# JOURNAL

OF THE

# FORESTRY COMMISSION.

No. 14: MARCH, 1935.

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### EDITORIAL.

**The New Commission.**

The Forestry Commission attained the age of fifteen years on the 29th November, 1934, and as the Commissioners are appointed for periods of five years a new Commission had to be appointed at that date. The former Commissioners remain with one exception: Sir Hugh Murray, after more than fifty years' forestry work in the Indian Forest Service, the Timber Supply Department, the Interim Forest Authority and the Commission, expressed his wish to retire. Sir Hugh's wide experience of forests and men has been of the utmost value to the Commission. As Assistant Commissioner in England and Wales he rendered signal service in connection with land acquisition; his methods may have been somewhat unorthodox but land was acquired in large areas at prices far below that which Government Departments had been accustomed to pay. Sir John Sutherland, who so well deserves the honour of Knighthood recently conferred on him, takes Sir Hugh's place on the Commission; he brings with him an unrivalled knowledge of Scottish conditions. Sir Alexander Rodger, appointed a Commissioner in 1932, shortly after retiring from the Indian Forest Service, is now more closely associated with the administrative and executive work of the Commission. It is interesting to note that of the original Commissioners only three remain on the active list, namely, the Chairman, Sir Francis Acland and Col. Steuart-Fotheringham.

Mr. J. M. Murray was appointed Assistant Commissioner for Scotland on 29th November last, and Mr. O. J. Sangar was given charge of the South-Western Division vacated by Mr. Murray. Mr. R. G. Broadwood, after eight years as Instructor at the Forest of Dean School, was transferred to Division 3, and was joined there by Mr. R. Cowell-Smith from the North-Eastern Division, Scotland. Mr. W. D. Russell, from Division 3, succeeded Mr. Broadwood at Dean School. Mr. L. A. Newton was posted to the North-Eastern Division and Mr. J. R. Thom went from the New Forest to Division 1. Mr. James Macdonald (Research) was promoted as Higher Grade District Officer and Mr. A. Warren was promoted to District Officer rank. Mr. W. A. Cadman (Division 5), Mr. J. M. Ross (Division 7), Mr. A. Watt (North-Eastern) and Mr. J. E. James (South-Western) were appointed probationary District Officers.

**Contributors to Next Year's Journal.**

The following Divisions have been selected as special contributors to next year's Journal: Division 4; the New Forest (Division 6); Forest of Dean (Division 7), and Scotland South-Western. Articles and notes are, however, welcomed from all members of the Commission's staff, and it is suggested that any good ideas should immediately be committed to paper and sent in through the usual channels. Contributions will be received at any time up to the end of December.

## CONFERENCE OF DIVISIONAL OFFICERS AT BENMORE, 1934.

This Conference, the third quinquennial meeting of Divisional Officers, occupied the week from 24th to 29th September and was presided over by Sir Roy Robinson.

One or two meetings were held each day and the afternoons were spent in visiting Commission plantations in the neighbourhood of Benmore. In addition a great deal of work was done by individual Divisional Officers in Committee.

The agenda consisted of the following items :—

Census of Plantations.
Forest Records.
Fire Protection.
Research.
Supervision.
Accounting.

*Census of Plantations.*—The most important item on the agenda was the Census of Plantations, which consisted of a stocktaking of established and unestablished plantations. The Census was also taken as the basis for a detailed discussion on plant supply, planting and silviculture generally. The procedure adopted was, first, the reading of papers by Mr. Murray and Mr. Long, secondly, discussion by all present, thirdly, consideration of the whole matter by a special Committee, who drew up a report. The report was then discussed and adopted with minor amendments. It was shown that out of 188,000 acres planted up to the end of 1931, 119,000 acres (64 per cent.) were returned as established and 69,000 acres (36 per cent.) as unestablished. Included among the unestablished plantations are some areas which may never produce a satisfactory crop. A rough estimate of the acreage which will probably have to be written off was made by Divisional Officers and the total was stated to amount to about 3,380 acres, representing 1.8 per cent. of the area planted.

There was general agreement that recently formed plantations are becoming established more quickly than formerly and it was considered probable that the rate would be still further accelerated. In the report the following matters causing delay in establishment are referred to :— the planting of difficult sites ; the use of plants of inferior grade ; certain unsuccessful methods of planting adopted in the earlier years ; the over-rapid clearance of coppice areas at the time of planting ; delayed weeding and beating-up ; damage done by rodents, fungi and insect pests.

Suggestions for the conduct of future censuses were made and it was decided to have maps prepared for the ready identification of unestablished areas.

*Forest Records.*—Following the same procedure as that adopted in the case of the previous item on the agenda, a paper on Forest Records was read by Mr. Sangar and after general discussion, followed by consideration of matters by a Committee, a report was drawn up and finally adopted. As it was considered impracticable to provide additional clerical staff it was decided that record keeping should be reduced to the bare essentials. Silvicultural records would be limited to an annual general statement of practice with detailed notes on departures therefrom. Forms should be kept giving, on prescribed lines, particulars of thinning, felling and natural regeneration and there should be an annual summary of operations and record of staff employed.

*Fire Protection.*—A paper was read by Mr. Young on Fire Protection. The subject was fully discussed by the meeting and it was left to a Committee to draw up specific recommendations. Questions dealt with included statistical notes on the loss from fire during the last ten years, expenditure on protective work, methods of assessing risks arithmetically, the lay-out and maintenance of fire lines, improved means of early detection of fire, and equipment for fire fighting.

*Research.*—Mr. Guillebaud read a paper on Research and at two sessions of the Conference this was discussed. The primary function of the Research Branch was stated to be the provision and dissemination of exact information required by those in charge of operations. In nursery work much had been done in the production of stronger seedlings and recent experiments had shown the importance of early sowing. There had been investigation into weed control in seedbeds and examination of nursery technique had brought to light desirable modifications. A statement of results of operations in the six costed nurseries on the grading of seedlings proved that it was a mistake to persist in the use of culls. In connection with plantation experiments reference was made to the manurial treatment of different types of soil and it was suggested that a short note for use in the Divisions might be prepared on this subject. It was stated that experimental work was frequently necessary in advance of large-scale planting in order to indicate the most suitable species. Other silvicultural investigations were dealt with, such as the importance of the origin of seed, beating-up problems, studies regarding root development of young trees and pruning. The work done on sample plots was reviewed and attention was drawn to the importance of making further use of the data obtained. A point was raised as to making sample plot data available more expeditiously and it was stated that this objection would be overcome. An effort would be made in future to give a fuller description of the soil in the plots. In regard to thinning operations it would be helpful if information could be made available as to the results obtained and if guidance could be given to the subordinate staff on the principles to be followed.

A paper on the subject of Superior and Subordinate Supervision was read by Dr. Steven, and one by Mr. Hopkinson on Accounting and Office Work.

*Report of the Conference.*—A full report of the Conference, together with copies of the papers read, was prepared.

# INK DISEASE AND OTHER ROOT AFFECTIONS.

By W. R. Day.

Perhaps the most marked result, during the last two decades, of research into the diseases of forest trees, has been the increasing recognition of the importance of species of *Phytophthora* as the cause of the dying of the root of broadleaved trees. In the traditional teaching of forest pathology, in this country, *Ph. omnivora,* the cause of disease in seedlings of beech and other broadleaved trees, was the only species of its genus mentioned. The only fungi considered important as causing the death of the roots of larger trees were *Armillaria mellea* (honey fungus), *Fomes annosus* (the principal cause of butt rott in conifers) and *Rhizina undulata,* one of the fungi said to cause the " maladie du rond " of conifers. Of these, only the honey fungus was considered to be important as affecting large trees, the other two species usually infecting plantations established not more than ten or twelve years. With regard to conifers the position is still the same, but in the case of broadleaved trees it is fundamentally altered by realising that species of *Phytophthora* are important and often common causes of the death of the roots of trees of all ages. The recognition has been world wide, and this genus has therefore come to have an important place in forest pathology.

In Europe, the first species to be recognised was *Phytophthora cambivora.* For many years the sweet chestnut, *Castanea sativa,* had suffered from an affection of the root known as the " ink disease." There had been many attempts to explain this disease, but none was satisfactory until Petri, in 1917, found that the fungus could always be isolated from the roots of diseased trees, and that the disease could be reproduced by infecting a healthy chestnut tree. In parts of France and Italy the disease was so serious in the chestnut orchards that it was imperative to find a means of combating it and this was done by introducing the Japanese sweet chestnut, *C. crenata* (=*C. japonica*), which has proved to be highly resistant to attack. The possibility that we had the " ink disease " of chestnut in this country was first realised in 1927, when Mr. Waldie, then a Forestry Commission mycologist, on returning from the New Forest, placed an ink stained root of chestnut on my table saying " there is the ink disease for you." This root came from Rhamnor Inclosure, and so many chestnuts died there that in the next year I went down and collected material from which the first cultures of *Ph. cambivora* were obtained, and the presence of the ink disease in Britain was definitely established. Since then, this fungus has also been isolated from dying chestnut in Devonshire, Herefordshire and Buckinghamshire. It has also been isolated from dying beech in Hampshire, Somersetshire, Devonshire, and Buckinghamshire. The parasitism of the isolated strains has been proved by inoculation and this has demonstrated that chestnut is very much more susceptible than beech.

