in the Forestry Commission Management Tables, (in preparation for publication) which are based upon an intensity slightly lower than the marginal thinning intensity. A stand is not being overthinned provided the marginal intensity is not being exceeded. As a very rough guide, a stand has recovered from its previous thinning, and is ready for another thinning, if the crowns of the trees have largely filled up the spaces previously made in the canopy.

Species like Norway spruce, Douglas fir, Sitka spruce and the Silver firs which are regarded to a greater or lesser extent as shade-bearers, require less growing space, show a greater total volume production, and have a denser foliage than the more light-demanding species like the larches and the pines. For this reason a shade-bearing crop thinned to a marginal intensity will look denser and more heavily stocked than a light-demanding crop also thinned to a marginal intensity.

Thinning Cycle

Thinning cycle is important in so far as a given *intensity* will result in a *light thinning* if the cycle is short, but a *heavy thinning* if the cycle is long. Long thinning cycles tend to be associated with better average prices because timber merchants find it more economic to handle relatively large volumes of timber, whereas short thinning cycles reduce the risk of windblow. The usual range of thinning cycles is from three years for young fast growing crops, to ten or twelve years for older, slower growing crops. The first thinning is usually made when the height of the crop is about thirty feet. If, however, windblow is a severe risk it may be desirable to thin the crop somewhat sooner.

Type of Thinning

Type of thinning is important in so far as careful attention to spacing, quality, and the productive potential of particular trees is concerned; but there is little evidence of important long-term differences in profitability between the various types of thinning consistently applied throughout the rotation. The aim should be to give progressive freedom from competition to the more vigorous, well-formed, healthy trees, and to remove badly-formed trees, especially if they are interfering with a potentially good tree. In particular, one should remove very coarse spreading trees, leaning trees (which produce compression or tension wood), forked trees, trees with spiral bark (this often indicates spiral grain in the stem wood), and trees with thin, unhealthy-looking crowns. Very suppressed, or small, dead and dying trees, are usually best ignored, unless they can be sold, because they have little effect upon their neighbours and do not justify the cost of cutting them. It is sometimes helpful to mark a number of well-spaced potential final crop trees early in the life of the crop—generally between 50 and 100 per acre. This ensures a good distribution of the final crop trees and helps the forester to decide which trees to remove.

THE THINNING OF MIXTURES

It is impossible to give very precise guidance on the thinning of mixtures because there is an infinite number of possible combinations of species in different proportions and arrangements, e.g. by single, double or treble rows. The relative rates of growth of different species vary at different periods during their life and on different sites. It frequently happens that one constituent of a mixture which appears to be more promising at a certain point in time is favoured in a thinning at the expense of the other constituent. At the time of a subsequent thinning, the situation may be reversed. Therefore, it is important not to plant mixtures haphazardly but rather to have a clear idea of the intended role of each species from the beginning. If a conifer is planted in mixture with a hardwood, in order to act as a nurse or to provide profitable early thinnings, the hardwood may have to be protected from the early vigour of the conifer. The same situation may arise where a non-exacting nurse such as Lodgepole pine is planted in mixture with a more exacting but more valuable species such as Sitka spruce. It is important to have a clear objective, but to be prepared to change that objective if it becomes apparent that the various species are not responding, as intended, to the thinning treatment.

A few general notes on particular mixtures are given below:

Scots pine and European larch

These species consort well together, though there is a tendency for the larch to outgrow the pine, especially if the crop is underthinned. The general rule should be to encourage the best-formed trees of either species.

Scots pine and Norway spruce

The development of this mixture depends on locality conditions. On light soils in East Anglia the pine usually goes so far ahead that it suppresses the spruce, and even heavy thinnings are unlikely to save that species. But on heavier soils in the north and west of Britain the spruce tends to outgrow the pine, though the latter may take the lead in the early stages.

Douglas fir and European larch

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

Japanese larch with Douglas fir or Sitka spruce

Here again the mixture may tend to become a pure crop of either species, and an early decision must be made as to what is wanted. By timely action the forester may swing the mixture either way, provided he keeps his objective before him all the time. As a rule, it will be more profitable to eliminate the larch.

Oak and Conifers

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

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

Ash and Conifers

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

Ash and other Hardwoods

Natural ash seedlings often spring up in mixture with other hardwoods. Provided such groups are carefully tended, favouring the ash wherever possible, useful mixed crops containing clean, well-developed ash can result, but only on fertile and well drained soils.

Mixed plantations where thinning has been delayed

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

RISK OF DISEASE

There are several tree diseases associated with thinning operations. The most important is the root and stem fungus—*Fomes annosus*. The spores of this fungus invade the cut stumps of felled trees and spread to adjoining, living trees, causing rot in some species and death in others. The cut stumps of all conifer species on soils which are not markedly acid should be painted with creosote within a few minutes of felling. More information is available in Forestry Commission Leaflet No. 5, *Fomes annosus*. *Rhizina undulata* is another root fungus which is of much less general importance than *Fomes annosus* but which may be locally serious, particularly on Sitka spruce. This fungus spreads from the site of fires. Therefore any fires for cooking meals should be made on hard rides, not in the plantations. More information is available in Forest Record No. 46, entitled 'Group Dying of Conifers' (H.M.S.O., 3s. 0d.)

Finally there are two species of Bark beetle which may breed in the bark of felled trees and build up a sufficiently large population to endanger the living trees. These are *Blastophagus* (formerly known as *Myelophilus*) *piniperda* on pines and, in East Scotland only, *Ips cembrae* on larches. Therefore all pines, and in East Scotland all larches, felled between March and October should be debarked within six weeks of being felled. Further information on the bark beetles is given in Chapter 15 of this Bulletin, page 67.

WINDBLOW

Windblow is likely to be a serious risk especially for spruces, Douglas fir and the larches, on 'shallow-rooting' clay soils and for most species on shallow peat soils particularly on high, exposed ground. The most serious risk occurs after thinning and when

the ground is waterlogged. Good drainage reduces the likelihood of waterlogging and also tends to encourage deeper rooting. Light thinnings are less likely to be followed by windblow than are heavy thinnings. Therefore where windblow is a serious risk it is advisable to achieve the desired thinning intensity by thinning lightly every few years, rather than by thinning more heavily at longer intervals of time. Thinning should also start early in the life of the crop when the trees are about twenty to twenty-five feet high. The risk of windblow is greatly increased when thinning is started after a long period of delay.

DRAINAGE

Felling operations are likely to damage drains, which may become filled with lop and top, or crumbled and partially blocked when the timber is being extracted by horse, tractor or winch. Therefore drains should, as a matter of course, be inspected and where necessary cleaned after each thinning.

SEASON OF THINNING

Thinning can be done at any time of the year, although it may have to be fitted in with seasonal forestry operations like planting and weeding. It is often a good idea to thin Norway spruce crops in November or December so that the tops may be sold as Christmas trees.

PREPARATORY MEASURES

Inspection Racks

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

Brashing

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

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

It is important in brashing that the branches should be cut cleanly and close to the stem. The best all-round tool, especially with inexpert labour, is a *sharp*, curved pruning saw with 5-6 points per inch and with a 2 ft. fawn-foot handle cut down from an axe shaft. The use of bill-hooks is not recommended, as in practice it is difficult to avoid damage to the bark and the cambium layers beneath it and to leave clean flush cuts. Brashing should not normally be taken more than six feet up the stem, nor should more than 1,000 trees per acre be brashed.

Cleaning

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

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

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

(c) 'Wolf trees'—these are vigorous but deformed trees of the planted species which are likely to interfere with the growth of better trees. A very vigorous tree which may appear to have a somewhat coarse branching habit should not necessarily be regarded as a wolf tree at this stage.

FIELD PROCEDURES

Methods of Marking

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

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

Marking may be done with paint, with a timber scribe, or by cutting a 'blaze' on one side of the tree with a slasher. The last-named method is quickest and gives an easily-seen mark, but it is only suitable for indicating those trees that have to come out. If it is decided to mark the trees that are *to be retained,*

paint should be used. White paints with a titanium base are found to last the longest; lead or zinc paints are apt to blacken in course of time.

Measurement

There are several methods of estimating the volume produced in a thinning operation. If there are very few trees, each of considerable value, it may be advisable for the buyer and seller to measure each tree together after it has been felled.

Normally it will be very much more economical to employ a sampling method either to select sample trees before the thinnings are felled, or to select samples after felling or conversion. Sampling after felling will normally be practicable only when the seller is also converting the produce, but it may occasionally be practicable under other conditions.

Sampling before the thinnings have been felled has several advantages, especially when dealing with conifers which can be felled easily by one man, since the samples can then be selected, felled and measured at the time of marking the thinnings. This avoids re-visiting the area and also produces a volume estimate which can be used for both advertisement and as a basis for price negotiation.

There are several methods of sampling: by means of sample plots, either circular or rectangular, by means of sample rows (in plantations), or by measuring one tree every 'so-many' trees. The last method is the most efficient as it ensures a good spread of sample trees throughout the area being thinned, and because every thinning has to be visited anyway at the marking stage.

There are many methods for obtaining the total volume of all the thinnings from the volume of the sample trees, but again one method is much more efficient than the rest, assuming that a reliable volume estimate is required either for selling the timber or for paying for the felling. This is the 'Tariff' method which is described in full in Forest Record 31 *Tariff Tables.* (H.M.S.O., 2s. 6d.)

The Tariff method of sampling and calculating the volume of standing thinnings in evenaged stands is adequate for most situations. Measurement of every tree after felling need only be contemplated when the timber is especially valuable and where agreed measure is desirable for the assessment of defects which have a great effect on the price. In the case of large trees, the reliability of the Tariff method can be increased by measuring the 'volume sample' trees in sections, or in produce categories, and by increasing the minimum number of volume sample trees somewhat.

FELLING AND EXTRACTION OF THINNED MATERIAL

Before undertaking a thinning it be essential that the point of sale and degree of conversion be known, so that the operations can be planned as a whole. The merits of sale 'standing', 'at stump', 'at roadside' or 'delivered to purchaser', and also of sale in the length or in various specifications, will have been considered. It is assumed in this section that the sale is at roadside and that a broad specification has been decided upon, i.e. timber, poles or standard lengths of pulpwood. Further conversions, if undertaken, to pitwood, or to fencing and rustic work specifications, are usually separate specialist jobs depending on skilled workers and detailed knowledge of markets.

Extraction is the key to any thinning operation, and consideration of the means of access to the wood should precede marking. The aim should always be to get wheeled transport as near to stump as possible. If either lorries or wheeled tractors can move in the wood, then it may be possible to load them without an intervening haulage operation. This means that primary conversion to the major specifications should take place 'at stump', so that the products can be separated at an early stage.

After this general consideration, the details of the stages may be taken in sequence.

Felling

The trees should always be felled in the line of extraction, and as far as possible their fall should carry them one step on their way to the road. This will not always be possible in dense crops, particularly Sitka spruce in which the poles must be pulled down, but again this pulling can be done towards the road, though it will involve *felling* away from it.

Only the smallest categories such as stakes should be axed down, all larger trees being felled with the saw. For first thinnings up to about two hoppus feet in volume, the bow saw is efficient, but thereafter if working is on any scale the power-driven chain saw proves cheaper. The old two-man, hand crosscut saw will soon be a museum piece! For thinnings, the chain saw should always be a light one-man model with a short guide bar of about eighteen inches. The weight has now been brought down to little over 20 pounds, and the saw can now be used for heavy branches; it is of course often used for crosscutting as well.

Although a one-man tool, the chain saw can cut enough wood for two, three, or more men to handle; but on safety grounds two men in a group are desirable while efficient working is unlikely if the group exceeds four. The method of working is for one man to fell while another assists with timber handling and creosotes the stumps of felled trees. Crosscutting may precede trimming, particularly if accurate cutting-to-length is not necessary, and the required lengths are long, i.e. there are few cuts per tree. All operations other than the felling are carried out

individually, each man trimming, extracting and possibly peeling parts of the tree as necessary. The aim should always be to leave the poles or billets ready for extraction. For further details see Forestry Commission Booklet No. 9. *Felling and Converting Thinnings by Hand*, (H.M.S.O., 2s. 6d.)

Extraction of Thinnings from Felling Point to Road

Where cost alone is considered, the order of lowest cost for moving a given load over a given distance is: Lorry, wheeled tractor, horse, winch and finally crawler tractor. But lorries can only work on a road, and wheeled tractors can only work on hard, fairly level ground. So until recently the horse has been the principal method in all hilly country, with the wheeled tractor only working in the flatter south and east. Big changes are now taking place. Much interest has recently been aroused by double drum winches, operated by the engine of a tractor, which are the first serious challenge to the horse in hilly country. Forestry Commission Booklet No. 12, *Double Drum Winch Technique*, gives further details.

The economics of all transport operations depend on loading and unloading as smoothly as possible, taking a large load, and moving fast. The last is of little importance however over short distances, and the first two are dependent on providing the correct equipment for the horse or tractor. This may comprise:

For tractor:	*For horse:*
Pole waggon	Trace harness
Small trailer	Swingle tree
Winch	Hook and chains
Sulky or logging arch, *or:*	Sledge, sulky or skidding arch
Alice Holt drawbar	Exceptionally: a light cart
Thetford tongs	
Hook and chain on three-point linkage	

A detailed consideration of extraction methods is given in Booklet No. 11, *Extraction of Conifer Thinnings*.

Conversion of Thinned Material

The commonest item of machinery is a mobile or tractor-mounted sawbench operating on roads or rides. Such equipment is commonly found on most estates, and will pay even if used on relatively few days of the year. It is useful for pitprops, fencing or firewood, but the powered chain saw is more economic if the poles are heavy or the specifications long—over about six feet.

General

The working of thinnings is a job requiring a good deal of organization and skill, and it may often be better to get it done by specialists, either by selling the trees standing or by employing timber contractors. Nevertheless, especially for small thinnings where marketing is so important, a forest squad of two or three men with chain saw, and horse or tractor, may do well. General experience is that for this heavy and largely manual work, piece-work or bonus payment is desirable. From early coniferous thinnings the average output to roadside for simple specifications should be about fifty hoppus feet per man per day—more detailed figures are given in the booklets noted above.

Chapter 14
DISEASES

NEARLY every plantation contains trees suffering from some sort of disease, but serious damage is fortunately uncommon. However the destruction of even a small proportion of the trees, and the damage to others, may result in a considerable loss of production. It is useful, therefore, to know something of the factors causing such loss. In many cases the damage is caused by fungi or other parasites, but often these organisms are able to attack only because the trees are growing under unsuitable conditions. To enumerate the factors that cause initial debility in trees, and may lead to attack by fungi, would entail a recital of the whole gamut of errors into which the silviculturist may fall, and of the difficult conditions to which trees are inevitably exposed. In our crowded island, where forestry is usually relegated to the less desirable soils and situations, one cannot expect always to grow trees under the best conditions. Often, to minimise the losses due to disease and adverse site factors, it is possible only to attempt the best choice of species for the site concerned, and thereafter to practice sound and careful silviculture.

Only the more important or conspicuous diseases are briefly described below. In a few cases control measures are suggested, but the value per acre per annum of a forest crop will not bear the high control costs that are now commonplace, for instance, in fruit growing. Much of the control of forest diseases must rest therefore in adaptations of normal nursery and silvicultural practices, for example, rotation of crops on to fresh disease-free ground in the nursery or the removal of diseased trees in thinnings in the forest.

DISEASES DUE TO NON-LIVING AGENTS

Frost is one of the most important causes of damage to trees in Britain. The foliage of evergreens may be damaged in winter when there are sudden changes from mild to freezing conditions, and when there are long periods of frost with bright sunshine or any other conditions causing repeated and fairly rapid freezing and thawing. In hard winters, similar freezing and thawing, which causes unequal expansion of the wood, may give rise to cracks in the stems of both conifers and hardwoods. These cracks occur particularly on the south side. However, the most serious form of frost injury to forest trees is the freezing of the delicate young shoots that are just expanding during the spring—generally known as 'late frost' damage. In the spring and autumn, the worst frosts occur on clear still nights, when the loss of heat by radiation is greatest. Under these conditions the damage occurs in places where the relatively heavy cold, air collects, such as in valleys, hollows or shelves on hillsides.

Species that are hardy against late spring frosts, in particular Scots pine, should be used for such sites in preference to the late frost-susceptible spruces and larches; though coppice cover, if available, may be thinned and underplanted with a shade-bearing species to which it will give shelter during the early frost-dangerous years, as described in Chapter 11. In all but the worst frost hollows, even susceptible species will eventually get their heads above the level to which the cold air collects on frosty nights, and will then grow away normally. This process may be hastened by the growth of trees on the slopes above. As these get thicker and taller they tend to hold up the downward flow of heavy cold air, so that less collects in the valley or hollow below.

Soil water conditions are probably the other factor causing most injury to trees. Trees seldom thrive well on soils with violent fluctuations in water content, usually between winter and summer conditions. When the water level in the soil is high the deeper roots die as a result of waterlogging. When the water level falls, the tree is left with an inadequate root system during the dry period. This often results in crown dieback, which may be aggravated by subsequent fungal attack. Any sudden alteration in the soil conditions may damage trees. Drainage may cause injury to trees which have adapted themselves to growing under rather wet conditions; while blockage of drains may harm those which have been used to well-drained soil. Such changes are best made gradually if there is a tree crop on the ground. The proper time for major alterations, such as extensive drainage, is before planting, so that the trees are not subjected to a sudden change.

Many other natural agents damage trees. The heat of the sun sometimes scorches young seedlings at soil level, so that they collapse and wither. It can also damage the stems of thin-barked trees such as beech, but only if they are suddenly exposed to full light after having been shaded. Over-thinning, so that too much sun reaches the stems, may thus result in patches of dead bark on the south side of the stems. Drought, as well as causing dieback in the crown, may produce cracks in the stems of conifers, especially fast grown dominants. It may also cause death of bark of both hardwoods and conifers.

Trees may also suffer from nutrient deficiency. This may be either because the elements are not present in the soil in sufficient quantity or because the nature of the soil prevents the tree from absorbing them. The first signs are usually yellowing or other discoloration of the foliage. In nurseries such deficiencies can be revealed by soil analysis and corrected by manuring. In the forest they tend to occur particularly on limestone and chalk soils, where the high lime content prevents the absorption of other minerals by the tree roots. Conifers, particularly Scots pine, often develop severe yellowing and dieback on such soils, and on highly calcareous sites, beech may be the only safe long-term forest crop, although conifers are often used as nurse crops, being grown on shorter rotations than the beech which they protect.

Wind, snow and the weight of ice can cause breakage in trees, leading to the entry of decay-causing fungi. Lightning, as well as striking and often shattering individual trees, can also kill groups of trees. In the latter case, live trees at the margin of the group usually have damaged branches on the inner side at a point some way below their tops.

Industrial fumes and smoke may make the growing of trees difficult near large manufacturing towns. In general, evergreen trees suffer more than deciduous ones. Few conifers can tolerate high fume concentrations, even the deciduous larches being affected. Among hardwoods, sycamore, elm and poplar are particularly tolerant. In summer, salt-bearing gales from the sea sometimes cause conspicuous browning of foliage for several miles inland. Drift of hormone weedkiller sprays from agricultural land into adjacent plantations can cause distortion of growing shoots and leaves, but the following year the trees generally resume normal growth.

FUNGAL AND BACTERIAL DISEASES

A. NURSERY DISEASES

Most nursery diseases except Damping-off and Grey mould occur also in the forest. The diseases described here are those which are primarily of importance in the nursery.

Damping-Off

This disease is caused by soil-inhabiting fungi which cause losses at a very early stage of germination (pre-emergence Damping-off), and which may also cause root infection and death of young seedlings (post-emergence Damping-off). Killing of seedlings by post-emergence infection usually takes place before the end of June, and is most serious in dense seedbeds under warm, moist conditions. Infected seedlings may occur either scattered through the seedbed, or in groups. In the latter case, the irregular distribution of the gaps gives the seedbed a very characteristic appearance. On light or medium loam soils, soil sterilization with formalin, before sowing, is effective, but in most nursery soils drench treatment with a suitable proprietary treatment such as 'Captan,' as soon as possible after the damage has been recognized, will prevent further serious development of the disease. The use of potassium permanganate against Damping-off is not recommended.

Grey Mould (F.C. Leaflet 50)

Attack by Grey mould (*Botrytis cinerea*) may occur on a wide variety of conifers, usually in the late summer, autumn and early winter. It is particularly prevalent on cypresses and *Sequoia*, but infection also takes place on Sitka spruce, Douglas fir, Japanese larch, Western hemlock and other species where these have been damaged or weakened by some other disease agency or by adverse climatic conditions. Most commonly, heavy infection by *Botrytis* follows frost damage. Infection may develop from the shoot tips, causing dieback (as after frost damage), or, as under dense, humid, two-year seedbed conditions, the fungus may colonise shaded needles and infect the bases of stems, causing death of the whole plant. This basal infection is most common in Western hemlock. Wherever infection occurs, a typical 'grey mould' develops from the killed tissue. Provided infection is observed at an early stage, control can be achieved by spray application of Bordeaux mixture.

Leaf Cast of Larch (F.C. Leaflet 21)

This disease is caused by the fungus *Meria laricis*, which infects young needles causing them to turn yellow and wither. It occurs widely on European and Hybrid larch, but rarely on Japanese larch. Infection proceeds up the shoot so that tips of the shoots of infected plants are always green. The disease rarely kills the plants but may seriously weaken them, and can greatly increase the percentage of culls. Leaf cast is best avoided by raising larch stock in nurseries well away from older larch, which may be the source of infection. In susceptible nurseries, colloidal sulphur sprays give good control, provided that the first application is made just after the time of flushing. On the affected needles, the fungus produces minute fructifications which can only be seen through a microscope.

