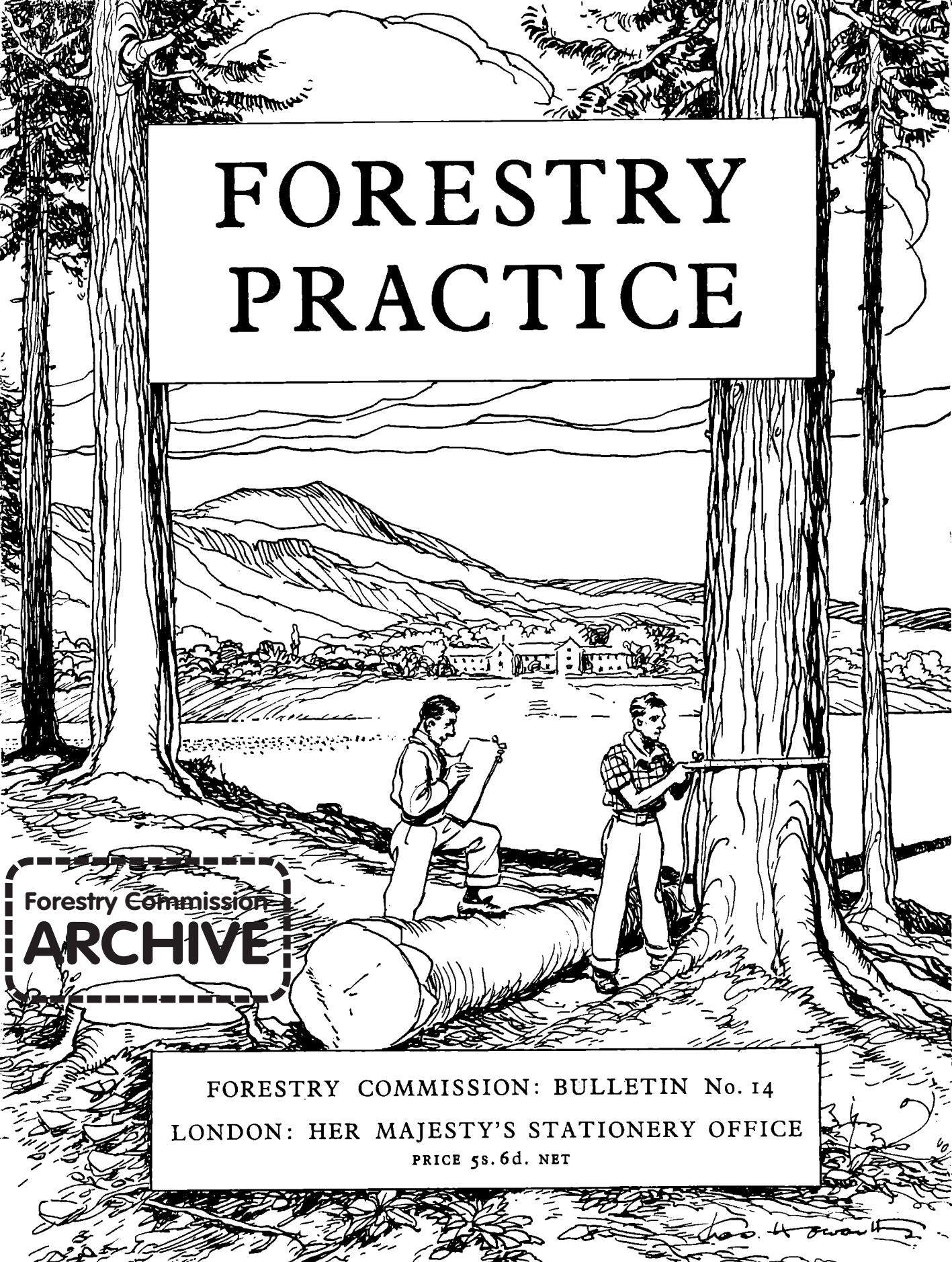
FORESTRY PRACTICE



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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

Seventh Edition 1958

LONDON: HER MAJESTY'S STATIONERY OFFICE
1958

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 twenty-four years, six 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 1956, to a group of Research Branch 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. In particular, Mr. R. A. Aldhous and Mr. R. Faulkner have covered the subject of nursery work, Mr. G. G. Stewart has dealt with the formation of new plantations, Mr. P. F. Garthwaite with the replanting of former woodland, and Mr. A. D. Miller with the management of coppice. The section on protection against diseases has been re-drafted by Mr. T. R. Peace, that on protection against insects by Dr. Myles Crooke, and that on protection against fire by Mr. H. L. Edlin; while Mr. E. G. Richards has written the chapters on the utilisation and preservation of timber. The general editing has been carried out by Mr. H. L. Edlin, under the supervision of Mr. James Macdonald, Director of Research and Education.

FORESTRY COMMISSION,
25 Savile Row,
London, W.1.
February, 1958.

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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 for the small-scale planter 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 is one of the most difficult and hazardous operations in forestry practice and requires a great deal of skill and 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 someone who is keen and who has a good deal of forest nursery experience, is available for managing the nursery, it is better to buy in seedlings for transplanting from a nurseryman. The general level of prices for such seedlings is agreed by the trade each year, and details are published in the forestry journals.

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 the most important single factor because it affects all cultural operations. Well-drained stone-free sandy loams are the most desirable because they are friable and therefore permit work to continue into late autumn and to start in early spring. They also minimise the risk of frost lift. The soil should have a combined silt and clay content of not more than 15 to 25 per cent. If the soil is too sandy there may be excessive leaching of plant nutrients and the risk of losing top soil by wind during dry spring weather, and by heavy rainstorms. Nevertheless, there are several highly productive nurseries on pure sand soils. Ideally the light top soil should be underlaid with a moisture-retentive sub-soil.

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.

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 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, and 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.

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

Once the site for the new nursery has been selected

and its size calculated, its shape and layout should be decided. A rectangular shape should be preferred because it 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, eight to ten feet wide, should be marked out 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.

The next step is to clear the ground vegetation and to cultivate the soil. Grassy areas are best tackled by deep ploughing, followed by alternate disc and tine harrowing at intervals of a few weeks through the summer.

During all operations great care should be taken to avoid bringing any subsoil to the surface. Ploughed grassland should not be used for seedbeds until the old turf has thoroughly decomposed, and should be used only for transplant or potato production during the first year of operation; any seedlings imported should be from a weed-free 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 p. 35)

If the site is exposed to strong winds permanent hedges should be planted. Lawson cypress, *Cotoneaster simonsii* or *Lonicera nitida* are all suitable species. Alternative species can be used if available, but *Thuja plicata* should never be used because of the risk of the fungus disease *Keithia thujina* infecting the hedge and becoming a permanent source of infection for any *Thuja* 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 found desirable the extent of ground enclosed in each section should not be less than one acre.

Where much mechanisation is contemplated it is desirable to have long uninterrupted runs of 300—450 feet for the machines; in this case sections should be long and thin, with hedges running parallel to the long axis of the section.

HEATHLAND AND WOODLAND NURSERIES

Since 1944 there has been a steady increase in the use of heathland sites for nurseries because of the excellent quality and higher yields of plants which they produce and the low cost of maintenance, due to the fact that they are almost free of weeds. Unfortunately the majority of suitable heathland areas are restricted to the eastern and southern parts of the British Isles and to light sandy soils derived from sandstones such as the Millstone Grit, or from Eocene sands. These soils usually support heather or ling, with some bracken and wavy-hair grass (*Deschampsia flexuosa*) in mixture. Where a pine plantation has been established on such a site, and the crop has developed to the pole stage and is saleable, it will even pay to clear patches up to one acre in size in sheltered situations, for use as nurseries.

On heathland sites (which if possible should 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. Burning the heather on the site before pulling is not recommended because this destroys part of the valuable surface peat layer. 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 an ironstone pan is present. Shallow ploughing will avoid turning up subsoil which is inimical to satisfactory seedling growth. The ground should be left in this condition over winter.

On pine-wood sites it is essential that the tree roots be carefully removed, causing as little soil disturbance as possible. To do this, remove the tops from the trees at a height of four or five feet. A wire rope is then led from a power-operated winch on a tractor (or a monkey winch can be used) to the top of the long stump, the roots and stump are then pulled out of the ground and the long stump cut off. After piling, the stumps can be burned at a point well away from the site.

After cultivation, on most soils fertilizers or manures are necessary, and are normally applied in the course of preparing for seedbeds or transplant lines. On very acid soils however (pH 4.5 or less) a *light* dressing of ground limestone or ground chalk at 5 hundredweight per acre should be applied immediately after the initial cultivation. On very light sandy soils, Bessemer basic slag may be applied at the same rate.

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 also on the age and species of the plant as well as on the origin and quality of the seed. The yield of seedlings per pound of seed varies with the season, the technique, and the character of the nursery used, so it is only possible to give guidance in broad terms.

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. Orders should be placed early, preferably by September for sowings in the following spring. It may be noted that many suppliers in Scotland now belong to the Scottish Forest Tree Seed Association, and can supply seed certified to have been collected from known good quality parent stands in Britain.

Tables 1a & 1b on pages 4 & 5 gives 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 (1a), then an additional increase of twenty per cent should be allowed for in the sowing density. This broad increase is necessary to compensate for the reduction in *germinative energy* which occurs in seed of low viability.

Table 1 has 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 broadcast sowing the same amount of seed.

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 licensed seed testing station at Alice Holt Lodge, Wrecclesham, Farnham. This station only deals with seed collected or imported by the Forestry Commission. Conifer seed from sources outwith the Forestry Commission can be tested for a small fee at the Ministry of Agriculture seed testing station in Cambridge or at the Department of Agriculture seed testing station at East Craigs, Edinburgh. Under the Seeds Act of 1920 seeds of all common forest tree species must be tested at an official or licensed seed testing station before they can be offered for sale.

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. The sowing areas prescribed in Column 8 of the conifer table (1a) should then be corrected on the basis of the estimated germination percentage only.

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 number of seeds that are full and have a white firm embryo and endosperm counted. The number of full seeds gives a rather high estimate of the germination percentage. The "cut test" is useful as a guide but the danger associated with this test is that one cannot 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

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 intervals to prevent moulds forming; thereafter, until sowing, it may need to be moistened occasionally to prevent drying out. See F.C. Leaflet 28, *Collection and Storage of Acorns and Beech Mast*, for details.

Alternatively, oak and beech and also chestnut are sometimes sown immediately after collection as described further on. Seed of many other hardwood species requires storage by stratification if satisfactory germination is to be ensured.

Good results can occasionally be obtained by sowing ash seed when it is still green, but a greater yield of plants is obtained by collecting fully ripened seed at the end of September and by stratifying for sixteen months before sowing (see F.C. Leaflet 33, *Collection and Storage of Ash, Sycamore, and Maple Seed*, for details).

PREPARATION OF THE GROUND

The site for seed beds should be ploughed in the autumn. On light soils, which do not have to be left rough ploughed 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 beds thrown up as soon as the ground is workable in the spring. 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, being set 5 feet apart and the soil being thrown on top of the seedbeds. The height of the beds should vary according to the soil type and climate, e.g. in wet west coast regions on heavy soils the beds at this stage may well be 9 or 10 inches above the alleys, whereas in the dry east the height will be 6 inches; this will allow for the beds finally settling to depths of 5, and 2 to 3 inches, respectively. On very heavy soils, instead of ploughing it is useful to ridge the ground 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.

In spring all seedbeds should be roughly cultivated and levelled (on ridged ground by pulling two ridges together with a rake and leaving alternate bottoms for alley centres); this should be done when the soil is moist but not dry. When this is done some weeks before sowing it affords an opportunity to kill the first germinating weeds.

Any bulky organic manures should be spread just before seedbeds are thrown up and are worked in during bed preparation.

Inorganic fertilisers should be applied with a fork into the top 3 to 4 inches of soil before the final levelling (see Chapter 4, page 16, 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 to two hundredweights, measuring 12 to 15 inches in diameter, and three feet six inches wide.

In heathland nurseries, if the nursery regime includes bare fallow for one year in the rotation, the procedure should be as above. However, it is more usual, particularly in Scotland, for heathland

TABLE 1A

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 from stratification, see page 6.
†For drill sowing add 25 per cent to these figures.

TABLE 1B

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	Sow 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 wt. of seed if 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:—

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

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

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

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

nurseries to be cropped with seedlings every year. In these cases, bed preparation cannot be started until the previous crop has been removed. On heathland seedbeds it is essential to compact the beds heavily by trampling or the use of very heavy rollers. Under-consolidation of the soil causes a reduction in germination and also lengthens the period of germination.

Tables 1a & 1b above gives the number of square yds. 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, and therefore one running yard of bed is equivalent to one square yard sown.

Soil Sterilisation

On very 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. The technique is simple and consists of mixing 1 gallon of 38 per cent formaldehyde solution with 15 or 25 gallons of

water and applying 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 6 weeks before sowing. 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 fertilisers can be applied. Care should be taken to avoid splashing exposed skin with formaldehyde and to avoid inhaling any vapours. Any splashed skin should be washed with water immediately, and rubber gloves should be worn.

PREPARATION OF SEED FOR SOWING

It is an advantage to mix small seed with red lead (1 lb. red lead to 10 lb. seed) as the coloured seed is more easily seen when sowing and so can be 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 they are just damp, when they can be mixed with the red lead. If they are too wet when mixed, the seeds stick together and are difficult to handle. Red lead gives no protection against mice or fungi.

For certain conifer species 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); lodgepole pine (1½ 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. Ash and gean collected early may be sown at once.

The construction of a stratification pit is shown in F.C. Leaflet 33. 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 1 cubic foot, with bottoms of ⅜-inch mouseproof netting and detachable mouseproof 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, if waterlogging and death of the seed are not to occur. When placed in the pit, the boxes or pots should not come to more than 12 inches from the top, so that a one-foot-deep layer of pure sand can be used to cap the pit to ground level. An alternative method, 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 to go in 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.

SOWING AND COVERING THE SEED

Most seed can be sown dry. There is no advantage in soaking seed before sowing and indeed the seed may be harmed if it is left in soak awaiting suitable weather conditions for sowing.

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. However, there is some evidence that spruces, *Tsuga* and *Thuja* should be sown before pines. Douglas and larch. *Abies* species, or 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, but such late sowings may be unavoidable in frosty or exposed nurseries.

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. Autumn sowing of oak can be carried out by two methods. The first is to plough out a 3 inch deep furrow and then space sound acorns along it at 1 lb. per 12 feet of furrow, covering these with a 9 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 by using a "cuffing board", a flat board on the end of a long wooden handle, draw the top inch of soil to the outside of the bed. Sow the acorns broadcast. Cover them with cuffed soil and follow with a very thin cover of sawdust or run a length of old telephone cable along the top; then add 2 to 3 inches of soil from the alleys. Leave the beds 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 prevents game and pigeon damage to the acorns during winter.

Drill Sowing

Drill sowing of conifers and other hardwoods is simpler for unskilled workers than 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 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, which can be made easier if the required amount of seed is emptied into the drill from a calibrated tube or a narrow-necked bottle. 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. An alternative method is to use a roller with laths nailed on to it crosswise; or to use 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.

Broadcast Sowing

The most widespread 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. Even 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.

Don't try to sow small seeds on windy days. For larger seeds (usually over $\frac{1}{8}$-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 the soil.

Covering Depth and Materials

After sowing, small seeds of all species except the large-seeded hardwoods should be covered with *grit or coarse sand.* This practice brings about more rapid and uniform germination than covering with soil or leaf mould.

The depth of cover is determined by the type of seed sown, and the rule of thumb in this connection is to cover the seed to a depth equal to one and a half times the length of the seed. This works out reasonably well in practice, and for instance $\frac{1}{4}$-inch cover is needed for Scots pine and Norway spruce, with $\frac{3}{8}$-inch for Corsican pine and Douglas fir, and $\frac{1}{8}$-inch for Sitka spruce and the larches.

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

Soil should only be used for covering large seed, e.g. sycamore, ash, oak, beech.

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 on European and hybrid larch for *Meria laricis* once germination is completed, and for *Botrytis* in late summer and autumn. These fungi and control measures are described later in Chapter 13, page 58. A look-out for insect attacks should also be kept and in particular for cockchafer, cutworms and aphids. A description of these insects, the damage they cause and the method of control, is described in Chapter 14, page 63.

Sheltering

It has long been the practice to shelter seedlings both against sun and against frost. However, the provision of shelter is expensive and hinders mechanical weed control by oil sprays or cultivation between drills. In recent years, in many Commission nurseries both in the south and the north, summer shelter has been omitted, with no apparent detrimental effect on crops. A possible reason for this is that nowadays, seed is often sown earlier than it was in the past, so that now seedlings may have grown large enough to withstand high summer temperatures; perfectly satisfactory crops even of silver firs and western hemlock have been raised in hot summers without shelter being given.

It is usually unnecessary to provide overhead shelter against insolation and drought in the northern part of Britain, but in East Anglia, and roughly south of the line between the Thames and Severn estuaries, there are occasions in summer when overhead shelters are beneficial. These are when the sun raises the soil surface temperatures to over 100°F, because should the temperatures reach 110° to 120° recently germinated seedlings will be killed at the root collar. Beech, western hemlock, western red cedar and shade-bearing silver firs such as *Abies grandis* are species most commonly shaded.

Portable screens can be made by nailing plasterers' laths, half to threequarters of an inch apart, on to a light framework, or by threading them between two sets of flexible wires. These screens should be laid across wires supported by short posts 9 to 12 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 under-developed roots.

Shelter against frost may in certain localities be essential, though here it must be said that a shelter will give protection against moderate and light frosts but will not protect crops against heavy frosts. It is the more difficult to make recommendations because the degree of protection given varies according to type of shelter; in the case of 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 is often 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 shelters are already erected, they should of course be put on when there is the risk of early autumn frost. Frost protection is particularly important on sites which can be regarded as frost pockets, and in years when there is a long mild autumn when seedlings do not harden-off in mid to 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' which is caused by alternate freezing and thawing of the soil.

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

WEED CONTROL

Weeds are extremely harmful to seedling growth. If left to develop they will smother and kill seedlings and reduce the vigour of any that survive by taking up water and nutrients that the seedlings could use. In controlling weeds the aim must be to kill or remove weeds soon after they have germinated, and if this is not possible, at least to kill or remove them before they have set seed.

Weeds can be controlled in forest nurseries by three different methods, removal by hand, disturbance by mechanical cultivation, and killing by sprays of mineral oils. Control by the first of these methods is time-consuming and costly, the second is possible only where seed has been sown in drills, while the third, though fairly cheap, has certain limitations because of the sensitivity of the crop. The most satisfactory way of controlling weeds in broadcast seedbeds, is by mineral oil sprays in combination with hand weeding. The use of a blow lamp to kill weeds immediately before seedlings appear above the soil is less satisfactory than a vaporising oil spray applied before seedlings emerge.

Selective weed killers 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 conifer crops and are unsuitable for use in forest nurseries.*

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 3, p. 15.