Apart from this fungus two other species have also been isolated, namely, *Ph. cinnamoni* and *Ph. syringae;* the former was obtained from chestnut coppice shoots in Brick Kilns Inclosure in the New Forest, and the latter from beech in Devonshire. Inoculation experiments have shown that these fungi are parasitic on either beech or chestnut, though again, the beech is much the more resistant.

The question arises as to the susceptibility of other species of trees to these fungi. It has been shown, both by our own inoculation experiments and others, that oak is very resistant to *Phytophthora* root rot. Walnut, on the other hand, is known to have been killed by it, and the result of the inoculation of a few specimens of elm and *Nothofagus* suggests that trees belonging to these genera may also prove to be somewhat susceptible. It is, indeed, probable that the fungi have a large number of possible hosts and also that more species of *Phytophthora* will yet appear as capable of causing this type of disease.

The aspect presented by the diseased trees is similar irrespective of the species of fungus and is much the same whether the tree is a beech or a chestnut. If only slightly affected the crown of the tree shows signs of slightly dying back ; the leaves turn brown early and the tree presents a generally unhealthy appearance. If the tree is badly attacked, so that the root collar is girdled, a wilting of the leaves is noticed in the case of chestnut, especially at the top of the tree, where they definitely hang down. A badly attacked beech does not show the wilting so obviously : in both beech and chestnut the leaves soon turn brown and drop off. Sometimes a badly affected tree has only sufficient vigour left to put out a few undersized leaves in the spring. If the root of the tree is examined, it will be found that part is dead, and in the case of chestnut, in soils rich in iron, an inky stain occurs in the dead bark, and also in the surrounding soil. In the beech this inky discoloration is not noticeable. It arises owing to the formation of ink by the tannin in the chestnut bark and the iron in the soil.

Almost always in chestnut and usually in beech the dying tissues extend for a short distance up the trunk. Frequently, especially in beech, exudations occur at these places. If the border of the dead and live bark is shaved clean, it will be seen, in a case where the parasite is spreading, that between the live bark and the dark brown dead tissues there is an intermediate watersoaked zone. It is in this zone that the fungus is to be found, and only from this can it usually be isolated. The most common place for the parasite to spread up the trunk is in between the buttresses of the roots. Wounds are not necessary for infection. In the case of isolated trees the disease may be controlled, sometimes, simply by exposing the affected roots to the air, when the parasite dies. Usually this can only be done in the early stages. Heavy treatments of the soil with sulphate of iron have also proved successful in saving individual trees. In the forest, however, no special treatment is possible and control depends on understanding the circumstances in which the disease is virulent. This is discussed below, but much is yet to be learnt with regard to this.

The inspection of a large area such as the New Forest, in which there are many types of soil, shows that although the disease may be generally distributed, its incidence is not equal in all parts. It is worst on the heavier, shallower and wetter soils. The deeper the soil and the better the physical texture the less are trees liable to suffer seriously from infection. The *Phytophthoras* are definitely favoured by moist soil conditions. Effective drainage, with good aeration provides conditions under which the disease tends to be held in check. A few examples will illustrate this. In the New Forest and Isle of Wight areas the ink disease of chestnut is worst either on heavy impermeable soils, or on water-logged gravels. In Rhamnor Inclosure, the soil is shallow and the sub-soil impermeable. A pit dug in the middle of infected chestnut showed :—

| | | |
|---|---|---|
| (1) | Humus .. .. .. .. .. .. | 1–2 in. |
| | Dark medium loam .. .. .. .. | 4–8 in. |
| | Mottled grey-brown impermeable clay .. | 3 ft. |

On this soil rushes appear after clear felling. The chestnut are very shallow rooted and the soil is evidently one in which drainage is difficult and unsatisfactory. The disease appears to have been noticed after the clear felling of large areas of the high forest and the chestnut in the remaining parts may have been rendered more susceptible by the increase in soil moisture consequent on this, especially as no effective measures appear to have been taken at the time to open up a good drainage system.

In Brick Kilns Inclosure two soil pits were dug, showing :—

| | | |
|---|---|---|
| (2) | Humus .. .. .. .. .. .. | 2 in. |
| | Light coloured powdery loam .. .. | 4-6 in. |
| | Mottled grey-brown impermeable clay, up to 3 ft. and beyond. | |

This is an essentially similar soil to that in Rhamnor Inclosure.

| | | |
|---|---|---|
| (3) | Humus .. .. .. .. .. .. | 1½ in. |
| | Dark medium loam .. .. .. .. | 7 in. |
| | Clayey gravel, probably of artificial formation .. .. .. | up to 3ft. and beyond. |

Three soil pits in Holidays Hill Inclosure provide an interesting series :—

| | | |
|---|---|---|
| (4) | Humus .. .. .. .. .. .. | 3 in. |
| | Poor sand with some clay .. .. .. | 1 in. |
| | Stagnant blue clay, with some gravel and iron mottling below. | |
| (5) | Humus .. .. .. .. .. .. | 4 in. |
| | Fairly good loam .. .. .. .. | 18 in. |
| | Below this the soil gradually merged into pure clay. | |
| (6) | Humus .. .. .. .. .. .. | 3 in. |
| | Beyond this a rich loam to a depth of over 3 ft. | |

The disease was present near to all pits. It was worst at No. 4, being very severe there, and least destructive at No. 6, which is obviously a good soil.

Until recently there were some good chestnuts in Clumbers Inclosure. On these being felled some good timber was produced, free from shake. The disease was present to a very slight extent. No trees had been killed by it, though a few were obviously suffering rather badly. A soil pit dug in Clumbers showed :—

| | | |
|---|---|---|
| (7) | Humus .. .. .. .. .. | 3 in. |
| | Friable sandy loam .. .. .. | 18 in. |
| | A more clayey and rather harder soil, but well drained .. .. .. .. .. | 3 ft. |

This is plainly a much better soil type than most of those given above and, in fact, this was shown by the height and size of the trees, which, for their age, must have been some of the best chestnut in the New Forest. The above soil pits were dug, and the soils described, by Mr. Gale, a forester in the New Forest Division.

The ink disease has also appeared among the chestnut in Parkhurst Forest in the Isle of Wight. The chestnut here grows mainly on an acid, flinty, sandy gravel (a so-called plateau gravel) which caps the hills. The soil is very variable in gravel content and also in quality of drainage. The top of the caps is well drained, but the lower slopes are liable to be wet owing to water seeping over the underlying clay. The remains of extensive drainage systems exist on these areas. The worst affected part had been clear felled a year or two previously and the coppice stools were dying from the disease. All the diseased trees were confined to the area covered by the old drainage, or stood on the heavy soil below the gravel cap. In March, 1934, a hole was dug in the gravel here and at once filled up with water to within six inches of the surface, and the wetness of the area was marked by the presence of rushes, tussock grass (*Aira caespitosa*) and sallows. There can be no doubt that the disease was much favoured by the bad soil conditions and that these could have been ameliorated had the old drainage been effectively opened up after clear felling.

The affected chestnut in Herefordshire grows on a deep but very heavy and water-retentive soil, which is most difficult to drain. The Devonshire and Somersetshire beech and chestnut are similarly situated, as also are those in Buckinghamshire. The affected beech in the latter county stood at the edge of a gravel cap where the soil water conditions were essentially similar to those in Parkhurst. Nearby, on a deep light loam, which was very well drained, there was no sign of disease. It would appear from this that the heavier and wetter soils are to be avoided in connection with this disease.

The dying back of beech also occurs on dry sites with a shallow soil. It has not yet been proved that any of the *Phytophthoras* are the cause of this. Undoubtedly adverse soil conditions are primarily responsible. This dying back on dry sites should not be mixed up with that occurring on wet soils. With regard to the latter, conditions are often variable, an excess of water in winter and spring may easily be followed by a shortage in summer, due either to the falling of the water table or to the slow movement of water in a very retentive sub-soil. Drainage tends to overcome these difficulties and makes deeper rooting permanently possible. The *Phytophthoras* become destructive on areas which are in any case difficult for root development and the recognition of this is fundamental to any attempt at control.

# PROGRESS REPORT ON RESEARCH: JANUARY, 1935.

By W. H. Guillebaud.

## 1. Nursery Experimental Work.

The principal subjects dealt with in 1934 were :—

- Density of sowing.
- Season of sowing.
- Stratification of seed in sand.
- Weed control.
- Investigation of soil fertility (in conjunction with the Macaulay Institute for Soil Research).
- Use of various organic substances for manuring conifer seedbeds.

## 2. Plantation Experiments.

*Peat Project.*—The past growing season has been favourable for spruce planted on peat soils at Beddgelert and in the North Tyne Valley. The slagged plots are making good progress even on the poorest types. On the scirpus peats of the west of Scotland *Pinus contorta* and Japanese larch continue to show promise but the older Sitka spruce plots show a definite falling off in rate of growth.

*Upland Calluna Soils.*—The most interesting recent development is the improvement in Corsican pine planted on ploughed ground in P. 29 at Allerston. After making a slow start these plants are now growing well and have caught up several of the other species.