Needle Blight of Western Red Cedar (F.C. Leaflet 43 *Keithia Disease of Thuja plicata*)

This disease is caused by the fungus *Didymascella* (*Keithia*) *thujina*. Infection causes the browning of individual scattered leaflets, as the fungus does not spread into adjacent leaflets, but under conditions of heavy infection, wilting of whole shoots may occur. The fructifications, which are small, round or oval structures produced on the surface of infected leaflets, are slightly swollen and olive-brown when mature, but when moribund appear as blackened cavities. This disease, commonly known as 'Keithia disease', can cause very heavy losses in Western red cedar nursery stock. Infection is rarely seen on first-year seedlings, but rapidly increases in severity on older seedlings and transplants. The disease can be avoided by rotation sowing in nurseries isolated from older Western red cedar. Good chemical control of the disease has been achieved recently by spray application of cycloheximide fungicide in late March.

Oak Mildew (F.C. Leaflet 38)

This is caused by the fungus *Microsphaera alphitoides*, which grows mainly on the outside of succulent leaves and shoots, covering them with a white bloom. It causes distortion and reduced growth rather than death. The fungus overwinters between the bud scales, and the shoots emerging from these buds are the first affected in the spring. Later, the disease is very effectively spread in the nursery by wind-dispersed spores. Provided spraying commences at the beginning of the flushing period, the disease can be effectively controlled with colloidal sulphur fungicides.

Leaf Rust of Poplar (F.C. Leaflet 27: *Poplar Cultivation*)

The leaves of some varieties of poplar are often covered in the late summer and early autumn with the orange pustules of *Melampsora* rust. The leaves wither earlier than usual with the result that the shoots do not ripen properly and may be cut back by autumn frost. The total damage done, however, is very small and no special measures are called for.

Fungicides

In view of the wide range of proprietary fungicides now available, no directions are given for their preparation. Instructions are always given on the tin or bottle, and it can be assumed that most trees will be unharmed by the average dose recommended for horticultural plants. A list of approved products

is obtainable free of charge from: The Ministry of Agriculture, Fisheries and Food, Plant Pathology Laboratory, Hatch Green, Harpenden, Herts., or the Ministry's Publications Department, Block C, Tolcarne Drive, Pinner, Middlesex.

B. DISEASES OF GENERAL IMPORTANCE IN THE FOREST

Honey Fungus (F.C. Leaflet 6)

Armillaria mellea, generally known as Honey fungus, attacks the roots of a wide range of coniferous and broadleaved trees, nearly always spreading from old infected hardwood stumps in the immediate vicinity. The disease is particularly apt to occur where conifers have been planted on old hardwood sites. Most of the commoner forest broadleaved species are moderately resistant, though many ornamental trees and shrubs are susceptible. Most conifers are susceptible. On affected trees white or cream-coloured sheets of fungal mycelium, sometimes streaked with brown or black, occur between the bark and the wood. This mycelium is of particular value in identification. Later, black bootlace-like strands, or rhizomorphs, develop under the bark of stems and sometimes of roots. These rhizomorphs can nearly always be found in the soil around roots infected by Honey fungus.

In early autumn, clusters of orange-brown toadstools occur at the base of infected trees. While they last, these are a valuable means of recognition, but they soon decay when autumn frosts begin.

The disease usually kills scattered single trees, so that the distribution of the disease may mitigate its severity. However, in young conifer crops on old hardwood sites groups of trees may be killed, particularly where adverse soil conditions such as drought and waterlogging occur. With age, the trees become more resistant. Older trees can often live for long periods with the fungus alive on some of their roots, without any apparent effect on their health. In most conifers infection causes root rot and this may be an important factor in decreasing stability and causing windthrow. In some conifers, particularly spruce, decay develops for a short distance up the stem, but rarely for more than two feet. Decay caused by Honey fungus has a very characteristic wet, stringy appearance. In the forest there is at present no treatment for this disease, but in gardens and arboreta grubbing-up of old stumps, to prevent them acting as centres of infection, is advisable before valuable trees and shrubs are planted. Later any trees that become infected should be removed with all their major roots.

C. DISEASES OF CONIFERS

White Pocket Rot: *Fomes annosus* (F.C. Leaflet 5)

Decay at the base of conifers is mostly caused by the bracket fungus *Fomes annosus*. This fungus may kill young trees by investing their root systems. As a root disease killing trees, it is most serious in pines on alkaline soils and on former farm land. As a cause of butt rot, it is worst on Western hemlock and Western red cedar, but our major species are all liable to attack. Pines however show some resistance to butt-rotting by this fungus.

Fomes annosus occasionally produces white mycelial tissue under the bark of infected roots but this is far more tenuous than that produced by the Honey fungus and is free from dark streaks. No black rhizomorphs are produced. The fruit bodies of *Fomes*, which are produced all the year round, are easily recognised. They occur as small brackets on stumps and at the base of killed trees, usually at soil level and often hidden beneath fallen needles. They are dark brown above, often with a conspicuous white margin, and the undersurface, which is perforated by numerous minute pores, is cream or white.

Fomes annosus, mainly because of the decay it causes, is probably responsible for greater losses to forestry in Britain than any other fungus. It is already present in most areas that have carried two or more crops of trees, though its attacks are less severe on some sites than on others. Nearly all *Fomes* butt rot in new plantations on virgin ground is caused by initial infection of felling stumps, as a result of wind-dispersed spores alighting on to the freshly cut stump surface. Infection spreads from the stumps to standing trees via root contacts, and in the same way infection is transmitted to further trees. The development of the disease in first rotation crops and its further development in the second rotation can be greatly retarded by treatment of freshly cut thinning stumps with creosote or sodium nitrite.

Dry Crumbly Rot: *Polyporus schweinitzii*

Although not as widespread and damaging as *Fomes annosus*, *Polyporus schweinitzii* is tending to spread in conifer crops in Britain. Conifers on sites which have previously carried hardwoods or pine are most subject to attack. Sitka spruce and Douglas fir are most frequently affected, but old trees of Scots pine can be severely decayed. As its name suggests, the decay is dry and crumbly, but it can also be recognized by its cracked appearance, and old decay has a characteristic cubically broken appearance. The fructifications are produced at the bases of stems, when they have a typical bracket form, or from the forest floor immediately above infected roots, when they are irregular stalked structures. The upper surface of the fructification is dark brown and its texture is well suggested by the common name of the fungus, "velvet top." The

lower surface is yellow-green in colour and is broken by numerous irregular pores. Very little is known of the biology of this fungus.

Group Dying of Conifers (Forest Record 46)

This disease is caused by the fungus *Rhizina undulata*, and most damage has occurred in Sitka spruce. Infection is associated with the lighting of fires in plantations, the most important fires being those lit at tea-breaks during thinning operations. The fungus spreads through the litter outwards from fire sites, causing severe infection in roots which it contacts. Infection is also transferred directly between adjacent root systems. The disease can continue for a period of 5 or 6 years following fire-lighting, causing the death of large groups of trees. The groups are frequently enlarged by wind-throw. The fructifications of *Rhizina* are shallow, cup-like structures, dark brown above, and are produced on the soil surface of fire sites, or on the litter below infected trees. The disease can be prevented in established plantations by prohibiting firelighting during thinning operations. Some loss of planting stock, of most conifer species, can result from infection originating from fires lit during clear-felling, but usually the damage is then slight and does not persist for more than one or two years.

Larch Canker (F.C. Leaflet 16)

This disease of European larch is now thought to be due to the combined action of frost and the fungus *Trichoscyphella* (*Dasyscypha*) *willkommii*. It is characterized by cankers on stems and branches and dieback of twigs. In severe cases trees can be killed outright. The small pink, cup-like fruit bodies of the fungus are produced on the cankers. The disease is most severe on sites where the larch is subject to frost damage. Susceptibility to canker is clearly related to the origin of the larch, high alpine provenances being most susceptible. The disease can be largely avoided by the use of larch of Scottish, Sudeten or Moravian origin. Hybrid and Japanese larches have high resistance to larch canker.

Dieback of Corsican Pine

Corsican pine planted at high elevations or in areas of high rainfall tends to die back. The dieback is accompanied by loss of needles and death of shoots over a period of several years, so that the tree declines gradually and plantations appear thin and unhealthy. The disease is associated with the presence of several fungi, particularly *Brunchorstia destruens*, which produces small, pin-head, dark-brown fruit bodies on the twigs, but fungal infection probably plays a secondary role in the development of this disorder.

Resin Top Disease of Scots Pine (F.C. Leaflet 49).

This disease, caused by the rust fungus *Peridermium pini*, is important at present only on Scots pine in north-east Scotland. The fungus produces cankers which commonly girdle the main stem and branches. The cankers are usually seen as large blackened, resin-soaked areas on the upper part of the stem. Dieback of the crown above large cankers frequently occurs, and this is nearly always followed by death of the whole tree. Vigorous crops are most susceptible to attack and dominant trees are more seriously affected than others. During May and June, large numbers of blister-like fructifications are produced on the surface of the cankers. Unlike White pine blister rust, *Peridermium pini* can spread directly from pine to pine. Infected trees should be removed as soon as possible in the course of thinning.

White Pine Blister Rust (F.C. Booklet 4: *Rusts of British Forest Trees*)

This disease of five-needled pines is caused by the fungus *Cronartium ribicola*. The severe damage to Weymouth pine (*Pinus strobus*) in Britain, since the fungus was introduced at the end of the last century, has dissuaded most foresters from planting this valuable species. The fungus spends part of its life cycle on currants (*Ribes* species), blackcurrant being the most susceptible. Wind-dispersed spores can carry the fungus for long distances from infected pines to currants, but only pines within a mile or so of currants are liable to infection. The incidence of disease in a pine crop cannot increase by direct transmission of infection from pine to pine. On the pine, infection produces cankerous swellings on branches and main stem, and in spring and early summer, conspicuous orange blisters are produced in large numbers on the cankers. Cankers frequently girdle stems, causing serious dieback or death of whole trees.

If Weymouth pine is to be grown, every effort should be made to avoid infection of the young plants, by raising them in nurseries remote from blackcurrants. Fungicides suitable for the protection of nursery stock are now also becoming available. Plantations should be restricted to sites at least a mile from currants, to minimise the danger of later infection of the trees.

Twisting Rust of Pine (F.C. Booklet 4: *Rusts of British Forest Trees.*)

This disease, due to *Melampsora pinitorqua*, which causes distortion and dieback of the current year's shoots of Scots pine, occurs only where pine and the alternate host aspen, *Populus tremula*, are growing in close proximity. So far, it is unknown in Scotland or Wales. The fungus produces bright yellow mealy fruit-bodies on the distorted shoots in the early summer, and later small orange spots appear on the aspen leaves. Corsican pine, which is resistant to the disease, should be planted instead

of Scots pine on sites in England where aspen occurs among the natural vegetation. Where Scots pine has already been planted, the disease can be kept under control by early and frequent cutting of the aspen suckers. Once the canopy has closed the pine suppresses the aspen and the disease dies out.

Needle Cast of Pine (F.C. Leaflet 48).

Needle cast of pine, caused by *Lophodermium pinastri* and other fungi, is common. The needles become brown and fall, usually in the winter or spring. In severe attacks defoliation may be nearly complete. Oval black fruit bodies are produced on the fallen needles. Fortunately the disease seldom occurs in epidemic form for two years running, and the trees are able to recover fairly easily from the loss of a single year's needles. *Lophodermium* attack also occurs in nurseries, and here the fungus can be partially controlled by spraying with Zineb fungicides. However, infection can be effectively prevented by siting nurseries some distance from older pines. The distance need be as little as a quarter of a mile.

Phomopsis Disease

Japanese larch and Douglas fir, both in the nursery and in the forest, often suffer from dieback of the twigs. Closer examination will disclose small sunken cankers on some of the other twigs. This disease appears to be caused jointly by frost, or other agencies of physical damage, and the fungus *Phomopsis pseudotsugae*, which produces small, pinhead, black fruit bodies on the dead bark. It is seldom serious.

Needle Casts of Douglas fir (F.C. Leaflet 18: *Two Leaf Cast Diseases of Douglas Fir*)

In Britain the two fungi causing needle cast of Douglas fir are *Rhabdocline pseudotsugae* and *Phaeocryptopus gäumannii*.

Rhabdocline attacks are most serious on Colorado or Blue Douglas, and Intermediate or Fraser River Douglas. Fortunately the silviculturally desirable and more commonly planted Coastal or Green Douglas fir is less seriously affected. Young needles are infected in the spring and turn brown during autumn and winter. In the following spring elongated, orange-brown fruit bodies appear on the needles, and spores are released which infect young developing needles. The life cycle thus takes a year, and the needles fall when the spores are shed.

Phaeocryptopus is extremely common in the west of Britain and infects all varieties of Douglas fir. The fructifications appear as a soot-like dusting on the underside of green needles and can be seen with a hand lens. It is less serious than *Rhabdocline*, but is occasionally associated with severe defoliation.

D. DISEASES OF BROADLEAVED TREES

Canker of Ash

Ash canker associated with the bacterium *Pseudomonas savastanoi* and with the fungus *Nectria galligena*, is fairly common. Bacterial cankers are usually very irregular and blackened, whereas those associated with *Nectria* are more regular in outline. In some instances frost may act together with *Nectria* in canker formation. Nothing is known of control measures for ash canker.

Bacterial Canker of Poplar (F.C. Leaflet 27: *Poplar Cultivation*)

This is the most important disease of poplars in Britain, causing large erumpent black cankers, which swell and break, and extensive dieback on some varieties of poplar. It is caused by one or more species of bacteria. The cankers vary in size and appearance and can be found on any part of the stem. The first signs of the disease are small cracks in the twigs, from which a whitish bacterial slime exudes in spring. Losses from the disease may be reduced by the use of resistant poplar varieties.

Dothichiza Canker of Poplar (F.C. Leaflet 27: *Poplar Cultivation*)

The fungus *Dothichiza populea* causes small sunken cankers on young poplars, often at the point where a twig joins the main stem. It occurs particularly on young, newly-planted poplars, especially on dry or difficult sites. Over-large plants, or plants that were crowded in the nursery are often attacked. Certain varieties, notably *P.* 'Robusta', *P.* 'Serotina' and *P.* 'Marilandica' are considered moderately susceptible, while others, including *P.* 'Gelrica' and *P.* 'Serotina erecta' are seldom attacked. Careful planting of good nursery stock on reasonably well-selected sites should enable even susceptible species to be used with safety. The disease is of little importance on established commercial poplars in Britain.

Bark Dieback of Beech

Dead patches frequently occur on the trunks of old beech. These often bear the pinhead red fruit bodies of *Nectria coccinea*, but the basic causes are probably climatic, e.g. winter cold and drought, encouraged by the over-maturity of the affected trees. Such wounds lead to invasion of the trunk by decay fungi, so that affected trees should be felled and utilized as soon as possible.

Watermark Disease of Cricket Bat Willow (F.C. Bulletin 17, *Cultivation of the Cricket-bat Willow* and Leaflet 20: *Watermark Disease*)

This bacterial disease is caused by *Erwinia salicis* which produces browning of the leaves of willow

followed by dieback of twigs and whole branches. A diffuse watery stain appears in the affected wood. In the principal willow-growing area of East Anglia and the neighbouring counties, legal measures are in force whereby owners are compelled to fell and dispose of diseased willows. These measures have restricted the spread of the disease. (e.g. *The Watermark Disease (Essex) Order.* S.I. 1953/No. 437. H.M.S.O. 3d.). Sets for planting must always be taken from healthy trees or stool beds.

DECAY

Many of the fungi which cause decay in standing trees are not true parasites. They can enter the dead heartwood only if the bark and sapwood, which cover it, is broken. Entrance may be gained through wounds, or dead roots, or through broken or dead branches. Every effort therefore should be made to avoid damage to trees; for instance wounds at the base caused during timber extraction are a common means of fungal entry. Pruning wounds should be kept as small and cut as cleanly as possible, so that they heal rapidly. Branches should always be removed as close to the base as possible; where a branch of any size or weight is involved, an undercut should be made first, to stop the weight of the falling branch tearing the bark and wood on its underside, when the main cut is made. Large pruning wounds should be coated with a bituminous dressing, such as 'Arbrex', to check the entry of the fungi which cause decay, but this is rarely needed for small wounds. Thinning, particularly of oak, should be carried out so that branch suppression and death in the earlier stages takes place before the branches are too large, and so that in the later stages the crown is preserved intact. Any tree showing obvious signs of decay, such as fungal fruit bodies developing at the base or round branch stubs, should be felled and utilized before it deteriorates further.

Chapter 15
INSECT PESTS

INTRODUCTORY

ALTHOUGH a large number of different types of insect pest are capable of causing damage to forest crops of all ages, relatively few of them have so far caused catastrophe or severely restricted the growth of stands in Britain. Usually the so-called balance of nature operates, wherein the pest species are controlled at numerically low levels by the influences of climate and of their own enemies, such as insect predators and parasites, disease, birds, small mammals, and so on.

In many cases insect damage has to be tolerated simply because it would be uneconomic to embark upon control actions. In others, intervention may be fully justified where either the crop would otherwise be severely damaged and the cost of control be less than the value of the growing stock, or, where the continued life of the stand is at risk. In the case of recurrent attacks the main consideration must be whether the cost of control can be offset by gain in annual increment. Examples occur in the nursery, in the establishment of new crops, and with some outbreaks of defoliators. Again, the numbers of some insects and the damage they do is directly related to the silvicultural condition of the crop. By observing the tenets of good silviculture and maintaining the crop in a sound condition, the scale of damage inflicted by some pests can be considerably reduced. A very important example occurs in pine woods, where the maintenance of forest hygiene and the correct planning of thinning and felling operations do much to restrict the damage which bark beetles and weevils can inflict.

But it should not be thought that the skilful practice of forestry, embracing correct choice of species and careful subsequent tending of the crop, will necessarily lead to the avoidance of insect troubles. Certainly it should always be the aim of foresters to keep their crops in as generally sound and healthy condition as possible, and in some instances such treatment will help to ward off the attacks of 'secondary' pests which are unable to initiate an outbreak unless some other predisposing factor of ill-health is operating in the crop; but a number of insect pests—including some of the most harmful species—are capable of attacking and seriously damaging, if not destroying, otherwise perfectly healthy and well tended stands. These latter types of insects are usually referred to as 'primary' pests.

Different types of insect infestation are usually associated with different ages of the host crop and it will be convenient, therefore, to consider in this section the main enemies which are of common occurrence in the different stages in the development of the crop. Obviously, in such a brief review, it is possible to do no more than quote a selection of examples and indicate which species of insect are currently of importance.

INSECTS ATTACKING TREE SEED

Many species of insect live in the developing seeds and cones of forest trees and their attacks can sometimes result in appreciable losses of seed. At the present time the most important of these pests is the Chalcid seedfly, *Megastigmus spermotrophus*, whose larvae hollow out the seeds of Douglas fir. (F.C. Leaflet 8.) Infestations by this insect are sometimes very heavy and can cause total loss of the seed crop. It is, therefore, always essential to make an inspection of the seed to determine its soundness before cone collecting is carried out. Other species of *Megastigmus* infest silver fir, larch, and Norway spruce seeds but they do less economic damage than *M. spermotrophus*.

The caterpillars of a number of Lepidopterous species (butterflies and moths) such as *Dioryctria abietella*, *Laspeyresia strobilella* and *L. conicolana*, the larvae of weevils such as *Pissodes validirostris*, and *P. notatus*, and the maggots of some Dipterous (two-winged) flies, feed upon and destroy a variety of coniferous seeds; but their attacks are not serious. The grubs of the long-snouted weevils of the genus *Balaninus* attack and hollow out acorns and chestnuts, whilst beech nuts are similarly infested by the caterpillars of the moth *Laspeyresia grossana*. Again, the attacks are not usually of a serious nature but they may on some occasions affect the success of natural regeneration schemes.

Other types of insect infestation can produce indirect effects on seed production. For example, the defoliation of oak by the Oak-leaf roller moth, *Tortrix viridana*, results in a marked reduction in acorn yield.

NURSERY PESTS

The most important nursery pests are soil-inhabiting insects and sap-suckers. Leaf-eating insects are not usually troublesome in the nursery but occasionally some moth and sawfly caterpillars and some species of leaf beetles damage various hardwood trees. These pests can be controlled with sprays of D.D.T. applied at the rates recommended in normal horticultural practice.

The two important groups of soil insects are the cutworms and the chafer grubs. Cutworms are the caterpillars of various species of Noctuid moths which remain in the soil during daytime and at night emerge to feed upon tree seedlings. The damage consists of gnawing at the collar region and this usually results in the young tree being cut off at or about soil level. When damage is detected the identity of the pest can be confirmed by digging up the caterpillars or looking for them on the surface of the soil at night with the aid of a torch. The caterpillars are grey in colour and measure about one inch in length; their characteristic reaction to handling or disturbance is to roll themselves up into a ball. Another check on the identity of the pest is the presence of holes—the entrance to the burrows—in the surface of the seedbed. Control can be achieved by using B.H.C., applied as half a gallon of concentrate (20% active ingredient) in 100 gallons of water per acre.