Pre-Emergence Spraying

For pre-emergence weed control, sprays of vaporising oil (*See* Note 1 below) at 10 pints per 100 square yards (60 gallons per acre) can be applied. The best time to spray is three to four days before seedlings germinate—though any time before that is nearly as good. Spraying with vaporising oil *after* seedlings have begun to emerge usually results in the death of those seedlings that are emerging. To estimate when to spray, a few seeds should be uncovered in two or three places in the bed. If any seeds have radicles $\frac{1}{4}$ to $\frac{1}{2}$ inch long, 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, but in extreme cases 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.

Post-Emergence Spraying

Control of weeds *after* seedling emergence is very much more dependent on 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 2 below) 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 spirit at the recommended rates. If the weed population consists mostly of moderately big weeds, it is doubtful whether it is worth while to spray. On the other hand, when a crop of weeds has recently germinated fairly uniformly, 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, 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 2) 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 per 100 sq. yards net (25 gallons per acre).

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

The first spray should not be applied until four weeks after the emergence of the last of the seedling crop, i.e. not before the first true leaves have fully 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 oil sprays must be removed by hand at the first opportunity.

Spraying Devices and Methods

Mineral oils can be applied with a knapsack air pressure sprayer, fitted with a pressure gauge, a lance and the finest 'fan jet' nozzles, or else a tractor-mounted sprayer should be used. A working pressure of 30 to 40 lb. per sq. in. is ideal for pre-emergence sprays, and this must be maintained during the spraying. For post-emergence spray, a lower working pressure e.g. 20-25 lb. per square inch, is preferable, because it allows a longer time in which to apply the spray. The rate of delivery should be determined by measuring with a stop watch the time taken to fill a one-pint measure. Having done this the time taken to cover the seedbed can be calculated. It is wise to use water in these trials 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 (very early morning or late in the evening) for spraying will reduce the risk of the spray drifting and causing damage to other seedbeds or transplants, or to hedges growing alongside.

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).

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 for seeds of many species of weeds remain fertile in the heaps for many years. Spreading old heaps of weeds back on to the nursery is a disastrous and expensive practice.

LIFTING AND GRADING SEEDLINGS

Seedlings are normally considered large enough to be lifted when 60-70 per cent or more 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 because of the difficulty of 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, although in good nurseries the pines, larches and Douglas firs are sometimes large enough at one year. In heathland nurseries the plants should be suitable for transplanting at the end of the first year. In lifting the seedlings, 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. 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 transporting to the transplant lines.

If the seedbeds are uniformly stocked, two or three sample one-yard-square units should be marked off and the number of plants suitable for lining-out selected. From the information obtained, the number of undersized or deformed plants can be assessed, and the seedbed area to be lifted to meet the lining-out programme can be calculated. When there is a great deal of variation in size the seedlings may be graded. It is often desirable to separate the tallest 50 per cent of the seedlings from the smaller plants, because the taller will often produce plantable trees after one year in the transplant lines, whereas the smaller plants may have to remain in the lines for two years. When grading, all culls, i.e. plants which are weakly, diseased or deformed, should be destroyed.

Storage, Packing and Transport

It is an advantage to lift and line out seedlings in the same nursery, but where it is necessary to pack and transport seedlings to another nursery, every effort should be made to keep the plant roots moist from the time of lifting to the time of receipt. Often several thousand plants will be moved in one operation, and therefore after lifting and grading, the plants should be tied in bundles of 100 and placed in a well prepared heeling-in trench (sheugh, or 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 one spade width wide, 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 mild. This will ensure that when the plants are required, they are not found to be frozen hard into the soil.

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-prepared for sowing in March. Experiments in Scotland have shown that if the seedlings are put into well-prepared trenches, satisfactory storage can be obtained over winter, irrespective of whether the plants are bundled or not. Spruce should be dealt with first, followed by pine and then larches. The operations can be started in mild weather in December if absolutely necessary.

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 dry. When plants have to be sent by rail they should be sent by passenger train or *express* goods train to reduce the time in transit, and should 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. Plants also can be safely sent in stout "Polythene" bags, providing the open end of the bag is folded over and secured with string. All bundles should carry two strong labels marked 'Keep Away From Heat', along with the address of the consignee, who should be advised as soon as the plants are despatched. Always avoid week-end travel for the plants.

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.

UNDERCUTTING SEEDBEDS

Undercutting seedbeds with a tractor-mounted undercutter is now being 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, e.g. oaks, pines, and Douglas fir, and helps to produce a more balanced plant by reducing the amount of shoot growth 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 3 to 4 inches, will produce plants which are virtually as good as one-plus-one transplants. If it is intended to use this technique it is advisable to sow the seed at half the rate prescribed in Tables 1a and 1b. Application of the technique to pines is at the moment restricted to seedbeds which are just too small for lifting at the end of the first year, and which experience tells will be too large at the end of the second year. If such beds are undercut in March at 3 inches depth, the shoot growth will be partially checked, the root system be made more fibrous, and the resulting "1 u 1" (1 year undercut 1 year) seedlings will be superior for transplanting to ordinary second-year seedlings.

Chapter 3

RAISING TRANSPLANTS FROM SEEDLINGS

THE object of transplanting 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 unless samples of the plants have been received. These samples should be carefully preserved because they may be needed for evidence if the supplier sends plants of a lower quality. Certain nurserymen now have available seedlings of the common conifers grown from certified seed collected from good quality parent stands. These plants are slightly more expensive but have the advantage of having a known and good origin.

Definite consigning instructions 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. In either case an adequate heeling-in trench, locally called a 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 on the day the plants arrive.

When the plants arrive, the bundles should be untied and the seedlings 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.

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 nursery be lined out in a weedfree 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 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 plants 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 2 sets out general recommendations for fertile good quality nurseries. On less fertile sites, where growth of plants is not so vigorous, slightly reduced spacings may be adopted.

If mechanized weed-control is to be used, a standard spacing between rows will be needed, in which case it will be the spacing *between plants only* that can be varied according to the age and species of plant to be lined out. In addition, the system of alleys between lining-out strips and rows must be allowed for. Eighteen-inch alleys should be allowed between six feet four inches wide (1 board length) strips if strip lining out is used. Where plants are lined out in long rows and it is proposed to control weeds by mechanical cultivators or by mineral oils from sprays mounted on a tractor, one row in every six to eight (depending on the distance between rows and the distance apart at which the tractor wheels can be set) should be omitted to allow the tractor to get through.

Also, five feet wide main paths may be left at convenient intervals across each section for access when weeding.

TIME OF TRANSPLANTING

The normal nursery transplanting season extends from October to April (excluding December and January), and 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. Japanese and European larches should be lined out before the middle of March because these two 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 (with the exception of Douglas fir) completed by the end of March, so that seed sowing can be carried out with as little delay as possible.

In Scotland, the lining out of rising two-year-old pines and spruces in July 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 in the south of Britain.

PREPARATION OF GROUND

Most of any ground which has been bare fallow would normally be reserved for seedbeds, but where bare fallow is available for lines, the ground 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 by hand or with a rotary cultivator. Ridged ground has to be levelled down with a disc harrow immediately before use, if the conventional system of long transplant lines is used.

Where one crop of transplants is to follow either seedbeds or a previous crop of transplants, and the ground is not cleared until early spring, the ground should be ploughed or dug over at the first opportunity, and cultivated by hand or by rotovator before lining out commences.

At the time of final cultivation or lining out, any manures and insecticides which may be required should be cultivated into the soil.

TABLE 2

RECOMMENDED LINING-OUT DISTANCES BETWEEN PLANTS

Species	Age of Seedling	Type of transplant to be raised	Spacing recommended in inches		Number of plants per 100 square yards (net)
			Between plants	Between rows	
Scots pine, Corsican pine, Sitka spruce and lodgepole pine	1+0	1+1	1½	6	14,400
Ditto	2+0	2+1	2	8	8,100
Douglas fir, larches	1+0	1+1	2	8	8,100
Ditto, also Lawson cypress, western red cedar, and western hemlock	2+0	2+1	3	10	4,320
Norway spruce and Sitka spruce	2+0	2+1	2	8	8,100
Norway spruce, Sitka spruce and silver firs	2+0	2+2	3	10	4,320
Oak, beech, ash, sycamore, sweet chestnut, wych elm, and gean	1+0	1+1 1+2	2 3	8 10	8,100 4,320
Ditto but excluding oak and sweet chestnut	2+0	2+1 2+2	2 3 4	8 10 10	8,100 4,320 3,240

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 2) with or without the assistance of lining-out boards. The use of lining-out boards has now become the accepted practice in most areas 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.

Irrespective of method certain general rules apply. 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 sheughed-in) close to the working point until required for handling.

The back of the lining-out trench must be vertical and the seedlings set upright against it; and it must be deep enough to accommodate the roots and allow them to hang freely without bending them. If some roots are exceptionally long and stout, e.g. two-year-old oak, the roots should be pruned cleanly to six inches with a sharp knife.

Hand Methods

Long Lining-Out Boards. When using the 'long' (ten or twelve feet) type of lining-out board, a gang of at least four and preferably five workers is advisable, two of whom do the spade work, two fill the lining-out boards and one usually acts as a runner to carry the boards from the filling bench to the spade-men. 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 threaded into notches in the boards. Each seedling is set so that its level, after transplanting and after allowing for soil settlement, will be the same as it was in the seedbed. The distance between plants is fixed by a slotted spacing bar. 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 juveniles and women whose nimble fingers often enable them to work faster than men. A common size of board is ten feet long, with sixty slots spaced two inches apart, thus holding sixty plants.

The first line or row of plants, which is usually six to eight boards in length, is marked out on the ground with a nursery line. A trench with one side vertical, to 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 later levelled off with the back of the spade. The catches holding the two halves of the board tightly together, so that they grip the plants, are relased, 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 from it, in the earth previously thrown up and levelled from the preceding row.

Strip Method. The 'Strip Method' of hand lining out uses a shorter board, only six feet four inches long. Most of the operations are similar to the lining-out procedure described above, except that lining out is carried out in sections one board length wide, with eighteen-inch-alleys between sections. The Paterson board, which is usually employed, consists of two unhinged un-notched parts, one of which fits snugly against a fixed notch member on the plant filling bench. Seedlings are threaded 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 small plants with $1\frac{1}{2}$ 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.

By using eleven-foot boards of the normal pattern, and omitting to fill the centre one foot or eighteen inches, the same pattern of strip lining out can be obtained. 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.

With the increasing use of machines for weeding, cultivation, and lifting, strip lining out is also carried out with transplant lines running lengthways down the strip. The number of lines per strip varies according to distance between lines, but the distance between strips from centre to centre should be the same as the centre-to-centre distance between seed-beds. This allows tractors to run either between beds or lines without having to alter wheel-distance settings.

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 dabbed 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 this earth is then firmed down and levelled.

Mechanized Methods

Mechanized methods can only be satisfactorily and economically applied to large sections on reasonably flat stone-free ground. Wide turning spaces for tractor and machine are necessary. There are two machines in current use, namely, "The Ledmore Lining-out Plough" and the "Holland" Transplanter. The former is made in Scotland, the second machine is imported from America.

The "Ledmore" plough is a tractor-hauled machine which will cover the plant roots firmly, and prepare a level platform and a suitable trench for the next 'run' simultaneously. Several squads are necessary for 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. The lining-out boards used are the conventional ten-foot long pattern. In operation the plough travels outwards and down one side of a rectangular section, and returns on the inward journey midway across the section and parallel to the first line; the process is repeated until the whole area has been lined out. The machine, which is mounted on the hydraulic lift of a tractor, is six feet long and consists of a main frame on which are carried the following implements from front to rear and in the order in which they are operated:

(a) a front skimmer which places fine soil against root tips;
(b) an adjustable pneumatic compaction wheel which firms the fine soil against seedling roots;
(c) the main ploughshare which turns the bulk of the soil into the trench;
(d) a soil leveller which roughly levels the plough soil;
(e) a compaction roller which firms the roughly levelled soil and controls the operating depth;
(f) a rear cutting disc which cuts the vertical edge of the next trench to receive the boards;
(g) a rear reverse skimmer which removes soil from the newly cut edge and provides the fine soil for the first skimmer on the next run.

In addition there is a stabilising wheel, a set of spikes for cultivating the soil before and after the lining-out operations, and a fertiliser distributor for placing fertilisers in the bottom of the prepared trench.

A shift lever makes it possible to move the whole plough from side to side, if necessary, in order to keep rows running parallel. The machine is designed to give an inter-row spacing of nine inches, and therefore the spacing distances between plants given in Table 2 will have to be either increased or decreased to provide a similar area of ground per plant.

"Holland" transplanting units are operated in pairs. Each unit consists of a vertical rotating metal disc bearing rubber flaps spaced at two-inch intervals round the inside periphery. In operation, plants are inserted between the flaps and the disc, and as the disc rotates the flaps close under the pressure exerted by a metal shield which extends to ground level. A slit trench opened by a narrow 'V' shaped share receives the plants as they are carried round and down into the trench. Two compaction wheels close the trench, thereby holding the seedlings firmly in position. Simultaneously, and as each seedling passes the end of the shield (thus releasing the pressure on the flap which then opens) the seedling is released. Units are spaced several feet apart on a metal frame, and the whole is propelled by its own power unit. Operators who 'fill' the flaps sit astride the planting units, and the machine is self-steered, either by an arm which runs in a groove previously scribed in the soil by the machine on a previous run, or by a light movable rail.

BEDDING OUT

Occasionally it happens that a seedbed, which has to be lifted for one reason or another, contains a high proportion of plants which are too small for lining out. These plants may have some special value, and if it is necessary to retain them they should be bedded out. Bedding out is a simple operation consisting of opening up a trench, with one side vertical, sufficiently deep to carry the plant roots. Seedlings are spread along this trench by hand, at intervals of half to one inch apart, and the soil is then returned to fill the trench and firmed. A second trench is prepared similar to the first, and 4 to 6 inches from it, and the process is repeated. Bedded-out seedlings should be lined out after one year to obtain plants suitable for forest planting.

WEEDING TRANSPLANT LINES

Hand Methods

Dutch hoes and wheeled hoes are the commonest 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 on temporary piles on the main roads, where they can be later collected by tractor and disposed of on a dump 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 steerage hoes, fitted with spring harrows suitable for cultivation between transplants lined out by machine or by the strip method, and also self-propelled cultivators which consist of a number of vertical discs fitted with cultivators, which discs rotate between the lines, are both being developed for inter-row cultivation; but at present, they are not extensively used.

Chemical Methods

Mineral oils can be applied to conifer transplant lines by knapsack air-pressure sprayer and lance, or, by tractor-mounted sprayer fitted with fan type 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 and during the growing season 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 some resistant weeds will have to be removed by hand. Transplant lines of broadleaves can only be sprayed when the plants are leafless and buds closed, i.e. autumn, winter and early spring.

Table 3 sets out the maximum rates of application for *transplant lines*. (Rates for *seedbeds* appear on pages 8 and 9.)

TABLE 3

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[3]	
		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[4]	25 gall.[4]	5 pints	30 gall.
	Broadleaved species	unsafe		unsafe	
Autumn, winter, and early spring	Douglas fir	unsafe		4 pints	25 gall.
	Pines, spruces	unsafe		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. Vaporising oils are subject to change according to market developments. Oils currently (January, 1958) available which have been satisfactory in Forestry Commission nurseries are 'Shellspark' and 'Esso Green Oil'.
3. White spirits are subject to change according to market developments. Oils currently (January, 1958) available and which have been satisfactory in Forestry Commission nurseries are 'Shell Weedkiller W', 'Shell White Spirit' and 'Esso White Spirit 100'.
4. 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.

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 handles 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.

On larger nurseries a tractor-mounted plant lifter can be used. This 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 actual lifting operation quite easy.

When grading plants, all culls, i.e. dying, deformed, unbalanced and damaged plants, should be discarded and burned. The residue should be sorted into suit-

able height classes. The grading of plants for forest planting ensures that given planting areas receive plants of similar size; this is a great 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. In practice, it is rarely necessary to distinguish more than two or three such height classes; very even lots of transplants may not require grading, but culls should always be removed.

It cannot be too strongly emphasised that surplus stocks, unless grown for re-sale, and also 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

The principles for packing, transport and storage of transplants are similar to those previously described for seedlings (see p. 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 soil were repeatedly cropped without the addition of any organic or inorganic fertiliser whatsoever, the soil would rapidly 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 fertilisers. The amount of fertiliser must be controlled 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. 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 in rare cases calcium, magnesium and copper deficiencies have been recorded.

Fertilisers can be applied either in organic form or in an inorganic form, and from numerous experiments it has been shown that the much cheaper inorganic fertilisers are quite as good a source of the major nutrients as the more expensive organic forms. Nevertheless, on soils which are low in organic matter or humus (less than 5 per cent), and also on heavy clay soils or light sandy soils, it may be necessary to apply bulky organic manures in order to improve the physical qualities of the soil, i.e. to lighten the soils in the case of clays, or to improve the moisture-retaining capacity of the sandy soils. This is best done by introducing a bulky green-crop into the rotation, or by applying hopwaste which may be obtained at very low cost from local breweries. Composted straw and hopwaste, or bracken and hopwaste, were used extensively in the immediate post-war years, but the very high costs of preparation were out of all proportion to their value, and they are only used to a very limited extent today. Simple hopwaste is much cheaper than hop manure, and for this purpose is equally effective.

Farmyard manure, which is becoming increasingly expensive as well as scarce, is not a suitable organic supplement because of the high content of weed seeds it contains, which can not be eliminated even by careful and expensive composting.

It is impossible to give an accurate manurial prescription for all nurseries, because so much depends on the soil type and the rainfall of the area. However, the following notes are intended to be a guide for fertiliser 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) and on light sandy sites. Granular fertilisers are preferable to non-granular fertilisers because they are easier to handle and are generally more effective than powdered fertilisers. Compound fertilisers have the advantage of making possible the application of two or more nutrient elements in one operation and without the disadvantage of having to mix fertilisers beforehand.

Manures To be Applied before Sowing and Lining out

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

14 lb. per 100 square yards (net) of granular potassic superphosphate. Repeat the dressing for each crop of seedlings or transplants.

If straight fertilisers 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.

In heathland nurseries, raw hop waste is normally applied, at 1,000 lb. (31 cubic feet) per 100 square yards in the first year of operation. In subsequent years 500 lb. (approx. 15½ cubic feet) per 100 square yards for seedbeds and 250 lb. (7½ cubic feet) per 100 square yards for transplant lines, should be applied.

Fertilisers should be applied to seedbeds at least one week before sowing. Seedlings for transplanting are more tolerant, and can withstand fertiliser applications immediately before transplanting takes place. 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.

It is unlikely that lime will be required in agricultural soils. If the pH value does however drop 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 (10 lb. per 100 square yards) should be broadcast over the area in autumn. This dressing may have to be repeated every 3 to 5 years. A soil analysis is essential to determine the lime content and pH value. The local County Agricultural Adviser will usually undertake the sampling, but 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, (where conifers are to be grown).

Broadleaved trees tolerate soils with much higher lime content than do conifers, and will grow quite well in soils with pH values of 6.5 and even slightly higher.