*Dorset Heaths.*—The P. 34 direct sowings on ploughed ground suffered from the drought and are not likely to prove as good as those of P. 33. Where the soil is a pure fine sand the pine seeds have germinated fairly well, but where there is much peat or flint germination is poor.

*Chalk Soils.*—The grey alder planted in the P. 30 and P. 31 experiments at Buriton are continuing to make good progress.

*Loams and Clay Soils (Hardwoods).*—Growth of oak was much below average in most of the experiments but ash have grown well. The tall ash plants in the P. 32 hoeing experiment in the Forest of Dean were badly frosted in May but made a fine recovery and with the aid of a certain amount of pruning appear little the worse.

At Oundle the effect of a belt of standing coppice adjoining one of the P. 31 plots of ash is very clearly marked. Some of the trees along the edge of the coppice are 9 feet in height with shoots of 20 to 30 inches, while shoots elsewhere seldom exceed 12 inches.

A note will be found elsewhere in the Journal on a weeding experiment on oak seedlings in grass.

*Pinus contorta* and Lawson cypress continue to show most promise in species experiments on a heavy clay soil at Drayton in Northants.

### 3. Field Work in Hand during P. 35 Planting Season.

*England and Wales.*

Beddgelert.—Top dressing of checked spruces with basic slag.

Clocaenog.—Application of slag and semsol to S.S. and J.L. Intensity of drainage.

North Tyne.—Top dressing of checked spruces with basic slag.

Harwooddale.—Application of basic slag and semsol to S.S. and J.L. Methods of planting J.L. and S.P.

Allerston.—Application of semsol to J.L. and S.P. Trial of seedlings of S.P. and S.S. bedded out densely.

Buriton.—Trial of *Alnus cordata* and *Tilia parvifolia.*

Yardley.—Planting out of stumped walnut transplants.

Rockingham, Drayton.—Trial of oak transplants spaced at 2 in. and 6 in. in the lines, manured and unmanured.

*Scotland.*

Inchnacardoch.—Semi field-scale trial of S.S. and P.C. planted with slag on scirpus peat.

Trial of various amounts of basic slag and mixtures of superphosphate and ground mineral phosphate applied to J.L., P.C. and Oregon alder. Preliminary trials with manures on various species.

Teindland.—Proveniance work with P.C. and S.S. Trial of different species on ploughed ground. Effect of semsol on J.L. Intensity of drainage.

*Clashindarroch.*—Proveniance work with E.L., M.P. and P.C. Extension of transplants of E.L. raised in different nurseries.

Benmore.—Drainage of scirpus knolls and trial of J.L., S.S., P.C. and Oregon alder.

Roseisle.—Proveniance work with S.P.

Glengarry.—Direct sowing.

Findon.—Proveniance work with S.P.

Braemore.—Proveniance work with N.S.

Drummond Hill.—Proveniance work with E.L.

*General.*—Methods of planting, and manuring experiments on calluna knolls. Experiments on root pruning.

### 4. Sample Plot Work.

The normal programme of remeasuring sample plots has been continued. Among new plots are two hybrid larch established at Dunkeld in Perthshire, the older of which is in the finest plantation of this tree in the country. The age of this plot is 25 years, mean height 61 feet, and true volume under bark 3,350 cubic feet per acre.

In addition to the sample plot work, data were collected on branch spread of different conifers in young plantations.

### 5. Research Work at Aberdeen.

Dr. E. V. Laing's investigation on root development of European larch is progressing and some interesting observations have been made on the lag which occurs between the flushing of the buds and the date when new root formation begins.

A series of pot culture experiments has been started by Dr. G. K. Fraser, working at the Macaulay Institute. Three distinct soils have been used, the profile layers collected separately and Scots pine seed sown on soil from each layer ; a series of manurial treatment was also applied. A feature of the experiment was the purpling of the seedlings in the plots to which no phosphate had been added.

### 6. Mycorrhiza Research.

A new series of field plot trials with composts on ploughed moorland at Allerston has given interesting results. Six different composts were used, but the only one to have a marked effect upon the growth of the pine seedlings was one prepared from spent hops. In a similar experiment at Wareham in P.33 all the composts improved growth though here also the hops gave the best result. Laboratory and field experiments with composts are being continued.

### 7. Research on Vole Disease.

Dr. Elton is continuing his investigation of vole disease with the aid of a grant from the Commissioners.

### 8. Advisory Committee on Forest Research.

A meeting was held at Thetford in June when the research programme was discussed.

### 9. Mycology.

*Elm Disease.*—A survey was carried out in September. The disease is still spreading but is not serious except locally in the Home Counties and east of England.

No case of *Graphium ulmi* has yet been recorded from Scotland, though another, so far unidentified, disease is apparently attacking elms in the north of England and in Scotland.

*Damping-off.*—For the second year in succession potassium permanganate failed to control damping-off which had been induced in pine seedlings. Further trials with this substance will be carried out.

*Butt Rot of Conifers.*—Very few specimens were sent in from the Divisions during the year. The predominant cause is *Fomes annosus*, but one case due to *Stereum sanguinolentum* has appeared.

*Frost Investigation.*—The study of factors accessory to frost as a cause of injury to forest trees was continued.

*Browning of Scots pine needles.*—A good deal of material sent in from different parts of the country has been examined. The discoloration does not appear to be caused by pathogenic fungi and the cause is still obscure.

*Ink Disease.*—In addition to *Phytophthora cambivora* two other species *Ph. syringae* and *Ph. cinnamoni*, have been discovered causing this disease, the former in beech in north Devon and the latter on sweet chestnut in the New Forest. The progress of the disease on chestnut in the New Forest has checked, possibly owing to the dry summer.

## 10. Entomology.

*Pine Beetle.*—An interim report by Mr. H. S. Hanson will be published shortly.

*Pine Weevils.*—A trial of different types of traps was carried out in the New Forest: there was a great difference in the relative cost and efficiency of the various traps. The best form was a bark trap, the pieces of bark being covered by a turf.

*Pine Shoot Moth.*—An investigation was carried out by Mr. J. M. Ross at Rendlesham; the report will be found elsewhere in the Journal.

*Oak Tortrix.*—There was a fairly severe outbreak in the Forest of Dean and for the first time for some years Tortrix appeared in considerable numbers in the Highmeadow Woods. Parasitism of the caterpillar appears to be on the increase in the Forest and it is hoped that this may have some appreciable effect in 1935 in reducing the attack.

A spraying experiment, using contact poison dust, was tried on a small scale in the Dean, but the dust proved relatively ineffective. It appears that the chemical control of the pest is possible only where arsenical dusts can be used.

*Chafer Larvae.*—The damage caused by the garden chafer, *Phyllopertha,* has been very serious in some nurseries. An experiment carried out at Delamere with *paradichlorbenzene,* used as a substitute for carbon bisulphide, proved unsuccessful. The investigation of possible methods of control will be continued.

## 11. Utilization.

Eight hundred railway sleepers of Douglas fir have been purchased from a timber merchant in Scotland for a practical trial on the railways, the timber coming from the Durris Estate. Other species to be included are Scots pine and beech, supplies of which have been arranged between the Forest Products Research Laboratory and the Railway Companies.

An important part of the project consists in methods of creosoting the sleepers and different treatments will be applied at the Laboratory.

# DIVISIONAL EXPERIMENTS ON THE TURF PLANTING OF SEEDLINGS.

By W. H. Guillebaud.

With the completion of a further set of plots laid down in P. 34, the present series of Divisional experiments, started in P. 32, is now concluded. Much useful experience has been gained as to the uses and limitations of seedlings for turf planting and future work will be concentrated on the endeavour to raise seedlings of improved quality for planting.

The report which follows is divided into five sections.

1. Result of the P. 34 seedling experiments.
2. Second year failures in the plots planted in P. 33.
3. Rate of growth of seedlings and transplants in the P. 32 experiments.
4. Analysis of results of the three years' experiments with notes on weather conditions and other factors.
5. Summary and conclusions.

## 1. Result of the P. 34 Seedling Experiments.

The summarised data are set out in Table I which is given in the same general form as in previous reports (P. 32 in Silvicultural Circular No. 9, and Forestry Commission Journal No. 12, and P. 33 in Forestry Commission Journal No. 13).

Before considering the table some mention is due of the weather conditions during P. 34. The winter of 1933-34 was abnormally dry over the greater part of the country; the temperature was above average and there was no prolonged spell of frost. March and April were on the whole favourable months, a good deal of rain falling in the south and snow in Scotland. Drought conditions prevailed in May and June in both countries and continued until the end of July in the south, but in Scotland the break came rather earlier. The absence of severe frost during the winter and the showery weather in March and April were both favourable to the success of seedlings planted not later than March. On the other hand, the excessive heat and drought during May and June, culminating in severity in England in July, were very adverse factors, calculated to try the strongest seedlings.

### The Losses.

#### *Sitka Spruce.*

In England and Wales the majority of the seedlings used were three years old but in Scotland 2-year and 3-year seedlings were used in about equal proportions. The average losses were :—

| | | *Seedlings.* | *Transplants.* |
|---|---|---|---|
| England and Wales | 2-year | 23 per cent. | 15 per cent. |
| ,, | 3-year | 32 ,, | 18 ,, |
| Scotland | 2-year | 14 ,, | 7 ,, |
| ,, | 3-year | 10 ,, | 4 ,, |

As in previous years the success has been definitely greater in Scotland where the results can be regarded as fairly successful. In both countries the transplants have given a higher survival than the seedlings, failures being only about half those of the latter. The losses in the 3-year seedlings

TABLE I.