Chafer grubs are white, curved, and wrinkled, with a brown head and three pairs of legs; they measure up to one and a half inches in length when full grown. They are the larvae of various species of chafer beetles of which the best known is the large May bug, *Melolontha melolontha*. The grubs live in the soil for from one to four years and during this period feed on the roots of seedlings and transplants. The roots are either stripped of bark or chewed through, the first symptom of attack being the browning of the foliage. The death of the plant is a common result of attack. Chafer grubs used to be the most important of the nursery pests, but with changes in nursery practice they are now less troublesome than before. Control can be effected with B.H.C. "Wireworm Dust". 1–1½ cwt. per acre is either worked into the top few inches of soil between the rows, or incorporated during the last cultivation before planting or sowing.

The Collembola (beetle) species *Bourletiella hortensis*, another soil-dweller, can cause heavy losses amongst conifer seedlings; Lodgepole pine seems particularly susceptible. The attack takes place on the hypocotyl and cotyledons of germinating seed. Death of the seedling can occur before emergence from the soil or, where damage to the hypocotyl has not been great, the shoot and leaves may be deformed. At the end of the growing season a surviving plant has a normal stem (often showing brown specks of dead tissue), on top of which is a bush of fattened distorted needles. After two years, the small trees appear perfectly green and healthy but bear 4 or 5 leaders—the kind of plant which will normally be rejected without thought by the nurseryman. It is possible that Collembola damage on a small scale may be quite common, and could account in part for the wide differences between laboratory determined germination percentage and survival in the field. These tiny jumping wingless insects are easily controlled by spraying with malathion. Use of D.D.T., B.H.C. or other chlorinated hydrocarbons may result in a temporary depression in numbers, but the population will be found to have recovered within a short time if not actually to have increased.

Sap-sucking insects, such as the aphids and the adelgids, are fairly common in nurseries, and their attacks may check and stunt the growth of the plants. The adelgids are restricted to coniferous trees and their presence can be detected by the patches of

white wool which they produce to cover themselves. *Adelges cooleyi* on Douglas fir, and *A. viridis* on larch and spruce, are the commonest kinds. Aphids occur on both coniferous and broadleaved nursery stock. For example, *Cinaropsis pilicornis* has been recorded damaging spruce, whilst *Phyllaphis fagi* on beech and *Myzus cerasi* on cherry are relatively common. These sucking insects can be controlled by the use of either malathion or B.H.C. sprays such as are used to combat the attacks of greenfly in gardens. In the case of species which protect themselves under wool, such as the various adelgids and *Phyllaphis*, it is essential to use a spray delivered with a good pressure to ensure penetration through the covering.

Occasionally, small weevils such as *Otiorrhynchus*, *Phyllobius*, and *Barypithes* cause damage in the nursery by feeding upon bark and leaves. These insects can be controlled by the use of D.D.T. or B.H.C. sprays or dusts.

INSECT ATTACKS ON YOUNG WOODS

Generally speaking, the first few years in the growth of a conifer crop are much more critical from the point of view of insect damage than is the same period in the life of a hardwood stand. This is particularly true when the new conifer crop has been planted on an area previously stocked with conifers which have been recently felled. In such a case insect pests which have multiplied in the stumps of the previous crop emerge to feed upon the young trees, on which they can inflict very serious damage. Sometimes, too, young crops planted near a recently felled area suffer damage when the insects migrate from it and attack the new planting. The insects concerned in such infestations are the well-known pine weevil, *Hylobius abietis*, and the black pine beetles, *Hylastes* spp.

The Large Pine weevil (F.C. Leaflet 1) breeds usually in pine stumps but occasionally also in the stumps of other conifers. The grubs which burrow beneath the bark of the roots and stump buttresses measure about three-quarters of an inch in length when full grown, and are white, curved, and legless, with a well-developed brown head and strong biting mouth-parts. Depending on climatic conditions and the locality of the site, the development period between egg-laying and the emergence of the young adults varies between one and two years. On emergence the weevils, which can live in the adult stage for two or occasionally more years, feed by stripping the bark off the newly planted conifers. When the bark is ringed the tree dies, and plants which have been attacked but not killed rarely make very successful growth. The incidence of attack can be very high and the total loss of the crop in a heavily infested area is not uncommon. Less severe attacks involve heavy expenditure in beating up. Douglas fir is the most attractive tree to the feeding weevil, but all the other commonly-grown conifers are also susceptible to attack.

Damage by the pine weevil can be avoided by allowing the site to lie fallow for a period of three or four years after felling. This time lag between felling and replanting permits the weevil population to breed up and then fall back to normal levels, but it has the disadvantages of the loss of the use of the ground for that period, of soil deterioration, and of an increase in weed growth on the area.

Alternatively, when an attack does develop, control may be attempted by the laying of billet and spray traps from which the weevils are collected daily. This is an expensive and not entirely efficacious procedure which has recently been superseded by the direct protection of a new crop with insecticides. D.D.T. is perhaps the most convenient of these insecticides to use. Emulsions of it can be used either as dips in which the shoots but not the roots of bundles of young trees can be immersed before planting out; or as sprays which can be applied to the individual young trees *in situ* after planting. Dusts can also be applied after planting but they are generally less convenient to handle than sprays.

The Black pine beetles also breed in conifer stumps and emerge to attack young coniferous trees. Damage is caused by this small bark beetle burrowing beneath the bark, at or below the collar region of the young tree, and the attack frequently causes the death of the tree by girdling. The attack is externally not so noticeable as is that of the pine weevil, but it is an easy matter to lift and examine obviously unhealthy and dying trees to determine if *Hylastes* is responsible. Fallowing or trapping, as for the pine weevil, are the normal methods of control recommended.

The Clay-coloured weevil, *Otiorrhynchus singularis*, can also bring about serious losses in new plantings. The larvae feed on the fine roots of various herbs and the adults upon the aerial parts of the forest trees and other plants. Western hemlock seems particularly prone to attack. The adult not only eats out triangular chunks from the needles but also removes the bark from the finer twigs and branches in a manner similar to that of *Hylobius*—feeding on the main stem. The creatures are dormant during the day time and may be looked for just under the soil surface at the base of the stem. Adult activity usually starts at the end of April or early May and continues throughout the summer months into September. Almost identical damage, particularly to larch, is sometimes caused by the small brown weevil *Strophosomus coryli*. Indeed, very often, these two work together. Effective control of both species may

be obtained by spraying with D.D.T. or B.H.C.

In the first decade after establishment a number of insect pests make their presence felt, again mainly in coniferous crops. The sap-sucking *Adelges* are usually conspicuous on Douglas fir, the larches, and the spruces, but their attacks are not greatly detrimental to the growth of the trees. One species, however, *A. nusslini*, so severely cripples the common Silver fir, *Abies alba*, by its attacks that the planting of this tree has had to be suspended in this country. (F.C. Bulletin 26, *Adelges Insects of Silver Firs.*) In young pinestands outbreaks of the two common Pine sawflies, *Diprion pini* and *Neodiprion sertifer*, are conspicuous and on occasion defoliation may be almost complete. (F.C. Leaflet 35, *Pine Sawflies.*) The infestations seldom persist for more than two or three seasons before they collapse naturally, and normally tree death is not caused, although there may be a noticeable decrease in height increment. Artificial control is not required. In young pine stands, too, the stem deformations produced by the attacks of the Pine shoot moth, *Evetria buoliana*, may be very frequent and give rise to concern; but careful subsequent tending of the crop can to a great extent rectify the damage done, and control action at the time of the infestation is not necessary (F.C. Leaflet 40, *The Pine Shoot Moth.*) The same applies to the Pine bud moth, *Evetria turionana*, which also causes stem distortions.

In hardwood crops of up to ten years of age defoliation by leaf beetles and by the caterpillars of moths and sawflies is sometimes encountered. Serious attacks are rare and recovery from damage is normally very good. Aphid attacks, too, may occur but again they do not seriously interfere with the growth of the crops.

INSECTS IN OLDER WOODS

Defoliators

Many species of leaf feeding insects cause damage of varying degrees of severity in older woods of all types. Some of the most potentially harmful forest pests are included in this group, and although crops in Britain have, by comparison with those in many other countries, been relatively free from serious attack of this type in the past, it is essential to realize that some of these insects constitute a menace to our present-day plantations. This is particularly true when the recent use of pure plantations is taken into account since, typically, the attacks of forest defoliators are most extreme when a large and uniform food source is available to them. It has also to be remembered that the defoliation of evergreens has usually a more harmful effect than that of deciduous trees, since the replacement of foliage by the latter is an easier process.

The most important forest defoliators in older crops are the caterpillars of moths and sawflies, but some examples also occur in groups other than these. For instance, beech leaves are often damaged by the weevil *Orchestes fagi*, the adults of which eat holes in the leaves whilst the larvae mine the interior of the leaf. Again, Sitka spruce is frequently defoliated by the aphid *Neomyzaphis abietina*, but recovery from attack is normally good unless the moisture conditions of the site are adverse.

Amongst the Lepidopterous group (butterflies and moths), examples of defoliators are the Pine looper, *Bupalus piniarius*, (F.C. Leaflet 32, *Pine Looper Moth*); the Pine beauty, *Panolis griseovariegata*, also on pines; *Semasia diniana* on larch and spruce; the winter moths, *Operophtera brumata* and *Hybernia defoliaria* on many hardwood trees; and the Oak leaf roller, *Tortrix viridana* (F.C. Leaflet 10, *Oak Leaf Roller Moth*). The sawflies on pine have already been mentioned, as has the fact that their attacks occur usually in young stands. Larch and spruce crops also carry a varied sawfly fauna, with seven species occurring on the former and eight on the latter. These sawflies on larch and spruce are of particular interest since they are all non-indigenous to Britain, having been introduced with their exotic hosts.

Only brief reference can be made to the forest status of the above insects. Most of them occur in some numbers in woodlands which include their host tree, but only a few of them have so far proved to be of economic importance. The Oak leaf roller is a well known pest which periodically causes damage to older oak woods. The trees usually recover fairly well, assisted by heavy Lammas shoot production, but a distinct loss of timber increment results. It is interesting to note that Sessile oak is less susceptible to heavy infestation than is Pedunculate oak.

The Pine looper moth was regarded as being of little importance until 1953 when the first serious epidemic requiring artificial control occurred. Of the larch sawflies, *Pristiphora erichsoni*, the Large Larch sawfly, caused widespread damage in the Lake District and North Wales in the early years of this century; but the most common and damaging species at the present time is *Anoplonyx destructor*. It is responsible for browning of the needles and occasionally complete defoliation of larch in many parts of Britain. Amongst the spruce sawflies, *Pristiphora abietina*, which defoliates current year's shoots, is the most important.

In general, the control of defoliators is a complicated operation since usually fairly large areas are affected and special equipment has to be used. The best advice that can be given is that a careful watch should be kept for these pests and that, whenever any evidence of undue activity on their part is detected, expert guidance should be sought. The

Forestry Commission Research Branch is always interested in reports of outbreaks, and will readily offer advice.

BARK BEETLES AND WEEVILS

These insects are, in the main, secondary pests whose numbers are usually dependent on the provision of suitable breeding sites. Multiplication normally takes place beneath the bark of sickly or dying trees or in freshly felled timber from which the bark has not been removed. When their numbers are high, however, they can attack and damage healthy growing crops. The most important British problems are connected with bark beetles on pine and larch, and weevils on the former tree. The insects concerned are the weevils, *Pissodes* spp. (F.C. Leaflet 29, *Pissodes Weevils*) and the bark beetles, *Blastophagus* (*Myelophilus*) *piniperda* or Pine shoot beetle (F.C. Leaflet 3, *Pine Shoot Beetles*) and *Ips cembrae*. The last species is a recent introduction to the country and is so far confined in distribution to East Scotland.

The two bark beetles, *Blastophagus* and *Ips*, breed in the type of material indicated above. The young adults feed by boring into twigs or branches. In the case of *Blastophagus* up the centre of young, usually one-year-old shoots, and in *Ips* in the cambium and wood, girdling branches up to 4 years old. These damaged parts break off and, since the leading shoot is often involved, permanent and serious distortions of the main stem can result. Control can be achieved by maintaining a good standard of forest hygiene, and it is thus a managerial rather than an entomological problem. It is unfortunately true to say that the general level of control in Britain is low and that, therefore, much unnecessary and avoidable damage is done to pine crops, particularly in the pole stage. The first essential in reducing damage is to restrict the breeding sites by putting in hand a thinning regime which regularly removes all sickly and dying stems. The second is that groups of trees damaged by such agencies as fire and windblow should be quickly felled and removed from the forest so that they do not become nuclei of infestation. The third essential is to ensure that stems which are felled in thinning and clearing operations are not left in the forest long enough for a brood to be produced from them. As a general rule, such material should not be left in the forest for more than six weeks from the time of felling, during the period from April to September. If removal within this time limit is not feasible, the bark beetle broods should be destroyed either by barking the timber or by spraying it with B.H.C. Forestry Commission Leaflet 3 gives further details of the methods which should be employed.

Good forest hygiene is also effective in controlling the numbers of *Pissodes* weevils.

INSECTICIDES

A list of 'Approved Products' is obtainable free of charge from the Ministry of Agriculture, Fisheries and Food (Publications), Block C, Tolcarne Drive, Pinner, Middlesex. In general, it is advisable to follow closely the advice given by the makers on the containers, or associated literature, for each product.

Chapter 16
FIRE PROTECTION

THE choice of measures to be taken to protect plantations from fire, on any private estate, will depend very much on the general distribution of the woodlands, and their composition by kind of tree and age of crop. On the one hand, it is very easy to spend more on protecting the trees than the risk of loss justifies. But on the other hand certain fire protection measures, such as the provision of good access routes, are so closely linked to good general management that their cost is justified on both counts. Moreover, the local Fire Brigades are always willing to assist the woodland owner as part of their service to the community. Indeed the fullest co-operation has been arranged in specific technical ways between the Fire Authorities, the Forestry Commission, the Timber Growers' Organization in England and Wales, and the Scottish Woodland Owners Association.

There are very few estates on which it would be worth while to follow the full precautions developed by the Forestry Commission unless they are one of an assembly of private properties whose boundaries march together and form a large forest area justifying a greater organization and more equipment than any one member could afford to provide, but which is financed communally. Where there are several hundred acres of young conifers, all very much of one age and size, established amid heaths and moors with an inherently high fire risk, the provision of look-out towers, full-time patrols in dry weather, specially equipped fire fighting lorries, and even portable wireless sets for quick communication, has been found well worth while.

But most private owners are faced with a much simpler problem, owing to the more scattered and varied character of their woods. It will seldom be

worth their while to invest in equipment that can only repay its cost by the protection it affords to large compact blocks of young conifers. Further, such equipment is only effective if there is constantly at hand a sufficient number of trained workers to handle it. Hence, on the average private estate it is better to concentrate on the provision of simple hand tools, supplemented perhaps by a portable motor pump, which will suffice for the usual squad of woodmen and such outside help as can be mustered. Reliance must be placed on the County Fire Service for specialized equipment and the trained firemen who know how to work it.

When a fire breaks out it presents a sudden emergency, and unless sound plans have been laid well ahead to cope with it, in collaboration with the Fire Service, the situation can easily get out of hand. So it is equally important to plan the layout of the woods, often years in advance of the anticipated risk, to lessen the chance of a fire getting into the plantations or spreading rapidly through them. Especially should the system of access to and through the woods be designed with the advice of the County Fire Service, since their multi-purpose vehicles will have to traverse them. Particularly must violent changes of gradient be avoided. The Fire Prevention Officer of the Fire Service will also be able to advise what other outside resources could be drawn on to aid the owner in protecting his woods or to lessen the financial loss resulting from a fire.

Fire Plans

It is a great help to bring together all one's ideas on the protective measures for estate woodlands in a Fire Plan, as is done by the Forestry Commission for all its forests. Discussions with the Fire Prevention Officer of the Fire Service should take place at an early stage of its compilation. Such a Plan should include a map of the woods showing access routes, water supplies, telephones, the main points at which fire brigades, etc., should report, and the differentiation of plantations according to their value and susceptibility to burning. Where relevant, it is desirable also to indicate future plantings, even though these may not be precise as to species or location. Once the plan has been prepared, it is a simple matter to revise it annually.

Precautions by Workers and Contractors

It should be impressed on every individual who comes to work in the woods that he is at all times responsible for taking the utmost care with fire in every shape or form. Contracts for the sale of timber should always include clauses defining responsibility for fire precautions and compensation for any damage incurred; the contractor's staff should be liable to take part in fire-fighting in just the same way as direct estate employees.

In practice, it is useless to try to stop all smoking by workmen in the woods, or to prohibit the lighting of fires for brewing up tea. A more practical line is to lay down times and places where men may smoke or light fires, with precautions to be observed, and to insist that these rules are followed.

A fire risk that is often overlooked is that from a chance spark or back-fire from a tractor engaged on woods work. These machines should have their exhaust pipes set vertically. It is only reasonable to insist that all such machines used in the woods should carry a chemical fire extinguisher; indeed, every lorry should be so equipped.

LESSENING FIRE RISK

A basic principle of forest fire protection is that the damage done, and also the difficulty of fighting a fire, increases with the area of land involved. Therefore it is most important to split up the woods by barriers, whether natural or artificial, that will either stop a fire spreading, or at least reduce its speed of spread. The basic unit of management for woodlands, known as the compartment, is very handy for this purpose; it commonly covers from twenty to thirty acres of ground, and is surrounded, or bordered at least on two or three sides, by roads or rides that serve to isolate it from its neighbours. Such roads or tracks are, however, of little value, either for fire-fighting or access, if they are allowed to become overgrown with inflammable vegetation such as gorse or heather. It is not enough merely to provide such breaks; they must also be maintained in good order. Accessibility, particularly to fire engines, is of prime importance at every stage of fire fighting.

The standard width for internal fire breaks is thirty feet. In a big woodland block a few wider barriers, up to sixty feet wide, may be advisable and could also provide space for stacking thinnings.

The importance, or otherwise, of external fire breaks on the periphery of a wood, depends very much on the nature of the surrounding land. Where a conifer plantation adjoins a main road, a railway line, or an expanse of moorland or common that is liable to catch fire, it is advisable to leave unplanted a strip of ground thirty feet wide and to treat it on the lines indicated in the following section. But where, for example, one is dealing with woods of broadleaved trees amid lush green pastures or arable land, there would be no point at all in leaving so much ground unplanted.

Fire Breaks

Both internal and external fire breaks must be kept in such a state that their surface will not carry fire. This means that all inflammable vegetation, such as heather, bracken, gorse, broom,

and the coarser types of grass, must be eliminated or kept right down, even if they are of kinds that will only burn during certain seasons for the year. There are two main ways of checking them, namely mown grass and cultivated fire breaks.

(a) **Mown Grass Fire Breaks.** These are probably the most attractive kind for most private estates. The object is simply to maintain a smooth carpet of good pasture grasses which remain green throughout the year. On many soils these are already present, and all that is needed is to encourage them by cutting or mowing back intrusive weeds of other kinds. In other situations, it is often worth while to establish pasture grasses by cultivating the ground, applying lime or fertilizers as required, and sowing a suitable seeds mixture.

It is important when using grass fire breaks to have a reasonably smooth surface over which machines can operate continuously. An annual cutting back of weeds entirely by hand is quite uneconomic. But on most estates powered mowing equipment is already available, and it will usually be found that one operator can cover the full length of rides involved in a very short time. Machines that are used successfully by many owners for this work include the motor scythes or brush-cutters, the gang mowers designed for cricket fields and golf courses, and even the ordinary tractor-drawn hay mower.

One great advantage of mown grass rides is that, if treated reasonably and not used when the ground is wet and soft, they will support light traffic, such as rubber-tyred tractors and trailers used to haul out small thinnings. It is also possible to drive a car over them, and they provide pleasant walking conditions for sportsmen.

It is not worth while to try to establish grass swards under the shade of trees. By the time that that stage is reached the major fire risk is usually over, and the main kinds of inflammable vegetation will also have been suppressed, and few grasses thrive in shade.

(b) **Cultivated Fire Breaks.** As an alternative to the mown grass fire break, the ground may be ploughed up and then smoothed down with a suitable harrow, or a disc or tine cultivator, or with a combination of these tools to suit local soil conditions. After the initial ploughing, an annual cultivation will often suffice.

This method is appropriate where the ground is too infertile to support pasture grasses. The annual cultivation costs little more than an annual mowing, but the surface is much less suitable for the passage of vehicles, especially when carrying timber, and less pleasant for pedestrians.

Wherever possible, some form of cambering should be brought into the formation of both mown and ploughed breaks. Unless they shed water rapidly, they become soft and inaccessible after a spell of heavy rain.

Where a road follows a fire break, it is best, in most situations, to site it in the centre, leaving a strip of ground on either side that can be mown or cultivated. Such strips will also serve as stacking grounds for poles, etc., cut from thinnings. Exceptionally, the slope of the ground may make it essential to site the road down one side of the fire break.

Fire Belts and Barriers

Belts of trees that do not themselves readily catch fire can be helpful in some, though by no means all, situations. Where broadleaved trees are already established, even if only in the form of hedgerow trees or coppice, it will pay to retain a strip of them as a fire-retarding barrier. But on poor land broadleaved trees grow so slowly in youth that it is worse than useless to plant them at the same time as a conifer crop; instead of providing a tall fireproof barrier, they will only give, for many years, a weedy strip that is costly to maintain and is itself an added fire danger.