Nitrogen Top Dressings for Conifer Seedlings and Transplants

If it is intended to produce one-year seedlings suitable for lining out, top dressings of nitrogen should be given in late June and late July. In acid agricultural nurseries (pH less than 5.5) and in heathland nurseries, 'Nitrochalk' at 6 lb. per 100 square yards 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 at each application will be adequate, using half rates for larches and Douglas fir.

When the object is to produce two-year seedlings, applications of 'Nitrochalk' or ammonium sulphate should be given at half the rates described above, 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 three to four weeks after lining out, with a second dressing in mid-July.

For most broadleaved species, top dressings of 'Nitrochalk' should be given at 6 lb. per 100 square yards, but very vigorous species, e.g. birch and alder, should only be given half this amount.

Nitrogen Top Dressings for Broadleaved Trees

Top dressings of nitrogenous fertilisers are best applied before rain is expected, but when the plants are still dry. After application, any further fertiliser which may have lodged in the leaves of the plants should be brushed off with a light birch broom.

MANAGEMENT

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 each year.

In some nurseries, particularly in low rainfall regions, the resting year is used for bare fallowing and repeated cultivations to reduce the weed population. In other nurseries, particularly 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, or else oats and tares, is sown.

The greencrop prevents the loss of nutrients by leaching, and also causes weed suppression. If pure oats are sown, a subsequent spraying with a MCPA spray will control the broadleaf weeds. Care must be taken to see that spraying is carried out on a *calm* day, using a high-volume sprayer at 100 gallons per acre to reduce the risk of spray-drift on to adjoining sections of transplants, seedbeds or adjoining agricultural crops. Sowing rates for a pure oat crop would be four bushels of oats (Yielder or Castleton Potato oats) per acre, or if mixed with tares two bushels of oats with 1¼ cwt. of Swedish or Scotch tares 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 in September—usually at the time when the tares begin to flower.

A suitable fertiliser dressing for greencrops is potassic superphosphate at 13 lb. per square yard, combined with sulphate of ammonia at 6 lb. per 100 square yards at the time of sowing the greencrop. A nitrogen top-dressing at a similar rate, 4 to 6 weeks after sowing, should also be applied.

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

Chapter 5

VEGETATIVE PROPAGATION FOR POPLARS AND WILLOWS

THE site for raising poplars and willows should be the most fertile and sheltered in the nursery, with a pH of over 6.5, 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" compound fertiliser applied at 20 lb. per 100 square yards.

Cuttings of well-ripened one-year-old wood, eight to nine inches in length, are taken. Succulent material, 'blind' cuttings and for poplars material less than pencil thickness, should be discarded. The cuttings can be taken any time after autumn, and should be heeled-in, in the lines, with only the tips of the cuttings protruding above the ground; or they can 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—15 inches between cuttings and 15—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 after transplanting, which should be carried out at a spacing of 2 feet by 3 feet if plants are to be lifted after one year, or 3 feet by 3 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 five 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 Planting* 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 13, page 58; while protection against insects is discussed in Chapter 14, page 63.

Rabbits. It is essential to fence the nursery securely against rabbits, using a fence constructed as per the specification on page 35. 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, and in large nurseries can find sufficient cover to remain hidden for a considerable period of time.

Moles. These animals cause considerable damage to seedbeds by burrowing under the soil, damaging seedling roots in the process or burying seedlings underneath the 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 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 alternative 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.

Birds. Rooks, pigeons, and game birds occasionally cause damage to newly sown greencrops and seedbeds of oak and beech. Scarecrows, gibbets, windmills and banging devices etc. are usually ineffective after a few days, as are many of the proprietary non-poisonous seed-dressing repellents. Finches sometimes cause considerable damage to ungerminated and recently germinated conifer seed, and short of protecting the beds with netting, strings or threads, there is little one can do about it. On the whole, however, attacks by birds are infrequent and spasmodic. Where they do occur attention must be paid to scaring the birds for so long as the trouble lasts.

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.

PART II
PLANTATION WORK
Chapter 7
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 eradiction 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. But it must be understood that these economic grounds can be satisfied 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 large is obvious to all those who live in the countryside, and therefore there are many factors which must be considered before the choice of species is made. It is not practicable in this Bulletin to do more than 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.

Finally, 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 species:

TABLE 4

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 latter if peat is present.	Wood sanicle, wild garlic and dog's mercury are sometimes present and often indicate suitable conditions for ash.

TABLE 4 (*Continued*)
PLANT INDICATORS (*Continued*)

Plant Associations	Site Conditions indicated	Tree species indicated	Remarks
Fern/grass	Steep, moist slopes.	Scots pine, European larch, 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.	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	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 (*Molinia caerulea*) is often found pure over large areas.
Ling Heather (*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.	Typical of the "grouse moor" in the North. Ling is an indicator of *unsuitable* conditions for spruces.
Ling Heather/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.

TABULAR NOTES ON INDIVIDUAL SPECIES

The main characteristics of the best known species are summarised in the tables which follow. It should be noted that the uses of the timbers, and their preservative treatment, are further discussed in Chapters 17 and 18.

TABLE 5

NOTES ON INDIVIDUAL SPECIES: MOST COMMONLY USED CONIFERS

Species	Conditions justifying Selection	Unsuitable Conditions	Notes on Timber	General Remarks
Scots pine, *Pinus sylvestris* L.	An adaptable tree which succeeds over a wide range of conditions. The easiest and often the only 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 good general utility timber, comparable in strength and working properties (grade for grade) with the imported timber of the same species from Scandinavia, which is known in the trade as "redwood". The wide range of uses includes joinery, constructional work, boxes, packing crates, railway sleepers, telephone poles, pitprops, fencing material and other estate purposes.	Although growth is rather slow and volume production is not high compared with more exacting species, generally it is a "safe" tree to plant.
Corsican pine, *Pinus nigra* var. *calabrica* Schneid.	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.	Avoid high elevations and loose ground. Not suitable for the northern and western uplands of Britain.	In general the timber is similar to that of Scots pine but is coarser in texture, has a larger proportion of sapwood and a somewhat lower strength.	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.
European larch, *Larix decidua* Mill. (Syn: *L. europaea*).	Site requirements are exacting. Does best on moist but well-drained moderately fertile loams. A strong light demander. A useful nurse.	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 or grass.	The timber is heavier and stronger than most other softwoods; widely used for fencing and general estate work. Other uses include pitprops, boat building, trawler equipment, vat making, waggon and lorry 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.

TABLE 5 (*Continued*)

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

Species	Conditions justifying Selection	Unsuitable Conditions	Notes on Timber	General Remarks
Japanese larch, *Larix leptolepis* Murr.	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.	Avoid dry sites and areas where the annual rainfall is low (under 30 inches); also badly drained sites, frost hollows and very exposed situations.	In general only the timber from thinnings has been utilised in any quantity and there has been a tendency to regard it as being less strong and less durable than European larch. The limited number of tests made to date on middle-aged Japanese larch timber have shown it to have much the same strength as European larch, but a lower density.	Resistant to larch canker. Gives a higher yield, up to middle age, than European larch or Scots pine.
Hybrid larch, *Larix eurolepis* Henry.	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.	—	Young material from thinnings appears similar to Japanese larch.	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 (from seed collected from second generation trees) may be inferior to European or Japanese larch.
Douglas fir, *Pseudotsuga taxifolia* Rehd. (Syn: *P. douglasii*).	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 loose ground, especially in youth.	A good contructional timber with a high strength/weight ratio in compression and bending. Used for pitprops, box and crate making, constructional work, and as a general-purpose softwood.	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.
Norway spruce, *Picea abies* Karst. (Syn: *P. excelsa*).	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. Subject to heart-rot on badly drained soils. Often checked by frost in hollows, but eventually wins through.	Suitable, grade for grade, for the wide range of uses for which imported Norway spruce or "whitewood" is used, e.g. joinery, building, pitprops, ladder and scaffold poles, boxes, and especially food box making.	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.

TABLE 5 (*Continued*)

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

Species	Conditions justifying Selection	Unsuitable Conditions	Notes on Timber	General Remarks
Sitka spruce, *Picea sitchensis* Carr.	Damp sites, generally, including exposed high land. Stands exposure better than any other common conifer; very suitable for high rainfall areas.	Avoid frosty or very dry sites. Unsuitable for heathery ground. Honey fungus is a risk in some scrub and coppice areas.	The timber of Sitka spruce is not generally so strong as that of Norway spruce, at least in its early years. Like Norway spruce it finds a wide range of uses where a softwood of the "whitewood" type is required.	A faster grower than Norway spruce and a very large volume producer.

Other Conifers

The species described 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 6

NOTES ON INDIVIDUAL SPECIES: OTHER CONIFERS

Species	Conditions justifying Selection	Unsuitable Conditions	Notes on Timber	General Remarks
Lawson cypress, *Chamaecyparis lawsoniana* Parl.	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 and infertile soils.	There is as yet 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.
Western hemlock, *Tsuga heterophylla* Sarg.	The less fertile moist but well drained sites, especially sides of valleys. A strong shade bearer and excellent for underplanting.	Unsuitable for dry sandy soils.	The limited amount of information available about the timber of home-grown hemlock indicates that it has a good chance of establishing itself as a building timber and—if graded for the purpose—as a joinery timber. So far it has been used mainly for pitprops and general estate work.	Is easily established under a light shade, for example of birch. Susceptible to bole fluting and to heart-rot on the better soils.

TABLE 6 (*Continued*)

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

Species	Conditions justifying Selection	Unsuitable Conditions	Notes on Timber	General Remarks
Lodgepole pine, *Pinus contorta* Dougl.	Flourishes on the poorest heaths and peats, where no other tree will grow, after suitable ground preparation. Stands exposure better than any other tree except Sitka spruce.	—	Little home-grown timber has been used except in the round as pitprops, but in its native habitat it is used for boxwood, transmission-line poles and pulp manufacture.	Is probably the best pioneer species in Britain and is now being widely planted, especially in the west and north.
Austrian pine, *Pinus nigra* var. *austriaca* Asch. Graeb.	Limestone sites in exposed areas. Useful for shelter-belts on light soils near the sea.	Not suitable for wet soils, or for planting in the north and west generally.	Little home-grown timber has been produced. Thought to be inferior to Scots pine in most properties.	Not worth planting except in certain conditions as a shelterbelt, or possibly as a nurse for beech. Tolerates smoke better than other conifers.
Weymouth pine, *Pinus strobus* L.	Cannot now be recommended owing to its susceptibility to White Pine Blister rust (*Cronartium ribicola*).	—	—	—
Californian redwood, *Sequoia sempervirens* Endl.	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. Little is known of the strength properties of home-grown timber. A valuable timber in its native habitat.	Usually slow in establishing itself. Best planted under tall cover.
Wellingtonia, *Sequoiadendron giganteum* Buch. (Syn. *Sequoia wellingtonia*).	Deep, moist, fertile soils in sheltered situations. Stands more shade and tolerates drier and more acid soils than the Californian Redwood.	—	Timber is similar to Californian redwood.	Windfirm. A hardy tree.
European silver fir, *Abies alba* Mill. (Syn: *A. pectinata*).	Does not at present appear to be worth planting owing to damage caused by the insect *Adelges nüsslini*. A strong shade bearer.	Avoid frosty localities and planting in the open.	The timber from this species has generally the same appearance and texture as spruce, or "whitewood", and is used for the same purposes.	—
Grand fir, *Abies grandis* Lindl.	Well-drained, moist, deep soils. Useful for underplanting.	Avoid frost hollows and poor soils, particularly really acid ones.	Similar to European silver fir.	In favourable situations, produces a large volume of timber rapidly.

TABLE 6 (*Continued*)

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

Species	Conditions justifying Selection	Unsuitable Conditions	Notes on Timber	General Remarks
Noble fir, *Abies nobilis* Lindl. (Syn: *A. procera*).	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 European silver fir.	Has proved a useful shelterbelt tree under certain west coast conditions.
Serbian spruce, *Picea omorika* Pan.	Similar to Norway spruce, but tolerates poor soils.	Similar to Norway spruce, but is frost hardy.	—	Useful in frost hollows where other spruces fail.
Western red cedar, *Thuja plicata* D. Don.	Moderately fertile soils, even if rather shallow, and fairly heavy clays. Stands shade well.	Avoid poor or very acid soils and exposed sites.	A lightweight timber of high natural durability suitable for roofing, shingles, ladder poles, weather boarding and exterior work where high strength not required.	Liable to attack by *Keithia thujina* in nursery seedbeds.
Mountain pine, *Pinus mugo* Turra	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 worst sites.	If big enough, suitable for fencing and rough crate and box making.	—
Maritime pine, *Pinus pinaster* Ait.	Thrives on sandy soils, especially in the south and west of England.	Not recommended elsewhere.	Resembles Scots pine but is usually of poorer quality. 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.	Sandy soils; light fertile soils, in the south and west of England.	Not recommended elsewhere.	Resembles Scots pine, but is usually coarse-grained 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 7

NOTES ON INDIVIDUAL SPECIES: PRINCIPAL HARDWOODS

Species	Conditions justifying Selection	Unsuitable Conditions	Notes on Timber	General Remarks
Pendunculate oak, *Quercus robur* L. (Syn: *Q. pedunculata*) Sessile oak, *Quercus petraea* Lieb. (Syn: *Q. sessiliflora*)	Well-aerated deep fertile loams. Grows fairly well on fertile heavy soils and marls. Strong light demander. Sessile oak tolerates less rich soils than does pedunculate oak.	Avoid shallow, ill-drained or infertile soils, frost hollows and exposed areas.	Oak has many uses. For example, prime clean oak is used for veneers, furniture, tight cooperage, interior joinery, parquet flooring, coffin boards and spelk baskets. Oak of lower quality is used for fencing, weather boards and waggon timbers.	Both species are very windfirm.
Beech, *Fagus sylvatica* L.	Chalk and limestone soils. Good loams of all types if well drained. Likes a mild 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.	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.
Ash, *Fraxinus excelsior* L.	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 sports goods, vehicle framing, tool handles and turnery. Also used for furniture.	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.
Sycamore, *Acer pseudoplatanus* L.	Fairly frost hardy. Stands exposure well.	As for ash.	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.	A useful tree as a windfirm mixture for conifers in shelterbelts. Grey squirrels can be very harmful.

TABLE 7 (*Continued*)

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

Species	Conditions justifying Selection	Unsuitable Conditions	Notes on Timber	General Remarks
Sweet chestnut, *Castanea sativa*	Needs a deep fertile soil, and it is 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.
Poplar, various hybrids, including: *Populus serotina* Hartig. *Populus robusta* Schn. *Populus eugenei* Louis. *Populus gelrica* Houtz. *Populus laevigiata*	Very exacting species; 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.	Poplar growing is a specialised job and is dealt with in Forestry Commission Bulletin No. 19, *Poplars* and Leaflet No. 27, *Poplar Planting*.
Poplar (various species); Balsam poplar, *Populus trichocarpa* Torr. et Gray. Grey poplar, *Populus canescens* Sm. Aspen, *Populus tremula* L.	Balsam poplar stands more acid conditions than the common hybrids. Grey poplar merits retention in woodlands.	— Aspen does not grow well anywhere in the British Isles.	As above.	As above.

Hardwoods of Limited Forest Value

Many of the species listed while of little commercial value, have valuable silvicultural virtues, which may make their cultivation worth while.

TABLE 8

NOTES ON INDIVIDUAL SPECIES: HARDWOODS OF LIMITED FOREST VALUE

Species	Conditions justifying Selection	Unsuitable Conditions	Notes on Timber	General Remarks
Birches: Silver birch, *Betula pendula* Roth. White birch, *Betula pubescens* Ehrh.	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 be not 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. Has good strength properties and could find a wider range of uses if grown to saw-log size.	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.

TABLE 8 (*Continued*)

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

Species	Conditions justifying Selection	Unsuitable Conditions	Notes on Timber	General Remarks
Field elm, *Ulmus procera* Salis. Wych elm, *Ulmus glabra* Huds.	Fertile, deep, moist, light loams. Frost hardy.	Wych elm appears to be more wind-firm than common elm.	Field elm is our most valuable hedgerow timber. Uses include coffin boards, weatherboarding, box ends, packing case manufacture, dock piles and fenders.	Field elm is usually grown only as a hedgerow tree. Wych elm thrives under forest conditions, particularly in northern and western valleys.
Common alder, *Alnus glutinosa* L.	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.	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.	Fertile soils.	—	Good for turnery, and is a favourite timber for wood-carving.	Of limited value. Wind-firm. Viable seed is produced only rarely.
Cricket Bat Willow, *Salix alba* var. *caerulea* Sin.	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.	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.	Fertile woodland soils, particularly over the chalk.	—	A valuable turnery and furniture wood.	One of the few trees to produce both good timber and showy blossoms.
Red oak, *Quercus borealis* Michx.	Fertile sandy soils.	—	A general-purpose hardwood; not a substitute for English oak.	Valued as an amenity tree because of its autumn colour. Grows rapidly. Nursery treatment resembles common oak.
Horse Chestnut, *Aesculus hippocastanum* L.	Fertile soils.	—	A white timber of fine texture used to a limited extent in turnery work and in making moulders' patterns and fruit trays.	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 a predator 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 our 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 has 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 may 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 8

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 9 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 10 and 11.

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. A considerable amount of present-day planting is done by direct notching without any sort of prior preparation, but we do now realise that some preliminary work can have great advantages on certain 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.

It was realised that until a new root system developed, almost on the surface of the ground, little or no growth took place, and the need for new planting techniques became obvious. The first successful development was the planting of the young trees on upturned turfs taken from drains cut on wet peat moorland, or on mounds of spoil on dry heaths. The success of these methods of "turfing" or "mounding" was so great that they became the standard methods of upland afforestation; and ploughing is little more than the mechanisation of these techniques. The application of large-scale ploughing, however, had to await the development of sufficiently powerful track laying tractors, which did not become available until about 1940. Since then most of the hill areas planted by the Commission have been prepared by ploughing.

The benefits of ploughing might be summarised in the following way: first, the reduction of losses of trees, and the more uniform early growth, due to

the ironing out of minor differences between poorer and better planting spots. Second, but most important, the more rapid early growth; this reduces the period the trees spend in the weeding—and most frost-susceptible—phase, and results in quicker establishment. Thirdly, increase in quality class of the crop. There is no doubt that on the poorer ground, the total production for any particular rotation will be increased substantially by ploughing. Also, the task of planting is made easier and quicker. Smaller—and therefore cheaper—plants may be used, and sometimes no weeding at all is required. Finally, fire risk is reduced for several years.

Against these advantages must be placed the future extraction difficulties imposed by the plough ridges, a possible increase in the tendency for windblow owing to the roots tending to run along the ridges or furrows rather than in other directions, and the greater initial expense. On balance, however, it is believed that on most workable sites the benefits far outweigh the disadvantages.