*Comparison of Seedlings and Transplants Planted P. 34.*

| Species and age. | Country. | Seedlings. | | | | | Transplants. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Thous. planted. | Average Loss % | Number of Experiments. | | | Average Loss % | Number of Experiments. | | |
| | | | | Total. | Under 7½% loss. | Over 7½% loss. | | Total. | Under 7½% loss. | Over 7½% loss. |
| S.S. (2 yr.) | E. & W. | 7 | 23 | 4 | – | 4 | 15 | 2 | – | 2 |
| | Scot. | 50 | 14 | 12 | 7 | 5 | 7 | 12 | 9 | 3 |
| S.S. (3 yr.) | E. & W. | 134 | 32 | 30 | 1 | 29 | 18 | 19 | 6 | 13 |
| | Scot. | 58 | 10 | 9 | 4 | 5 | 4 | 8 | 6 | 2 |
| N.S. (2 yr.) | E. & W. | 2 | 36 | 1 | – | 1 | – | – | – | – |
| | Scot. | 17 | 18 | 7 | 1 | 6 | 2 | 7 | 6 | 1 |
| N.S. (3 yr.) | E. & W. | 63 | 24 | 9 | 1 | 8 | 11 | 5 | 3 | 2 |
| | Scot. | 15 | 10 | 6 | 2 | 4 | 1 | 6 | 6 | – |
| E.L. (2 yr.) | E. & W. | – | – | – | – | – | – | – | – | – |
| | Scot. | 7 | 40 | 4 | – | 4 | 15 | 4 | 1 | 3 |
| J.L. (2 yr.) | E. & W. | 1 | 23 | 1 | – | 1 | 36 | 1 | – | 1 |
| | Scot. | 12 | 32 | 5 | – | 5 | 14 | 3 | 1 | 2 |
| J.L. (3 yr.) | E. & W. | – | – | – | – | – | – | – | – | – |
| | Scot. | 5 | 12 | 1 | – | 1 | – | – | – | – |
| C.P. (2 yr.) | E. & W. | 10 | 32 | 3 | – | 3 | 29 | 3 | – | 3 |
| | Scot. | – | – | – | – | – | – | – | – | – |

in England and Wales are rather high averaging as they do 32 per cent. over a total of 30 experiments in which 134,000 seedlings were used. This year there were not as many experiments on mineral soils as in previous years and the indifferent results in the south may be largely ascribed to the summer drought.

Very successful results with seedlings were obtained in the following forests, in which the failures at the end of the first year were less than 5 per cent.

*Sitka Spruce.*

| *Forest.* | *Age.* | *No. planted.* | *Losses %* | *Soil.* |
|---|---|---|---|---|
| N. Strome | 2 | 1,000 | 4 | Peat |
| Inchnacardoch | 2 | 3,400 | 3½ | Mineral |
| Leanachan | 2 | 4,400 | 3¼ | Peat |
| Glenloy | 2 | 2,200 | 4 | Peat |
| ,, | 3 | 2,200 | 1 | Peat |
| Glenhurich | 2 | 4,400 | 2 | Peat |
| ,, | 3 | 4,400 | 2 | Peat |
| Halwill | 3 | 2,000 | 3 | Mineral |

### NOTES.

*Soil.*—Of the 34 experiments carried out in England and Wales the turf in 21 cases was composed of peat, in 2 of a mixture peat and mineral soil and in 11 of mineral soil only. The heaviest individual losses (Bawtry 78 per cent. and Chepstow 80 per cent.) were on mineral soil, in both cases of a sandy or stony nature. Although the best individual result, at Halwill where the loss was only 3 per cent., was obtained on a clay loam soil carrying a strong growth of molinia, the general trend of the results favours the peaty, rather than the mineral soil, turfs. In Scotland 17 out of 21 experiments were on peat or peaty loam and the only really bad failure (90 per cent. of Blackcraig) was on mineral soil.

*Season of Planting.*—The majority of the seedlings (34 out of 53 experiments) were planted in March and April. The later planting, *i.e.*, in April, was quite successful, but the data as a whole do not justify singling out any particular month as the most favourable. A season of planting experiment in Hope Forest was an exception as here the later planting of both seedlings and transplants was much more successful. Losses at Hope were as follows :—

| | *Percentage Failures.* | |
|---|---|---|
| *Date of Planting.* | *Seedlings.* | *Transplants.* |
| January | 50 | 54 |
| February | 27 | 24 |
| March | 3 | 7 |

In this case the late planting proved decidedly the best.

*Quality of Seedlings.*—This was described in most cases as good; the 3-year seedlings as a rule, averaged 6 in. in height. No clear relation is apparent between proportion of losses and quality of plant. One or two instances will serve to illustrate this :—

| *Forest.* | *Quality of Seedlings.* | *Age. Years.* | *Size. in.* | *Percentage Failures.* |
|---|---|---|---|---|
| Myherin | Very poor. | 3 | 6 | 60 |
| Kielder | Selected. | 3 | 12 | 50 |
| Leanachan | Weak. | 2 | 4 | 3 |
| Glenbrittle | Spindly. | 3 | 6–10 | 9 |

*Planting Methods.*—With very few exceptions planting was done on thin turfs from 3–4½ in. in thickness, insertion was by dibble in Division 2, by semi-circular spade in Division 1 and elsewhere by the side notch method.

A special experiment planned and carried out by Mr. Long at Dovey Forest may be mentioned here. On the Bryncynfil Working Section 3-year seedlings and 2+1+1 transplants were given the following treatments. A. Planted on freshly cut turfs. B. Planted on turfs that had been cut a year, and C. Direct notched into the natural surface. Results were as follows :—

| | *Percentage Losses.* | | |
|---|---|---|---|
| | *A. Freshly Cut Turfs.* | *B. Year Old Turfs.* | *C. Direct Notch.* |
| | % | % | % |
| Seedlings | 28 | 70 | 50 |
| Transplants | 25 | 60 | 55 |

Both seedlings and transplants are described as having a good colour and making growth in A, but yellow and in check in B and C. It is rather surprising that the raw peat should be a better medium for plant establishment than peat which had weathered for 12 months; possibly in this dry season the raw peat held a greater amount of available moisture.

## *Norway Spruce.*

As in Sitka spruce the experiments in Scotland were evenly divided between 2-year and 3-year seedlings, while in England and Wales, with one exception, all the experiments were carried out with 3-year seedlings.

The average losses were :—

| | | Seedlings. | Transplants. |
|---|---|---|---|
| England and Wales | 2-year | 36 per cent. | — |
| | 3-year | 24 ,, | 11 per cent. |
| Scotland | 2-year | 18 ,, | 2 ,, ,, |
| | 3-year | 10 ,, | 1 ,, ,, |

The results are similar to those for Sitka spruce and Scotland again has done better than England and Wales. The 3-year seedlings have on the average suffered lower losses than the 2-year seedlings, although it is doubtful if the difference is really significant. In Scotland the failures in the transplants were negligibly small.

Outstanding results in which the seedling losses were all below 5 per cent. were recorded in the following forests :—

*Norway Spruce.*

| *Forest.* | *Age.* | *No. planted.* | *Losses %* | *Soil.* |
|---|---|---|---|---|
| Glenloy | 2-year | 1,100 | 3 | Peat and mineral. |
| ,, | 3-year | 1,100 | 1 | ,, ,, |
| S. Strome | 3-year | 1,100 | 2 | Mineral. |

NOTES.

*Soils.*—In Scotland almost all the planting was on mineral soils, but in England and Wales peat soils predominated. There was no apparent relation between type of soil and proportion of losses.

*Season of Planting.*—In Scotland all but four experiments were planted in April. The England and Wales experiments were spread over the four months, January to April, but were mostly in February and March.

*Quality of Plants.*—Mostly described as good. Size of 2-year seedlings varied from 3 to 6 in. and of 3-year seedlings from 4 to 10 in. Small, 3 to 5 in., 2-year seedlings did well at South Strome, losses being under 10 per cent.

*Planting Methods.*—Dibble in Division 2, side notch in the rest of England and Wales and in Scotland.

*European Larch.*

Only four experiments on turfs were carried out this year and these were all in Scotland with 2-year seedlings. The losses in the seedlings averaged 40 per cent. as compared with 15 per cent. in the transplant controls. Failures were thus distinctly high in the seedlings but moderate in the transplants.

NOTES.

*Soils.*—These were all mineral, with no peat covering.

*Season of Planting.*—One experiment was planted in January, two in February and one in March. The lowest losses were in the area planted in March.

*Quality of Seedlings.*—Generally good. Size varied from 4–8 in. to 10–12 in.

*Method of Planting.*—Thin, 2–3 in., turfs planted by side notch.