Where, however, broadleaved trees are known to do well, they have been shown to give very useful protection. Examples are poplar and birch, both of which have been used effectively as 'spark-catchers' beside railway lines. But it is no use growing them unless local soil conditions are right, and they must be given the same attention as a timber crop.

Japanese larch has proved the most generally useful tree to plant as a fire belt on the poorer ground, particularly in the west. While not in itself fireproof it is fire-retarding since its branches carry no dead needles, and it grows so rapidly that it soon suppresses ground vegetation and lessens the chance of fire at that level.

Other forms of barrier that are worth preserving where they are found, though not worth making specially, include hedges, walls of stone or brick, and ditches or similar watercourses. These, and indeed all other fire breaks, should never be regarded as fire-proof, but only as obstacles to the rapid spread of a blaze that will give fire fighters a chance to check it.

All these belts or barriers are best sited along a road or ride, so that access to them is easy. They seldom extinguish any fire themselves, but they do provide a reasonable line from which to attack it.

Breaking up the Woods with Different Types of Crop

It is a common experience when fighting an actual fire, that its progress goes on unhindered through a crop of one kind and age of tree, but is checked as soon as it meets woods of another

character. That is not to say that it dies out, but rather that it slows down, giving fire fighters a better chance to defeat it. Therefore, where the lay-out and scheme of management of the woods permits, it is a good plan to avoid large homogeneous blocks.

On the same lines, the retention of a strip of pasture between two large woods is a sensible precaution, since it can help to confine any fire to one or the other of them.

The main risk is naturally in young conifer crops up to twenty years of age; it lessens thereafter as the crops get older, suppress ground vegetation, and are thinned out. But in some districts, especially those with peaty woodland soils, fires will spread even under mature pinewoods.

Brashing

Brashing, or the removal of side branches to a height of about six feet, is generally practised in young conifer woods, as an aid to future harvesting. Regarded simply as a fire protection measure, it is very valuable, particularly on the margins of young conifer woodlands which are not on exposed sites. Many fires start among the rough vegetation of rides or woodland boundaries, and quickly climb up into the crowns of adjacent trees. The removal of side branches from a few rows of trees along the edges creates a gap that is less easily crossed. As a further precaution, the 'brash', or dead branches that fall to the ground, can be moved inwards, away from the edge of the plantation. However, side branches down to ground level where the plantations are on exposed sites can be very beneficial and under these circumstances it is preferable to maintain a fire-proof strip along the margins of the wood.

It is sound practice, irrespective of future plans to brash fully, partially, or not at all inside the conifer plantation, to quarter each compartment by a brashed alleyway immediately the bottom six feet of branches have been killed by canopy formation. By an alleyway is meant simply the width between two rows of trees. These two rows need only be brashed half-way round, on the sides adjacent to the alleyway, but the brashings must be pushed back into the crop so as to give unimpeded access down the alleyway. The provision of such internal access is invaluable at the time the crop is growing through its period of maximum fire danger.

Protective Burning

The burning-off of dry vegetation, in early spring, around the margins of plantations, provides a temporary fire-proof barrier that is effective through the following summer; but it must be repeated annually. The operation itself, even under skilled supervision, is always attended by a high degree of risk, since an unforeseen change in wind direction can quickly bring disaster. It should never be regarded as an effective substitute for a proper mown or cultivated fire break. Where it is unavoidable, as for example in connection with the burning-off of a moor or common, a proper fire line should be made and the burning operations commenced outside that. There are now on the market chemicals, known as dessicants, which, 2 or 3 weeks after application, render lush grass dry and burnable. The advantages will be obvious; fire lines can be prepared by burning in the safe summer period, and a long stretch can be dealt with conveniently by utilizing each dry day in variable weather, since the dessicated grass remains burnable for a fortnight or so. These dessicants have a residual fertilizing effect, so that a fresh growth of grass eventually develops on the burnt trace. Some care in timing the summer burn is required to ensure that this regrowth is green during the succeeding fire season, January to April.

Except during the period from November to March inclusive, a licence is required for heather or grass burning in England and Wales. In Scotland muirburn is only allowed during a specific period, which normally runs from 1st October to 15th April. In all circumstances, the proprietors of adjacent land must be notified in advance, and the work may only be done during daylight hours.

Emergency Water Supplies

In many places it is surprisingly easy to arrange a supply of water that will prove invaluable to fire-fighters in dry weather, and to do it at low cost. Quite a small dam, properly sited on a small stream, may hold back several hundred gallons of water and make it possible to fill hand pumps or buckets, or even to supply a power pump for a critical half hour or so. When considering such measures, remember that the drainage of the woods must not be obstructed; while to avoid softening the foundations of a road, a dam should always be sited on the upstream side of a bridge or culvert.

Where ponds, lakes, or large rivers already exist, they can often be brought into the scheme of fire protection by making a short access route, passable to lorries and fire engines.

The desirability of enlisting the help and advice of the local Fire Service on all aspects of natural water supplies, and access thereto, cannot be overstressed.

The Importance of Easy Access

Once a fire starts the main thing is to get a lot of men and equipment there quickly. This is only possible if attention has been paid to ease of access well ahead. Only too often a lorry or a fire engine has been halted, far from the scene of a fire, by a

locked gate, a broken culvert, a fallen bridge, or even a thoroughly bad patch of road. Obviously roadways must eventually be repaired in order to get out thinnings or timber. If they are tackled early on, they will greatly reduce the risk of a fire spreading before people can arrive to check it. Sometimes it is thought desirable to keep gates locked to check trespass or theft; but in most situations the loss that is likely to be suffered from such causes is quite trivial compared to that from one serious fire.

EQUIPMENT AND ARRANGEMENTS FOR FIRE FIGHTING

A modest stock of fire-fighting equipment should be provided for that purpose *and that purpose only*. Otherwise it will always be missing, or broken, when most needed. It is a good plan to paint it red and to label it 'For fire use only'. This nucleus will often be supplemented, in the emergency, by whatever tools people can lay their hands on, but the main point is to have the essentials always ready.

Fire-fighting equipment should always be kept at some central point, such as an estate yard, where people see it daily and everybody knows where it is. It is worth while to design a rack with a space for each item, so that if any are missing their absence can be seen at once. Never lock fire-fighting tools away out of sight. People forget where they are, or if they remember that, forget who's got the key.

The closer equipment can be kept to the likely means of transport, such as car, van, or lorry, the better. One or two owners have equipped trailers that can be promptly attached to the tow-bar of an estate wagon.

The items that should always be at hand are:

(1) Fire beaters.
(2) Bill-hooks, for cutting more beaters.
(3) Axes, for cutting fire breaks through tree crops.
(4) Spades and mattocks, for cutting fire trenches through peaty soil, shovelling earth on to the flames, etc.
(5) Rakes, for raking away surface litter and so quickly forming a fire line on the floor of plantations.
(6) Buckets.
(7) Hand pumps, preferably of the knapsack pattern.
(8) Torches or hurricane lamps for use at night.
(9) Wire-cutters and crowbars to clear obstructions.

Several types of fire beaters are in use, preference depending on local conditions of ground and vegetation. Commonest is the birch broom, made by wiring birch branches on to a springy birch pole some six feet long. It is cheap, and has the advantage that, being useless for any other purpose, it can safely be left in a holder on the edge of the woods, ready for any passer-by to pick up and use; but it only remains serviceable for two years if kept under cover, or for one year if left in the open, and must then be replaced.

Other forms of beater have a wire-netting head, or one composed of sheet rubber or tin, perforated with holes to lessen air resistance. Long-handled shovels are preferred in some districts, while on hillsides with blue moor grass an ordinary sack, moistened at intervals to stop it catching fire, is found best.

On an estate of any size a Land Rover is invariably available. Even if this is intended primarily for the farm manager it will certainly be impressed for service by the forestry staff if a fire occurs in the woodlands. The Land Rover's value for this purpose can be enormously enhanced by installing a simple water pumping outfit, tailored to the body so that carrying capacity is virtually unchanged, and powered by an integral electric pump fitted under the bonnet. This arrangement, using a 20-gallon supply of water and a pistol-type variable nozzle, is purely a first-aid device but, as such, has already proved itself all over the country. Design and component details may be obtained from the Forestry Commission.

Fire Patrol

The maintenance of a fire patrol is an expensive business, especially as overtime rates have to be paid outside normal working hours. On most estates it is probably only worth while at exceptional times, such as Bank Holidays, and then only at such places as are most frequented by the public. For the rest, it is usually obligatory to rely on the ordinary vigilance and responsibility of the estate staff, tenants, and their families. Those who live in positions that give a good view of a major source of fire risk, such as a main road or a railway, can well be encouraged, by tenancy concessions, to keep a constant look-out. It may be worth while to improve existing conditions by equipping them with telephones, or removing occasional trees to enlarge their field of view. Where patrols are employed as such, they should be provided with a bicycle, or better still an estate van, so that they can get to any fire reported or sighted as soon as possible.

The Forestry Commission's experience over many years has been that the greatest risk of fires occurs in the spring months, especially in March, April and May, when vegetation is dry and dry easterly winds often prevail. At all times of year, the afternoon hours are the most dangerous time of day;

this is due to a combination of drier atmospheric conditions and greater human activity, than obtain at other hours. At such times, therefore, special vigilance is necessary.

The major sources of risk can be broadly classed as 'adjacent land', which includes railways, the verges of main roads, and land held by neighbours, particularly in hill country or moorland. A fire arising actually within the woodlands is a much less frequent event. Patrols should therefore be concentrated on the fringes of the plantations.

Each patrolman should be given clear instructions on how and where to report. He should also be advised how to deal with members of the public who are found lighting fires, or smoking whilst trespassing, in or near the woods. A tactful approach here will often result in the friendly co-operation of people who may not appreciate the risks to which woods are subject.

Each patrolman should carry a notebook, which should contain a brief statement of his duties, and a list of useful telephone numbers.

It is a great help to have suitable notice boards, warning the public of fire risks, set at places where they cannot easily be overlooked. Those who persist in lighting fires cannot then protest that they have had no warning. Notice boards may usefully carry an invitation to the public to call for assistance if they sight a fire—the estate's telephone number being shown for that purpose.

Calling out the Men

Arrangements for calling out estate fire-fighters should be as simple and informal as possible, but every man should know what his job is. There will always be key men, such as the owner himself or his estate forester, who will take a leading part; but arrangements should never depend on the presence of any one individual, who may be absent at the critical time for any one of a dozen good reasons. Normally, the forester will rush out to the fire himself, driving the vehicle carrying the fire-fighting tools and taking with him as many men as he can find in a few minutes. In his absence one, or preferably any one of two, estate workmen should have the responsibility of getting the tools there.

The rest of the staff should be under instructions to go at once to the scene of any suspected fire by whatever means is quickest. As a rule the word is soon passed around, or they see the smoke rising, Some kind of audible fire warning, such as a ship's siren or even a loud whistle or a huntsman's horn, may help here. It is always wrong to waste time getting a big gang together—the fire will be growing much faster than the band of helpers. A few determined men, soon on the spot, will have a much smaller task in front of them, and can do more good than a score or more, half an hour later.

Telephone Calls

Before going to the fire, the forester or other person in charge must make sure that the fire brigade is being called in. If, as in practice usually happens, he leaves this job to his wife, he must make sure she knows where the fire is believed to be. The phone number of the brigade should always be kept handy; if in doubt dial 999 and ask the operator for the Fire Station.

Even if there is some doubt as to the location of the fire, or whether it is a wildfire at all, the Fire Brigade should still be notified immediately, without the delay that may be involved in confirmation or cancellation. Almost all Fire Brigades prefer what occasionally turn out to be bona-fide false alarms to delayed calls, but if there is any doubt on the point, enquire of the County Chief Fire Officer or Firemaster.

Fire Fighting Methods

The most effective method of fire-fighting that can be followed by a small gang of men equipped with simple hand tools, consists of beating, coupled with the use of limited supplies of water. Practically every forest or moorland fire develops two flanks. By concentrating the men on one flank of the fire, it is usually possible, amid vegetation and trees up to a few feet high, to beat down the blaze from a reasonably cool position. It is essential that the men should beat together, and advance slowly along the line of fire towards its head. Thus they can check its spread first on one side, and then tackle the other.

If water is available from knapsack pumps or a small power pump, it will greatly simplify the task of beating. Always use limited water supplies as an aid to beating; they won't go anywhere at all if you try to put the fire out with water alone. An assault on the blaze by water alone is only effective if the big pumps of a fire brigade arrive, and then only if they have unlimited water supplies to draw on.

The Land-Rover first-aid water equipment, mentioned earlier, is designed to use a little water efficiently. By aiming the pistol-nozzle at the roots of the flames a 3-second burst either with the jet or fan-spray can achieve impressive results, especially when used on the hottest spots holding up men using beaters. The 20-gallon supply of water may well last 20 minutes, using this technique.

Conditions at the front or head of an advancing fire are usually too hot for beaters to face. But eventually it is sure in this country to come up against some barrier such as a road or a stream, where its advance is temporarily slowed down and its force is slackened; then attack becomes possible.

Attention should also be given to the farther side of the barrier. It is only too easy for odd sparks to jump across and to start a fresh blaze.

While beating has, from long usage, become the commonest form of fire-fighting, the use of earth can be equally or more effective under certain conditions. Mineral soil, free from humus, thrown in spadesful or flicked as a shower over a wider area, will reduce the temperature of the burning fuel, or cut off oxygen by sheer smothering action. This technique can be particularly useful where there is much coppice or rocky outcrop or any other such feature making beating impossible or less than normally effective.

If a fire gets into plantations much above waist height, beating and the use of earth become very difficult, and unless ample water is available it is best to concentrate all men, and all efforts, along the fire breaks around the block concerned. Provided the fire can be kept within these, the loss is unlikely to exceed thirty acres. Whereas once it gets across only one barrier another thirty acres or so is soon involved. Therefore vigilance and effort should be concentrated on the 'safe' side of the break, to stop sparks jumping over.

Counter-firing, that is the deliberate lighting of a fire in advance of the main outbreak, should only be done as a last resort, and only on the authority of the owner or his forester in charge. It should only be attempted from a good fire-break, and only when ample men are at hand to control the counter fire. The object is to create a burnt-out strip, in advance of the blaze, so forming a gap too wide for the flames to jump.

Training Fire Fighters in Advance

Beating is far more effective if done by a trained gang. It is well worth while to take a few hours off each spring for an exercise of this kind. It can often be carried out on some odd spot of waste ground. But it is as well to advise the fire brigade in advance, to save them a possibly unnecessary journey! It is better still to invite the local fire brigade to participate in the exercise. The training should be made as realistic as possible, and include the reporting of the fire and the transport of men and tools to its scene. It provides a good opportunity for refreshing the men's ideas on the right course of action.

All estate staff should be told what to do if they come across a fire starting. The most useful general rules are:

(1) If you see a fire starting, tackle it.

(2) If after a few minutes it is clearly beyond your control, leave it and report it immediately.

(3) If there are two or more of you, one should run to report it, the rest should continue to fight it.

Reliefs and Refreshments

Fire-fighting is hard, hot, and thirsty work, and men must not be expected to endure more than an hour or two of it without respite. If a fire is going to last any longer, arrangements must be made for them to take short breaks, in turns, during which time they can be given liquid refreshment. There is some truth in the remark heard at one serious conflagration, that what was needed to get it out was not more water, but more beer!

Precautions after the Main Fire

Once the main blaze is under control, it is most unwise to relax precautions. Men are tired, and outside help wishes, not unnaturally, to go home. But burnt logs can smoulder for hours, or even days, and so can peaty soil. It is essential, therefore, to keep a few men on the spot to tackle chance new outbreaks, until such time as all risk of flare-up is removed. This work—which will often involve overnight vigilance—should be properly organized, with provision for the men to be relieved at set hours. It is important that a proper job of work should be arranged; nothing is more demoralizing than just hanging around, especially during the midnight hours. A particularly useful job of this nature is the cooling down of hot spots, be they earthy or smouldering roots and fallen trees, by shovelling on earth and then turning this fresh cool earth, mingled with the hot debris, over and over until the temperature of all parts of the burnt area is such that a bare hand can be plunged into it without discomfort.

Payment should always be offered to outside helpers, even if they have come as volunteers, for the work they have put in. It may also be advisable to compensate them for damaged clothing.

CO-OPERATION WITH OUTSIDE AGENCIES

Fire Brigades

The local fire brigades have a general duty to assist in the prevention and extinction of forest fires, in exactly the same way as they have for other forms of property. Their help can be most effectively given only if they are familiar with the property at risk, know who owns it, and how best to reach it. Therefore, every prudent proprietor should get in touch with his County Fire Officer (in England and Wales) or his local Firemaster (in Scotland), and arrange for him to inspect the woods and discuss whatever special risks are involved. It is a good thing also to provide the fire service

with a copy of the forestry Plan of Operations, or such parts of it as the Fire Service prefer, especially as quite a number of the sections should have been compiled in collaboration with Fire Service personnel. Once this very useful contact has been made, it should be renewed annually before the start of the spring fire danger season and the occasion used to ensure that any alterations in arrangements are fully understood on both sides.

Police

The police should be notified as soon as a fire of any size occurs. They can give valuable help in such matters as communications, traffic control, and the summoning of military aid should the fire become really serious.

Forestry Commission

Although the Forestry Commission is not directly responsible for fire control on private estates, it is always willing to give advice, free of charge, on the fire protection problems of any particular property. Where privately owned woodlands lie close to Commission forests, the Commission is always ready to work out some scheme of mutual assistance. Enquiries on these matters should be addressed to the local District Officer.

Where, despite proper precautions, a plantation established with the aid of a Commission grant is destroyed by fire, the Commission is prepared to make a further grant towards the cost of replanting.

Neighbouring Estates

Where one's neighbours also have plantations exposed to the risk of fire, it is very advisable to consult them and agree on a common plan. Fire is no respecter of estate boundaries.

Insurance

Several groups of fire insurers are now able to forecast the likelihood of loss by fire in plantations of various kinds, and to quote reasonable premiums for insurance against loss. Enquiries regarding such insurance cover are handled by most brokers and by certain tariff companies. It is feature of all such insurance schemes that the owner must not select only his most vulnerable woods for protection; the risk must be fairly spread over woods of various types.

Compensation

If it can be established that a fire arose through the operations of some individual or concern, such as the careless owner of adjoining land, substantial compensation may be claimed. The amount payable by railways, is, however, limited to £200 for any one fire. In all cases, it is advisable to lodge notice of claim as soon as possible after the event.

Salvage

Not all fire-damaged material need be written-off. It is often possible to salvage some for low-grade uses. The sums received, however, will rarely do more than pay for the cost of clearing the ground.

PART III
UTILISATION

Chapter 17
LICENSING OF FELLING AND GENERAL MARKETING ARRANGEMENTS

LICENSING

Felling licences are governed by the Forestry Act, 1951. Not all tree felling, however, requires a licence, and most of the exceptions are set out in Section 2 of the Act. For example, no licence is needed to cut down dangerous trees, trees growing in orchards or gardens, small trees below 3 inches diameter (4 inches in the case of silvicultural thinnings), or for cutting coppice or underwood below 6 inches diameter. Furthermore, no licence is required if the amount of timber to be felled in any calendar quarter, irrespective of the size of the trees, is less than 825 cubic feet, provided the owner is not going to sell more than 150 cubic feet of it; neither is any licence required if the felling is in accordance with the plan of operations for dedicated woodlands. And, should there be any doubt about it, no licence is necessary to cut up trees that have blown over, even if a whole wood has blown down.

Most other fellings must first be licensed by the Forestry Commission, and the regional Conservator, whose address is given at the end of this Bulletin, should be asked for the necessary Application Form. An example of a Felling Licence Application Form is given as Appendix III to this Bulletin, and if an owner thinks that any part of it will be difficult to complete he should consult the Conservator when applying for the form.

Licences are often conditional on the land being replanted after felling, but the owner is always consulted before any condition is imposed and if he objects to the proposed conditions he will be advised as to the course of appeal open to him.

Except when the trees are covered by a Tree Preservation Order, forestry work is not subject to control under the Town and Country Planning Acts.

Nevertheless timber felling can seriously change the appearance of the countryside, so the Forestry Commission consults local planning authorities about many applications for licences, especially when the trees are in a particularly beautiful area. This consultation often results in the owner being asked to make alterations to his proposed felling, thus averting the need for a Tree Preservation Order. And on those occasions when the felling would ruthlessly damage the scenery, as, for example, when it is proposed to remove all hedgerow timber from a wide area, it enables the local authority to take control by means of a Tree Preservation Order.

GENERAL MARKETING ARRANGEMENTS

The planned marketing of produce is essential if markets are to be supplied with sufficient regularity to give confidence and price stability.

The first consideration in the preparation and sale of forest produce is for the owner to study the demand for timber either locally, regionally or nationally, and then to see which types of demand he can best and most profitably meet from his own woodlands. The amount of time and energy which must be spent studying potential markets and finding out ways and means of supplying them depends on which of several methods of sale is adopted. An owner may sell his trees standing in the wood or felled 'at stump' or 'at roadside' to a merchant, or he himself may manufacture and sell the finished product. No one method can be recommended as being in all circumstances better than another, and on the same estate it may be best at any one time to use different methods for different lots of timber.