There are three main types of land on which ploughing is normally done—wet sites (mainly peat), dry heaths, and grassy sites. On the first of these, the wet sites, draining is the most obvious requirement, but it is quite clear that raising up the plant out of the vegetation is also essential. These two needs are well met by turf ploughs such as the Cuthbertson single mould-board model which cuts a fairly deep drain and at the same time inverts a turf ridge which may be planted as it lies; or else thick slices may be cut from it and spread on the surface of the ground at the required planting spacing, and the trees planted in these turfs. Opinions differ as to which is the better of these two practices, but as a rule the furrows are usually spaced seventeen to twenty-two feet apart, to allow for two or three rows of turfs to be spread between furrows. But on the very poorest deep peat, the furrows are spaced five to six feet apart and all planting is done on the turf ridges.

Other types of ploughs are also used, but most provide only turf ridges and normally they need to be used in conjunction with a draining plough. For example, a Cuthbertson double mould-board plough, which provides two slices of turf from one furrow, may be used at appropriate spacings between drains made by a single mould-board model. The alignment of the drains made by a draining plough needs careful forethought and this will be discussed later.

On the dry heaths, ploughing has two main objects: first to break up the shallow layer of surface peat, and second to reduce the compaction in the underlying mineral soil, breaking up the pan where this exists. Such work can be done with relatively simple but necessarily robust ploughs. The commonest type in use with the Commission is the "Tine" plough which can be used either with or without a mould-board. Ploughs on heathland are used to give furrows at intervals of about five feet, and the furrows should run round the contour, rather than up and down the hill, as in this way moisture is conserved and any tendency towards erosion is lessened.

The third main type of ground we called "grassy sites"; but this type might be more correctly defined as sites where it is important to secure freedom from competing vegetation. Examples are grasslands on mineral soil and chalk downland. Various types of plough are used on these sites, including strengthened agricultural ploughs; ploughing is generally at five feet intervals, but occasionally complete surface ploughing is used.

All ploughing as a preparation for planting requires a powerful tractor, and Commission practice has been to use standard commercial makes of about thirty to forty horse-power. On very soft peatland, tractors with specially wide tracks are required.

Up to the present, most ploughing has been carried out by the Forestry Commission, and 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 often planted by private owners, partly owing to lack of suitable equipment, and partly because of the extra initial expense. But 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.

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.

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-aligned 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, an initial spacing of 15 to 30 feet might be regarded as normal (drains to be maintained as permanent, would of course, be at a much wider spacing) but 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, it is essential for the bottom to go a few inches into the mineral soil.

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 exceptional to find sites where their use is justified economically.

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 meet 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 9 below gives some general specifications of different types of fences; these specifications will of course vary with local conditions and customs.

TABLE 9

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. 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)	Round 6-7 in. 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. 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.
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.

TABLE 9 (*Continued*)

FENCING SPECIFICATIONS (*Continued*)

Type	Straining Posts	Intermediate Posts	Wire	Wire Netting	Erection
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 9

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.

Generally 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 emphasis. 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; generally, however, the best position is either in the bottom of the furrow, or on that side of the furrow which lies nearest the ridge. In these positions, the plant receives most benefit from the cultivation of the soil, and is unlikely to be troubled by the reinvasion of vegetation, usually heather, for a number of years, by which time the young plant should be established. 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 competing vegetation 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 October or November to March or April. Our climate is 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 into May.

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 nor too large and which has a good stout stem, or put in a more technical way, has a high ratio of root collar diameter 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, or else 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 18.)

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.

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.

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 waterlogged; 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.

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 die 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.

USE OF FERTILISERS AT TIME OF PLANTING

Little need be said about this as there are very few commonly planted soils on which the use of fertilisers is necessary. However, on the poorest wet peat moorlands characterised by deer grass, a phosphatic fertiliser—ground mineral phosphate is the best known—applied during the first season after planting, is essential for the growth of any species which might reasonably be planted on land of this type. The fertiliser is applied as a powder to the turf around the plant at the rate of 1½ to 2 oz. per plant. A similar technique is useful on the poorer quality dry heaths, although the results are not so striking as on the poor wet peats; early growth of all species is helped but pines appear to need phosphate least. Experience has shown that the application of other fertilisers is scarcely ever worth while.

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 and exceptionally even 8 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 10 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 10

SPACING DISTANCES FOR FOREST PLANTING

Species	Normal Spacing in feet	Maximum Spacing in feet
Scots pine	4½— 5	5
Corsican pine	5	6
European larch	5½— 6	8
Japanese larch	5½— 6	8
Hybrid larch	6	8
Douglas fir	5½— 6	8
Norway spruce	5	6
Sitka spruce	5 —5½	8
Western hemlock	5	8
Lodgepole pine	4½— 5	5
Grand fir	5½— 6	8
Other conifers	5	—
Oak	3 — 4	5
Beech	3 — 4	5
Ash	3 — 4	6
Sycamore	4	6
Poplar	18—24	—
Willow	30—40	—
Other hardwoods	3 — 4	—

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 what 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.

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 10

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 on 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 14, page 63. 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.

First of all we must decide how much, if any, of this regrowth, generally classed as "scrub", we wish to retain, and for what purpose. If it is good enough, we may keep all or part of it, or perhaps only selected stems or groups, to form a future timber crop. Alternatively, we may retain some or all of it *temporarily* with the object of using it as a nurse crop to some better class of tree that we propose to plant beneath or amidst it. The third possibility is to clear the lot, and replant from scratch.

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, not only do we invite a vigorous regrowth of coppice shoots and weeds of all kinds, resulting in high weeding costs, but by baring the soil we expose it to serious drought effects and loss of accumulated humus. This results in a high death percentage in the plants we put in, and their relatively poor performance in relation to weed growth; further, many species will suffer setbacks due to late spring frosts.

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 woody 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. But the indications so far are that such methods are more costly, and more complicated to operate in practice, than is clearance by hand tools. 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 organise 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, and also prevents the dissipation of the humus layer on the ground. 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 moisture is retained in the soil under the shade.

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. It is better to leave too heavy a shade, than allow too much light. 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 trees 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, to 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.

Having established our new crop under overhead cover, periodical even thinning of the cover is necessary to keep the young trees growing vigorously, and to prevent mechanical damage of the leading shoots by contact with the branches of the cover. A safe "rule-of-thumb" guide, assuming initial overhead cover was approximately the ideal, is that cover should be removed over the different species in the following manner:

A. Semi-shade bearers. Douglas fir, Norway spruce, oak, sycamore, maple, etc.: Thin the cover to half its density after the 2nd growing season; repeat after the 4th growing season; remove the remainder after the 6th growing season.

B. Shade bearers. Beech, hemlock, *Thuja*, Lawson cypress, Silver fir, as above but on a three or four year cycle of thinning the overhead shade, depending on the rate of growth of the underplanted crop. The cover will therefore all be away in nine to twelve years after planting the new crop.

The degree of shade can best be judged in the summer months, while the leaf is on the trees. Signs of undue overshading of the young trees are fairly easy to recognise; symptoms are a lack of vigour and sturdiness in growth, the production of short and slender leading shoots and side branches, and thin rather pale-coloured needles in the conifers. The "rule-of-thumb" guide above should always be supplemented by observation, and plans formulated accordingly.

In each thinning of 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. Ring-barking is occasionally resorted to, to kill the cover-trees without felling them, particularly if they are considered unsaleable; but this practice should be avoided as far as possible, since the trees so treated look most unsightly and take many years to disappear.

Used in this way for cover and gradually removed, the scrub or coppice may yield some returns at each thinning which would not be obtainable if all were cleared at time of planting. Where there are markets for turnery poles, birch treated as recommended, the heavier poles being removed at each thinning, should yield a high proportion of material suitable for this market. Poles of other species may yield firewood or temporary fencing stakes; but if there is no market they can be left in the plantation between the rows of planted trees. *Thinning of the overhead cover should always be carried out in the winter months;* this will minimise damage to young trees planted below. The lop and top should be disposed between the rows and will quickly rot.

Two further advantages of this 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. 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.

Chapter 11

TREATMENT OF COPPICE

WHEN certain tree species are felled their stumps have the ability to make new woody shoots from dormant and adventitious buds, these shoots being called "coppice". The great majority of broadleaved trees behave in this way, but very few conifers do so. Each coppicing stump will make several new shoots, the number depending on the age, size, and vigour of the parent tree and root system, and generally varying between six and about twenty. A coppicing stump is usually referred to as a "stool".

The ability of a newly cut hardwood stump to make effective coppice growth is regulated chiefly by two factors, the age of the stem which has been cut and the fertility of the site, and while it is not possible to be precise on this matter it is certainly true that the vigour of coppice shoots is progressively reduced as the age of the cut stem increases beyond forty years, and also that the age up to which a stump will coppice is greater on sites of high soil fertility than where the quality of the soil is low. Because of this, instances have occurred on very fertile sites where stumps from stems up to 100 years old have produced vigorous coppice, whereas on poor sites stumps only twenty years old may coppice weakly or not at all.

It appears that the effective age is that of the stems cut, and not that of the older root system, for if the coppice shoots are cut at intervals not exceeding about thirty years the root systems of several broadleaved trees species are able to yield anything from six up to ten or more successive crops before the vigour of the root fails.

Because coppice shoots draw on an established root system they are characterized by very vigorous growth during their early years; with annual height increments of anything between two feet and six feet for the first several years they quickly outgrow young plants raised from seed. To take advantage of this very high rate of growth, which allows coppice stems of several hardwood species to develop to pole size within fifteen to twenty years, it has been the custom for centuries to manage certain woodlands on successive coppice rotations to meet the demands of some specialized and fairly local market.

Coppice woodlands may be either "simple coppice", that is managed entirely for the production of coppice shoots, in which every stem is cut at the rotation age, or "coppice with standards" in which a number of stems of a timber species, known as "standards", are scattered through the coppice and allowed to grow for several coppice rotations.

However, over the greater part of Britain the demand for the products of coppice systems has, with the exception of chestnut coppice, fallen sharply during the present century, so that a problem has arisen of converting uneconomic coppices into some better paying form of high forest.

SIMPLE COPPICE

Coppice is worked by clear cutting every year, or period of years, an area known as a "coupe", or locally as a "cut" or a "cant". The length of the rotation is decided chiefly on the basis of the size of the coppice material required and an estimate of the probable rate of growth; then, ideally, the woodland is divided into the same number of equal-sized annual coupes as there are years in the rotation. If one coupe is cut each year the quantity of annual

outturn should be reasonably constant. It is important that the coupes should be arranged so that each has access to a hard road or ride, so that produce cut on one coupe is not extracted through the younger crop on neighbouring coupes, or damage will be done. A system of long narrow coupes with the small end abutting on to a track is helpful here. If coppice stools become enfeebled after repeated cutting they should be replaced by replanting or by layering.

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 was estimated in 1953 that about 30,000 acres of chestnut coppice, regularly managed, are needed to maintain the British 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 of one-plus-two or two-plus-two years should be planted at seven to eight foot spacing; these may be cut back as soon as they are established 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) 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, and it is 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 wire to prevent warping and to straighten individual pales.These bundles should be set aside and allowed to season before being used.

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. 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 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.

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.

In some places, however, there is still a lively demand for hazel coppice, and in order that the position could be studied as a whole, a survey was made recently by the Rural Industries Bureau of the extent to which hazel coppices are worked system-

atically, and this, together with a discussion of the present and future prospects of the industry, and including a review of new forms of utilization, has been published by the Forestry Commission as their Bulletin 27, *Utilisation of Hazel Coppice*. There are about 167,000 acres in Britain carrying hazel in the form of simple coppice, coppice with standards, and scrub, of which only about 12,000 acres are worked regularly. The remaining 155,000 acres constitute largely unproductive or derelict woodlands, which would give better returns under some other crop.

The number of years taken for hazel coppice to reach the desired size depends on the fertility of the site, and the presence or absence of standard trees whose shade may weaken the vigour of the coppice stems. An average rotation may be taken as nine years, though locally it may be as short as six years, especially if the form of utilization demands a high ratio of smaller rods, or as long as twelve years where growth is slow or where larger rods are wanted. During this period the rate of production is quite high and averages about two tons weight of green material per acre per annum. One acre of good hazel coppice may produce an average of 10,000 rods, enough to make 25 dozen sheep hurdles, and in addition there should be 200 to 300 bundles of pea sticks and ten bundles of bean rods.

As with all coppice systems, the stems should be cut cleanly and close to the ground so as to encourage new shoots to spring from the rootstock rather than from the stumps of the cut stems, and felling should be done during the dormant season because summer cutting tends to weaken the stools. When cutting, it is usual to lay all the stems in bundles or 'drifts', with the butts pointing in the same direction, to simplify the later sorting. Where the coppice is to be made into wattle hurdles it is important to use it fairly soon after cutting, as if it is allowed to lie for too long it dries and becomes difficult to work. Hence it is usual to cut quite a small area and then "work it up" into hurdles before resuming the cutting. Where this is done on piece work, a common rate in 1957 is £8 to £10 for cutting and laying the rods, plus £2 per dozen for hurdles. A skilled man may make a dozen hurdles a day which would probably be sold at roadside for about £5 a dozen. Extra payments are made for preparing minor produce such as bean rods and pea sticks.

Another major use for hazel coppice is to provide the rods used in making the crates in which pottery is packed. Rods for this purpose are mostly ten to twelve feet long and carefully graded by half-inch size classes of butt diameter, and with different numbers per bundle depending on the butt diameter. Piece work rates in 1957 are about £8 to £10 per acre for cutting and laying the rods, plus about 2/6d. per bundle for making them up. These bundles would sell at roadside for about 5/- per bundle or £25 per load of 100 bundles.

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 WITH STANDARDS

Coppice with standards is a system designed to grow two separate crops on the same woodland area. One part of the crop consists of coppice and is managed exactly as for Simple Coppice, while the other part consists of a relatively small number of trees called "standards" scattered over the area and managed on the selection system. Although standards are usually oak, beech, or ash, coniferous standards are sometimes found. A proportion of the standards is felled each time the coppice is cut from the coupe in which they are standing, and at the same time a number of seedling trees are reserved to be allowed to grow into standards.

While the coppice-with-standards system was well fitted to the requirements of a predominantly agricultural economy, it is now generally considered to be inefficient; the relatively low stocking of short-boled timber and the greatly declined market for underwood products being the principal disadvantages. Consequently, most such areas are now being converted either to high forest or to simple coppice.

COPPICE FOR PAPER PULP AND FIBREBOARD

Until recently the outlets for small-sized hardwood poles and timber were declining, but new developments in the fields of paper and fibreboard manufacture have opened up fresh markets. There are factories in the south of England which are ready to pay reasonable prices for such material, if it is available within a reasonable lorry haul. This makes it easier to dispose of stuff cut when clearing coppices; but it is still too early to say whether the yield and value of coppice poles for these purposes will make it worth while to retain coppices with such markets in view.

CONVERSION OF COPPICE TO HIGH FOREST

During the last half century there has been a considerable drop in the demand for products of coppice woodlands so that there is now a legacy of such woods which can no longer be managed at a profit. However these old coppices often occupy good forest ground capable of growing valuable high forest, and it is a common practice to establish high forest crops, either broadleaved or coniferous, on old coppice areas. Generally speaking sweet chestnut coppice has maintained its position in the market, so that there are three main problem types of coppice woodland: (1) the slow-growing oak coppices of the West, (2) the 155,000 acres or so of neglected hazel coppice, some with standards and some purely coppice, chiefly occurring in the southern half of England, and (3) the woodlands which have regenerated naturally to a mixture of coppice and seedling growth, some of timber species and some not, following exploitation cuttings of broadleaved forest on fertile soils.

The following methods of conversion to high forest have been used with success:

(1) Where the coppice is sufficiently vigorous and of a species which will develop into timber, the stems are retained, tended, and thinned, until in the course of time they form a high forest which under favourable circumstances may not be distinguished from one of seedling origin.

(2) Where the coppice is not capable of growing into timber, either because the stools lack vigour or because the site quality is too low to allow the species present to develop into timber of acceptable quality, or because, like hazel, it is not a timber species, then it is necessary to introduce new plants to replace the coppice. Broadly speaking this may be done either:

(a) By clear cutting the coppice and replanting on bare ground.

(b) By retaining some of the coppice as a shelterwood or in some pattern of groups or strips to provide sheltered conditions for the new plants, and to reduce the costs of establishment. Trees of some shade-tolerant species are then planted between the stems of the overwood.

These operations have been described in the previous chapter.

Chapter 12

THINNING

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

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

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

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

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

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

The main object of thinning is the benefit of the final timber crop. However desirable an early cash return may be, it should be a secondary consideration; and whenever a thinning is necessary it should be undertaken, even though no use whatever can be made of what is taken out. Neglect may lead to the loss of the whole crop through wind-throw or snow damage and may therefore be very false economy. Where thinnings are delayed the bulk of the timber may be formed on many thin stems of low total value. It is usually much more profitable to grow a smaller number of larger trees of better quality. A note on Thinning Grants appears on page 87.

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.

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

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

Cleaning

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

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

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

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

Development of Extraction Routes

In large plantations easy access is desirable for the removal of produce from thinnings. On flat or moderately sloping ground it may be worth while to remove single lines of trees at intervals, thus providing sufficient space for the passage of a lorry; if this is done when the crop is young, the break in the canopy closes over rapidly and there is little or no loss in production, provided the plantation is well stocked and uniform in growth.

CLASSIFICATION OF TREES

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

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

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

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

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

7. *Dead and Dying Trees.*

These seven classes are illustrated in Figure 1.

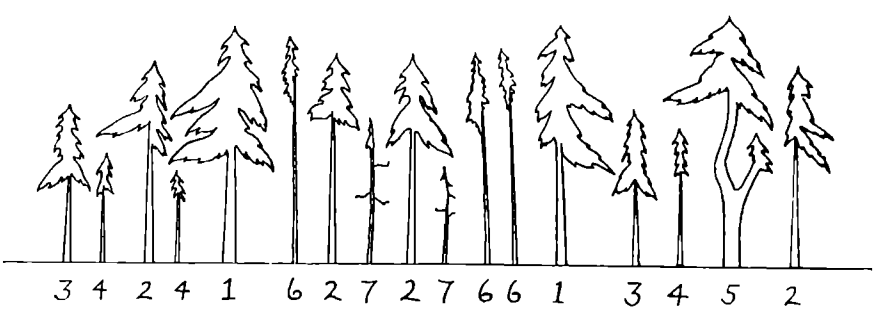

Fig. 1. The main types of trees encountered in thinnings.

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

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

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

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

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

PROCEDURE

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

(a) The removal of definitely harmful trees, particularly *Whips* and *Wolves* and *diseased* stems.
(b) The provision of more growing space for the best of the *Dominant* and *Co-dominant* trees.
(c) The even distribution over the ground of the trees that are likely to form the final crop.
(d) The utilisable value of the stems that are removed.

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

Methods of Marking

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

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

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

FREQUENCY

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

Thin every 4 or 5 years with Scots Pine, Norway Spruce, Corsican Pine and most hardwoods.
Thin every 3 or 4 years with European Larch and Ash.
Thin every 3 years with Sitka Spruce, Douglas Fir and Japanese Larch.