*Direct Notching.*—Beside the regulation experiments with seedlings planted on turfs, seven experiments were carried out in the two countries with European larch seedlings planted by direct notch. These were planted in different forests to the turfing experiments and so comparison is rather doubtful, but the take on the whole was quite good. There were only two cases of loss of over 30 per cent., in the other five experiments the losses were below 10 per cent. and compared very favourably with the transplant controls.

### *Japanese Larch.*

Two-year seedlings were planted in five forests in Scotland and the counts showed an average loss of 32 per cent., the comparable figure for the transplants being 14 per cent. The most striking difference was at Blackcraig, where there were 80 per cent. of losses (the only bad result in the seedlings) while the adjacent 1+1+1 transplants had a death rate of only 6 per cent. The seedlings were described as very big but well-rooted. One Scottish experiment with 3-year seedlings was relatively successful : 5,000 seedlings were planted and failures amounted to only 12 per cent.

NOTES.

*Soil.*—The turf was composed of peat in four out of the five experiments in Scotland.

*Season of Planting.*—With one exception all were planted in February.

*Quality.*—Good.

*Method of Planting.*—Dibble in one experiment in Scotland. Side notch in the remainder.

Japanese larch seedlings were also planted by direct notch (not on turfs) in 8 acres in Wales and 3 in Scotland. Only one of the results (Myherin) was really bad with a loss of 73 per cent. and here some special factor must have been involved, because the transplant controls gave the even heavier loss of 80 per cent. In a similar experiment in another compartment of the same forest the losses in the seedlings were only 21 per cent. and in the transplants 11 per cent. In the remaining direct planted areas the losses in the seedlings ranged from 1 to 39 per cent., averaging 23 per cent. The plots were all on mineral soil.

### *Corsican Pine.*

Three experiments were carried out in England using 2-year seedlings planted on upturned furrows after ploughing. There was an average loss of 32 per cent., a result which compares not unfavourably with the adjacent transplants, in which the failures averaged 29 per cent.

### SUMMARY OF RESULTS OF P. 34 PLANTING.

The results are generally on a par with those of the previous year; the spruce seedlings have done moderately well in Scotland but rather badly in England and Wales, and in both countries losses have been decidedly higher than in the transplants planted for comparison. Neither of the larches has made a good showing and again the seedlings have proved inferior to the transplants. The small number of Corsican pine seedlings put in have been relatively successful.

### 2. SECOND YEAR FAILURES IN THE PLOTS PLANTED IN P. 33.

The following table shows the average increase by the end of P. 34 in losses found in the seedlings and transplants put in in P. 33. The percentage is based upon the original number of trees planted. The different seedling ages have not been distinguished because the data were so similar that a separation appeared unnecessary.

TABLE II.

| Species. | Country. | No. of Experiments. | Increased Loss in Second Year. | |
|---|---|---|---|---|
| | | | Seedlings. | Transplants. |
| | | | Per cent. | Per cent. |
| Sitka spruce .. | England and Wales | 11 | 5 | — |
| | Scotland .. .. | 32 | 6 | 1 |
| Norway spruce | England and Wales | 6 | 8 | — |
| | Scotland .. .. | 31 | 9 | 2 |
| European larch | Scotland .. .. | 10 | 8 | 4 |
| Japanese larch.. | England and Wales | 4 | 16 | 8 |
| | Scotland .. .. | 14 | 9 | 3 |

The average increase in losses in the seedlings has not been serious, but there is a general trend for the second year losses to be greater in the seedlings than in the transplants and thus further to emphasise the superiority of the latter.

3. RATE OF GROWTH OF SEEDLINGS AND TRANSPLANTS IN THE P. 32 EXPERIMENTS.

The data are set out in Tables III and IV below. Table III gives the length of the average leading shoot at the end of the third year after planting for all those experiments in which transplant comparisons were available. In many of the experiments, however, only seedlings were planted, and there were no control plots of transplants for comparison. For the sake of completeness the whole of the seedling data have been summarised in Table IV.

TABLE III.

*Rate of Growth of the P. 32 Seedlings and Transplants in the third Growing Season after Planting.*

| Species and Age. | Country. | No. of Experiments. | Mean length of leading shoot at end of P. 34. | |
|---|---|---|---|---|
| | | | Seedlings. | Transplants. |
| | | | in. | in. |
| S.S. 2-year .. | England and Wales | 11 | 1·9 | 3·2 |
| | Scotland .. .. | 8 | 4·3 | 6·4 |
| N.S. 2-year .. | England and Wales | 5 | 1·8 | 4·9 |
| | Scotland .. .. | 7 | 4·0 | 5·1 |
| E.L. 1-year .. | Scotland .. .. | 3 | 6·0 | 11·3 |
| E.L. 2-year .. | England and Wales | 4 | 5·5 | 6·6 |
| | Scotland .. .. | 4 | 8·9 | 13·7 |

TABLE IV.

*Rate of Growth of the P. 32 Seedlings (complete data) in the third Growing Season after Planting.*

| | S.S. 2-year. | N.S. 2-year. | N.S. 3-year. | E.L. 1-year. | E.L. 2-year. | J.L. 1-year. | D.F. 2-year. |
|---|---|---|---|---|---|---|---|
| England and Wales .. | 2·5 in. | 2·1 in. | — | — | 7·1 in. | 7·8 in. | — |
| No. of Experiments .. | 23 | 14 | - | — | 8 | 4 | — |
| Scotland .. .. | 4·2 in. | 4·7 in. | 4·8 in. | 5·9 in. | 9·3 in. | 9·4 in. | 18·8 in. |
| No. of Experiments .. | 20 | 9 | 3 | 5 | 8 | 4 | 1 |

Reference to Table III shows that in every case the seedlings are behind the transplants in rate of growth. In the spruces the difference is much more marked in England and Wales than in Scotland. In England and Wales after three years' growth the seedlings are still barely out of check, putting on shoots of only 1½ to 2 in. in length on the average ; the transplants on the other hand have begun to get away and with shoots of 3.2 and 4.9 in. are definitely out of check. It is unusual to find Sitka spruce developing more slowly than Norway spruce, but the latter doubtless were planted on better sites. In Scotland the difference between the seedlings and transplants is much less marked. The seedlings with shoots of 4.3 and 4.0 inches are well out of check and are not far behind the transplants in rate of growth.

In European larch the position as regards the relative growth of the two types of plants is reversed in so far as the two countries are concerned. In England and Wales both seedlings and transplants are growing at about the same rate (average shoot 5 to 6 in.). In Scotland the transplants are growing much the faster although the seedling growth (shoots of 6.0 and 8.9 in.) is quite satisfactory.

The complete data given in Table IV put the seedlings generally in a more favourable light. The average shoot length of 2.5 in. over 23 experiments with Sitka spruce in England and Wales justifies the conclusion that the plants as a whole are getting away. The Norway spruce mean shoot length is also slightly up compared with Table III. In the case of the 2-year seedlings of European larch, inclusion of the extra data has raised the average shoot from 5.5 to 7.1 in. for England and Wales and from 8.9 to 9.3 in. for Scotland. The good growth of the 1-year Japanese larch seedlings, which do not appear in the previous table, will also be noted. A single plot of Douglas fir in Scotland has made remarkably fast growth.

It is most probable that the present difference in rate of development of the seedlings and transplants will disappear in course of time, but even if this should be the case, the less rapid growth of the seedlings during the first few years after planting is a disadvantage, especially where there is heavy weed growth to contend with, as it may involve one or more extra weedings as compared with the transplants.

## 4. Analysis of Results of the Three Years' Experiments.

Table V sets out the results of the three years' work as far as planting losses in the major species are concerned. The figures in brackets after the transplant percentage losses (last column) give the number of experiments on which these data are based, transplant comparisons being available for only a proportion of the total number of experiments carried out in each year. In the case of the spruces, the data for the 2-year and 3-year seedlings have been combined as the difference between the results from the two ages of plants did not appear sufficient to necessitate their separation.

Table V.

*Sitka Spruce.*

*2-year and 3-year Seedlings.*

| Year of Planting. | No. of Experiments Carried Out. | No. of Seedlings Planted. | Proportion of Failures. | |
|---|---|---|---|---|
| | | | Seedlings. | Transplants. |
| | | 1,000's | Per cent. | Per cent. |
| | England and Wales. | | | |
| P. 32 | 24 | 228 | 19 | 8 (13)* |
| 33 | 12 | 240 | 30 | 12 (4) |
| 34 | 34 | 141 | 31 | 17 (21) |
| | Scotland | | | |
| P. 32 | 28 | 168 | 9 | 2 (17) |
| 33 | 33 | 124 | 13 | 4 (19) |
| 34 | 21 | 108 | 14 | 7 (20) |
| Total | 152 | 1,009 | Mean 18 | 8 (94) |

*Norway Spruce.*

*2-year and 3-year Seedlings.*

| Year of Planting. | No. of Experiments Carried Out. | No. of Seedlings Planted. | Proportion of Failures. | |
|---|---|---|---|---|
| | | | Seedlings. | Transplants. |
| | | 1,000's | Per cent. | Per cent. |
| | England and Wales. | | | |
| P. 32 | 16 | 136 | 19 | 4 (5)* |
| 33 | 5 | 63 | 28 | 28 (2) |
| 34 | 10 | 65 | 26 | 11 (5) |
| | Scotland. | | | |
| P. 32 | 12 | 62 | 11 | 2 (8) |
| 33 | 37 | 134 | 13 | 4 (19) |
| 34 | 13 | 32 | 16 | 2 (13) |
| Total | 93 | 492 | Mean 16 | 5 (52) |

* The figures in brackets indicate the number of experiments in which transplant controls were laid down.