The following private woodland owners' organisations offer advice on marketing problems and disseminate information on existing markets to woodland owners. Their services are normally available to members only. The Timber Growers' Organisation, whose headquarters is at 35 Belgrave Square, London, S.W.1., undertakes this work on behalf of woodland owners in England and Wales, while the Scottish Woodland Owners Association, 6 Chester Street, Edinburgh 3, offers similar assistance to timber growers in Scotland. They prepare statistics on sales, and on the cost of harvesting and conversion.

Standing Sales

The sale of trees 'standing' to the merchant, apart from its simplicity, has two great virtues; firstly it enables the owner to know at once what he is getting for his trouble in growing the timber, and secondly it involves him in the least outlay, worry, work and risk. The timber to be sold is marked, tree by tree, in a thinning, or by marking the boundaries of the area in a clear felling. In marking the thinning, and within the rather wide limits of good silvicultural practice, attention must be given to the customer's possible requirements—in this case the timber merchant's.

The volume of the trees marked must then be obtained, keeping separate records for each species and major size-class. If the owner, his agent or his forester is not knowledgeable about the correct methods of estimating the volume of standing timber, then the services of a forestry consultant should be sought.

As noted above application must be made for a licence to fell timber—and it is wise to obtain, before any measurements are made, the necessary application form from the Forestry Commission. (See Appendix I, page 98).

The decision must now be taken whether to offer all the timber in one parcel or divide it up into separate parcels. The object of offering separate parcels is not necessarily to try to get different merchants to purchase different lots, but to allow for this contingency if one single purchaser cannot be found for the whole of the timber on offer. Such cases are bound to arise, especially if the timber being sold comprises two such widely different types as small conifer thinnings and mature hardwoods.

Each parcel must now be described separately. It is usual to give, for each species, the estimated number of trees, the estimated volume of the average tree and the total estimated volume. Division of the volume, by species, into quarter-girth classes is often helpful to owner and merchant in arriving at the price to be paid.

The conditions under which the timber is to be sold should be drawn up, bearing in mind that whilst the owner must safeguard his position and cater for contingencies, every unnecessary restriction he imposes on the buyer will reduce the price he will be offered. The conditions of sale should be notified to interested merchants before they inspect the timber.

Contracts for Standing Sales

When tenders have been received, and the owner has decided which to accept, a legally binding contract incorporating the conditions of sale should be drawn up and signed.

It is not possible to give in detail all the points which should be covered in an individual contract. The following is a list of the items which are usually covered.

(1) General description of the timber included in the sale. A precise description of the boundaries of stands, of the method used to mark thinnings, and details of volumes, should all be given. Method and time of measurement, e.g. before or after felling.

(2) Purchase price: Method of payment—lump sum or per cubic foot; terms of payment (e.g. cash in advance or by instalments); method of invoicing; point at which the ownership of the timber passes from the grower to the purchaser.

(3) Period of contract: Date of entry by purchaser; completion date for the whole contract, and dates for completion of specified parts; and date for removal of produce and purchaser's equipment.

(4) Logging requirements: Standard of workmanship required, e.g. height of stumps; disposal of lop and top; avoidance of damage to remaining trees, ditches, streams, fences, dykes, etc.

(5) Access routes: Clear indication of which access routes, belonging to seller, may be used and under what conditions. Repairs to and maintenance of access routes.

(6) Working sites: Indication of sites owned by seller which may be used by purchaser, and conditions attached thereto, e.g. sites for stacking, seasoning, loading, erection of sawmills and other buildings. Provisos regarding entry on seller's land let to tenants.

(7) Claims: Settlement of third party claims for damages caused by purchaser or his servants and claims for damages to seller's property including standing trees not in the sale. Claims by purchaser for improvements carried out by him. Descriptions of the conditions of the seller's properties, e.g. fences, gates, roads, buildings, will be required to facilitate subsequent settlement of claims. Such descriptions must be agreed by the purchaser.

(8) Fire precautions: Fire precautions to be observed by purchaser and his servants, including liability of the latter to assist in extinguishing fires.

(9) Animals: Restrictions on use of or keeping of animals on the estate by purchaser or his servants.

(10) Sub-Contractors: Limitations on employment of sub-contractors by purchaser: Obligations by sub-contractors to observe the general conditions of sale.

(11) Penalties: Penalties for non-compliance with contract.

(12) Arbitration in the event of dispute.

Sales after Felling

There are a number of reasons why an owner may not wish to sell timber standing. He may wish to find employment for his men during the worst months of winter, or he may wish to convert the timber in his own sawmill. The felling may have to be carried out with extreme care to avoid damage to natural regeneration, or the trees available for sale may be too scattered to attract a timber merchant. Whatever the reasons, and assuming that the trees are to be converted by the owner into produce such as pit-props, fence posts, stakes, strainers or sawlogs, the first step is to find a purchaser for the produce. The necessity of finding markets for produce before any tree is felled cannot be too strongly emphasised.

Assuming that markets have been found, tools and equipment must then be assembled and men made available. Considerable knowledge is needed to choose the right types of tool, and the work will call for a considerable degree of skill on the part of the forest worker. The wrong types of tool or poor tools in untrained hands can only lead to financial loss.

It is almost impossible to overstress the dependence of the profitable preparation of produce on the competence and experience of the forester or woodman in charge; a good supervisor can often make a success of these operations, where an inexperienced man would fail. Unless the amount of work and the labour force justify the employment of a competent supervisor it is often best not to attempt this type of work. There are few more certain ways of losing money than to employ unsupervised labour, unless the men are thoroughly skilled and completely reliable.

The question of transport to the consumer will have to be considered. If the sale is made to or through a timber merchant it will often be found that he is willing to arrange collection from any point in the forest accessible to road vehicles, but many consumers will not collect. Provision must therefore often be made by the owner to deliver prepared produce, either in his own road transport or through a road haulier. The latter course is to be preferred unless the vehicles can be kept fully employed on the estate. In negotiating or quoting prices the owner should find out whether he is to do the loading of the customer's vehicles, when he should quote a 'free on transport' (F.O.T.) price, or whether he has to deliver the produce ('delivered price'). If the customer is to collect and do his own loading, the quotation or negotiation should be for timber or produce 'at roadside'.

Some owners, not wishing to sell their timber standing, prefer to sell the whole tree at stump or at roadside or rideside, rather than to convert the trees themselves. A purchaser should be found before the trees are felled. The sale should be the subject of a contract, between the owner and the purchaser, covering the same points as for a standing sale.

PRICES

In a number of European countries the general level of timber prices, so far as these affect the forest owner, is in the main decided either at the annual auctions of standing timber in State forests or at the annual price negotiations conducted between the associations of merchants and of owners.

In Britain statistics on prices paid for timber grown on private estates are collated by the Commonwealth Forestry Institute at Oxford and the Department of Forestry at Aberdeen University as well as by the two woodland owners' associations. Prices paid for its own standing softwoods are published regularly in the trade journals by the Forestry Commission.

National mining timber price agreements are negotiated periodically between the National Coal Board on the one hand and the home timber trade on the other. Details of these price agreements are published in the leading forestry and timber trade journals from time to time. Details may also be obtained from the National Coal Board, Purchasing and Stores Department, Timber Branch, 20 Albert Embankment, London, S.E.1.

Intrinsic quality apart, there are a number of factors such as species, whether the stand is pure or a mixture, ease of access, size of parcel, and local or regional demand, which have to be taken into account in deciding on the market value of a parcel of timber, and it is impossible to list them in any order of priority since each factor will have a greater or less effect on price in different circumstances.

Home produced timber accounts for only a small part of the country's total needs; the level of imported timber prices has a strong influence on the general level of home timber prices. The needs of the individual merchant for a particular parcel of timber will always play a big part in deciding the price he is prepared to offer; if he has already bought heavily he will probably only be interested in further purchases at a bargain price. Should his order books for sawn timber be full and his stocks of round logs low, he may be prepared to buy some not too large parcels at a higher price than normal, in order to keep the goodwill of his customers and employ his

resources whilst he looks around for larger quantities at a more reasonable price. In the absence of any marked fluctuations in imported timber prices, and when supply and demand are in balance in the home trade, ease of extraction and proximity to markets weigh heavily with the merchant in deciding price, quality for quality, of the standing timber. The conditions of sale, over which the owner himself has a fair degree of control, also have to be reckoned with. In the same vein, care taken in making up the various lots in a sale always pays. The timing of a sale is important, particularly with hardwoods where winter felling is often preferred; adequate time must be allowed for the timber to be inspected and for details of the contract to be negotiated with the successful merchant. Care taken in arranging for thorough inspection of the parcel and extraction routes is usually well worth while.

The sale of timber, as with every other sort of sale, also carries with it the indefinable but none the less extremely important element of service. Thus it may often be more profitable in the long run to offer continuity of supplies at a fair and reasonable figure rather than to attempt to secure the highest possible price on an *ad hoc* basis; especially, but not exclusively, is this true of sales of prepared produce, where customers will look for regularity and punctuality of supply and an adherence to the specification.

The appraisal of all these and other relevant factors is an expert job and, where the estate itself lacks the necessary experience, the services of a consultant or one of the woodland owners' organisations should be sought.

Chapter 18
USES OF TIMBER

A DISTINCTION must be made between the possible uses to which home-grown timber may be put, and the existence of a market for any particular assortment of timber at any one time in any one place. Unless he is to use the produce on his own estate, the owner must in all cases satisfy himself what markets are in fact open to him at the time, *before* embarking on the preparation of produce. Not only would a full list of possible uses by sizes, species and specifications be too unwieldy to include here, but it would be of doubtful value to the owner. However, a selection of some of the commoner items is given below in order to give a guide to possible categories of produce:—

Saw Timber, Including Sawn Mining Timber

Hardwoods. There is a large market for sawn hardwood mining timber in Britain. This provides a useful outlet for the lower qualities of hardwoods in a considerable range of sizes if the material is prepared to the National Coal Board's specifications. The manufacture and marketing of hardwood sawn mining timber is, of course, a job more for the timber merchant than the estate owner, unless he has an estate sawmill and a sales organisation.

The remaining markets for home-grown sawn hardwoods are considerable, and include, for example, furniture manufacture, cooperage, railway wagon repair, wood turning, general estate use, building construction, pallet and stillage manufacture, and, to a lesser extent, vehicle body building, shipbuilding, box-making, and dunnage.

The greater part of these demands is for timber of good quality, accurately sawn, adequately seasoned and delivered promptly at a competitive price; with few exceptions, the job of converting the log into sawn lumber is best left to the timber merchant. Generally speaking it is difficult to dispose of saw logs cut from trees less than 8 inches quarter-girth at breast height, unless there is a shortage of larger trees. While as long lengths as possible are desirable, much of the imported sawn hardwood comes in in lengths of 6 to 10 feet. Lengths of 18 feet are required for some of the traditional home-grown hardwood markets. As the timber merchant's requirements for saw logs will vary from time to time, the owner, if he is to carry out his own felling and cross-cutting, must first find out what lengths and diameters of log are wanted at the time.

Softwoods. The imported timber with which home-grown sawn softwoods have to compete is freely available in lengths of 11 to 17 feet, the Scandinavian range going up to 21 feet and West Coast Canadian up to 24 feet—without considering special lengths. It follows that the home merchant would prefer the bulk of his saw-logs to give a comparable range of lengths. He will, however, generally have a market for a limited quantity of shorter lengths, and softwood saw-logs in sizes as low as 6 feet long by 6 inches top diameter under bark are accepted by some timber merchants.

The market for sawn softwood mining timber can absorb a considerable quantity of softwood, low-grade saw-logs from early thinnings, and also waste

arising during the conversion of round to sawn timber.

As with hardwoods the job of sawmilling is one generally best left to the home timber trade.

Round Mining Timber or Pitprops

There is virtually no demand for round hardwood pitprops, but the demand for round softwood timber for use underground in mines provides one of the most important outlets for softwood thinnings in Britain. Pitprops generally have a slenderness ratio of one in twelve, i.e. the top diameter in inches is equal to the length in feet. However, the needs of an individual pit or group of pits will vary from time to time, and the sizes currently in demand should be ascertained and an order obtained *before* poles are cut into pitprops. Owners who are entering this market for the first time, and who do not know how to obtain this information on sizes, are well advised to seek help and advice from a forestry consultant or from the Timber Growers' Organisations or the Scottish Woodland Owners Association, a local timber officer of the National Coal Board, or to sell through a forestry co-operative society or a timber merchant.

Pitprops are generally required to be delivered to the collieries peeled and in a seasoned condition, but especially in South Wales round softwoods are also purchased as unpeeled 'tonnage' wood. Peeled pitprops vary in size mainly from 2 feet by 2½ inches top diameter, under bark, to 9 feet by 8 inches t.d.u.b., the greatest usage being of props of 3 feet by 3 inches to 6 feet by 6 inches.

Pulpwood, Fibreboard, Chipboard, Wood-wool, and Wood-wool Slab Material

In recent years the increased production from privately owned and Commission forests has resulted in the setting up of new paper and board industries in various parts of Britain; some of them use home-grown timber exclusively. The specifications for raw material, even between plants manufacturing the same product, are varied, and are sometimes amended in the light of experience or of changed marketing conditions. *It is therefore important to obtain details of the specifications and prices applicable, at any one time, to any individual factory, direct from the firm concerned.*

It is also essential to agree with the firm, in advance, the method of payment, e.g. by weight or volume, and the condition of the timber at the time of delivery, e.g. fresh-felled or otherwise.

Paper Pulp. The spruces are the main species of softwoods required, but other species are accepted locally on occasions. The range of diameters is from 3½ to 12 inches under bark and of lengths from 37 to 48 inches.

There are two hardwood pulpmills in Britain. One, in Monmouthshire, accepts broadleaved species such as oak, ash, beech, birch, Sweet chestnut, sycamore, elm, alder and lime, in lengths of 3½ to 4½ feet, and diameters of 3½ to 12 inches over bark. The other, in Kent, accepts most home-grown hardwoods other than oak, in lengths of 3½ feet and diameters of 2 to 10 inches under bark.

Fibreboard. For fibreboard manufacture most conifers and certain hardwoods (in mixture) are acceptable; other species of hardwoods such as oak may be specifically excluded, and in some cases hardwoods are only acceptable if they comprise less than a specified proportion of the total deliveries. The range of diameters can go as low as 2 inches under bark and as high as 12 inches, and lengths may be down to 3 feet and up to 14 feet.

Chipboard. For the manufacture of chipboard, other than that made exclusively or mainly from industrial wood waste, coniferous roundwood is preferred. The minimum diameter acceptable is about 1½ to 2½ inches under bark, and the most common length is 6 feet 6 inches.

Wood-wool and Wood-wool Slab. There is considerable variation in the sizes and species required by the different manufacturers, but the pines are generally preferred. The timber is required to be straight, seasoned, free from large knots and cross-cut square with the length. The acceptable diameters usually fall between 6 and 11 inches under bark.

Fencing Materials

Cleft Chestnut Fencing. Good clean well-grown standing Sweet chestnut coppice from 12 to 16 years old, is in demand by paling makers mainly in the counties of Kent and Sussex, and also to a lesser extent in other southern counties of England. Stakes to support the fencing vary from 4 to 6 feet in length, by 2½ to 3 inches top diameter, and may be of species other than chestnut. The addresses of chestnut fencing and hazel hurdle manufacturers (see below) can be obtained from the Rural Industries Bureau, 35 Camp Road, London, S.W.19.

Hazel Garden Screens and Hurdles. Hazel coppice from 6 to 10 years old, if of good quality, may be sold standing for the manufacture of wattle hurdles and garden screens, mainly, but not exclusively in the southern counties of England. Stakes are required to support the hazel screens or hurdles, as for chestnut fencing.

Post and Rail Fences. A typical roadside morticed cattleproof fence calls for sawn posts 6 inches by 3 inches by 7 feet long; ; with 9-foot rails sawn 3½ inches by 1½ inches; and intermediate or prick posts 3½ inches by 1½ inches by 6 feet.

For motorways, the minimum cross-section for

posts is 6 inches by 3 inches or 5 inches by 4 inches in 7 feet 6 inch lengths; rails are required to be 3½ inches by 1½ inches if in hardwood, or 4 inches by 1½ inches if in softwood. All species must be treated with preservative under pressure, except that oak rails may be used untreated if so specified, but in this event they must be free from sapwood.

Where nailed post-and-rail fences are prepared for use under the Ministry of Agriculture and Fisheries and Food, and the Department of Agriculture and Fisheries for Scotland's *Farm Improvement Scheme*, sawn posts must have minimum dimensions of 5½ inches by 2½ inches by 6 feet 6 inches (or if half-round timber is used two rails may be cut from a log at least 6 inches in diameter under bark); the rails must have a minimum cross section of 3½ inches by 1½ inches (or if half-round two rails may be cut from a pole 4 inch minimum diameter under bark). All round or half-round, and sawn or cleft material of most species, must be treated with a preservative by an approved process before it can qualify for a grant under this scheme.

Post and Wire Fences. A typical specification calls for posts 5½ feet long, square sawn 3 by 3 inches, or 3½ by 3½ inches in cross-section, or quartered from 7 to 8 inch top diameter material; or round with a 3 to 3½ inch top diameter or half-round with a 4 inch face at top. Straining posts are sawn 6 by 6, or 7 by 7, inches in cross-section or more commonly, round 7 to 8 inches minimum top diameter; all by 7 to 7 feet 6 inches in length.

Where post and wire fences are prepared for use under the Ministry of Agriculture, Fisheries and Food and the Department of Agriculture and Fisheries for Scotland's *Farm Improvement Scheme*, the intermediate posts must be at least 5 feet long and have a minimum top diameter of 3 inches (or a minimum cross-section of 3 inches by 3 inches if sawn), straining posts must be 7 feet long and have a minimum top diameter of 7 inches (or a minimum cross-section of 6 inches by 6 inches if sawn), and struts must be at least 6 feet long and have a minimum diameter of 4 inches (or a minimum cross-section of 4 inches by 4 inches if sawn). Except where droppers are used, the struts must be at least 9 feet long.

For deer fencing, posts may be 8½ feet long by 3 inches by 3 inches or the equivalent in quartered material, with straining posts 9 inches top diameter by 10½ feet long.

General. Many variations will be found in the size and specifications of fencing timber. The use of cleft ash rails in parts of England is a case in point. Where no preservative treatment is contemplated, the species most commonly in demand are oak, sweet chestnut and larch; all should contain a high proportion of the naturally durable heartwood.

Where preservative treatment of less naturally durable species is contemplated, round material of practically any home-grown timber may be used, since the outer sapwood layers of most woods can be readily impregnated. Where sawn fencing material is specified, and is to be impregnated by a non-pressure process, the spruces, hemlock and Douglas fir may be excluded because these species take preservative satisfactorily *only under pressure*.

Telegraph Poles

The Post Office is prepared to consider purchases by tender of home-grown telegraph poles from private estates provided that the lots offered contain 100 or more poles. Scots pine poles are preferred, but Douglas fir and European larch are also acceptable. A high standard is required.

Woodland owners wishing to supply this market should contact the Director of Contracts, Telephone House, Temple Avenue, London, E.C.4, from whom tender forms, conditions of tender and specifications may be obtained.

Turnery Poles

Some turneries are prepared to accept their material in the pole length. Except for hazel, which is accepted in diameters of 1 inch and up, the smallest size of pole normally acceptable is a pole of 3 inches top diameter by 6 feet 6 inches in length. Birch, ash, sycamore, beech and hazel are among the hardwoods accepted in the round.

A second type of turnery material is also used—the turnery square. This is sawn from conventional sizes of saw log, and in addition to the species mentioned above, home-grown oak, elm, alder, lime, walnut, horse and sweet chestnut, willow, cherry, apple, pear, holly, laburnum and poplar are used. Softwoods are not acceptable for the turnery trade.

Rustic Poles

Near big towns there is much demand for poles for the manufacture of rustic and pergola work. Such work is commonly of softwood, especially larch, although hardwoods may be used. A common size range is from 8 feet to 20 feet in length with a top diameter of ¾ inch, butts from 1½ to 4 inches. Smaller sizes are also used for filling-in, in some types of rustic work.

Hedging Materials

In districts where fields are bounded by hedges there is a demand for such items as hedge stakes in bundles of 20, length 4 to 4 feet 6 inches by 1½ inches top diameter; and heathers, 1½ inches butt diameter up to 12 feet in length. Sizes and specifications vary

with the locality; coppice-grown material is specially suitable for conversion into these classes of produce.

Horticultural and Agricultural Poles and Stakes

There is throughout the country a demand by amateur gardeners, market gardeners and professional nurserymen for poles and stakes of many species and sizes. The demand extends to agriculture where the drying of hay and corn is often carried out, particularly in Scotland, on the four-legged stands commonly called 'tripods'.

Poles for the drying of hay and peas. These poles are assembled into so-called tripods on which the hay or peas are hung to dry. The majority of poles used are 6½ feet by 1¼ to 1¾ inches top diameter. Some designs call for 2 inch diameter material, the lengths required varying according to the design of the structure; but with such diameters generally 7 to 8 feet pieces are needed. Softwoods are used much more frequently than hardwoods.

Stakes. Commonly used stake sizes run from 4 feet by 1½ inches top diameter to 7 feet by 2½ inches top diameter.

Longer stakes used, for example, to prop up fruit trees, or to fence in poultry, may be anything up to 10 feet in length with a top diameter of up to 4 inches. Of the commoner species, sweet chestnut, oak and larch containing a proportion of heartwood give the longest life, but other less naturally durable species are also in demand. In some localities there is a growing demand for non-durable species treated with a reliable wood-preservative, the extra small cost being far offset by a much longer life in service.