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

GRADES OF THINNING

For sample plot work a number of grades or intensities of thinning have been defined, but for simplicity only the more important ones are described here. There are two distinct types of thinning: *low thinnings* and *crown thinnings*. The general idea of a *low thinning* is to accelerate the processes of nature by cutting out the smaller trees, although in a heavy low thinning some of the larger trees, including dominants, may be cut out as well. In a *crown thinning*, on the other hand, thinning is mainly restricted to dominant trees which are competing with other dominants. The better sub-dominant and co-dominant trees are left. The object is to produce a stand in which the best dominants are given sufficient

room for rapid development, while the spaces between them are occupied by smaller trees.

Up to a few years ago low thinnings were the general practice in Great Britain; recently, however, there has been much thought about crown thinnings. They are more efficient in promoting the development of the best trees, and the thinnings are easier to sell because they are of larger average size. On the other hand, the many small trees which are left standing may complicate the extraction of produce, and may make a plantation look "untidy". In light-demanding species crown thinnings are usually practicable only in young crops, because later the trees with crowns below the level of the dominants tend to become suppressed and may die.

Light Low Thinning

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

A light thinning will remove: (a) Dead and suppressed trees, the latter being trees whose leading shoot is under part of the crown of a taller adjacent tree. (b) Those sub-dominants which can be removed without breaking the canopy. These are usually those trees which are badly shut in on one side but not yet actually suppressed; they are in any case short trees. (c) Whips. If these are numerous, as they sometimes are in a neglected plantation, it may be impossible to remove all of them without exceeding this grade of thinning. On the other hand, if only sporadic (i.e., occurring at irregular and infrequent intervals), they can and should be all cut out in a light thinning. (d) Lastly, there are wolf trees and other trees with badly shaped stems. Even in a light thinning it is correct to remove occasional malformed trees in the upper canopy. This will involve local breaks in the canopy, but as long as they are small and local the general character of the thinning will not be affected.

Moderate Low Thinning

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

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

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

Heavy Low Thinning

This is an intensification of the moderate thinning, involving a general and considerable breaking of the canopy, though there are limits beyond which it is inadvisable to go.

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

sub-dominant should be retained unless it is required for soil cover.

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

Crown Thinnings

In the same way as it is customary to distinguish between light, moderate and heavy *low thinnings* it is convenient to distinguish between light, moderate and heavy *crown thinnings*, although these grades cannot be defined accurately in practice.

In a *light crown thinning* only a limited number of dominant trees is removed in any one operation, the object being to reduce crown competition among the better dominants without ever eliminating it. In a *heavy crown thinning* a limited number of the best dominants, usually about 100 per acre, are freed from all crown competition from the first thinning onward, by cutting out any tree that touches the crown of a selected tree. A *moderate crown thinning* is intermediate between these two extremes.

CHOICE OF GRADE

Low thinnings and crown thinnings, light thinnings and heavy thinnings, all have a place in British forestry. The correct type and grade of thinning to adopt in any given stand will depend on a number of circumstances, including: species, age, height, rate of growth, general vigour of the crop, previous treatment, markets for produce of varied sizes and the objects of management. For example light-demanding species such as the larches require heavier thinnings than more shade-tolerant species such as Norway spruce; young, fast growing and vigorous crops should be thinned more heavily than older, slow growing and less vigorous crops; sudden drastic departures from previous thinning treatment should be avoided because they encourage wind-blow and may adversely affect timber quality; where markets for small produce are restricted crown thinnings may pay better than low thinnings; where the main object is to produce timber of specified dimensions in the shortest possible time thinnings should be heavy, while the rapid building up of a reserve of standing timber demands a conservative thinning regime.

In subsequent sections recommendations are made for the treatment of each of the major species at various stages of their growth. But although it is true that each species has its own characteristics, which govern the treatment to be applied, it is none the less true that each plantation must be considered on its merits, with particular reference to its life history.

The thinning schedules given in this pamphlet are intermediate between a pure low thinning and a pure crown thinning, but they approach more closely to a low thinning; they are also intermediate between the light thinnings which were customary in the past and the very heavy thinnings which may be found advisable under certain conditions.

For this reason the treatment of plantations in which thinning operations have been delayed is dealt with separately throughout.

Advice can be given only in broad general terms, and is subject always to local factors which may be of overriding importance. The important point to realise is that the growth of a tree crop may be controlled not only by thinning, but by varying the intensity of the thinnings as occasion demands.

STOCKING DENSITIES

There appears to be a general demand for guidance as to the correct stocking of plantations of the different species at different stages in the development of the crop. An attempt has been made, by selection from the Commission's sample plot data and from current practice, to give a table for some of the major species. Table 11 shows how the number of trees may be expected to diminish with increasing height, if the thinning prescriptions given in the text are followed. As has been stated previously much lighter and much heavier thinnings than those indicated may often be justified and may even be desirable under certain conditions. The heights given in the table are not the mean height of the crop, but are the top height—that is, the average height of the larger (dominant) trees in the crop. This is an easier value to estimate in the plantation than the mean height. The top height can be obtained by measuring a few of the larger dominant trees, but omitting trees with broken crowns, also any outstandingly large and tall individuals. The average height of the trees measured will give a fair estimate of the top height of the crop.

The stocking in a young plantation ready for its first thinning depends greatly on the planting distance. A plantation planted at 4 feet by 4 feet will start with over 2,700 trees per acre; even though many will be suppressed before the time of the first thinning, there may still be 1,500 to 2,000 trees standing on the acre. On the other hand, a plantation established at 5½ feet by 5½ feet has an initial

stocking of only 1,440 trees per acre, a figure which early casualties may easily reduce to 1,000 trees or thereabouts. If the initial stocking is high any heavy reduction in the number of stems should be spread over several thinnings. It is rarely advisable to remove, in one thinning, more than two-fifths of the trees.

The table has been based in each case on the average rate of growth of the species concerned, having regard to the sites on which that species is usually planted. It is important, however, to realise that plantations of exceptionally rapid growth carry a larger number of stems per acre than the figure shown in the table, for a given height; conversely, in the case of slow-growing woods the numbers given in the table will require to be reduced.

The best trees are seldom uniformly spread over the ground; thinning is always a compromise between the irregular spacings of Nature and the ideal. It is better to have two perfectly shaped trees standing closer to each other than is theoretically desirable, rather than sacrifice one for the sake of a much inferior tree placed at just the required distance.

TABLE 11

AVERAGE NUMBER OF TREES PER ACRE AFTER THINNING

Top Height of Trees in Feet	Scots Pine	Corsican Pine	European Larch	Japanese Larch	Douglas Fir	Norway Spruce	Sitka Spruce	Oak	Beech	Ash
30	1,100	1,200	800	800	1,000	1,300	1,300	1,400	1,400	1,100
35	850	950	650	650	850	1,200	1,100	1,100	1,200	900
40	700	750	500	500	700	950	900	900	1,100	700
45	550	600	400	400	600	750	725	650	850	450
50	450	500	300	300	500	625	600	450	700	300
55	375	425	250	250	400	525	500	300	500	175
60	300	350	200	200	350	450	425	200	400	110
65	250	300	175	175	300	375	350	150	275	100
70	200	250	150	150	275	325	300	100	200	90
75	175	210	130	—	250	275	250	80	160	85
80	160	180	120	—	225	250	225	60	130	80
85	140	160	110	—	200	225	200	50	100	—
90	125	150	100	—	175	190	175	40	80	—
95	110	135	95	—	160	170	160	35	70	—
100	100	125	90	—	150	160	150	30	60	—

DRAINAGE

One of the objects of thinning is to secure the stability of the crop; but a well-thinned plantation may still be subject to wind-throw if the drainage is neglected. Time and again, wind-blows are found to start along blocked main drainage channels. Once a blow has started it may spread through the entire plantation. So look to the drains at each thinning, and make sure that any surplus water can get away freely.

TREATMENT OF INDIVIDUAL SPECIES

A. CONIFERS—PURE CROPS

Scots Pine

This is seldom a fast-growing tree, average rates of growth being 25 feet at 20 years and 50 feet at 40 years. This means that fairly long intervals may be left between successive thinnings, but systematic treatment is nevertheless necessary.

In southern England attacks by the pine shoot moth (see page 65) may lead to the formation of many "wolves" owing to the distortion of leading shoots; the removal of the worst of these requires attention at the earliest thinnings. Scots pine is relatively intolerant of shade, and suppressed trees seldom survive long under their taller neighbours.

Thinnings should always be barked or removed from the plantation before the pine shoot beetle, which breeds freely in the butt lengths, can emerge to attack the surrounding trees (see page 66).

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

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

Corsican Pine

In southern Britain, Corsican Pine is a moderately fast-growing tree, reaching top heights of 35 feet in 20 years and 67 feet in 40 years. It is less subject to damage by the pine shoot moth, so that wolf trees are comparatively rare. Thinnings cut during the winter should be removed or barked before the end of spring to avoid pine beetle damage to neighbouring trees.

In *normal plantations* the first thinning should be made when the trees are about 30 to 35 feet high, working to a Moderate grade. Any closely packed groups of Dominant or Co-dominant trees should be broken up. Second and subsequent thinnings should be continued on a Moderate grade, at intervals of 4 to 5 years, increasing in the later stages.

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

European Larch

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

In *normal plantations* the first thinnings should be made before the trees are 30 feet in height, removing whips, weakly suppressed trees, and wolves, and breaking up any dense groups of dominants. Subsequent thinnings should follow at intervals of 3 to 5 years, aiming at providing ample growing space for the crowns of the best trees. In the later stages these selected final crop trees, numbering 100 to 150 per acre, should be virtually isolated from each other.

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

Japanese Larch

Between the ages of 10 and 25 years Japanese larch is usually the fastest growing of all our coniferous trees, reaching top heights of 33 feet in 15 years and 53 feet in 25 years. Unless frequently thinned, a crop may easily get out of control. Some plantations contain many badly shaped dominants with wavy (corkscrew) stems, which are liable to become wolf trees, and must be removed at the first opportunity. If thinning is delayed the whole crop may tend to develop into whips, whilst suppressed trees seldom survive for long.

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

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

Hybrid Larch

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

Douglas Fir

If planted on soft rich soils, Douglas fir is very liable to windthrow or damage by wet snow, and *it is therefore essential to start thinning early and to repeat it at frequent intervals.* Wolf trees are frequent, and where they cannot be cut out without damage to the surrounding trees, it may be necessary to ring them. But Douglas fir responds rapidly to thinning, and large gaps, such as occur where wolves are removed, very soon close over. Height growth is rapid, up to 50 feet at 20 years and 87 feet at 40 years.

Delay in thinning at this stage may have serious consequences.

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

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

Norway Spruce

The rate of growth of Norway spruce is only moderate, reaching 32 feet at 20 years and 59 feet at 40 years. It is a moderate shade-bearer, requiring more light in the drier areas. Sub-dominant trees that have fallen below the level of the canopy have an exceptional power of recovery; if freed in time they may develop into useful trees within 20 years. Wolf trees are relatively uncommon.

In *normal plantations* the first thinning should start at a top height of 30 to 35 feet, working to a Moderate grade. Subsequent thinnings are continued every 4 to 5 years, on a Moderate grade.

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

Sitka Spruce

On favourable sites Sitka spruce is a very fast-growing tree, reaching heights of 45 feet in 20 years and 87 feet in 40 years. As a result windthrow is a danger, especially on soft wet soils, such as peats. Wolves are rare but may develop on exposed sites through the breakage of crowns. Usually the crop is very uniform.

In *normal plantations* the first thinnings should be made at a top height of 35 to 40 feet, on a Moderate grade, removing whips, wolves, and suppressed trees. Subsequent thinnings should follow at 3-year intervals working on a Moderate to Heavy grade in order to break up the groups of Dominants and Co-dominants. Later the interval may be lengthened to 5 years.

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

Other Conifers

Shade-bearing conifers such as Lawson cypress, western red cedar, western hemlock, and *Abies grandis*, should all be thinned moderately until the trees are from 40 to 50 feet in height. After that, if branch suppression is satisfactory, thinnings on a somewhat heavier grade may be made. Where thinnings have been delayed they should be light and frequent at the outset. Normally the interval between thinnings should be about 4 years.

B. HARDWOODS—PURE CROPS

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

Oak

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

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

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

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

Beech

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

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

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

Ash

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

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

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

Sycamore

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

Sweet Chestnut

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

Birch

Birch is seldom planted as a forest crop, but existing stands of naturally-grown trees may be worth improvement by thinning. It is a quick-growing light-demanding tree, and any individuals outgrown by their neighbours soon become suppressed and die out. It is therefore important to ensure that the lead is not taken by mis-shapen trees, with bent, forked, fluted, or elliptical stems. As the best demand is likely to be for large veneer quality butts, preference should be given to large straight cylindrical stems free from defects. It may be worth while to prune the side branches of these to a height of 20 feet.

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

Poplar

The thinning of poplar plantations differs from other species on account of the wide spacing at which the trees are initially planted. The spacings generally adopted usually lie between 18 feet and 24 feet each way (134 and 75 trees per acre respectively). If spacings closer than 24 feet have been adopted, thinning at least once will be required to produce a properly grown final crop. Thinning should be undertaken as soon as the crowns begin to meet; if it is left until there has been real crown competition, recovery of growth afterwards is likely to be delayed. Owing to the wide initial spacing it is difficult to

make a thinning except by the removal of trees on a geometrical pattern, e.g. every second tree in every second row or some such arrangement, and as far as possible the smaller, more crooked, and cankered stems should be removed.

Pruning, including the removal of epicormic shoots, is an important aspect of poplar cultivation, and should be carried out at intervals of not more than three years, and preferably every year.

Other Hardwoods

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

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

C. MIXTURES

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

Scots Pine and European Larch

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

Scots Pine and Norway Spruce

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

Douglas Fir and Eurpoean 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. Larch yields valuable early thinnings, but is a light cropper at the timber stage. As a rule, therefore, it will be more profitable to eliminate the larch.

Oak and Conifers

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

Mixtures of oak with one conifer (such as larch, pine, or spruce) in equal proportions are somewhat easier to deal with, but the oak is very intolerant of shade, and tends to be suppressed by the faster-growing conifer when that reaches a height of 25 to 30 feet. It is essential to get in early, cutting out the most dominating conifer stems before they have time seriously to damage the oak below them. Three 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.

Oak and Beech

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

Ash and Conifers

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

the more thriving ash trees must be given ample head room in good time.

Ash and other Hardwoods

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

Mixed Plantations where Thinning has been Delayed

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

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

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

Chapter 13

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 considerable loss of production. It is useful, therefore, to know something of the factors causing such loss. In many cases fungi are solely responsible for the damage, but often they attack only because the trees are growing under unsuitable conditions. To enumerate the reasons which cause initial debility in trees and lead to attack by fungi, would entail a recital of the whole gamut of errors into which the silviculturist can fall, and of the difficulties 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. All one can do, to diminish losses from disease, is to choose the best possible species for the sites we have to plant, 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 in, for instance, fruit growing. Much of the control of forest diseases must rest therefore in adaptations of normal nursery and silvicultural practices, for instance 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 AGENCIES

Frost is one of the most important causes of damage to trees in Britain (F.C. Bulletin 18). Cold winters cause browning of the foliage of evergreens and sometimes dieback of twigs, the damage being due more to the loss of water from the leaves or needles under conditions where it cannot be replaced from the frozen ground or through the frozen stem, than to actual low temperatures. Winter damage is therefore more likely to occur in exposed places. Cracks in the stems of hardwoods may occur during hard winters when the stems alternatively freeze and thaw, leading to unequal expansion of the wood. These cracks occur particularly on the south side. In the spring and autumn, however, 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.

Frost-hardy species, in particular Scots and Corsican pine, should be used for such sites in preference to the 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 10. 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 agencies 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 also produce cracks in the stems of conifers, especially fast grown dominants.

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 in many places beech is the only safe long-term forest crop.

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.

Industrial fumes and smoke make the growing of trees difficult near large manufacturing towns. In general, evergreen trees suffer more than deciduous ones. Few conifers can tolerate fumes, 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 weed-killer sprays from agricultural land is a new menace, which has recently been reported damaging trees. The hormone type distorts leaves and growing shoots, but the following year the trees will 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 included here are those which are much more important in the nursery.

Damping-Off

In young conifer seedbeds, groups of seedlings may collapse. This is due to a number of soil-inhabiting fungi, which can also attack seedlings before they emerge. Later they lessen the growth rate of older seedlings, which are too big to be killed, by destroying many of the feeding roots. Generally Damping-off does most damage in dense seedbeds under moist warm conditions. Application of Cheshunt compound will sometimes prevent further spread, if it is applied immediately the first signs of damage are noted. Soil sterilisation, for instance with formaldehyde, done prior to sowing, greatly lessens the risk of Damping-off. Infected ground, if it has not been sterilised, should not be used for seedbeds for several years, including at least one year under fallow.

Grey Mould

Grey mould (*Botrytis cinerea*) attacks a wide variety of conifers in the late summer, autumn and early winter. It is particularly prevalent on the cypresses and *Sequoia*, but also attacks Sitka spruce, Douglas fir, Japanese larch, western hemlock and other species. Sometimes it follows autumn frost damage, greatly increasing it. Tip dieback may be caused, in which case the end of the shoot bends over, dies and becomes brown. In dense seedbeds the fungus may colonise shaded needles and invade

the bases of the stems so that the whole upper part dies off. A typical 'grey mould' is formed on the killed portions.

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. Infection proceeds up the shoot so that the tips of the shoots on infected plants are always green. The disease reduces the size of the plants, and can greatly increase the percentage of culls. Leaf cast can usually be avoided by growing larch on fertile soil, so that the plants can be lined out as one-year seedlings and planted out in the forest as one-year-plus-one-year transplants. The disease is always worst on young trees spending a second year on the same ground. Sulphur sprays provide a fairly easy control.

Blight of Western Red Cedar

This disease is due to the fungus *Keithia thujina*, which causes browning first of individual scale-leaves, and later of whole shoots. Small pin-head, brown fruit bodies can be seen on affected foliage. *Keithia* is one of the most damaging nursery diseases, severe attacks causing very heavy losses. No satisfactory spraying programme has yet been worked out. New nurseries should be kept free of the disease as long as possible by bringing in western red cedar solely in the form of seed.

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, and is easily controlled by sulphur sprays. The fungus overwinters between the bud scales. The shoots emerging from these buds are first affected. Early spraying to control the fungus before it has spread from these to other shoots is essential.

Leaf Rust of Poplar (F. C. Bulletin 19 and Leaflet 27)

The leaves of some varieties of poplar are often smothered 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.

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 hosts, nearly always spreading from old infected stumps in the immediate vicinity. As centres of spread, broadleaved stumps appear to be more dangerous than coniferous ones, so that the disease is particularly apt to occur where trees have been planted on old hardwood sites. Most of the commoner forest hardwoods are moderately resistant, though many ornamental trees and shrubs are susceptible. Most conifers are susceptible. On affected trees cream coloured sheets of fungal mycelium, streaked with brown or black, occur between the bark and the wood. Later, as the bark dries, black bootlace-like strands develop under the bark of stems and roots.