*European Larch.*

| Country. | Age. | P. Yr. | No. of Experiments Carried Out. | No. of Seed-lings Planted. | Proportion of Failures. | |
|---|---|---|---|---|---|---|
| | | | | | Seedlings. | Transplants. |
| | | | | 1,000's | Per cent. | Per cent. |
| Scotland .. | 1 | P. 32 | 8 | 18 | 27 | 3 (2)* |
| ,, .. | 1 | P. 33 | 4 | 7 | 43 | 11 (2) |
| | | | Total 12 | 25 Mean | 32 | 7 (4) |
| England and Wales .. | 2 | P. 32 | 12 | 57 | 29 | 11 (5) |
| Scotland .. | 2 | P. 32 | 13 | 20 | 14 | 5 (6) |
| ,, .. | 2 | P. 33 | 8 | 23 | 19 | 8 (6) |
| ,, .. | 2 | P. 34 | 4 | 7 | 40 | 15 (4) |
| | | | Total 37 | 107 Mean | 23 | 9 (21) |

*Japanese Larch.*

| Country. | Age. | P. Yr. | No. of Experiments Carried Out. | No. of Seed-lings Planted. | Seedlings. | Transplants. |
|---|---|---|---|---|---|---|
| England and Wales .. | 1 | P. 32 | 5 | 46 | 38 | 10 (1) |
| Scotland .. | 1 | P. 32 | 8 | 12 | 30 | — |
| ,, .. | 1 | P. 33 | 5 | 8 | 28 | 9 (2) |
| | | | Total 18 | 66 Mean | 32 | 9 (3) |
| England and Wales .. | 2 | P. 33 | 3 | 3 | 25 | 21 (3) |
| Scotland .. | 2 | P. 33 | 12 | 38 | 20 | 8 (7) |
| ,, .. | 2 | P. 34 | 5 | 12 | 32 | 14 (3) |
| | | | Total 20 | 53 Mean | 24 | 12 (13) |

* The figures in brackets indicate the number of experiments in which transplant controls were laid down.

It should be noted that the means for each species and type of plant have been weighted by the number of experiments carried out and not by the number of trees planted.

## Discussion of Table.

(1) *The Scale of the Experiment.*—The largest number of experiments carried out as well as the greatest number of seedlings planted dealt with

Sitka spruce, of which over one million seedlings were planted in 152 separate experiments. Norway spruce with nearly half a million seedlings spread over 92 experiment comes next in order. The larches were used in smaller numbers but still on quite a considerable scale, 132,000 European larch seedlings having been planted in 49 plots, and 120,000 Japanese larch seedlings planted in 38 plots.

(2) *The Survival Value of the Seedlings.*—(a) *The Spruces.*—The average figures for proportion of failures are remarkably similar for the two species of spruce and for all practical purposes the data could be combined. The best year for the seedlings was P. 32 when losses in both species were about 10 per cent. in Scotland and 20 per cent. in England. Results were not so good in the drier summers of 1933 and 1934 and the losses rose to about 15 per cent. in Scotland and 30 per cent. in England and Wales. The consistently greater success with seedling planting in Scotland is very striking and may be due to various factors, *e.g.* : climate (drought less prolonged than in the south), better plants and planting—on the matter of size alone the advantage was generally with England and Wales—better soils, or better selection of sites. As to this last point, the England and Wales figures are to some extent swelled by some very heavy failures which occurred when planting on relatively dry mineral soils. The great majority of highly successful results (losses of under 5 per cent.) on the other hand have been obtained on soils where the turf was composed of peat, the remainder being on more or less marshy mineral soils.

Combining the results for the two countries it will be seen that over the three years the losses of the seedlings have averaged 18 per cent. in Sitka spruce and 16 per cent. in Norway spruce. These cannot be regarded as unsatisfactory except in comparison with the corresponding figure for the transplant controls which show a mean loss of only 8 per cent. in Sitka spruce and 6 per cent. in Norway spruce. Here again the division between the two countries is much more definite than that between the two species. In Scotland the transplant failures were very few on the average, only exceeding 5 per cent. in one out of the six aggregates (Sitka spruce, P. 34, losses 7 per cent.). The means of transplant losses in England and Wales, being based on fewer data, are not quite so reliable, but it is apparent that the losses were heavier than in Scotland, though still much below those in the (England and Wales) seedlings.

The numbers and proportions of what may be termed major successes with spruce seedlings (cases where the losses were below 5 per cent.) are set out in Table VI.

Of the major successes 83 per cent. were in Scotland, and 17 per cent., mostly in P. 32, in England and Wales. It will be observed that the precentage of major success has dropped heavily in P. 34 which was also the year of the most serious and prolonged drought. In the other two years the results are distinctly encouraging.

(b) *The Larches.*—The combined results over the three years show a remarkable correspondence between the two species. On the average the 1-year seedlings of both species have lost 32 per cent. as compared with a transplant loss of 7 per cent. in European larch and 9 per cent. in Japanese larch. Losses in the 2-year seedlings amounted to 23 per cent. in European larch and 24 per cent. in Japanese larch, the corresponding transplant losses being 9 per cent. and 12 per cent. respectively. Most of the planting was done in Scotland where the seasons were on the whole more favourable than in the south.

TABLE VI.

*Number of Experiments in which the seedling losses were below 5 per cent.*

| | Sitka spruce. | | | Norway spruce. | | |
|---|---|---|---|---|---|---|
| Year. | Total No. of Experiments. | No. with loss under 5 per cent. | Proportion of Success. per cent. | Total No. of Experiments. | No. with loss under 5 per cent. | Proportion of Success. per cent. |
| P. 32 | 52 | 19 | 37 | 28 | 8 | 29 |
| P. 33 | 45 | 14 | 31 | 42 | 12 | 29 |
| P. 34 | 55 | 7 | 13 | 23 | 3 | 13 |

(c) *Other Species.*—A few experiments were carried out with other species such as Douglas fir and Corsican pine, but these are not included in the table because they were too few to be representative. With the possibility of dry weather following, the turf planting of either Douglas fir or Corsican pine seedlings will always be rather a risky proceeding.

*Notes on Weather and Other Factors.*—While it may be a truism to say that there is no such thing as a normal season in Great Britain, the weather conditions in two out of the past three years have been quite unusually abnormal. The winters of all three years have been exceptional for their mildness (there were no prolonged spells of frost) and thus one of the factors which often militates against the use of seedlings (specially spruces) has been absent. This is unfortunate because it means that there has been no test of the resistance of the seedlings to severe winter cold; also trials of different dates of planting during the winter have for the same reason lost much of their significance.

As regards the spring, 1932 was decidedly dry, especially on the West Coast of Scotland, while both 1933 and 1934 were characterised by severe late spring and summer drought. In both years the drought was much more prolonged in England and Wales than in Scotland. Many losses undoubtedly resulted from the lack of rain and excessive heat, seedlings in general suffering much more severely than the transplants.

Many cases were recorded where seedlings flushed normally but withered away and died in the latter part of June and in July. The transplants on the other hand appeared to have greater stamina, except on the drier mineral soils, and were mostly able to survive until the weather broke.

*Quality of Seedlings and Sites.*—Throughout the investigations the instructions have been that selected seedlings should be used and unfavourable sites (*e.g.* exposed areas, difficult peat types, etc.) avoided. In the main these instructions have been carried out; with a few exceptions the seedlings used have been described by the reporting foresters and foremen as good. The sizes varied greatly; in the spruces the 3-year seedlings were usually, though by no means invariably, bigger than the 2-year seedlings used in the same year. There was no very apparent correlation between size and success of establishment. As already stated in the report on the P. 34 experiments cases occurred where large seedlings were used and there were heavy losses and—per contra—some very small seedlings gave excellent results. In each case probably the seedlings selected were the best (Grade I) of the batch in question and, as the Grading Project has shown, the biggest plants of any given batch are the most viable. In the larches the connection between quality of seedling and success of establishment was more evident than in the spruces. Many of the heavy losses occurred in larch seedlings which were described as drawn up or weakly.

As regards age of seedling, the percentage losses in the 2- and 3-year seedlings of the spruces compared so closely that the two ages could be readily combined in a summary table without doing any violence to the data. This does not necessarily imply that both ages are of equal value for turf planting. A series of carefully controlled experiments would be required to decide this point, but it at least suggests that the difference is not likely to be very great. In the larches, as might be expected, the 1-year seedling has decidedly less power of resistance to adverse factors than the 2-year seedling, and in some cases this extends over to the second year after planting.

As far as it is possible to judge from the locality descriptions, the sites have been carefully selected and definitely unfavourable growing conditions avoided. Thus the scirpus-dominant types of peat have been excluded as well as high lying exposed areas. In most of the spruce and Japanese larch experiments the turf has been composed of peat, but there were some major exceptions, notably in the Midlands and south of England, where spruces have been planted on mineral mounds; it is on this type of soil that most of the really heavy losses have occurred. On the other hand wet mineral soils with a juncus or molinia-juncus type of vegetation have often given excellent results with losses of less than 5 per cent.