Pea sticks. Sold bundled, often 25 to the bundle; 4 to 5 feet long. Commonly prepared from the trimmings arising from the working of the chestnut, hazel or other coppice species or from the clearance of hardwood scrub. Branches of spruce, Douglas fir and other conifers may also be used, especially in regions where coniferous woods predominate.

Bean rods. Sold bundled; often 25 to the bundle. Length 7 feet and over by ¾ to 1 inch top diameter. Commonly of hardwood.

Hop poles. Length 16 to 20 feet. Top diameter 2½ inches to 5 inches. Traditionally of Sweet chestnut, although larch is also used. The butts of hop-poles are usually treated with creosote—often by hop-farmers themselves—to give extra life to the sapwood layers.

Other Forest Produce

A few tanneries, mainly in rural areas, purchase oak bark. It is only possible to strip the oak bark during the late spring and early summer when the cambium is actively dividing. It must be thoroughly air-dried before delivery; and it must *always* be stacked with the outer surface uppermost as rain will wash away the valuable tannins from the inner surface.

Foliage of Western red cedar, Silver firs, Lawson cypress and holly can often be marketed to the florist trade for the manufacture of wreaths and decorations. Christmas trees are another example of a profitable ornamental market.

Chapter 19
TIMBER PRESERVATION

WOOD is a chemically stable material which under many conditions can be expected to have an almost indefinite life. It is, however, liable to attack by wood-destroying fungi and insects. Although, under certain circumstances, marine borers, the common furniture beetle, the house longhorn beetle and other insect pests can cause considerable damage, attacks by wood-rotting fungi constitute a much more widespread danger in Britain.

Since most fungi cannot develop in wood which has a moisture content of less than 20 per cent, the use of thoroughly seasoned timber will minimise the danger of attack, but if immunity is to be maintained indefinitely, the timber must be kept below the critical moisture content throughout its period of service. Where this is not possible, incidence of decay can easily be reduced by impregnating the wood with a suitable preservative. And it is fortunate that most of the chemicals which prevent fungal attack effectively, also inhibit attack by wood-destroying insects.

Some of the practical aspects of preservative treatment in relation to estate use are discussed below.

TIMBERS USED IN DIRECT CONTACT WITH THE GROUND

The comparative life of different species of home grown timbers when used, untreated, in direct contact with the ground has been estimated by Forest Products Research Laboratory; the main findings are shown in Table 12 below. The data refer only to heartwood; the sapwood of all species is perishable and would come in Col. (1). The posts used in the experiments were 2 by 2 inches in cross section; posts of larger section would last longer. In general the increase would be considerable with timbers in Col. (3) and (4) but only small with the others.

TABLE 12

ESTIMATED LIFE OF HEARTWOOD TIMBER USED IN DIRECT CONTACT WITH THE GROUND

Useful Life in Years			
Less than 5 years	5-10 years	10-15 years	15-25 years
(1)	(2)	(3)	(4)
Conifers			
Sitka spruce	Silver firs Douglas fir Hemlock (*Tsuga*) Norway spruce Scots pine	Larch (all species) Californian redwood (*Sequoia*)	Yew Western red cedar (*Thuja*)
Hardwoods			
Alder Ash Beech Birch Elm Hornbeam Horse Chestnut Lime Plane Poplar Sycamore Willow	—	Turkey Oak Walnut	Oak Sweet Chestnut

Timber which is in direct contact with the ground will almost always have a moisture content of more than 20 per cent, and will therefore be in constant danger of fungal attack. As suggested above, the only way of appreciably lengthening the life of timber in such conditions is to adequately impregnate it with a suitable wood preservative. Indeed it is common experience to find that after proper preservative treatment many non-durable species give a longer life in contact with the ground than species of high natural durability, which have not been treated.

It is not necessary, nor is it always practicable, to impregnate the timber throughout. But it *is* necessary to obtain sufficient penetration of the preservative to ensure that subsequent splitting or abrasion will not unduly expose untreated wood. Impregnation may be done under pressure or in an open tank. For timber to be used in contact with the ground, surface treatment by brushing, spraying or dipping is *not* recommended.

Choice of Method

The choice between pressure and open tank treatment will depend largely upon the permeability of the species to be treated and the life required of the timber in relation to the hazards to which it is exposed. In no case will the open tank process give better results than the pressure process, but as indicated below, a fairly wide range of species can be treated by the open tank method to give a long service life even when the timber is to be used in directed contract with the ground.

If a life of over 20 years is contemplated, and the timber comprises *heartwood* or mainly *heartwood*, then only the pressure process is likely to raise the performance of the following species to the desired level, i.e. a minimum retention of creosote of 10 lb. per cubic foot: Norway and Sitka spruce, Douglas fir, poplar and willow.

The open tank method properly applied should give similar results for the *heartwood* of the following species: Scots pine, ash, elm, birch, the Silver firs, beech, hornbeam and sycamore.

With the exception of the larches, the *sapwood* of all species listed in Table 12 above can be impregnated by the open tank method to give an absorption of 10 lb. or more of creosote per cubic foot and a life of well over 20 years.

The *heartwood* of the following species already has an expectancy of life in the region of 20 years without treatment. It is also very resistant to impregnation with preservatives, but its life can generally be increased to an appreciable extent by an open tank or, preferably, a pressure treatment: oak, sweet chestnut, walnut, the larches, Western red cedar and yew.

Creosote has been mentioned above as a suitable wood preservative for use in the pressure or open tank method but other types are also available commercially. Most of these incorporate mineral salts, and most again are proprietary substances. Technical advice on their application is obtainable from their makers, and must be followed closely.

For convenience some practical details of the method of operating the open tank process are given below. The operation of a *pressure* method is a more complex job, but detailed instructions are provided by the firms who make the equipment.

Material Particularly Suitable for Treatment by the Open Tank Method

Round material of all species is suitable for treatment by the open tank method. But the best results are achieved in those species with permeable sapwood such as the pines, beech, birch, sycamore, oak, ash, elm, and alder.

Sawn timbers of pine, ash, elm, birch, Silver firs, beech, hornbeam and sycamore are also suitable, even if they have a high proportion of heartwood.

It is often suggested that for fencing stakes, posts and strainers, it is only necessary to treat that part in contact with the soil. Practical experience has varied considerably on this point and no hard and fast rules can be laid down. The method is, however, generally successful only where material to be treated contains a fairly high proportion of naturally durable *heartwood*. If the timber consists mainly of *sapwood* or has a non-durable *heartwood* there is a risk that the untreated top of the post or strainer will decay before the treated butt. Apart from the dangers of fungal decay, *Lyctus* beetle attack can be serious in the untreated sapwood of oak, ash and other ring-porous hardwoods.

Preparation of the Timber

All timber should be seasoned before treatment. As a rough guide autumn and winter-felled round material, if peeled immediately after felling and piled as shown in Figure 3, will dry out sufficiently by the following late spring or early summer. Squared or quartered fencing timbers may be piled in a similar manner. Spring and summer felled material should dry out sufficiently in about two months. The timber should have lost at least a quarter of its original fresh-felled weight before it is treated. This weight loss can be measured by weighing a few sample pieces before and after seasoning.

The *complete* peeling of roundwood not only greatly accelerates drying but is essential, since the bark and bast layers form a more or less complete barrier to the penetration of preservatives.

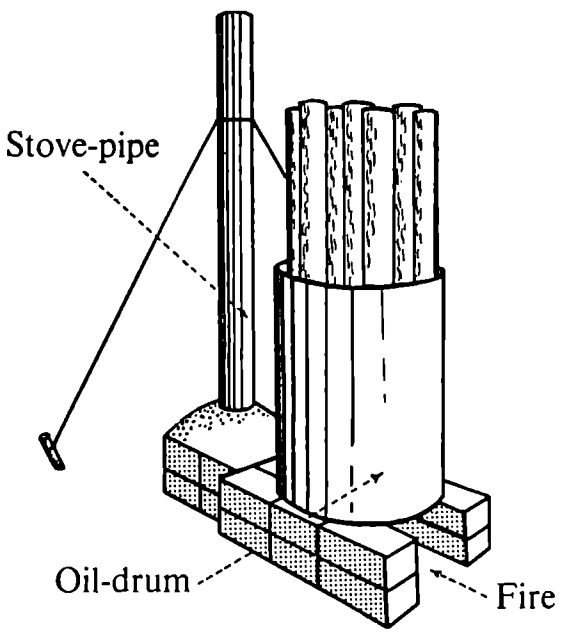

Fig. 1. Simple Creosoting Tank for Butt Treatment of Fence Posts by the Hot-and-Cold Process.

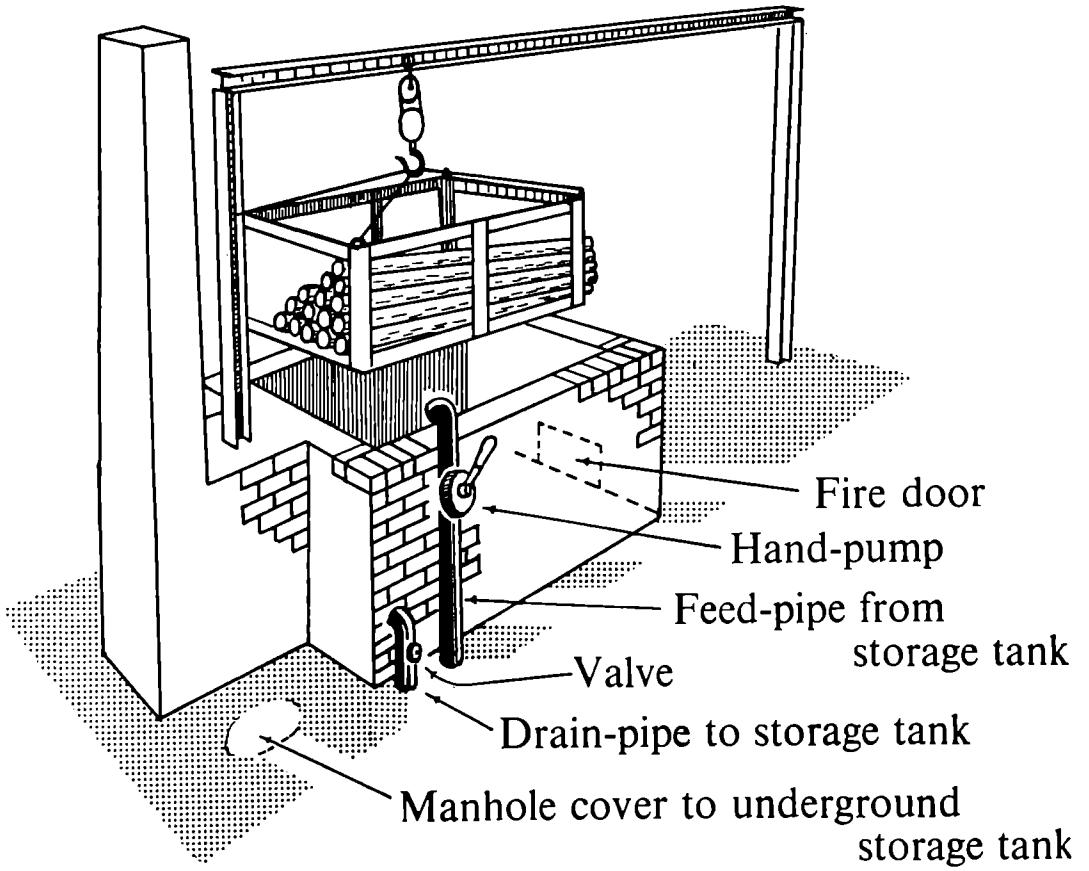

Fig. 2. Creosoting Equipment for the Full Immersion of Fence Posts and other Estate Timbers by the Hot-and-Cold Process.

The Design of the Plant

There are many different types of open tank in use, the simplest consisting of a metal tank supported on a few bricks so as to enable a fire to be lit below it. More elaborate tanks are equipped with an overhead gantry for loading and unloading the charge and an underground storage tank for the creosote. Examples are given in Figures 1 and 2. Good results depend as much on the careful operation of the plant as on its design, and anyone wishing to set up a plant for the first time should visit a selection of the existing plants operated by other estate owners, timber merchants or the Forestry Commission.

The timber to be treated is placed in the tank and the tank filled with cold creosote. The tank is then heated up to 80° C (180° F) and maintained at this temperature for 2 hours. The fire is then drawn and the whole allowed to cool. *The absorption takes place during this cooling period.*

The level of the creosote should be maintained during the cooling period. The timber may be removed when the tank has cooled.

Alternatively the tank may be re-heated and maintained for an hour or so at 80° C (180° F) before removing the timber from the hot creosote. This will expel up to about half the creosote from the very permeable species, which will often have absorbed more than is necessary for adequate preservation: the timber will also dry more quickly, making it more convenient to handle. A fresh charge may be immediately immersed in the hot creosote. After 2 hours' immersion at 80° C (180° F), the fire may be drawn and the cycle repeated.

Whichever method is used it will generally be found that only one charge can be treated every 24 hours, assuming that no night shifts are worked. Two or more charges can be treated in a day if two tanks are used. One tank only need be provided with some form of heating. The timber is first

immersed in the hot creosote tank and the temperature (which will have been lowered by the insertion of the charge of timber) raised to 80° C (180° F) and maintained at this level for 2 hours. The charge is then removed and immediately placed in the cold creosote tank where it is allowed to cool. A fresh charge may be put in the hot tank while the first charge is cooling. As an alternative to creosote, certain water-borne preservatives can also be applied by a hot and cold process.

WOOD USED OUTDOORS BUT NOT IN CONTACT WITH THE GROUND

Where wood is used outdoors but *not* in contact with the ground, its moisture content will, during dry periods, frequently fall below 20 per cent, and any decay which has started during wet periods will be temporarily arrested. In such situations the useful life of the various species shown in Table 12 will be much increased.

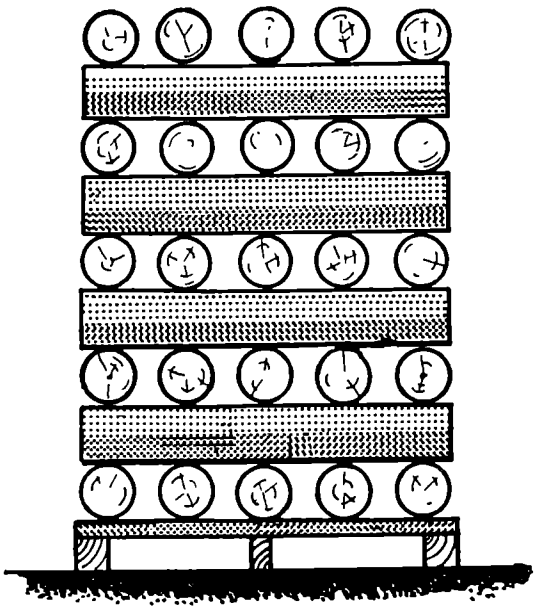

Fig. 3. Arrangement of Logs in a Stack for Air Seasoning. Note Supports to Keep Lowest Logs Clear of Ground.

The heartwood of the more durable species such as larch, Western red cedar, oak and sweet chestnut should give 50 years life or more outdoors without preservative treatment. The less durable species can be made to last for many years if they are regularly brushed with a preservative every few years. Best results are obtained if the work is done during a spell of dry, and preferably warm, weather. When ordering the preservative a formulation suitable for application by brush should be specified. It should also be stated whether the preservative is required for exterior or interior work.

Scarcity and high cost of labour may make regular brush treatment of estate buildings and other timber difficult or costly, and consideration should therefore be given to the use of pressure or open tank treated timbers for new wooden buildings.

Lower retentions of preservation may be accepted than for timbers in contact with the ground, and all the commoner non-durable constructional timbers should give satisfactory service after open tank treatment.

A free advisory service on all aspects of wood preservation—including types of preservative available, their methods of application, and the location of commercial impregnation plants—is maintained by the British Wood Preserving Association, 6 Southampton Place, London, W.C.1., to whom requests for literature or advice on specific problems may be addressed.

WOOD USED INDOORS

Where timber is used in interior work and the moisture content can be kept below about 20 per cent, it will last almost indefinitely provided that the building is of sound design and is properly maintained. As an insurance against such risk as does exist from insect or fungal attack, the timber may be treated with a preservative.

The choice of preservative and process employed will depend on a number of factors; for example whether or not the timber is in contact with masonry or concrete; whether or not the surface is to be painted. Further information on this and other aspects of wood preservation is contained in the Ministry of Agriculture, Fisheries and Food 'Fixed Equipment on the Farm' series of leaflets (3 Whitehall Place, London, S.W.1) and in selected publications of the Forest Products Research Laboratory, Princes Risborough, Aylesbury, Bucks., from whom a current list may be obtained.

PART IV
MISCELLANEOUS INFORMATION

Chapter 20
TOOLS AND EQUIPMENT

Forest operations are still to a large extent carried out manually and it is important to see that the correct tools are available for each job. It should be clearly understood however that this is only one facet of a good system of working, others being good organisation with clear objectives, training in the particular job and the use of incentives. It should also be said at the start that it is no good providing tools, however good, unless there are adequate arrangements for their storage when not in use and for their maintenance. For this the correct equipment must be obtained, made available to the workers and instruction given in its use. Sometimes one skilled man can be found to undertake all the sharpening, refitting of handles and similar work, but it is not wise to rely on him exclusively. It is preferable to encourage all the men to look after their own tools.

The provision of a personal set of the principal items, both tools and maintenance gear, should be the aim, rather than to keep all tools for general use. A small stock of spares is worth keeping, particularly spare shafts ordered to fit those tools which in the nature of things are likely to get broken; axes, slashers and brushing hooks. These requirements for storage and maintenance can be met if a tool shed can be fitted out, not only with racks for tools, but also with a bench and vice with good lighting; north daylight is best of all.

The following notes on tools do not pretend to be exhaustive, but indicate the type recommended for particular forest jobs.

Rather extravagant claims are often made for new tools but in general a skilled man will do better with well maintained tools to which he is accustomed, than with 'the latest innovation' thrust upon him. If a new item is worthwhile a trial by an enlightened worker will soon produce a reasoned verdict, particularly if the work is eased or increased output is reflected in the pay packet. One must also remember that there is a limit to the number of tools that can be carried at one time and for this reason a distinction is necessary between the basic tools essential for a job and special tools which may occasionally be needed. For certain tasks, draining, scrub clearing or felling, it may be necessary to organise the work in successive stages using different tools.

Draining

Various types of spade, fork and shovel are the main tools; items particular to certain site types are:

Pick axe for rocky ground.

Diamond pointed drain shovel, this is the bottoming spade for clay.

Square drain bottoming spade for peat or loam.

Rutter, the draining spade for peat.

Hill drain drag, 3-pronged, for removing turf from drains.

A heavy 10-*inch file* is needed for sharpening, every day in stony ground or where roots are being cut.

Fencing

Various types of *Post hole digger* are available.

Pinch bar and *Wooden maul* or special *Post driver* for driving stakes.

Metal shafted claw hammer and *Fencing pliers.*

Special *Wire straining devices*, and *Ring fasteners* for fixing netting to wires.

Scrub Clearing

A combination of felling and weeding tools will be required according to the vegetation type.

Planting

A worn *Garden spade* is a valuable planting tool especially on ploughed ground; the handle and blade should be almost in line.

Mansfield and *Schlich planting spades* are also used locally.

Mattocks with grubbing blade and pick are used for steep hill sides, and screef planting.

Weeding

Reap hooks with 6-inch handle and 14-inch blade for light weed growth: herbaceous, grass, or young coppice regrowth.

Light brushing hooks with 30-inch handle and 16-inch blade for more than one season's growth, particularly of bramble or coppice under one inch in diameter.

Heavy brushing hook for gorse, blackthorn and older coppice; most used in clearing for planting.

All these hooks are sharpened with a *long flat tapered Carborundum stone.*

Portable brushcutters become economic in dense coppice or other woody growth.

Billhooks for cutting woody growth when cleaning thicket-stage plantations.

Brashing and Pruning

A curved *Pruning saw* 20-inches long, with 6 points per inch, is recommended for general use in removing branches from standing trees.

For brashing, the saw should be fitted with a short handle 2 ft. long, best made from a cut down axe shaft. For higher pruning, wooden handles are satisfactory up to 6 or 8 feet in length but sets of 3 by 7 feet lengths of aluminium rods enable all heights up to 24 feet to be tackled.

For sharpening a *slim taper saw file* (6-inch triangular) and *saw-set pliers* are required. A special vice may be used in the wood for daily sharpening, or spare blades should be carried.

Chisel pruners are good for green branches but any one handle length can only clear about 3 feet of bole so many visits are needed to each tree.

Marking and Measuring

A *Slasher* with 2-foot handle is the best tool for the marking of trees to be cut. For marking those to be retained or pruned an *Aerosol type paint spray* is best. *Quarter girth tapes*, a *Box tape* or *Measuring rods*, and *Scribes*, *Felt ink markers*, *Timber crayon* or *Timber hammer* may be required for measuring sample trees, logs, etc.

Felling

The *Chain saw* is now the principal tool and should be light and normally have an 18-inch guide bar. Three chains should be used in rotation and a complete set of maintenance gear as recommended by the maker is essential; the main items here are the *Chain vice* and *File guide* to obtain the correct angles when sharpening.