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 kills scattered single trees rather than groups, so that the distribution of damage may mitigate its severity. With age, the trees become more resistant, so that losses fall more on the earlier thinnings than on the final crop. Older trees can often live for long periods with the fungus alive on some of their roots, without any apparent effect on their health, but with some loss of wind stability, and a limited amount of basal decay. 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

Butt Rot (F. C. Leaflet 5, Fomes annosus)

Decay at the base of young conifers is mostly the work of one fungus, *Fomes annosus*. This fungus can also attack and kill young trees, which are too small to become decayed. As a root disease killing trees, it is most serious on pines, but as a cause of decay in young conifers it is worst on spruce and larch, among the principal species.

Fomes annosus can be distinguished from Honey fungus, because the fans under the bark of infected roots are far more tenuous and are free of dark streaks. No black "bootlaces" are produced. In addition the fruit bodies of *Fomes*, which can be

found all the year round, are small brackets at the base of the tree, usually at soil level. They are dark brown above and cream beneath.

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. Its development in plantations on virgin ground can be greatly delayed by treating the freshly-cut stumps of thinnings with creosote. This prevents the spores of the fungus from infecting the cut surfaces, and subsequently using the stump as a centre from which to colonise the roots of adjacent living trees.

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 *Dasyscypha willkommii*. It is characterised by cankers on stems and twigs and dieback of the twigs and branches. In severe cases trees can be killed outright. The small pink, cuplike fruit bodies of the fungus are produced on the cankers. The disease is much worse on larch planted on unsuitable sites, particularly in frost hollows. It is also much more serious on larch of High alpine origin. It can be avoided if larch of Scottish origin is planted on reasonably good sites.

Dieback of Corsican Pine

Corsican pine planted at high elevations or in areas of high rainfall tends to die back. This 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. Planting of Corsican pine should be confined to drier sites at low elevations.

Branch Rust of Pine (F. C. Booklet 4)

This disease of pine, caused by the fungus *Peridermium pini*, is important only in one or two areas such as East Anglia and north-east Scotland. The fungus causes swellings on stems and branches from which orange blister-like fruit bodies emerge in early summer. Infected trees should be removed in the course of thinning.

White Pine Blister Rust. (F. C. Booklet 4)

This disease, caused by the fungus *Cronartium ribicola*, attacks five-needled pines, especially Weymouth pine, *Pinus strobus*, so severely that the cultivation of the tree in Britain has largely been given up. The fungus spends part of its life cycle on currants, *Ribes spp.*, blackcurrant being the commonest host. Pines within a mile or two of currants are liable to infection, and in view of the widespread cultivation of the latter, there are few places where five-needled pines can be planted at a greater distance from currants. On the pine the fungus causes swellings on the branches and main stem, on which conspicuously orange and white blisters occur in the spring and early summer. Later extensive dieback may develop. There is no control, but plantings of Weymouth pine, in mixture with other species, more than one mile from the nearest currants may succeed. Another five-needled pine, *Pinus peuce*, which is resistant to the fungus, is worthy of further trial.

Twisting Rust of Pine (F. C. Booklet 4)

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

Needle cast of pines, 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* is also found in nurseries, but not regularly enough to justify preventive spraying. Defoliated nursery stock should never be used for planting in the forest, but should be either destroyed or held over for a further year in the nursery.

Dieback of Douglas fir (F. C. Leaflet 14)

Douglas fir both in the nursery and in the forest often suffers 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 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)

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

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.

Needle Rust of Spruce (F. C. Booklet 4)

The needles of Norway spruce are occasionally turned bright orange - brown by the fungus *Chrysomyxa abietis*. The colour develops during the winter and the needles are shed at the beginning of the summer. Defoliation on individual trees can be very severe, but the disease seldom attacks two years running and the intensity of attack varies markedly from tree to tree, so that the total damage done is slight.

D. DISEASES OF BROADLEAVED TREES

Canker of Ash

Ash canker associated with a 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. Bulletin 19 and Leaflet 27)

This disease, which causes large erumpent black cankers breaking through the bark as raised patches, and extensive dieback on some varieties of poplar, is caused by the bacterium *Pseudomonas syringae*. The first signs of the disease are small cracks in the twigs, from which greyish bacterial slime exudes in spring. The disease can easily be avoided by the use of resistant varieties of poplar.

Dothichiza Canker of Poplar (F. C. Bulletin 19 and Leaflet 27)

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 which were crowded in the nursery are often attacked; while certain varieties, notably *P. robusta*, are more susceptible. Careful planting of good nursery stock on reasonably well-selected sites should enable even susceptible varieties to be used with safety. Once the trees are established they become quite resistant.

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 utilised as soon as possible.

Watermark Disease of Cricket Bat Willow (F. C. Bulletin 17 and Leaflet 20)

This bacterial disease is caused by *Bacterium 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 measures are in force whereby owners are compelled to fell and dispose of diseased willows. These measures have restricted the spread of the disease. Sets for planting must always be taken from healthy trees or stool beds.

DECAY

Most 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, and through broken or dead branches, large enough themselves to contain heartwood. 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. 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 utilised before it deteriorates further.

Chapter 14

INSECT PESTS

INTRODUCTORY

ALTHOUGH a large number of different types of insect pest are capable of causing damage to forest crops of all ages, it is relatively seldom in this country that insect attacks prove catastrophic or very seriously restrict the growth of the stands. Usually the so-called balance of nature operates, wherein the pest species are controlled at numerically ow 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 what insect damage occurs has to be tolerated simply because it would be uneconomic to embark upon control actions. In particular it has to be remembered that any outlay on control may have to be made several times in the course of the rotation—a condition differing basically from agricultural practice where expenditure on control can be offset against the annual value of the crop. In other cases, however, intervention may be fully justified where otherwise the crop would be lost or very severely damaged. 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 does 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.

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 are not of such importance as *M. spermotrophus*.

The caterpillars of a number of Lepidopterous species 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 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, whilst beech nuts are similarly infested by the caterpillars of *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 adverse effects on seed production. For example, the defoliation of oak by *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 DDT

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 Aldrin, which is applied at the rate of one gallon of concentrate containing 30 per cent of the active ingredient in one hundred gallons of water per acre.

Chafer grubs (F. C. Leaflet 17) are white, curved, and wrinkled, with a large 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. Although no recent research work has been done on this topic, it is probable that they can be adequately controlled by the use of the soil insecticide, Aldrin, mentioned above.

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 most frequently occurring species. 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 nicotine or benzene hexachloride 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 DDT sprays or dusts.

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. (F. C. Leaflet 25.) 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 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 mouthparts. 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 the new crop with insecticides. DDT 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 (F. C. Leaflet 4) 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.

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. (F. C. Leaflet 7.) 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.) In young pinestands outbreaks of the two common pine sawflies, *Diprion pini* and *Nediprion sertifer*, are conspicuous and on occasion defoliation may be almost complete. (F. C. Leaflet 35.) 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 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.

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 realise 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 examples of defoliators are the pine looper, *Bupalus piniarius*, (F. C. Leaflet 32); the pine beauty, *Panolis griseovariegata; Semasia diniana* on larch and spruce; the nun moth, *Lymantria monacha*, on spruce; the winter moths, *Cheimatobia brumata* and *Hybernia defoliaria* on many hardwood trees; and the oak leaf roller, *Tortrix viridana* (F. C. Leaflet 10). 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 incremental loss probably results. It is interesting to note that sessile oak is less susceptible to heavy infestation than is pedunculate oak.

The pine looper was regarded as being of little importance until 1953 when a rather serious epidemic occurred; aerial spraying of insecticides had to be resorted to in this case. 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.

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 problem is that of bark beetles and weevils in pine stands. The insects concerned are the weevils, *Pissodes* spp. (F. C. Leaflet 29) and the bark beetle, *Myelophilus piniperda*, which is known as the pine shoot beetle (F. C. Leaflet 3).

The latter insect breeds in the types of material indicated above and the young beetles feed by boring up the centre of pine twigs. These hollowed shoots break off and, since the leading shoot is often infested, permanent and serous distortions of the main stem can result. The control of the pine shoot beetle 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 this country 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 cannot constitute 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 for 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 DDT. The relevant leaflet gives further details of the methods which should be employed.

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

Chapter 15

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 County Fire Brigades are always willing to assist the woodland owner as part of their service to the community.

There are very few estates on which it would be worth while to follow the full precautions developed by the Forestry Commission for most of its own forests. 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 powerful water pumps and the trained firemen who know how to work them.

When a fire breaks out it presents a sudden emergency, and unless sound plans have been laid well ahead to cope with it, the situation can easily get out of hand. But it is perhaps even more 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. It is also important to consider what outside resources are available to aid the owner either to combat the fire itself, or to lessen the incidence of financial loss that results from it.

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, similar to that which is prepared by the Forestry Commission for all its forests. This always includes a map of the woods, showing access routes, water supplies, and telephones and the main points at which fire brigades, etc., should report. Once it 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. It is only reasonable to insist that all such machines used in the woods shall carry a chemical fire extinguisher; indeed, every lorry should be so equipped.

PLANNING WOODLANDS TO REDUCE 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; and this also provides space for stacking thinnings. In a big woodland block a few wider barriers, up to sixty feet wide, may be advisable.

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 of the year. There are two main ways of checking them.

(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 fertilisers 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 very costly. 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 brushcutters, the ordinary tractor-drawn hay mower, and even the gang mowers designed for cricket fields and golf courses.

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; but 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.

(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, 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 to site it in the centre, leaving a strip of ground on either side that can be mown or cultivated.

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. It is not in itself fireproof, but it grows so rapidly that it soon suppresses ground vegetation and lessens the chance of fire at that level. Its lower branches are then easily brashed away to give an effective gap between the ground and the crowns of the trees.

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 stop 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, even mature pinewoods will carry fire.

Brashing

Brashing, or the removal of side branches to a height of about six feet, is often practised in young conifer woods, but opinions differ as to its economic value. Regarded, however, as an aid to fire protection, it has a definite part to play on the margins of young conifer woodlands. 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.

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 first be made preferably by screefing off a strip of vegetation down to mineral soil, and the burning operations commenced outside that.

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 specified 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 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 much less than 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 promptly be 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, 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.

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, may be reminded of the need 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 lorry 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 round, 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.

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 the 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.

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.

If a fire gets into plantations much above waist height, beating becomes 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 possible unnecessary journey! 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 usually wishes, not unnaturally, to go home. But burnt logs will smoulder for hours, or even days, and so will peaty soil. It is essential, therefore, to keep a few men on the spot to tackle chance new outbreaks, until such time as heavy rain falls. This work—which will often involve overnight vigilance—should be properly organised, with provision for the men to be relieved at set hours.

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 plan to provide the fire service with a plan of the estate, showing the roads suitable for fire engines, and the lay out of the plantations. Once this very useful contact has been made, it should be renewed annually before the start of the spring fire danger season.

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 or Conservator of Forests.

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 a 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, such as firewood. The sums received, however, will rarely do more than pay for the cost of clearing the ground.

PART III

UTILISATION

Chapter 16

LICENSING OF FELLING AND GENERAL MARKETING ARRANGEMENTS

LICENSING

UNDER the Forestry Act, 1951, a licence is normally required for the felling of growing trees. The main exception to this general rule gives an owner the right to fell without a licence trees on his land containing up to 825 cubic feet per quarter and to sell before or after felling up to 150 cubic feet of this amount per quarter. Other exceptions allow the felling of dangerous trees, trees growing on land comprised in an orchard or garden; and trees of a diameter not exceeding 3 inches, or, in the case of thinnings, not exceeding 4 inches, or again, in coppice or underwood, not exceeding 6 inches in diameter. Application for a licence should be made to the Forestry Commission on the official form which may be obtained from the Conservator for the area. A copy of the form currently used is reproduced as Appendix III to this Bulletin, on page 92.

The form must be completed by the owner or other person having an interest in the land which enables him to fell the trees growing there. This means that, if licensable trees are sold before being felled, it remains the duty of the landowner to see that a licence to fell is subsequently obtained. The notes included on the application form, particularly that relating to the marking of trees, should be studied carefully.

In appropriate circumstances, the Forestry Commissioners may require the land that is cleared by the felling to be replanted, and in that event a licence will only be issued subject to Replanting Conditions.

MARKETING ARRANGEMENTS

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. However, there is little doubt that for the owner who lacks either knowledge of markets and marketing, or the time to apply such knowledge as he may have, the standing sale has most to commend it on grounds of simplicity. Selling timber felled at stump is a slightly more complex operation but of course calls for less skill and knowledge than a sale at roadside.

Standing Sales

The sale of trees standing to the merchant, apart from its simplicity, has two great virtues; firstly it enables the owner at once to know 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 called upon.

As noted above, a licence to fell the timber must be applied for and it is wise to obtain, before any measurements are made, the necessary application form from the Forestry Commission. (See Appendix III, page 92.)

The decision must now be taken whether to offer all the timber in one parcel or to divide it up into separate parcels. If the total quantity being sold is small, that is only a few thousand cubic feet, it is unlikely that it will pay to divide it into two or more parcels or lots. Where one is dealing with ten or more thousand cubic feet it may pay to offer it in separate parcels. The object of offering separate parcels is not 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 wise 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 all sorts of contingencies, every *unnecessary* restriction he imposes on the buyer will reduce the price he will be offered.

It is advantageous in large sales to have copies made of a map showing the location of the timber, and access routes and other relevant information.

The timber may now be advertised in the press or offered to selected timber merchants. The advertisement or circular should give, as a minimum, the species, total estimated volume and estimated number of trees in each species, date by which tenders are to be submitted, and the address of the owner or his representative.

Apart from arranging to show interested merchants the parcel or parcels of timber, the owner or his representative should let them have copies of the conditions of sale and the fuller data on volumes and size classes mentioned above. It is also reasonable to show any interested merchant how the volumes were calculated.

In this connection it is sometimes advantageous with larger timber to negotiate the sale on the basis of *estimated* standing volumes, but to arrange that the contract will stipulate for the actual payment to be made on the basis of *actual* felled measure. The owner should say clearly what he intends to do in the document outlining the conditions of sale. Payment on felled measurement removes an element of gamble for both owner and merchant, but the value of the timber must justify the extra expense of the owner's and merchant's representatives jointly measuring every tree once it has been felled.

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

Conditions for Standing Sales

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. As mentioned above the conditions to be imposed under each head should be notified as conditions of sale to interested merchants before they inspect the timber.

(1) *General description of the timber included in the sale.* Description of the boundaries of stands to be clear-cut, method used to mark thinnings, details of volumes.

(2) *Purchase price.* Method of payment—lump sum or per cubic foot; deposits; method of invoicing; ownership of the timber at various stages.

(3) *Period of contract.* Date of entry by purchaser; completion date for whole contract and dates for completion of specified parts.

(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 tentants.

(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 condition 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.

(9) *Animals.* Restrictions on use of or keeping of animals on the estate by purchaser or his servants.
(10) *Sub-Contractors.* Limitations on employment by purchaser of sub-contractors. 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 pitprops, 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. Much will also depend on the experience of the forester or woodman in charge; a good forester can often make a success of preparing produce where an inexperienced man would fail.

The operations to be performed and the tools required will vary with local circumstances, but the following general guidance may be given as to types of tool required.

(1) *Marking.* Trees to be felled should be marked by slasher, axe, billhook, timber scribe or paint.
(2) *Felling and Snedding*
Larger Trees. Two-man cross-cut saws or one-man power saw.
Smaller Trees. One or two-man cross-cut or bow saws, or one-man power saw.
In addition axes and wedges will be required.
(3) *Cross-cutting.* Saws as in (2) above plus measuring rods or tapes and callipers or girthing tapes.
(4) *Peeling.* Peeling spades or draw knives.
(5) *Extraction.* Horse or tractor; drag chains, timber arch or trailer.
(6) *Maintenance Tools*
Hand Tools. Files, saw sets, sharpening stones and similar equipment must be provided for day-to-day maintenance of hand tools for the workers. For major sharpening operations more elaborate equipment must be provided.
Power Tools and Machinery. Maintenance equipment recommended by the maker must be provided. Arrangements must also be made for major overhauls to be undertaken in accordance with the maker's instructions.

Consideration will also have to be given to the question of transport from the roadside to the consumer. 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. Many consumers will not, however, collect; indeed it would be unreasonable to expect them to do so. 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".

Trees to be felled must be marked, and the workers instructed as to the sequence of operations to be performed, e.g. fell, trim out (sned), peel and cross-cut at stump, extract produce to rideside; or, fell, trim out, extract to rideside in the length, cross-cut and peel.

It is equally important that the workers be instructed as to what sizes and specifications of produce are to be prepared. Skilled supervision is required if the best use is to be made of each tree and waste is to be reduced to a minimum. Indeed the finding of the best markets and the organisation of work in the woods and in the office to meet the requirements of those markets is not to be undertaken lightly. 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, and the sale should be the subject of a contract between the owner and the purchaser. The contract should cover 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. Prices paid for timber in Britain in the successive stages of marketing are for the most part the subject of individual negotiation.

The compilation of useful price statistics is therefore possible only with the co-operation of a considerable number of individual woodland owners. At present (1957) the Imperial Forestry Institute at Oxford is implementing such a scheme covering private estates in England and Wales. Further information, including a list of publications, may be obtained direct from the Institute.

Regional mining timber price agreements are negotiated periodically between the National Coal Board on the one hand and suppliers 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.11.

Intrinsic quality apart, there are a number of factors 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.

So long as home-produced timber accounts for only a small part of the country's total needs, the level of imported timber prices will have 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 as long as supply and demand are in balance in the home trade, ease of extraction and proximity to markets will 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, will also have to be reckoned with. In the same vein care taken in making up the various lots in a sale will always pay in the long run. The timing of a sale is important, particularly with hardwoods where winter felling is often preferred; in this connection adequate time must be allowed for the timber to be inspected and details of the contract to be negotiated with the successful merchant.

The sale of timber, as with every other sort of sale, also carries with it the rather 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 should be called upon.

Chapter 17

USES OF TIMBER

A DISTINCTION must be made between the possible uses to which home-grown timber may be put and the actual 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 individual 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 some sort of guide to possible categories of produce.

(1) 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 has spread to agriculture where the drying of hay is now frequently

carried out on the four-legged stands commonly called "tripods".

Pea sticks. Sold bundled, often 25 to the bundle; 4 to 5 feet long. Commonly prepared from the trimmings arising from the working up of 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.

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 × 1½ inches top diameter to 7 feet × 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 reasonable 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, any extra cost being offset by a longer life in service.

(2) Rustic Poles

Near big towns there is a good demand for poles for the manufacture of rustic and pergola work. Though much more commonly of softwood, especially larch, 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.

(3) 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 4½ feet 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.

(4) 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 7 feet in length, by 2½ to 3 inches top diameter, and may be of species other than chestnut.

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 cattle-proof fence calls for sawn posts 6 in. × 3 in. × 7 feet long; with 9 feet rails sawn 3½ in. × 1½ in. of hardwood, or 4 in. × 1½ in. of softwood; and intermediate or prick posts 3½ in. × 1¼ in. × 5 ft. 9 in. Other common specifications call for posts 5 in. × 2½ in., or 5 in. × 3 in., with rails 10 feet to 12 feet long. Where rails are *nailed* to posts, posts may be half-round, e.g. 6 in. × 3 in. in section.