*Season of Planting.*—In accordance with instructions practically all the planting was carried out after the end of December to reduce the risk of exposure to winter frost. February and March were the principal planting months in the south, but in Scotland a considerable number of plots were established in April and some in May. The data give no particular clue as to the best time of planting, apart from a certain number of especially heavy failures arising from the planting of larch seedlings in April. As against this, April planting of larch was successful in four experiments in Scotland in P. 33.

*Method of Planting.*—Thin, 3 to 4 in., turfs have been used in most of the experiments and the standard method of planting has been the side notch. Division 2, especially during the last two years, has adhered to a method of dibbling, while thick turfs planted with the semicircular spade have been the normal practice in Division 1. There is no definite evidence favouring especially any of these methods, all have given bad as well as good results on occasion. The advantages of planting deeper than normal have been investigated in some detail by Mr. Long in Division 2 ; the evidence was generally in favour of moderately deep planting.

## Summary and Conclusions.

Divisional experiments on the use of seedlings for turf planting have been carried out on a uniform basis over a period of three years. The principal species used were Sitka spruce, Norway spruce, European larch and Japanese larch ; graded seedlings were selected for planting and unfavourable sites generally avoided. In the majority of the experiments control blocks were planted with transplants. The weather conditions in all three years were somewhat exceptional being characterised by mild winters and prolonged periods of drought during the growing season.

The data in respect of establishment losses indicate that the seedlings of all species have proved less reliable than the transplants. While there have been many very successful results with seedlings there have been an almost equal number of major failures, the transplants on the other hand have given almost consistently good results. Whether for climatic or other reasons, seedlings have been much more generally successful in Scotland than in England and Wales. Many of the major failures in the spruces have occurred where the turf has been composed mainly of mineral soil of a relatively dry type. On such ground the seedlings appear to succumb readily to summer drought. Evidence is also given showing that second-year losses are generally higher in the seedlings than in the transplants.

In considering these results it is important to remember that although selected seedlings were used in the majority of the experiments, the plants in most cases did not come from beds which had been raised specially for planting. It is probable that with few exceptions the seed beds were overstocked for this purpose, and such overstocking must have reacted unfavourably upon both roots and shoots, reducing the stamina of the plants.

It is proposed that the Research Branch shall take over the problem at this point, concentrating on the raising of seedlings in thinly stocked beds and on manurial and other treatments necessary for the production of sturdy plants with a higher survival value as planting stock.

The very considerable measure of success achieved with the use of spruce seedlings for turf planting justifies the conclusion that with certain precautions as to quality of plant and site they can be used in place of transplants when there is a shortage of the latter. At the same time, it must be recognised that spruce seedlings of the type employed hitherto are less reliable as planting stock than transplants, they are subject to greater failures—sometimes disastrously so—and growth during the first few years will be less rapid. Seedlings also show less recuperative power than transplants in face of damage by hares, rabbits or black game.

There appears no reason for modifying the conclusion arrived at in earlier reports as to the precautions necessary when using spruce seedlings for turf planting. These are—

1. Top grade seedlings only should be used, profusion of roots and general sturdiness are more important qualities than height.
2. Exclude the poorer peat types, also mineral soils (especially in the Midlands and south of England) which are liable to dry out in periods of drought. In general, peat turfs are safer than turfs composed of mineral soil.
3. Avoid exposed sites generally.
4. Plant somewhat deeper than normal.

The use of seedlings of either European or Japanese larch for turf planting is much more problematical than in the case of the spruces, and it seems probable that except where there is a peat turf better results may be obtained by direct planting. The greatest attention should be given to the quality of the plants, and especially to the root system.

## THE RAISING OF STRONG CONIFER SEEDLINGS.

Two experiments, carried out at Kennington Nursery, Oxford, by Mr. J. Macdonald, as part of the above project, have given results of considerable interest.

A. In the first of these the factor studied was date of sowing. It is generally known that early sowing is advantageous but there are sometimes difficulties connected with tilth and in a large nursery the ground required for seedbeds may be under lines which cannot be cleared in time for sowing early. However the results outlined below suggest that it is worth while making every effort to secure early sowing.

Three species were used. Japanese larch, Sitka spruce and Pinus contorta. The dates of sowing were March 22nd (Early Sowing) and May 8th (Late Sowing), 1934. Seed was sown in drills and sand used for covering the seed. (*Note*—The use of coarse dry sand for covering very largely overcomes the tilth difficulty as seed can be sown under conditions which would be impossible if the seed had to be covered with the ordinary nursery soil.)

The following are the provisional results :—

(1) *Germination.*

| | *Early Sowing.* | | *Late Sowing.* | |
|---|---|---|---|---|
| J.L. | General | on April 26 | Sporadic | on June 27 |
| S.S. | do. | on May 9 | do. | on June 29 |
| P.C. | do. | on May 9 | do. | on June 30 |

Thus both early and late sowings took about the same time to germinate (from 6 weeks to 2 months). It must be remembered however that 1934 was a drought year and the dry spell set in about the end of April. In a normal season the late sowings of Japanese larch and Pinus contorta would probably have germinated more quickly.

In this case the seedlings from the early sowings had about 2 months longer growing season than those from the late sowings.

(2) *Production per lb. of Seed.*

| | *Early Sowing.* | *Late Sowing.* | *Ratio early Sowing to late Sowing.* |
|---|---|---|---|
| J.L. | 45,000 | 12,000 | 4 : 1 |
| S.S. | 83,000 | 7,000 | 12 : 1 |
| P.C. | 67,000 | 3,000 | 22 : 1 |

The date of sowing has thus made all the difference between success and virtual failure, as far as yield of seedlings is concerned. The season of course was exceptional but it is evident that early sowing is a very efficient means of insurance against failure in a drought year.

The results are amply borne out by the experience of other sowings in Kennington nursery, any seed sown before about the middle of April did well while all the May sowings were very poor.

(3) *Size of Seedling.*

| | *Early Sowing.* Maximum in. | Average in. | *Late Sowing.* Maximum in. | Average in. |
|---|---|---|---|---|
| J.L. | 6 | 3½ | 2 | 1¼ |
| S.S. | 3 | 1½ | 1½ | ¾ |
| P.C. | 3 | 1½ | 1½ | ¾ |

The early sown seed which was got in under favourable conditions produced seedlings which were able to establish themselves before the drought set in and produced not only many more but also much stronger plants than those from the late sowings. The former can be lined out at one year while the latter are too small to handle.

B. *Trial of organic Manures.*

Owing to the difficulty of obtaining adequate supplies of broadleaved humus or farmyard manure for the purpose of enriching nursery soils in humus, it was decided to experiment with other forms of vegetable matter which might be possible substitutes.

The following substances were used :—

(*a*) Sorbex peat from Sorbex Peat, Ltd., of 7, Queen Street, London, E.C.4. Price about 13*s*. 6*d*. per bale.* Sorbex is a yellowish rather strawy material, only imperfectly humified.

(*b*) Moss peat mould from the London and Provincial Moss Litter Co., Ltd., of Argyll House, Euston Road, London, N.W.1. Price about 7*s*. 6*d*. per bale. This is a black crumbly material well humified.

(*c*) Peat from the Cwm Ddu bog on Beddgelert Forest. This peat was sent to the nursery in October, 1932, for some stratification experiments and was kept stored in a box. It is a black amorphous peat taken from some distance below the surface of the bog.

(*d*) Compost prepared from mustard grown in the nursery in 1933. Ammonium sulphate was used as the composting agent.

(*e*) Decomposed weed compost.

There was the usual control which received no organic material.

* The price of 9*s*. per bale has been quoted for 100 bales delivered from Bremen in North Germany to a Scottish seaport.

All treatments were replicated. The beds were prepared in the usual way ; no inorganic manures were applied ; substances (*a*) to (*d*) were applied in the form of a 50 per cent. mixture of the substance and nursery soil, the depth of the mixture laid on the bed excavated for the purpose being 4 in. In the case of (*e*) the decomposed weed compost formed a layer on the bed 4 in. in depth (there was no further admixture with nursery soil). Species Norway spruce, Sitka spruce, and Pinus contorta.

Seed sown broadcast on April 24th, 1934, and covered with sand. Densities : N.S., 1 lb. to 400 sq. ft ; S.S., 1 lb. to 800 sq. ft ; P.C., 1 lb. to 600 sq. ft. The weed compost plots were sprayed with sodium chlorate after sowing with the object of killing any germinating weeds, but the treatment proved so prejudicial to the germination of the tree seeds that this set of plots had to be written off.

(1) *Production of Seedlings per lb. of seed.*

| | *N.S.* | *S.S.* | *P.C.* |
|---|---|---|---|
| Sorbex Peat | 29,000 | 86,000 | 56,000 |
| Moss Peat Mould | 29,000 | 23,000 | 15,000 |
| Beddgelert Peat | 28,000 | 35,000 | 22,000 |
| Mustard Compost | 15,000 | 13,000 | 5,000 |
| Control | 21,000 | 21,000 | 11,000 |

The highest production of all species has been given by the Sorbex peat which has increased the output of S.S. and P.C. by 4 and 5 times respectively, compared with the control. Beddgelert peat comes second with a decided increase in the yield of S.S. and P.C. but moss peat mould has given as good results as Sorbex with N.S. It is curious that the mustard compost should have depressed the germination of all three species.