Bowsaws will serve for small thinnings; they should have a tapered frame 36 inches long and the blade should be highly tensioned. The narrow blades with hardened teeth do not require skilled maintenance and are of two types; with cutters and rakers for felling, cutters only for crosscutting. Exceptionally, larger extensible bowsaws or the traditional *Crosscut* may be used; the latter should have lance teeth and rakers.

The traditional heavy 6- or 7-pound axe dates from the time it was the main felling tool swung at arm's length for large trees. Today even 5-pound axes are becoming rare. *2½—3½ pound Axes with handles 24—28 inches long* are best particularly as the chain saw can be used for heavy branches. No feller is complete without his double-sided *Axe stone* for use twice daily.

Other tools which may be needed are those to get the tree down, *Long handled tongs*, *Sappie* or *Canthook; Peelers* which should be long handled; also *plastic Wedges* for chain saws; for preparing split material *iron Wedges* and a *Sledge hammer* are needed.

A FOREST TOOL SHEET

Besides the general run of tools for each worker to use, no forest or estate can be operated efficiently without a full outfit of tradesmen's tools. The following list of items is based on an actual stock-taking at one of the Commission's forests. It includes nursery tools, forest tools, and maintenance equipment.

See also page 22 for details of nursery tools.

Anvil, 2 cwts.
Acre Grid, for mapping
Axes, Felling
Balance, Household
Balance, Spring

Bags, Planting—rubberised
Bags, Game
Baskets for weeding
Barrow, Steel
Barrow, Wooden

Bars, Crow
Binoculars
Bits for brace
Bevel, Joiner's
Boards, Transplanting

Boots, Rubber Knee
Boxes, Seedling
Brace, Joiner's
Buckets
Burners, Heather

Cans, Watering
Chain, Gunters, for surveying
Chisel, Cold
Chisel, Wood
Canopy for Lorry

Cutters, Wire, 9-inch
Cultivators, 5 prong
Drags, Drain, 3 prong
Dwang & Chain
Extinguishers, Fire

Foot Pump for tyres
Forks, Digging
Forks, Manure
Forks, Stone
Gauge, Morticing

Gloves, Heavy Rubber
Grindstone, Foot
Gun, Grease
Gun, 12-bore
Gun Cleaning Rod

Hammer, Claw
Hammer, Mash
Hammer, Napping
Hammer, Sledge
Hedging Knife

Hoes, Dutch
Hooks, Reaping
Hooks, Bill
Hooks, Brashing
Hygrometer

Irons, Branding
Ladder, Extension
Lamps
Lantern, Ever Ready
Lining Out Tables & Trestles

Mall, Cast Iron
Machine, Weighing
Mattocks, Planting
Measure for oil
Oil Can

Paraffin Tank
Picks, Navvy
Plane, Joiner's
Pliers, Cutting
Pump, Semi-rotary

Rain gauge
Rakes, Garden
Reels & Pins, Garden
Riddles
Rule (Boxwood)

Sampler for soil
Saws, Hack
„ Bow
„ Hand
„ Crosscut

Saws, Pruning
Saw Set (Eclipse)
Scissors
Screwdriver
Scythes

Secateurs
Shears, Hedging
Shovels, Drain
Shovels, Square Drain
Shovels

Slashers
Spades, Garden
„ Mole
„ Semi-circular
„ Planting, Schlich's pattern

Spanner, Ring
Spirit Level
Spokeshave, Steel
Sprayer, 'Four Oaks' pressure
Spades, Rutter

Staple Extractors
Static Water Tanks
Stencil, Zinc Figures
Stob Piercer
Strainer, Wire Chain

Squares, Joiner
Stone Oils Set
Tape, 100-foot in case, for surveying
Thermometer
Traps, Mole

Traps, Rabbit, Juby
Tarpaulins
Trowels, Bricklayer's
Vice, 4-inch jaws
Knapsack & Firepumps

SAFETY EQUIPMENT

Where tools are regularly carried or transported to work they should be masked and carried or stowed in a safe manner. *Guards* are obtainable for certain tools, for others they can be manufactured, e.g. old canvas hose pipe is useful for saws. The most difficult are hooks, but here split rubber or plastic hose can be used.

In certain jobs where timber or hooks and wires are moving at head height *light plastic helmets* should be worn. They are also desirable for fellers on heavy timber.

For handling timber, especially in cold weather, *armoured palm gloves* are useful, while for weeding

in thorn and comparable jobs either thick *leather* or *cotton gloves* are worth while. It is to be hoped that really satisfactory *eyeshields* for brashing and pruning, and *safety boots* for high rainfall areas will soon be available.

FIRST AID OUTFITS

(Based on The Agriculture (First Aid) Regulations, 1957 (S.I. 1957, No. 940) Price 4d. net (by post 7d.) (H.M.S.O.).

Employers' Responsibilities

Employers of forestry workers must provide, in a place easily accessible to the workers, a first aid box or cupboard and, if necessary, additional containers, conspicuously marked 'First Aid', equipped with specified First Aid requisites and an instructional First Aid leaflet issued by the Agricultural Departments.

The equipment has been chosen on medical advice and the minimum requirements are set out below; but there is nothing to stop an employer providing additional items if he wishes. Some manufacturers market ready-made kits which conform with the Regulations.

The official First Aid leaflet is available free of charge from the Ministry of Agriculture, Fisheries and Food, Publications Branch, Block C, Government Buildings, Tolcarne Drive, Pinner, Middlesex, the Department of Agriculture and Fisheries for Scotland, Broomhouse Drive, Edinburgh, 11, or from the local offices of these Departments.

What you Need

A forestry unit with *one to three workers* requires a small *box* or *cupboard* containing:

1. Sterilized wound dressings	*Quantity*
(*a*) finger dressings (containing either absorbent or boric acid lint)	3
(*b*) small plain wound dressings	2
(*c*) medium plain wound dressings	2
2. Triangular bandages of which the base shall not be less than 51 in. and each of the other two sides not less than 36 in.	2
3. Waterproof adhesive wound dressings of the following measurements:	
1½ in. by 2 in.	3
2 in. by 3 in.	3
4. Absorbent cotton wool, half-ounce packet	1
5. Official First Aid leaflet	1

For a unit with *four* to *ten* workers a larger number of items is needed in the *box* or *cupboard* as follows:

1. Sterilized wound dressings	*Quantity*
(*a*) finger dressings (containing either absorbent or boric acid lint)	6
(*b*) small plain wound dressings	3
(*c*) medium plain wound dressings	3
2. Triangular bandages of which the base shall not be less than 51 in. and each of the other two sides not less than 36 in.	3
3. Waterproof adhesive wound dressings of the following measurements:	
1½ in. by 2 in.	6
2 in. by 3 in.	6
4. Absorbent cotton wool, half-ounce packets	2
5. Official First Aid leaflet	1

For *every further* 30 workers (*or fraction of* 30) above the first 10, a *container* with the same contents as the larger box is needed. You do not have to provide more than three of these containers in addition to the initial box on any unit.

Where a British Pharmaceutical Codex standard exists, the items should be of a grade or quality not lower than that: for instance, wound dressings numbered 7, 13 and 14 would satisfy the requirements of items 1 (*a*) (*b*) and (*c*) respectively.

A contractor-employer must provide for his own men in the same way as other employers of forestry labour, but where an employer lends a man to a neighbour without any financial transaction taking place, the borrowing employer has to provide for the man loaned to him.

As forest work is often done at points distant from the office or base, it is highly advisable to equip each separate squad, and each van or lorry used for transporting men, with its own first aid outfit.

Chapter 21

GRANTS AND ADVICE FOR WOODLAND OWNERS

Introduction

The Forestry Commission provides financial assistance to woodland owners in a number of ways, in order to help them to restore their existing woods to full production and also to plant new ones. The various forms which this aid may take, and the amounts currently payable, are set out below. The nature of the grants, the amounts payable, and the regulations covering payment are subject to revision from time to time; this chapter gives the position at 1st August, 1964. The Government welcomes the increasing acreage of timber planted by private owners; this reached, in 1962, 35,000 acres, a record for any one year.

Technical Advice

Before commencing any scheme of work that is likely to attract a grant, owners are strongly advised to consult their appropriate Conservator of Forests, whose address will be found on pages 96 to 97. Free technical advice on the general suitability of any scheme will gladly be given by the Conservator.

The Commission cannot, however, undertake the detailed management of a scheme, or such tasks as the preparation of a Plan of Operations, the actual replanting of woodlands, or the sale of timber. An owner who requires help in these respects is recommended to consult one of the associations of woodland owners, a co-operative forestry society, a forestry consultant, or a firm of land agents that undertakes such work; there are also a number of concerns which will undertake tree planting on a contract basis.

Forms of Application for the various grant schemes, and the requisite forms for the Plan of Operations, are obtainable from the Conservator of Forests for the district concerned. No work should be started until the scheme is approved.

The Dedication Scheme

This scheme, which was launched in 1947 and has already been adopted by over 2,200 estates, involving over 733,000 acres of woodland, provides the most comprehensive form of assistance. Briefly, the owner enters into a Covenant or Agreement with the Forestry Commission, under which he undertakes to manage his woodlands for the main purpose of timber production in accordance with an agreed Plan of Operations, and to ensure skilled supervision. In return he receives, under the Basis II provisions which have been most generally adopted, the following financial grants:

(1) A Planting Grant, currently £22. 4s. per acre, for every acre satisfactorily planted, replanted, or otherwise restocked, after the date of dedication. Partial planting is treated *pro rata.*

(2) An *annual* Management Grant, in respect of all effectively managed woodlands, which for this purpose include those existing at the date of dedication, plus in most cases a further area determined by the agreed Plan of Operations, to cover replanting and extensions. The amount of grant is currently at the rates of 20/- per acre for the first 100 acres, 13s. 4d. for the second 100 acres, and 8s. 6d. for the remainder, on any one estate.

Alternatively, an owner may elect, at the outset, to receive assistance under the Basis I arrangement. He will then receive 25 per cent of the approved net annual expenditure on the dedicated woodlands, until such time as they become self-supporting. If he adopts this Basis, he must keep accounts in a prescribed form.

An owner who dedicates his woodlands binds himself, and his successors in title, not to use the lands so dedicated for any purposes other than forestry. Provision is however made for a relaxation of this requirement should exceptional circumstances arise. When a Dedicated estate changes hands, the successor in title is invited to continue to manage the woods under the approved Plan of Operations, and if he undertakes to do so he becomes entitled to the appropriate grants.

The requirement that the woods shall be managed for timber production does not mean the exclusion of sport or the disregard of amenity, but rather their reconciliation with the needs of good silviculture. To meet the requirements of skilled supervision, it is normally desirable that a trained forester be employed; but this is not essential if the owner himself, or his agent, has the requisite silvicultural knowledge and time available. Inspections by Forestry Commission officers, at annual intervals or more frequently if the need arises, are an integral part of the scheme; such visits have been found mutually valuable for the exchange of technical information and the discussion of problems.

Any reasonable area of woodland will be considered for the Dedication Scheme or for the allied Approved Woodlands Scheme, described below.

Approved Woodlands Scheme

This scheme is intended to meet the needs of those

owners who are prepared to manage their woodlands in accordance with a Plan of Operations approved by the Forestry Commission but who cannot, or do not wish to, enter into the long-term legally binding arrangements that are an integral part of the Dedication Scheme. Under the Approved Woodlands Scheme a Planting Grant is payable at the rate appropriate to the Dedication Scheme, and is currently £22. 4s. per acre; £16. 13s. of this is paid in the year of planting, and the balance of £5. 11s. is paid five years later, provided the plantations have been properly maintained. No Management Grant is paid. Some 500 owners, with 155,000 acres of woodlands, are already taking part in this scheme.

Small Woods Planting Grant

Although most small woods or pieces of ground suitable for tree planting will be considered for the Dedication or Approved Woodlands Schemes, many owners wish to replant such areas without including them in a comprehensive plan of management. A grant at the current rate of £22. 4s. per acre is available for approved planting, replanting, or natural regeneration in such places. The first instalment of £16. 13s. per acre becomes payable as soon as planting has been satisfactorily completed. The balance of £5. 11s. is payable five years later, provided the plantation has been properly established and maintained. There are, however, no management grants. Lands eligible for Small Woods Planting Grants are:

(I) On any estate (irrespective of the total woodland area):

(*a*) Detached blocks less than 5 acres in extent.

(*b*) Narrow strips and belts, e.g., those averaging 3 chains (198 feet) or less in width, which are detached or are only joined to larger blocks of woodland at one end.

(*c*) Detached blocks of bad access, not exceeding 15 acres if of good shape, but up to 30 acres if the shape is bad.

(II) On an estate with a total woodland area of less than 150 acres:

All blocks irrespective of size, shape and accessibility, provided that there is no individual accessible wood of good shape exceeding 35 acres in extent.

A minimum area of one acre, in one block, must be planted each year and all schemes must have been approved before planting begins. The grant is not payable in respect of an area for which a tree planting grant is being made under the Agriculture Act, 1957, or related legislation.

Each year some 1,000 owners receive these Small Woods Grants. Each plants, on average, 4 acres, making 4,000 acres annually.

Grants for Shelterbelts under the Agriculture Act, 1957

Grants of *up to one third* of the cost of establishing shelterbelts *on any farm* may be made under a Farm Improvement Scheme authorised under the above Act. These grants are not administered by the Forestry Commission, and information concerning them should be sought from the Ministry of Agriculture, Fisheries and Food, Whitehall Place, London, S.W.1; or from the Department of Agriculture and Fisheries, Broomhouse Drive, Saughton, Edinburgh 11, in respect of farms in Scotland. In certain circumstances such a grant may provide a higher proportion of the total cost than would the alternative Small Woods Grant provided by the Forestry Commission; the two Grants cannot be paid for the same area.

Poplar Planting

No special grants are available for poplar planting, but the usual acreage grants are available provided the Conservator is satisfied that the land concerned is more suitable for poplars than for other tree species, and provided also that only approved varieties of poplars are used.

Felling Licences

A licence is usually required for the felling, or sale for felling, of growing trees, under the Forestry Act, 1951. This Act (copies of which may be obtained from H.M. Stationery Office, price 1s. 3d. or 1s. 6d. post free) should be consulted for the legal definitions of exceptions from licensing, but it may be noted here that the main exceptions listed are:

(*a*) Trees in gardens, and fruit trees.

(*b*) Any trees below 3 inches in diameter, measured five feet from the ground.

(*c*) Underwood below 6 inches in diameter, measured five feet from the ground.

(*d*) Thinnings below 4 inches in diameter, measured five feet from the ground.

(*e*) Dedicated Woodlands, provided the felling is in accordance with the agreed Plan of Operations.

In addition, an owner may fell up to 825 cubic feet of timber (hoppus measure) per quarter of a calendar year, for use on his own property, without a felling licence. Of this quantity he may, if he wishes, sell without licence 150 cubic feet but not more.

In nearly all other circumstances a Felling Licence is required, and application should be made to the appropriate Conservator of Forests, who will arrange for the trees to be inspected. Where it is in the national interest that the ground shall be restocked, the Commission is empowered to impose Replanting Conditions on the issue of a felling licence. When the

wood is replanted in accordance with such Conditions, appropriate Planting Grants may be claimed, always provided that an application has been made to the Conservator before planting is started.

If a Tree Preservation Order is in force for the trees concerned, it is usually necessary for the local planning authority to be consulted, and exceptions (*a*) to (*d*) above do not always apply.

Purchase, Lease or Feu of Woodlands by the Forestry Commission

Where an owner is unable, for any reason, to proceed with the planting and management of his woodlands or potential woodlands, on his own account, the Forestry Commission is ready to consider their acquisition—either by purchase, long lease or feu—on terms to be mutually agreed. Enquiries should be directed to the appropriate Conservator, whose address appears below.

Income Tax and Estate Duty on Woodlands

Special arrangements, which may operate to the advantage of the owner, apply to the assessment for Income Tax of income derived from the ownership or occupation of woodlands. Other special arrangements are made for the assessment and payment of Estate Duty on woodland property following a death. Information on these points will be found in Forestry Commission Leaflet No. 12: *Income Tax and Estate Duty on Woodlands*, which has been prepared under the authority of H.M. Inland Revenue and is published by H.M. Stationery Office, price 1s. 3d. (1s. 6d. post free).

ADDRESSES OF THE MAIN OFFICES OF THE FORESTRY COMMISSION

Headquarters

Chairman: The Earl Waldegrave, D.L. *Director General:* Sir Henry Beresford-Peirse, Bt., C.B., F.R.S.E. *Deputy Director General:* G. B. Ryle,, C.B.E. *Secretary:* H. A. Turner. Forestry Commission, 25 Savile Row, London, W.1. (Regent 0221).

Directors of Forestry

ENGLAND

J. R. Thom, 25 Savile Row, London, W.1. (Regent 0221).

SCOTLAND

J. A. Dickson, 25 Drumsheugh Gardens, Edinburgh, 3. (Edinburgh Caledonian 4782).

WALES

J. Q. Williamson, M.B.E., Victoria House, Victoria Terrace, Aberystwyth. (Aberystwyth 2367).

Conservators of Forests

ENGLAND

North West

J. S. R. Chard, Forestry Commission, Upton Grange, Upton Heath, Chester. (Chester 24006).

Cumberland, Westmorland, Lancashire, part West Riding of Yorkshire (Lune and Ribble Valleys), Cheshire, Shropshire, Staffordshire, Warwickshire, Leicestershire, Nottinghamshire and Derbyshire.

North East

G. J. L. Batters, Forestry Commission, Briar House, Fulford Road, York. (York 24684).

Northumberland, Durham, Yorkshire (except that part of West Riding in Lune and Ribble Valleys).

East

G. W. Backhouse, Forestry Commission, Block D, Brooklands Avenue, Cambridge. (Cambridge 54495).

Lincoln, Rutland, Norfolk, Cambridge, Northamptonshire, Bedfordshire, Oxfordshire, Buckinghamshire, Hertfordshire, Essex, Suffolk and Huntingdonshire.

South East

R. H. Smith, Forestry Commission, 'Danesfield', Grange Road, Woking, Surrey. (Woking 2270).

Berkshire, London, Middlesex, Kent, Sussex, Surrey and Hampshire (except New Forest and Isle of Wight).

South West

C. A. Connell, O.B.E., Forestry Commission, Flowers Hill, Brislington, Bristol, 4. (Bristol 78041).

Herefordshire, Gloucestershire (except Forest of Dean), Wiltshire, Dorset (west of Salisbury—Blandford—Poole Road), Worcestershire, Somerset, Devon and Cornwall.

Deputy Surveyor, New Forest

W. A. Cadman, Forestry Commission, The Queen's House, Lyndhurst, Hants. (Lyndhurst 300).

Part of Hampshire (New Forest and Isle of Wight), part Dorset (east of Salisbury—Blandford—Poole Road).

Deputy Surveyor, Forest of Dean

R. G. Sanzen-Baker, Whitemead Park, Parkend, Lydney, Glos. (Whitecroft 305).

Forest of Dean.

SCOTLAND

North

H. A. Maxwell, Forestry Commission, 60 Church Street, Inverness. (Inverness 32811).

Caithness, Sutherland, Ross and Cromarty, Inverness, part Argyll (Mull and areas west of Loch Linnhe), Nairn (except north-east corner), Moray (southern areas only), Orkney, Shetland.

East

G. I. Mackenzie, Forestry Commission, 6 Queen's Gate, Aberdeen. (Aberdeen 33361).

Nairn (north-east corner only), Moray (except southern areas), Banff, Aberdeen, Kincardine, Angus, Kinross, Fife (except south-west corner), part Perth (areas north and east of Crieff).

South

J. A. B. Macdonald, O.B.E., Forestry Commission, Greystone Park, Moffat Road, Dumfries. (Dumfries 2425).

Midlothian, East Lothian, Berwick, Roxburgh, Selkirk, Peebles, Dumfries, Kirkcudbright, Wigtown, part Ayr (south of Kilmarnock), part Lanarkshire (south-east of Lanark).

West

J. W. L. Zehetmayr, Forestry Commission, 20 Renfrew Street, Glasgow, C.2. (Glasgow Douglas 7261).

Argyll (except Mull and areas west of Loch Linnhe), part Perth (areas west of Crieff), Stirling, Dunbarton, Renfrew, Clackmannan, part Fife (south-west corner only), part Ayr (north of Kilmarnock), part Lanarkshire (north-west of Lanark), West Lothian, Bute.

WALES

North

F. C. Best, Forestry Commission, 15 Belmont, Shrewsbury. (Shrewsbury 4071).

Anglesey, Caernarvon, Denbigh, Flint, Merioneth, Montgomery, Radnor, Cardigan (except south-west and south-east).

South

J. E. James, Forestry Commission, St. Agnes Road, Gabalfa, Cardiff. (Cardiff 62131).

Pembroke, Carmarthen, Brecknock, Glamorgan, Monmouth, south-western and south-eastern parts of Cardigan.

Director, Research

A. Watt, C.B.E., Forest Research Station, Alice Holt Lodge, Wrecclesham, Farnham, Surrey. (Bentley 2255).

Chief Education Officer

J. H. James, Forestry Commission, 25 Savile Row, London, W.1. (Regent 0221).

Other Useful Addresses

Royal Forestry Society of England, Wales and Northern Ireland, 49 Russell Square, London, W.C.1. (Museum 4892).

Royal Scottish Forestry Society, 7 Albyn Place, Edinburgh 2. (Caledonian 7402).