Post and Wire. A typical specification calls for posts 5½ feet long, square sawn 3 × 3 inches, or 3½ × 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. Straining posts are sawn 6 × 6 or 7 × 7 inches in cross section or, more commonly, round, 7 to 8 inches minimum top diameter; all by 7 to 7½ feet in length.

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

General. Many variations will be found in the sizes and specifications of fencing timbers. The use of cleft ash rails in parts of England is a case in point. The species most commonly in demand, where no preservative treatment is contemplated, 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; the larches are an important exception. Where sawn fencing material is specified, and is to be impregnated by a *non-pressure process*, the spruces and Douglas fir may be excluded as taking preservative well only under pressure.

The owner wishing to cut fencing material for his own use—as distinct from meeting the specific requirements of a customer—should note that most species which are not naturally durable can by proper preservative treatment be given a service life at least as long as, if not longer than, the untreated heartwood of oak, sweet chestnut and European larch.

(5) Round Mining Timber (Pitprops)

There is little 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 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 to sell through a forestry co-operative society, an established timber merchant, or a pitwood agent.

Pitprops are required to be peeled and in a seasoned condition, except in Scotland and South Wales where some unpeeled props are also used. Pitprops vary in size mainly from 1 foot 6 inches × 2½ inches top diameter, under bark, to 12 feet × 10 inches t.d.u.b., the greatest usage being of props of 3 feet × 3 inches to 6 feet × 6 inches.

(6) 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 6½ feet 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.

(7) Pulpwood, Fibreboard and Chipboard Material

In recent years technical progress in the pulp and board industries has widened the range of species and sizes acceptable as a raw material, and there is every indication that further technical advances may be expected. To quote the classical pulpwood specifications would therefore be misleading. Equally the time has by no means arrived when all assortments of wood and wood waste can be sold on a commercial scale as pulpwood, and the numbers and types of pulp and board mills in this country are still somewhat limited. The notes which follow attempt to indicate the general range of sizes and species of home-grown pulpwood and board material saleable in Britain in 1958; the specifications applicable at any one time to any one individual firm may be obtained from the firms in question on request.

Paper Pulp. The main species of softwoods required to-day comprise the spruces, but species of the whitewood type and young pines containing little or no heartwood may also be acceptable. In most cases larches are specifically excluded. The range of diameters is from 2½ to 12 inches and of lengths from 37 to 40 inches.

There is one hardwood pulpmill in Britain which currently accepts for paper pulp manufacture most broadleaved species such as oak, ash, beech, birch, sweet chestnut, sycamore, elm, alder and lime, in lengths of 4 feet, and diameters of 3½ to 12 inches.

Fibreboard. For fibreboard manufacture most conifers and certain mixed hardwoods 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 quarter of the total deliveries. The range of diameters can go as low as 1½ inches 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 not made exclusively or mainly from industrial wood waste, conifers are preferred. Generally the minimum diameter acceptable is about 1½ to 2 inches, and the minimum length 3 feet, 3 inches.

Wood Waste. Although it is possible to meet part of the existing requirements of the pulp and board industries from round-wood offcuts, there is as yet only a comparatively small usage of sawmill slabs and offcuts in this country.

Again it must be emphasised that the rate of progress of development in the pulp and board industries is such that intending suppliers of roundwood, roundwood waste, sawmill and industrial wood waste should ascertain the requirements of the individual firms rather than assume that such and such a species or specification is, or is not, acceptable, as a result of past information received.

(8) Saw Timber (Including Sawn Mining Timber)

Hardwood. In contrast to *round* hardwood mining timber 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. The manufacture and

marketing of hardwood sawn mining timber is, of course, a job more for the pitwood or 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, and box-making.

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 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 × 6 inches top diameter under bark are accepted by some timber merchants.

The market for sawn softwood mining timber can absorb a not inconsiderable quantity of conifer thinnings, low-grade saw-logs and 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.

Chapter 18

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 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, 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 Laboratory's findings are reproduced in Table 12 below. The data refer only to heartwood; the sapwood of most species is perishable and would come in Col. (1). The posts used in the experiments were 2 × 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			
0–5 years	5–10 years	10–15 years	15–25 years
(1)	(2)	(3)	(4)
Conifers			
Sitka spruce	Silver firs		
	Douglas fir	Larch	Yew
	Hemlock (*Tsuga*)	Sequoia	
	Norway spruce	Western red cedar (*Thuja*)	
	Scots pine		
Hardwoods			
Alder	Elm (Dutch or Wych)		Oak
Ash	Poplar (Grey)	Turkey Oak	Sweet Chestnut
Beech	Willow (Crack or Cricket Bat)	Walnut	
Birch			
Elm (European)			
Hornbeam			
Horse Chestnut			
Lime			
Plane (London)			
Poplar, Black Italian			
Sycamore			
Willow (White)			

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. 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 direct contact 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 should be followed closely.

For convenience some practical details of the method of operating the open tank process are given below.

Material Particularly Suitable for Treatment by the Open Tank Method

Round material of all species (except the larches) is particularly suitable for treatment by the open tank method since it is not difficult to completely impregnate the outer sapwood layers.

Sawn timbers, which are liable to comprise mainly or wholly heartwood, of Scots pine, ash, elm, birch, silver firs, beech, hornbeam and sycamore are also suitable.

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 4, 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.

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.

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 2 and 3. 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.

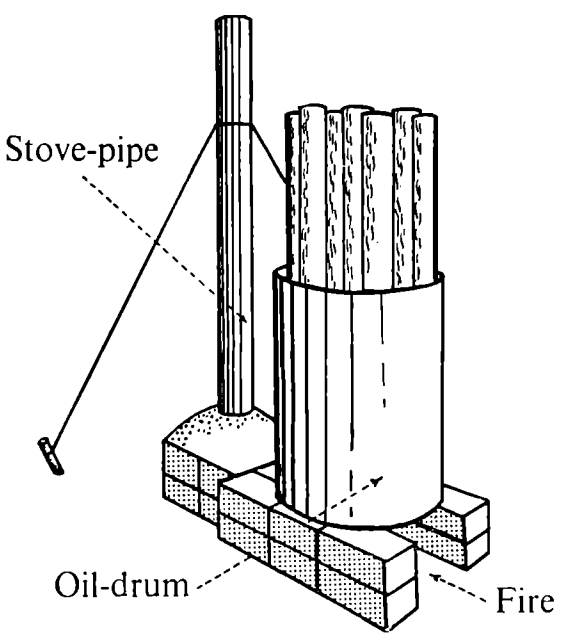

Fig. 2. *Simple Creosoting Tank for Butt Treatment of Fence Posts by the Hot-and-Cold Process.*

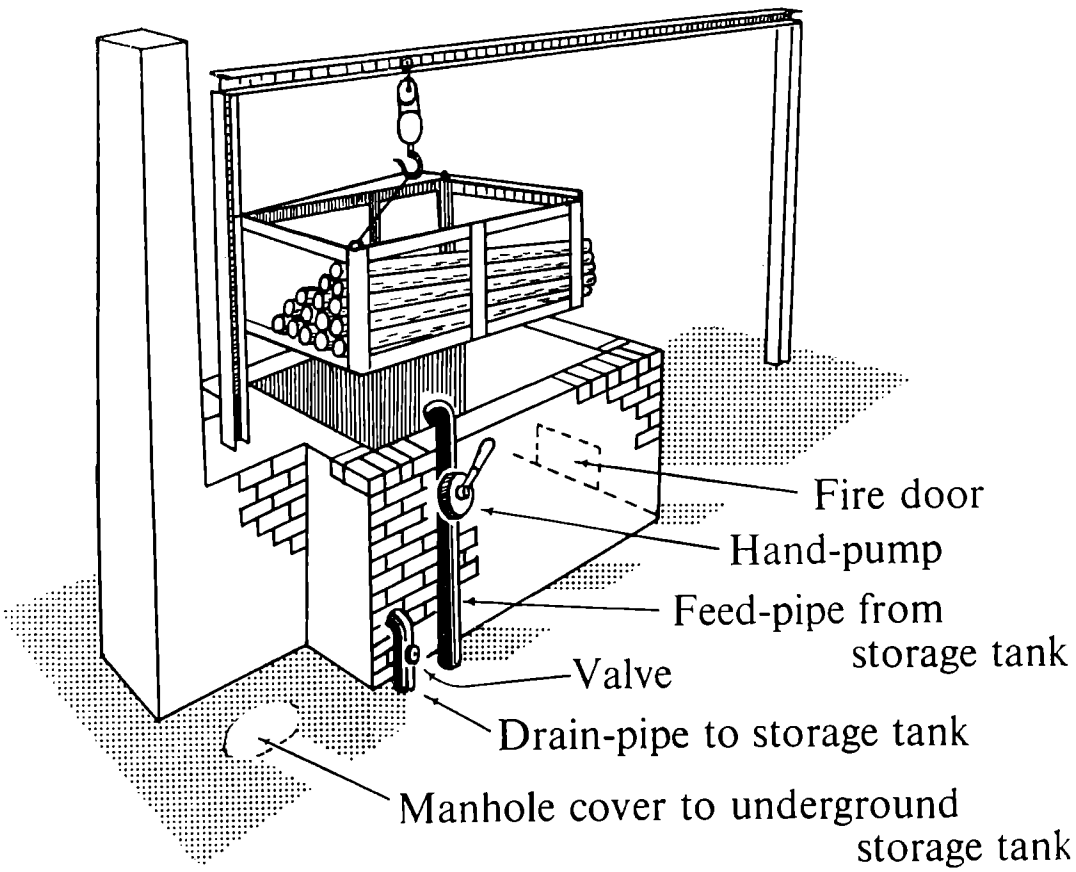

Fig. 3. Creosoting Equipment for the Full Immersion of Fence Posts and other Estate Timbers by the Hot-and-Cold Process.

The timber to be treated is placed in the tank and the tank filled with cold creosote. The tank is then heated up to 180°F and maintained at this temperature for 2 hours. The fire is then drawn and the whole allowed to cool. *The absorption takes places 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 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 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 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.

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

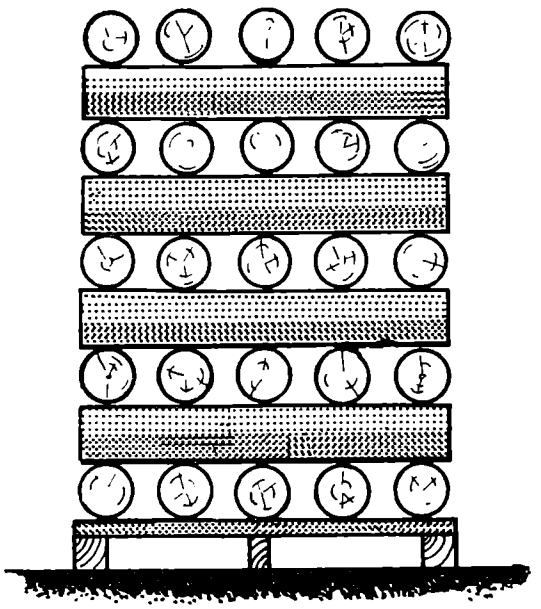

Fig. 4. Arrangement of Logs in a Stack for Air Seasoning. Note Supports to Keep Lowest Logs Clear of Ground.

life of the various species shown in Table 12 will be very much increased.

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 asked for. It should also be stated whether the preservative is required for exterior or interior work.

Scarcity of labour and high wages 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 preservative 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 of the Farm" series of leaflets and in selected publications of the Forest Products Research Laboratory, Princes Risborough, Bucks., from whom a current list may be obtained.

Chapter 19

TOOLS AND APPLIANCES

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

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

A very wide range of makes and patterns of the more usual forestry tools, such as spades, axes, and bill-hooks, is stocked by the principal manufacturers

and their agents. Various designs are preferred in certain districts, sometimes as a matter of custom, but frequently because local peculiarities of soil or plant growth call for particular shapes of tools, especially of spades and bill-hooks. When ordering new tools it is advisable to bear in mind such local preferences, and unless a change is desired for some definite reason, to make sure that the customary pattern is obtained. A general list of the equipment likely to be required by the forestry section of an estate is set out below.

Adze
Acre Grid for Maps
Auger
Axes, Felling, and Trimming
Billhooks, Various Types
Boots, Rubber
Boards, Lining-out
Brace and Bits
Broom, Bass
Brushes, Creosote and Tar
Bradawl
Chisels, Various
Cold Set
Crowbar
Cutters, Wire
Dogs, Timber
Drag, Draining
Drawknife
Files, Various Types
Forks, Various, for Digging
Gimlet
Grindstone for sharpening axes, etc.
Hammer, Sledge
Hammer, Claw and Ball Pein
Hatchet
Hoes, Various
Hooks, Staff, Brushing or Reap
Knives, Budding and Pruning
Mattocks, Grubbing and Pick-ends
Maul
Mallet
Pickaxe
Pincers
Pliers, Various
Rammer
Rake
Rasps, Various
Rollers, wooden, for nurseries
Saws, of various types, including Bow, Hand, Rip, Back, Cross-cut and Pruning
Screwdrivers, Various
Scribe, Timber
Scoop, Mud
Scythe for furze or whins
Secateurs
Set, Saw
Shears
Shovels, Various
Slasher
Spanner, Adjustable
Spades, various patterns, for digging and tree planting
Spokeshave
Stones, Axe and Scythe
Strainers, Wire
Trowels, Long and Short handle
Vices, Hand and Bench
Wedges, Various sizes for felling
Wrenches, Adjustable.

Tool Maintenance. The proper care of tools is especially important in forestry, where they have to be used under rough conditions in all sorts of weather. Cleaning, oiling, and sharpening are all jobs that can be done when wet weather obliges the staff to remain in shelter; but they should not be left over for such occasions. The sharpening of saws, in particular, is a task needing special skill and equipment; if regularly done, it will amply repay the trouble taken by greater output. Certain makers now issue leaflets on tool maintenance, and the instructions given therein should be closely followed.

First Aid Equipment. Under the Agriculture (Safety, Health and Welfare Provisions) Act, 1956, and the Agriculture (First Aid) Regulations, 1957, first aid boxes must be provided at every agricultural unit, which term, in this context, includes woodlands. Details of equipment are given in the Regulations, and suitable boxes may be obtained from most chemists.

PART IV

MISCELLANEOUS INFORMATION

Chapter 20

FORESTRY COMMISSION ASSISTANCE FOR WOODLAND OWNERS

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 pamphlet gives the position at 1st January, 1958.

TECHNICAL ADVICE

Before commencing any scheme of work that is likely to attract a grant, owners are advised to consult their appropriate Conservator of Forests, whose address will be found of page 90. 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 or the actual replanting of woodlands. An owner who requires help in these respects is recommended to consult one of the co-operative forestry societies which are now established in several districts, a forestry consultant, or a firm of land agents that undertake 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.

THE DEDICATION SCHEME

This scheme, which was launched in 1947 and has since been adopted by some 900 estates, involving over 400,000 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 apply 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 of £17 per acre for every acre satisfactorily planted, replanted, or otherwise restocked, after the date of dedication.

(2) A Maintenance Grant of 5s. 6d. per acre per annum on all productive woodlands for 15 years from the date of dedication.

(3) A Maintenance Grant of 5s. 6d. per acre per annum on all land satisfactorily restocked whether by planting or natural regeneration, to run for 15 years from the date of such restocking.

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.

In addition to these grants an owner of Dedicated woods may also claim the Scrub Clearance Grant and the Thinning Grants, described later.

Full details of the Dedication Scheme, including the text of the legal documents, and the forms for the Plan of Operations, will be found in Forestry Commission Booklet No. 2, *The Dedication of Woodlands*.

An owner who dedicates his woodlands binds himself, and his successors in title, not to use the lands so dedicated for any purpose 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 requirement 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 valuable for the exchange of technical information and the discussion of problems.

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 one-half the rate appropriate to the Dedication Scheme; it is currently £8 10s. 0d. per acre; 75 per cent of this is paid in the year of planting, and the balance is paid five years later, provided the plantations have been properly maintained. No Maintenance Grants are paid, but an owner may claim, in appropriate circumstances, the Scrub Clearance Grant and the Thinning Grants.

SMALL WOODS PLANTING GRANTS

Although all small woods or pieces of ground suitable for tree planting will be considered for the Dedication or Approved Woodlands Scheme, some owners wish to replant such areas without including them in a comprehensive plan of management. A grant at the current rate of £17 per acre is available for approved planting, replanting, or natural regeneration in such places. The first instalment of £12 15s. 0d. per acre becomes payable as soon as planting has been satisfactorily completed. The balance of £4 5s. 0d. is payable five years later, provided the plantation has been properly established and maintained. There are, however, no maintenance grants. Lands eligible for this grant are defined as set out below:

(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 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 two acres, in one block, must be planted each year. The grant is not payable in respect of an area for which a tree planting grant is being made under the Hill Farming Act, 1946, or related legislation.

SCRUB CLEARANCE GRANT

This grant may be claimed only in respect of the following descriptions of woodland:

(a) Dedicated woodlands (Basis I or Basis II).
(b) Approved woodlands.
(c) Small woods or planting areas eligible for the Small Woods Planting Grant.

It is payable for the clearance of unproductive scrub, the clearing of which is estimated to cost more than £17 net per acre, from land which the owner undertakes to restock with trees.

The rates are:

(i) For areas estimated to cost more than £17 net per acre to clear, but less than £27 net: £8 10s. 0d. per acre.
(ii) For areas estimated to cost more than £27 net per acre to clear: £13 10s. 0d. per acre.

The appropriate planting grant, as applicable to each description of woodland, will be payable in addition. In order to ascertain whether any particular piece of land qualifies for a scrub clearance grant, owners should consult their local Conservator of Forests. This grant is available only for schemes begun within the five years from 1953 onwards. It is payable in two instalments, the first of 75 per cent on completion of the clearance and planting, and the balance five years later, provided the area has been satisfactorily maintained. A minimum area of two acres, in one block, must be cleared in each year. The grant cannot be claimed for land concerning which another grant has been, or may be, paid for clearance of scrub under a rabbit clearance scheme. Neither can it be paid for clearing areas which have become scrub since 1948.

POPLAR PLANTING GRANTS

A choice of two grants is offered according to the way in which the poplars are planted. Grant I at the rate of £8 10s. 0d. per acre applies to poplars planted in compact blocks, and Grant II at the rate

of 2s. per tree where poplars are planted in narrow rows or lines. In Woodlands Dedicated under Basis II, the appropriate acreage rate for poplars is £17 per acre, and in "Approved Woodlands" £8 10s. 0d. per acre. In block planting, the trees must not be spaced closer than 18 feet apart, nor wider than 24 feet. In line planting, the spacing must not be closer than 18 feet. The objects of these provisions are to ensure that the trees have plenty of growing space and to avoid the need for early thinning.

The minimum acreage for which a grant will be payable is 2 acres on any one estate in any one year in the case of Grant I, and 100 trees similarly in the case of Grant II. The grants are payable in instalments, normally half in the year of planting and the balance five years later.