Timber Growers' Organisation (For England and Wales), 35 Belgrave Square, London, S.W.1. (Belgravia 5323).

Scottish Woodland Owners Association, Ltd., 6 Chester Street, Edinburgh, 3. (Caledonian 1903).

Society of Foresters of Great Britain, c/o Forestry Commission, 25 Savile Row, London, W.1.

Commonwealth Forestry Association, at: Royal Commonwealth Society, Northumberland Avenue, London, W.C.2. (Whitehall 7209).

Commonwealth Forestry Bureau, at: Commonwealth Forestry Institute, South Parks Road, Oxford. (Oxford 57891).

Forest Tree Seed Association of England and Wales, 25 Savile Row, London, W.1. (Regent 0221).

Scottish Forest Tree Seed Association, 25 Drumsheugh Gardens, Edinburgh, 3. (Caledonian 4782).

APPENDICES

Appendix I

FELLING LICENCE APPLICATION FORM

FORESTRY COMMISSION. Form G. 11

FORESTRY ACT, 1951

APPLICATION FOR LICENCE TO FELL GROWING TREES

(To be submitted in Duplicate, but see Note 2 and other Notes overleaf before completing this application.)
(Please use BLOCK CAPITALS)

For Office Use Only
L.A. No.....
Licence No. .....

County ..... Estate .....

Parish(es) ..... Name of Wood(s).....

Nearest Railway Station and distance therefrom.....

Name of Applicant.....

Address .....

.....

Tele. No.....

Name of Agent, or other person to whom licence and other correspondence is to be sent.

.....

Address .....

Tele. No.....

A. Description. (A 6 in. O.S. Sheet SIGNED by the applicant showing area concerned must be submitted.)—See Notes (a) and (b) below.

Type of Operations	Chief Species	Identification of Trees, i.e., how they are marked (see Note (c) below)	Area (Acres)	Approx. Age of Trees (Years)	Total Number of Trees	VOLUME (Hoppus Cu. ft.) TAPE OVER BARK	
						Conifers	Broadleaved
1. Clear Felling ..							
Thinning							
3. Other Felling ..							
4. Hedgerow Trees. To include all isolated trees and small clumps under 1 acre not forming part of a wood			////////// ////////// //////////				
					Total Volume ..		

B. General. 1. Proposed date of commencement of felling..... 2. Proposed date of completion.....

3. Date(s) of previous applications() (if any) to fell the trees described above.....

4. Proposed treatment of land after felling (see Note 3 (a) overleaf).....

..... (if necessary, continue on separate sheet)

C. Declaration. I hereby apply for a licence authorising the felling of the growing trees described above.

I CERTIFY

(1) that as (state whether freeholder, owner, lessee, etc.).....I have such an estate or interest in the land on which the trees are growing as enables me, with or without the consent of any other person, to fell the trees.

(2) that there *is / is not in force a Tree Preservation Order made or having effect as if made under section 28 of the Town and Country Planning Act, 1947, or under section 26 of the Town and Country Planning (Scotland) Act, 1947, and relating to the trees.

*(3) that the proposed felling is in accordance with the Plan of Operations approved by the Commissioners on.....

Signature.....(date) .....

*Delete the words which do not apply.

D. To be completed if a Tree Preservation Order is in Force. (See Note 4 overleaf).

1. Order made by.....Council.
2. Number of Order and date confirmed.....
3. Reason for proposed felling.....

For Office Use Only.	Notes.	This Application to be submitted to:—
Entered in L.A. Register by.....	(a) The plan is part of the licence application and will be retained by the Conservator.	
Census Map No.		
Stand No.	(b) The Conservator will accept a tracing from the 6 in. O.S. sheet in lieu provided it gives sufficient detail to enable the area to be precisely identified.	
Category.....		
National Grid No.....	(c) Except for a clear felling, the trees to be felled MUST be clearly marked and the details entered in this column.	
Estate File Ref.		

EXPLANATORY NOTES

(These notes do not constitute legally binding interpretations of the Statute or the Regulations, and are intended only for the guidance of applicants.)

1. Copies of the Forestry Act, 1951 (price 1s. 3d. net) and the following Regulations made thereunder may be obtained from H.M. Stationery Office or through any bookseller:—

The Forestry (Exceptions from Restriction of Felling) Regulations, 1951 (S.I. 1951, No. 1725) (price 2d. net).

The Forestry (Felling of Trees) Regulations, 1951 (S.I. 1951, No. 1726) (price 8d. net).

The Forestry (Exceptions from Restriction of Felling) (Amendment) Regulations, 1959 (S.I. 1959, No. 96) (price 3d. net).

2. Applications.

These should be submitted if possible at least three months before it is desired to commence felling. They should be in DUPLICATE except in the cases described in Note 4 below. Any additional information relevant to the application should be submitted in a separate note.

All applications will be acknowledged by the Conservator and thereafter applicants are requested to quote the Licence Application number in all subsequent communications. If an application is incomplete in any material respect it will not be accepted but will be returned to the applicant, and the three months' time limit for a decision will begin only when a fully completed application has been received.

3. Conditions.

(a) **Treatment of the area after felling (Part 1, Sect. B.5 overleaf).** Under Section Three of the Act the Commissioners may, after consultation with the applicant, attach such conditions to any licence as appear to be expedient for securing the stocking or re-stocking of the land with trees and for the maintenance of these trees. The applicant should accordingly give all the information he can as to the measures he proposes for the stocking or re-stocking of the land after felling.

(b) **Stocking or re-stocking of alternative land.** The applicant may, if he so desires, suggest other land which he is prepared to stock or re-stock in place of that on which the trees to be felled are growing.

(c) **Second signature in special cases.** If it appears to the Commissioners that the applicant is not entitled to such interest in the land as would enable him to comply with the conditions of a licence (e.g., if he is not the land owner and has no power under a lease or covenant to replant the land) they may give him notice accordingly and may postpone consideration of the application until the person so entitled becomes a party to the application.

4. Tree Preservation Orders.

(a) Where the trees described in the application are subject to a Tree Preservation Order or interim Preservation Order, Part 1 Sections C (2) and D must be completed and the application submitted in TRIPLICATE; the application will be treated by the conservator as if it were also an application for consent to fell the trees under the Order. It is preferable that applications relating to trees subject to a Preservation Order should be made separately from other applications.

(b) Any licence granted by the Forestry Commissioners is sufficient authority for the felling of the trees specified therein notwithstanding anything in any Preservation Order affecting the trees which came into force before the date of the licence. If, however, a Tree Preservation Order is made on or after the date of the licence it has the effect of cancelling the licence.

Appendix II

LIST OF FORESTRY COMMISSION PUBLICATIONS

The following publications were available from H.M. Stationery Office (addresses on page ii), or through any bookseller, on 1st April, 1964. Prices in brackets include postages at inland rates.

Reports

Annual Report for the Year ended 30th September, 1963. (H.C. 169, Session 1963–64) 7s. 0d. (7s. 6d.)

Report on Forest Research for the Year ended March, 1962. (71–2–0–60) 13s. 0d. (13s. 9d.)

Report by the Commissioners on Post-War Forest Policy, 1943. (Cmd. 6447) 5s. 6d. (5s. 11d.)

Report of the New Forest Committee, 1947. (Cmd. 7245) 3s. 6d. (3s. 11d.)

Report of the Committee on Hedgerow and Farm Timber, 1955. (71–23–0–56) 4s. 0d. (4s. 5d.)

Report of the Committee on Marketing of Woodland Produce, 1956. (71–28) 4s. 6d. (5s. 0d.)

Small Pulp Mill Survey, 1959. By Sandwell & Co. Ltd., Consulting Engineers, Vancouver, Canada. (71–31) 4s. 0d. (4s. 5d.)

Board Mill Survey, Economic Study, United Kingdom. By Sandwell & Co. Ltd., Consulting Engineers, Vancouver, Canada. April, 1959. (71–32) 5s. 0d. (5s. 6d.)

Report of the Forest of Dean Committee. (Cmd. 686) 8s. 0d. (8s. 5d.)

Joint Report

Bark Form and Wood Figure in Home-grown Birch. (Joint Publication with F.P.R.L. listed as Forest Products Research Laboratory Special Report No. 18 (D.S.I.R.)) 4s. 0d. (4s. 4d.)

Reports on Census of Woodlands

No. 1. Woods of Five Acres and Over. 1947–1949. (71–11–1) 12s. 6d. (13s. 5d.)

No. 2. Hedgerow and Park Timber and Woods under Five Acres, 1951. (71–11–2) 5s. 0d. (5s. 5d.)

No. 3. Welsh County Details. 1947–49. (71–11–3) 4s. 0d. (4s. 7d.)

No. 4. Scottish County Details. 1947–49. (71–11–4) 10s. 0d. (10s. 9d.)

No. 5. English County Details. 1947–49. (71–11–5) 12s. 6d. (13s. 7d.)

Bulletins

No. 17. The Cultivation of the Cricket Bat Willow. 2nd Edition, 1958. (71–5–17*) 5s. 0d. (5s. 5d.)

No. 20. Studies on British Beechwoods. 1952. (71–5–20) 12s. 6d. (13s. 1d.)

No. 21. Tree Root Development on Upland Heaths. 1954. (71–5–21) 10s. 6d. (11s. 0d.)

No. 23. Mull and Mor Formation in Relation to Forest Soils. 1954. (71–5–23) 10s. 0d. (10s. 7d.)

No. 24. The Volume-Basal Area Line—A study in Forest Mensuration. 1955. (71–5–24) 9s. 0d. (9s. 5d.)

No. 25. Studies of North-West American Forests in Relation to Silviculture in Great Britain. 1955. (71–5–25) 6s. 0d. (6s 5d.)

No. 26. Adelges Insects of Silver Firs. 1956. (71–5–26) 8s. 6d. (9s. 0d.)

No. 27. Utilisation of Hazel Coppice. 1956. (71–5–27) 10s. 0d. (10s. 5d.)

No. 28. Sitka Spruce in British Columbia. A study in Forest Relationships 1956. (71–5–28*) 20s. 0d. (20s. 8d.)

No. 29. Shelterbelts and Microclimate. 1956. (71–5–29–60*) 20s. 0d. (20s. 8d.)

No. 30. Exotic Forest Trees in Great Britain. 1957. (71–5–30*) 17s. 6d. (18s. 3d.)

No. 31. Code of Sample Plot Procedure. 1959. (71–5–31) 15s. 0d. (15s. 7d.)

No. 32. Afforestation of Upland Heaths. 1960. (71–5–32) 17s. 6d. (18s. 3d.)

No. 33. Status and Development of Elm Disease in Britain. 1960. (71–5–33) 10s. 0d. (10s. 5d.)

No. 34. Chalk Downland Afforestation. 1961. (71–5–34) 10s. 0d. (10s. 6d.)

No. 35. Pruning Conifers for the Production of Quality Timbers. 1962. (71–5–35) 6s. 6d. (7s. 0d.)

No. 36. Mycorrhizal Associations and Calluna Heathland Afforestation. 8s. 0d. (8s. 6d.)

Forest Park Guides (*Fully illustrated*)

Argyll. 3rd Edition, 1954. (71–18) 4s. 0d. (4s. 6d.)

Border (Northumberland, Cumberland, Roxburghshire). 2nd Edition, 1962. (71–29–0–62) 5s 0d. (5s. 6d.)

Border Forest Park. Short Guide. 6d. (9d.)
Dean Forest and Wye Valley. (*reprinting*).
Dean Forest and Wye Valley. Short Guide, 1963. 9d. (1s. 0d.)
Glen More (Cairngorms). 3rd Edition, 1960. (71–24–60*) 5s. 0d. (5s. 6d.)
Queen Elizabeth Forest Park Guide. Ben Lomond, Loch Ard and the Trossachs, 1954. (71–16) 3s. 6d. (4s. 0d.)
Snowdonia. 3rd Edition, 1963. (71–20–0–63) 5s. 0d. (5s. 6d.)
Snowdonia. Short Guide, 1962. 6d. (9d.)

Guide Books (*Fully illustrated*)

Bedgebury, Kent (National Pinetum and Forest Plots). 3rd Edition, 1962. (71–22–0–61) 3s. 6d. (3s. 11d.)
Bedgebury Pinetum and Forest Plots. Short Guide. 1962. 6d. (9d.)
Cambrian Forests. 1959. (71–30*) 5s. 0d. (5s. 6d.)
Forests of North-East Scotland. 1963. (71–34) 5s. 0d. (5s. 7d.)
Glamorgan Forests. 1961. (71–33*) 5s. 0d. (5s. 6d.)
New Forest. 3rd Edition, 1961. (71–9–0–61) 5s. 0d. (5s. 6d.)
North Yorkshire Forests. 1963. 7s 6d. (8s. 0d.)
Westonbirt Arboretum. 1964. 9d. (1s. 0d.)

Booklets

No. 1. Woodland Mosses (Fully illustrated). 1947. (71–6–1–56) 6s. 0d. (6s. 5d.)
No. 3. Chestnut Blight caused by the Fungus Endothia Parasitica. (Illustrated in colour) 1951. (71–6–3–58) 2s. 6d. (2s. 9d.)
No. 4. Rusts of British Forest Trees. (Illustrated in colour) 1955. (71–6–4) 2s. 6d. (2s. 10d.)
No. 6. National Forest Parks. 1961. (71–6–6) 2s. 6d. (2s. 10d.)
No. 7. The Plan of Operations. A Guide to the Preparation of the Plan of Operations for Dedicated and Approved Woodlands. 1962. (71–6–7) 3s. 0d. (3s. 4d.)
No. 8. Aids to Working Conifer Thinnings. 1962. (71–6–8) 3s. 0d. (3s. 4d.)
No. 9. Felling and Converting Thinnings by Hand. 1962. (71–6–9) 2s. 6d. (2s. 10d.)

Leaflets (70–9999)

No. 1. Large Pine Weevil (Hylobius abietis), Revised 1960. 1s. 9d. (2s. 0d.)
No. 2. Adelges cooleyi, an Insect Pest of Douglas Fir and Sitka Spruce. Revised 1960. 9d. (1s. 0d.)
No. 3. Pine Shoot Beetles. Revised 1962. 8d. (11d.)
No. 5. Fomes Annosus: A Fungus causing Butt Rot and Death of Conifers. (Revised 1961). 1s. 0d. (1s. 3d.)
No. 6. Honey Fungus. Revised 1958. 6d. (9d.)
No. 8. Megastigmus Flies attacking Conifer Seed. Amended 1961. 1s. 0d. (1s. 3d.)
No. 10. Oak Leaf Roller Moth. 1962. 9d. (1s. 0d.)
No. 12. Income Tax and Estate Duty on Woodlands. Revised 1959. 1s. 3d. (1s. 6d.)
No. 15. Felted Beech Coccus. 1956. 9d. (1s. 0d.)
No. 16. Larch Canker and Dieback. 1962. 9d. (1s. 0d.)
No. 18. Two Leaf-Cast Diseases of Douglas Fir. Revised 1956. 8d. (11d.)
No. 19. Elm Disease (Ceratostomella ulmi). Revised 1962. 9d. (1s. 0d.)
No. 20. Watermark Disease of the Cricket Bat Willow. Revised 1962. 8d. (11d.)
No. 21. Leaf Cast of Larch. Revised 1963. 6d. (9d.)
No. 27. Poplar Cultivation. 2s. 0d. (2s. 4d.)
No. 28. Collection and Storage of Acorn and Beech Mast. Revised 1962. 6d. (9d.)
No. 29. Pissodes Weevils. 1962. 6d. (9d.)
No. 30. Sooty Bark Disease of Sycamore. (Illustrated in colour) 1952. 9d. (1s. 0d.)
No. 31. The Grey Squirrel. A Woodland Pest. 1962. 1s. 6d. (1s. 9d.)
No. 32. Pine Looper Moth. Bupalus Piniarius. (Illustrated in colour) 1959. 1s. 3d. (1s. 6d.)
No. 33. Collection and Storage of Ash, Sycamore and Maple Seed. Revised 1960. 9d. (1s. 0d.)
No. 34. Badgers in Woodlands. 1960. 1s. 0d. (1s. 3d.)
No. 35. Pine Sawflies. (Illustrated in colour) 1955, reprinted 1962. 2s. 0d. (2s. 3d.)
No. 36. Crossbills. Revised 1962. 1s. 0d. (1s. 3d.)
No. 37. The Capercailzie. 1956. 9d. (1s. 0d.)
No. 38. Oak Mildew. 1956. 6d. (9d.)
No. 39. The Quality of Poplar Plants. 1957. 6d. (9d.)
No. 40. The Pine Shoot Moth and Related Species. 1957. 9d. (1s. 0d.)
No. 41. Crested Tit. 1958. 1s. 0d. (1s. 3d.)
No. 42. Woodpeckers in Woodlands. 1958. 1s. 0d. (1s. 3d.)
No. 43. Keithia Disease of Thuja plicata. Revised 1963. 1s. 3d. (1s. 6d.)
No. 44. Voles and Field Mice. 1958. 1s. 0d. (1s. 3d.)
No. 45. The Roe Deer. (*In the press*).
No. 46. Titmice in Woodlands. 1962. 1s. 9d. (2s. 1d.)
No. 47. Birds and Woodlands. 2s. 0d. (2s. 3d.)
No. 48. Needle-cast of pine 1s. 3d. (1s. 6d.)
No. 49. Resin-top Disease of Scots Pine (*In the press*).
No. 50. Grey Mould in Forest Nurseries (*In the press*).
No. 51. Chemical Control of Weeds in the Forest. (*In the press*).

Binders for leaflets. To take any number, will also hold Forest Records. (71–8–0–61) 3s. 0d. (3s. 6d.)

Forest Records

No. 5. General Volume Table for Oak in Great Britain. 1963. 1s. 3d. (1s. 6d.)
No. 6. General Volume Table for Beech in Great Britain. 1950. (71–12–6) 9d. (1s. 0d.)

No. 7. General Volume Table for Birch in Great Britain. 1950. (71–9999) 6d. (9d.)
No. 8. General Volume Tables for Scots Pine in Great Britain. (71–12–8) 2s. 6d. (2s. 9d.)
No. 9. General Volume Tables for European Larch in Great Britain. 1950. (71–12–9–61) 2s. 0d. (2s. 3d.)
No. 10. General Volume Tables for Norway Spruce in Great Britain. (Revised 1961). (71–12–10–61) 2s. 0d. (2s. 3d.)
No. 11. General Volume Tables for Corsican Pine in Great Britain. 1951. (71–576–11) 1s. 6d. (1s. 9d.)
No. 14. General Volume Tables for Japanese Larch in Great Britain. 1952. (71–12–14) 9d. (1s. 0d.)
No. 15. General Volume Tables for Douglas Fir in Great Britain. 1952. (71–12–15) 1s. 6d. (1s. 9d.)
No. 19. The Manufacture of Wood Charcoal in Great Britain. (Revised 1961). (71–12–19–61) 3s. 0d. (3s. 4d.)
No. 21. Use and Manufacture of Wood Flour. 1953. (71–12–21) 6d. (9d.)
No. 22. Shelterbelts for Western Hill Farms. 1963. (71–12–22–63) 3s. 0d. (3d. 4d.)
No. 28. Volume Table for Small Hardwood Trees. 1954. (71–12–28–56) 1s. 0d. (1s. 3d.)
No. 29. Use of Forest Produce in Sea and River Defence in England and Wales. 1954. (71–12–29–56) 1s. 9d. (2s. 0d.)
No. 30. Growth and Yield of Sweet Chestnut Coppice. 1956. (71–12–30) 3s. 0d. (3s. 4d.)
No. 31. Tariff Tables. 1962. (71–12–31–62) 2s. 6d. (2s. 10d.)
No. 32. New Ways of Using Tariff Tables. 1962. (71–12–32) 1s. 3d. (1s. 6d.)
No. 35. Use of Home-Grown Timber in Packaging and Materials Handling. 1957. (71–12–36) 2s. 6d. (2s. 10d.)
No. 36. Provisional Yield Tables for Oak and Beech in Great Britain. 1958. (71–12–36) 2s. 6d. (2s. 9d.)
No. 37. Alignment Charts and Form Height Tables for Determining Stand Volumes of Conifers, Oak and Beech. 1958. (71–12–37) 1s. 9d. (2s. 0d.)
No. 38. Design of Poplar Experiments. 1950. (71–12–38) 1s. 9d. (2s. 0d.)
No. 39. Collection of Cones from Standing Trees. Revised 1962. (71–12–39–63) 4s. 0d. (4s. 4d.)
No. 40. Preliminary Yield Table for Poplar. 1959. (71–12–40) 1s. 9d. (2s. 0d.)
No. 42. Use of Home-Grown Softwood in House Construction. 1959. (71–12–42) 1s. 3d. (1s. 6d.)
No. 43. Establishment Methods for Poplars. 1960. (71–12–43) 2s. 0d. (2s. 3d.)
No. 44. Creosoting Plant at Thetford Chase. 1960. (71–12–44) 2s. 6d. (2s. 10d.)
No. 45. Fires in State Forests in the Years 1929–1956. 1961. (71–12–45) 3s. 0d. (3s. 4d.)
No. 46. Group Dying of Conifers. 1961. (71–12–46) 3s. 0d. (3s. 4d.)
No. 47. Provisional Yield Tables for Abies grandis and Abies nobilis. 1961. (71–12–47) 3s. 0d. (3s. 4d.)
No. 48. The Dropmore Pinetum. 1963. (71–12–48) 5s. 6d. (5s. 10d.)
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