Because there are many varieties of poplar, some of which are unsuitable owing to their liability to disease, grants are only payable in respect of those varieties which are generally immune. The following hybrids are recommended: *Populus serotina; P. laevigiata; P. robusta; P. gelrica; P. eugenei.*

THINNING GRANTS

As the early thinnings in plantations are not always remunerative, an owner of woodlands may apply for a grant of £3 15s. 0d. per acre in respect of the first and second thinnings of young conifer, broadleaved, or mixed woodlands. A stand, to be eligible for a grant, must be within certain limits of height or, alternatively, of quarter girth. Broadly speaking, the limits for coniferous crops are 35 feet in height *or* 4 inches in quarter girth; the limits for broadleaved crops are 40 feet in height *or* 6 inches in quarter girth. The area to be thinned must not be less than two acres in one block. Full details are given on the Application Form to be obtained from the Conservator of Forests for the area in which the woodlands are situated.

GRANTS FOR SHELTERBELTS UNDER THE HILL FARMING AND LIVESTOCK REARING ACTS, 1946 TO 1956

The Hill Farming and Livestock Rearing Acts, 1946 to 1956, provide for grants of *up to* 50 *per cent* of the approved cost of establishing shelterbelts *on upland stock-rearing farms*, as part of a general scheme for the improvement of the farm. 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, 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.

GRANTS FOR SHELTERBELTS UNDER THE AGRICULTURE ACT, 1957

As an alternative to the grants mentioned in the preceding section, 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. Details are obtainable from the Agricultural Departments whose addresses appear above.

LOANS

Where woodlands have been Dedicated the Commission is prepared to make available to woodland owners loans to cover a substantial part of the cost of replanting. Loans may also be made, in other circumstances, and particularly, when a felling licence has been refused under the Forestry Act, 1951, in order that capital may be available for the systematic management of the woodlands. A normal period for such loans is thirty years. Arrangements for repayment must be agreed, and satisfactory security must be provided; this will normally be the plantations themselves, but in some circumstances collateral security would be required. Young plantations, and areas replanted with the aid of loans, must be insured against fire.

Repayment of the loan may be deferred for fifteen years, but payment of interest begins one year from the date of commencement of the loan. The rates at which loans are made depend on those ruling at the time; they are currently (June, 1958):

Loans for not more than 15 years: 6¾ per cent.
Loans for more than 15 years: 6 per cent.

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 12: *Income Tax and Estate Duty on Woodlands.*

Appendix I

FORESTRY COMMISSION PUBLICATIONS

Obtainable from H.M. Stationery Office at the addresses shown on inside back cover. Prices in brackets include postage.

Reports

Annual Report of the Forestry Commissioners for 1957, 5s. 6d. (5s. 11d.)
Report by the Commissioners on Post-War Forest Policy, 1943, 4s. 0d. (4s. 5d.)
Report on Forest Research for 1957, 9s. 6d. (10s. 0d.)
Report of the New Forest Committee, 1947, 3s. 6d. (3s. 11d.)
Census of Woodlands, 1947-49, 12s. 6d. (13s. 3d.)
Census of Hedgerow and Park Timber and Woods under Five Acres, 1951, 5s. 0d. (5s. 5d.)
Report of the Committee on Hedgerow and Farm Timber, 1955, 4s. 0d. (4s. 6d.)
Report of the Committee on Marketing of Woodland Produce, 1956, 4s. 6d. (5s. 0d.)

National Forest Park Guides

Argyll, 4s. 0d. (4s. 6d.)
Dean Forest and Wye Valley, 5s. 0d. (5s. 6d.)
Glen More, Cairngorms, 4s. 0d. (4s. 6d.)
Glen Trool, Galloway, 5s. 0d. (5s. 6d.)
Hardknott, Lakes, 2s. 0d. (2s. 5d.)
Queen Elizabeth Forest Park (Ben Lomond, Loch Ard and the Trossachs), 3s. 6d. (5s. 0d.)
Snowdonia, 5s. 0d. (5s. 6d.)
Border Forest Park, 5s. 0d. (5s. 6d.)

Guide Books

Bedgebury Pinetum, Kent, 3s. 6d. (3s. 11d.)
New Forest, Hampshire, 5s. 0d. (5s. 6d.)

Bulletins

No. 13. Studies on Tree Roots 3s. 6d. (3s. 11d.)
No. 17. The Cultivation of the Cricket Bat Willow, *Reprinting*
No. 19. Poplars, 7s. 6d. (8s. 0d.)
No. 20. Studies on British Beechwoods, 12s. 6d. (13s. 1d.)
No. 21. Tree Root Development on Upland Heaths, 10s. 6d. (11s. 0d.)
No. 22. Experiments in Tree Planting on Peat, 10s. 0d. (10s. 7d.)
No. 23. Mull and Mor Formation in relation to Forest Soils, 10s. 0d. (10s. 7d.)
No. 24. The Volume-Basal area line—a study in Forest Mensuration, 9s. 0d. (9s. 5d.)
No. 25. Studies of North-West American Forests in relation to Silviculture in Great Britain, 6s. 0d. (6s. 5d.)
No. 26. Adelges Insects of Silver Firs, 8s. 6d. (9s. 0d.)
No. 27. Utilisation of Hazel Coppice, 10s. 0d. (10s. 5d.)
No. 28. Sitka Spruce in British Columbia, £1 0s. 0d. (£1 0s. 8d.)
No. 29. Shelterbelts and Microclimate, 17s. 6d. (18s. 2d.)
No. 30. Exotic Forest Trees in Great Britain, 17s. 6d. (18s. 2d.)

Leaflets

No. 1. The Large Pine Weevil, 6d. (8d.)
No. 2. Adelges Cooleyi, An Insect Pest of Douglas Fir and Sitka Spruce, 4d. (6d.)
No. 3. Pine Shoot Beetles, 8d. (10d.)
No. 4. The Black Beetle (Hylastes ater) and other closely allied Beetles, 6d. (8d.)
No. 5. Fomes Annosus: a Fungus causing Butt Rot and Death of Conifers, 8d. (10d.)
No. 6. Honey Fungus, 6d. (8d.)
No. 7. Adelges attacking Spruce and other Conifers, 6d. (8d.)
No. 8. Megastigmus Flies attacking Conifer seed, 6d. (8d.)
No. 10. Oak Leaf Roller Moth, 6d. (8d.)
No. 12. Income Tax and Estate Duty on Woodlands, 9d. (11d.)
No. 14. Phomopsis Disease of Conifers, 3d. (5d.)
No. 15. Felted Beech Coccus, 6d. (8d.)
No. 16. Larch Canker, 2d. (4d.)
No. 17. Chafer Beetles, 6d. (8d.)
No. 18. Two Leaf-cast Diseases of Douglas Fir, 8d. (10d.)
No. 19. Elm Disease, 6d. (8d.)
No. 20. Watermark Disease of the Cricket Bat Willow, 4d. (6d.)
No. 21. Leaf Cast of Larch, 3d. (5d.)
No. 23. Pit-props, 2d. (4d.)

No. 25. Replanting of Felled Coniferous Woodland in relation to Insect pests, 2d. (4d.)
No. 26. The Spruce Bark Beetle, 6d. (8d.)
No. 27. Poplar Planting, 1s. 3d. (1s. 5d.)
No. 28. Collection and storage of Acorns and Beech Mast, 4d. (6d.)
No. 29. Pissodes Weevils, 6d. (8d.)
No. 30. Sooty Bark Diseases of Sycamore, 9d. (11d.)
No. 31. The Grey Squirrel, 9d. (11d.)
No. 32. Pine Looper Moth, 9d. (11d.)
No. 33. Collection and storage of Ash, Sycamore and Maple seed, 6d. (8d.)
No. 34. Badgers in Woodlands, 9d. (11d.)
No. 35. Pine Sawflies, 9d. (11d.)
No. 36. The Crossbill, 9d. (11d.)
No. 37. The Capercailzie, 9d. (11d.)
No. 38. Oak Mildew, 6d. (8d.)
No. 39. The Quality of Poplar Plants, 6d. (8d.)
No. 40. The Pine Shoot Moth, 9d. (11d.)

Forest Records

No. 1. Revised Yield Tables for Japanese Larch in Great Britain, 6d. (8d.)
No. 2. The Raising of Aspen from Seed, 6d. (8d.)
No. 4. Cambial Injuries in a Pruned Stand of Norway Spruce, 9d. (11d.)
No. 5. General Volume Table for Oak in Great Britain, 4d. (6d.)
No. 6. General Volume Table for Beech in Great Britain, 4d. (6d.)
No. 7. General Volume Table for Birch in Great Britain, 3d. (5d.)
No. 8. General Volume Tables for Scots Pine in Great Britain, 1s. 6d. (1s. 8d.)
No. 9. General Volume Tables for European Larch in Great Britain 9d. (11d.)
No. 10. General Volume Tables for Norway Spruce in Great Britain, 1s. 0d. (1s. 2d.)
No. 11. General Volume Tables for Corsican Pine in Great Britain, 1s. 6d. (1s. 8d.)
No. 12. Girdling or Banding as a Means of Increasing Cone Production in Pine Plantations, 6d. (8d.)
No. 14. General Volume Tables for Japanses Larch in Great Britain, 9d. (11d.)
No. 15. General Volume Tables for Douglas Fir in Great Britain, 1s. 6d. (1s. 8d.)
No. 16. The Effects of Partial Soil Sterilization with Formalin on the Raising of Sitka Spruce and other Conifer Seedlings, 1s. 6d. (1s. 8d.)
No. 17. Adelges Attacking Japanese and Hybrid Larches, 1s. 3d. (1s. 5d.)
No. 18. The Use of Large Diameter Wheels and Tyres on Forest Extraction Vehicles, 9d. (11d.)
No. 20. Use of Chutes for Extraction of Thinnings, 6d. (8d.)
No. 21. Use and Manufacture of Wood Flour, 6d. (8d.)
No. 22. Shelterbelts for Welsh Hill Farms, 2s. 0d. (2s. 4d.)
No. 23. Fires in State Forests in the Years 1929-1952, 1s. 6d. (1s. 8d.)
No. 24. Revised Yield Tables for Conifers in Great Britain, 1s. 6d. (1s. 8d.)
No. 25. Japansese Larches at Dunkeld, Perthshire, 2s. 6d. (2s. 10d.)
No. 26. Drought Crack of Conifers, 2s. 6d. (2s. 10d.)
No. 27. Use of Home-Grown Timber in Wood Turning and Related Trades in Scotland in 1953, 1s. 3d. (1s. 5d.)
No. 28. Volume Table for Small Hardwood Trees, 1s. 0d. (1s. 2d.)
No. 29. The Use of Forest Produce in Sea and River Defence in England and Wales, 1s. 9d. (2s. 1d.)
Also: Shelter Belts for Farmland. (Ministry of Agriculture Fixed Equipment of the Farm Leaflet No. 15) 1s. 3d. (1s. 6d.)
No. 30. Growth and Yield of Sweet Chestnut Coppice, 2s. 6d. (2s. 8d.)
No. 31. Tariff Tables for Conifers in Great Britain, 1s. 0d. (1s. 2d.)
No. 32. New Ways of Using the General Tariff Tables for Conifers, 1s. 3d. (1s. 5d.)
No. 33. Provisional Yield Table for Western Hemlock in Great Britain. 1s. 9d. (1s. 11d.)
No. 34. Experiments on the Chemical Control of Rhododendron ponticum. 9d. (11d.)
No. 35. The Use of Home-Grown Timber in Packaging and Materials Handling. 2s. 6d. (2s. 10d.)
No. 36. Provisional Yield Table for Oak and Beech in Great Britain. 2s. 6d. (2s. 8d.)

Britain's Forests Series

Forest of Ae, 6d. (8d.)
Culbin, 1s. 0d. (1s. 2d.)
Drumtochty, 1s. 3d. (1s. 5d.)
Glentress, 1s. 0d. (1s. 2d.)
Rheola, 6d. (8d.)
Loch Ard, 1s. 0d. (1s. 2d.)
Strathyre, 1s. 0d. (1s. 2d.)
Thornthwaite, 1s. 0d. (1s. 2d.)
Coed Y Brenin, 1s. 0d. (1s. 2d.)
Coed Y Brenin (Welsh Version), 1s. 0d. (1s. 2d.)

Booklets

No. 1. Woodland Mosses, 6s. 0d. (6s. 4d.)
No. 2. The Dedication of Woodlands, 2s. 6d. (2s. 10d.)
No. 3. Chestnut Blight caused by the Fungus Endothia parasitica. *Reprinting*
No. 4. Rusts of British Forest Trees, 2s. 6d. (2s. 8d.)

Unpriced Publications

The publications listed *below* are not available from H.M. Stationery Office, but will be sent free of charge on application to: The Secretary, Forestry Commission, 25 Savile Row, London, W.1.

Pamphlets

(1) Grants for Woodland Owners.
(2) The Forestry Commission in Scotland.
(3) Forestry in Wales.
(4) (Also in Welsh: Coedwigaeth yng Nghymru.)
(5) Heath and Forest Fires: Instructions for Fire-fighting.
(8) Training as a Forester.
(9) Britain's New Forests.
(10) Books and Periodicals on Forestry and Allied Subjects.
(11) Starting a School Forest.
(12) Camping Facilities at National Forest Parks and the New Forest.

Appendix II

ADDRESSES OF CONSERVATORS OF FORESTS

The addresses of the Conservators for various parts of the country, and the extent of their charges, are set out below. Enquiries regarding technical advice, planting and similar grants, the Dedication Scheme, and felling licences, should be addressed to the appropriate Conservator.

ENGLAND

North West

Upton Grange, Upton by Chester, Cheshire. (*Chester* 24006)

Cumberland, Westmorland, Lancashire, part West Riding of Yorkshire (Lune and Ribble Valleys), Cheshire, Shropshire, part Herefordshire (north-west of Leominster), Staffordshire, Warwickshire, Leicestershire, Nottinghamshire and Derbyshire.

North East

Briar House, Fulford Road, York. (*York* 24684).

Northumberland, Durham, Yorkshire (except that part of West Riding in Lune and Ribble Valleys).

East

Forestry Commission, Block D, Brooklands Avenue, Cambridge. (*Cambridge* 54495).

Lincoln, Rutland, Norfolk, Cambridge, Northamptonshire, Bedfordshire, Oxfordshire, Buckinghamshire, Hertfordshire, Essex, Suffolk, and Huntingdonshire.

South East

"Danesfield", Grange Road, Woking, Surrey. (*Woking* 2270).

Berkshire, London, Middlesex, Kent, Sussex, Surrey and Hampshire (except New Forest and Isle of Wight).

South West

Forestry Commission, Flowers Hill, Brislington, Bristol 4. (*Bristol* 78041).

Herefordshire (except part north-west of Leominster), Gloucestershire, Wiltshire, Dorset (West of Salisbury—Blandford—Poole Road), Worcestershire, Somerset, Devonshire and Cornwall.

Deputy Surveyor, New Forest

Forestry Commission, The Queen's House, Lyndhurst, Hants. (*Lyndhurst* 300).

Part Hampshire (New Forest and Isle of Wight), part Dorset (East of Salisbury—Blandford—Poole Road).

SCOTLAND

North

Forestry Commission, 60 Church Street, Inverness. (*Inverness* 608).

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

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

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

Forestry Commission, 20 Renfrew Street, Glasgow, C.2. (*Douglas* 7261).

Argyll (except Mull and areas west of Loch Linnhe), part Perth (areas south and 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

15 Belmont, Shrewsbury. (*Shrewsbury* 4071).

Anglesey, Caernarvon, Denbigh, Flint, Merioneth, Montgomery, Cardigan (except south-west), Radnor.

South

Forestry Commission, St. Agnes Road, Gabalfa, Cardiff. (*Cardiff* 33051).

Pembroke, Carmarthen, Cardigan (south-west only), Brecknock, Glamorgan, Monmouth.

ADDRESSES OF OTHER MAIN OFFICES

HEADQUARTERS

25 Savile Row, London, W.1. (*Regent* 0221).

ENGLAND

The Director of Forestry for England, 1 Princes Gate, London, S.W.7. (*Kensington* 9691).

SCOTLAND

The Director of Forestry for Scotland, 25 Drumsheugh Gardens, Edinburgh, 3. (*Edinburgh Caledonian* 4782).

WALES

The Director of Forestry for Wales, Victoria House, Marine Terrace, Aberystwyth. (*Aberystwyth* 367).

DIRECTOR OF RESEARCH AND EDUCATION

25 Savile Row, London, W.1. (*Regent* 0221).

RESEARCH STATION

Alice Holt Lodge, Wrecclesham, Farnham, Surrey. (*Bentley* 2255).

CHIEF EDUCATION OFFICER

1, Princes Gate, London, S.W.7. (*Kensington* 9691).

Appendix III

FELLING LICENCE 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.....

PART 1.

A. Description. (A 6 in. O.S. Sheet SIGNED by the applicant showing the area concerned must be submitted.)—See Notes (a) & (b) below.

Type of Operations	Chief Species	Identification of Trees, i.e., how they are marked (see Note (*b*) below)	Area (Acres)	Approx. Age of Trees (Years)	Total Number of Trees	VOLUME (Hoppus Cu. ft.) TAPE OVER BARK			
						Over 6 ins. Q.G.		6 ins. Q.G. and under, See Note (*c*) below.	
						Conifers	Broadleaved	Conifers	Broadleaved
1. Clear Felling									
2. Thinning									
3. Other Felling									
4. Hedgerow Trees. To include all isolated trees and small clumps under 1acre not forming part of a wood									
		Total Volume							

B. General. 1. Proposed date of commencement of felling.....2. Proposed date of completion.....

3. If thinning, has a Thinning Grant been applied for?.....(date).....

4. Date(s) of previous application(s) (if any) to fell the trees described above.....

5. 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;

OR

that I obtained the right to fell the trees by virtue of a contract for the sale of the trees made before 7th February, 1951, viz., on the.....

(2) that there $\frac{\text{* is}}{\text{is not}}$ 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 $\frac{\text{*Plan of operations}}{\text{Working Plan}}$ approved by the Commissioners on.....

.....*(under Dedication $\frac{\text{Covenant}}{\text{Agreement}}$ dated.....).

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.....		
Dedication Scheme.....	(*d*) Measurements over 6 ins. and under 6 ins. relate to quarter girth at breast height, tape over bark.	
Thinning Grant Scheme.....		

EXPLANATORY NOTES

(These notes do not constitute legally binding interpretations of the Statute or the Regulations, and are intended only for the guidance applicants.)

1. **Copies of the Forestry Act, 1951 (price 1s. 6d. 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 6d. 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 I, 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 appears 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 postpone consideration of the application, and would give notice accordingly, until such time as the person has who such an interest is joined with the applicant.

4. **Tree Preservation Orders.**

(*a*) Where the trees described in the application are subject to a Tree Preservation Order or interim Preservation Order, Part I 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 tree ssubject 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.

(4250) Wt.2858/2425 K36 9/57 J.W.Ltd. Gp.356

C.B.H. 31268 - Wt. 2858 - Dd. 2425 - K36 - 5/58

S.O. Code No. 71 - 5 - 14 - 57