The improvement in the germination brought about by the peat substances is interesting because in such a dry season the addition of so large an amount of organic matter might have been expected to upset the water relations of the soil instead of which it seems to have had the reverse effect, except in the case of the compost.

(2) *Size of Seedling.*

| | *N.S.* | | *S.S.* | | *P.C.* | |
|---|---|---|---|---|---|---|
| | *Max.* | *Av.* | *Max.* | *Av.* | *Max.* | *Av.* |
| | *in.* | *in.* | *in.* | *in.* | *in.* | *in.* |
| Sorbex Peat | 3 | 2 | $4\frac{3}{4}$ | $2\frac{1}{4}$ | 4 | $2\frac{1}{4}$ |
| Moss Peat Mould | $3\frac{1}{2}$ | 2 | 4 | 2 | $3\frac{3}{4}$ | $2\frac{1}{4}$ |
| Beddgelert Peat | 4 | $2\frac{1}{2}$ | 4 | $1\frac{3}{4}$ | $4\frac{1}{2}$ | $2\frac{1}{4}$ |
| Mustard Compost | $2\frac{1}{4}$ | 1 | $1\frac{1}{2}$ | $\frac{3}{4}$ | $1\frac{1}{2}$ | $\frac{3}{4}$ |
| Control | $2\frac{3}{4}$ | $1\frac{1}{4}$ | $2\frac{1}{2}$ | $1\frac{1}{4}$ | $2\frac{3}{4}$ | $1\frac{1}{4}$ |

Apart from the mustard compost all the manures have improved growth but there is evidence of differential response of these three species. Sorbex peat has given the best results with S.S. while N.S. and P.C. are both largest in the plots treated with Beddgelert peat. The differences between any of the three peats are not very great, but taken in conjunction with the germination data it would seem that Sorbex peat and Beddgelert peat are rather preferable to the moss peat mould.

The seedlings produced in the peat-treated plots are sturdy and many of the plants are furnished with lateral shoots. The root systems appear well balanced and there has been a greater production of sublaterals than in the nursery soil alone. The real proof—the development of the seedlings when lined out or planted out—is still to come but there seems no reason to anticipate anything but good results.

In the quantities used at Kennington, either the Sorbex peat or the moss peat mould would be very expensive on a large scale and it remains to be seen if smaller quantities can be used successfully, the lasting properties have also to be determined. A point to bear in mind with regard to the Beddgelert peat is that it had been kept in store for 18 months before use, raw peat straight from a peat bog might not give equivalent results.

So far as it goes the experiment is useful as showing that we need not be solely dependent on green manuring, farmyard manure, or broadleaf humus as sources of humus for nursery soils.

# MARKETING OF HOME-GROWN TIMBER.

By D. Maitland.

The success of large-scale production and distribution of any commodity depends for a great measure on careful study of actual and potential markets. There is a well-known story of a British manufacturer of raincoats who sent his catalogues for fifteen years to Egypt and was surprised that he was not overwhelmed with orders from that rainless country. On the other hand, at a time when English bootmakers were neglecting the Canadian markets on the assumption that they could never compete in it with the United States, one of their number, wiser than the rest, made a personal tour of the Dominion, and sold more English boots in Canada during the next year than the whole industry had sold there for several years.

The profitable utilization of forest products claims no exemption from the law that would-be suppliers must make detailed investigations of demand, and must inform themselves from time to time of the actual requirements of users, of the reasons that underlie their preferences and prejudices, of the conditions of trade and transport that affect their purchases, and of any changes that may be taking place in the general trend of the industries concerned.

With this principle in mind enquiries have now been carried out under the supervision of the Home-grown Timber Committee into the demand for timber in the box and packing-case trade in Great Britain and in the coal-mining industry in England and Wales, and it is proposed in the immediate future to extend this form of investigation to the turnery trade.

In the first of these enquiries information was obtained from 185 box and packing-case makers, whose annual consumption of timber ranged from less than twenty standards up to six or seven thousand, and from 36 large manufacturing concerns who imported their boxes from Continental countries in the form of shooks, or bundles of tops and bottoms, sides and ends, which only needed on arrival to be assembled with a nailing machine.

The chief complaint of the latter class was the alleged inaccurate and unreliable sawing in British sawmills, and the question of using home-grown timber was seldom considered ; but the almost universal preference of the British box and case makers for foreign timber was definitely based on certain specified advantages which it was stated to possess. These may be summed up as comparative freedom from knots, efficient seasoning and grading, regularity of supply, and cheapness ; and it is by concentrating on a gradual improvement in these respects particularly that a larger share of this market is likely to be gained.

In the second enquiry 163 coal-owning firms were interviewed, including most of the large associated groups as well as many independent owners. One fact which stands out from this investigation is the harm that was done to the home-grown pitprop trade by Britain's unavoidable dependence on it during the war. Timber of all sorts and conditions was felled, often with the sap in full flow, and sent into the mines, much of it entirely unsuitable for underground use, and the memory of this experience persists like a nightmare. In isolated cases the prejudice is being broken down, but further progress will be sadly hampered unless there is very careful selection, preparation and grading to required sizes of all timber offered to the mines.

The report on box-making has been published and that dealing with investigations into the use of timber in coal-mining will be issued shortly.

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## SITKA SPRUCE TIMBER FROM BENMORE.

The following report by Mr. J. T. Smith, of Messrs. A. and G. Paterson, Ltd., on timber grown at Benmore has been received by the Assistant Commissioner, Scotland :—

At the end of November, 1934, the Forestry Commission supplied us with thirty (30) short round blocks of home-grown Sitka spruce from Benmore Estate, Argyllshire.

We sent ten of these to our Silverbank Sawmills, Banchory, with instructions to leave them in running water for three months, and twenty of them to our Craiginches Sawmills, Aberdeen, to be sliced into box boards at our Robinson Rocking Beam Guillotine Slicer.

On 3rd December, 1934, in presence of Dr. Steven and Messrs. Bird and Wilson, of the Forestry Commission (Aberdeen), the logs were sliced. The wood appeared to be particularly clean, slightly discoloured at the heart, but as supplied very suitable for box-making.

Before slicing, the blocks had been slabbed by a circular saw (14 gauge) on three sides to enable the blocks to be fed to the slicer. They were placed in a steaming kiln for three hours in exhaust steam (no record of pressure within the kiln).

The string measurement of the logs in the round as received was :—

| *Length.* | *Quarter-Girth.* | *Contents.* | | |
|---|---|---|---|---|
| in. | in. | | ft. | in. |
| 17½ | 6¼ | — | 4 | 9 |
| 17½ | 5¾ | — | 4 | — |
| 17½ | 7¼ | — | 6 | 4 |
| 17½ | 7 | — | 5 | 11 |
| 17½ | 6⅛ | — | 4 | 4 |
| 17½ | 8 | — | 7 | 9 |
| 17½ | 7¾ | — | 7 | 3 |
| 17½ | 7¼ | — | 6 | 4 |
| 17½ | 6⅝ | — | 5 | 1 |
| 17½ | 8⅛ | — | 7 | 9 |
| 17½ | 7¾ | — | 7 | 3 |
| 17½ | 7¼ | — | 6 | 4 |
| 17½ | 8 | — | 7 | 9 |
| 17½ | 6⅞ | — | 5 | 6 |
| 17½ | 7¼ | — | 6 | 4 |
| 17½ | 7⅛ | — | 5 | 11 |
| 17½ | 6⅜ | — | 4 | 9 |
| 17½ | 6¾ | — | 5 | 6 |
| 17½ | 7½ | — | 6 | 10 |
| 17½ | 7⅝ | — | 6 | 10 |
| 20 logs. | | 10 | 2 | 6 |

These logs produced :—

8 pieces 17½ in. × 3 in. × $\frac{3}{16}$ in.
204 „ 17½ in. × 4 in. × $\frac{3}{16}$ in.
843 „ 17½ in. × 5 in. × $\frac{3}{16}$ in. 614 ft. 3 in. sq. ft., 9 ft. 7 in. cu. ft.

The blocks were weighed on a small Pooley Sack steelyard machine as received before kilning.

4 at 82½ lb.
4 at 96½ lb.
4 at 110 lb.
4 at 109 lb.
4 at 102½ lb.

500½ lb. = 45 to 46 cu. ft. per ton (49 lb. per cu. ft.).

| | |
|---|---|
| The boards, weighed in the hot state immediately after slicing, were .. .. .. .. .. .. | 358½ lb. |
| Firewood or waste, ex slicer .. .. .. .. | 30½ „ |
| Firewood or waste from sawing 3 sides of blocks .. | 51½ „ |
| | 440½ lb. |

Sawdust not recorded.

| | |
|---|---|
| The weight of the boards after being stacked from December 3rd to January 8th was .. .. | 289½ lb. |

*Note.*—There will be further slight loss in square cross cutting the boards to exact length.

The boards contained 9 ft. 7 in. cu. ft., which weighed 289½ lb., showing approximately 74 cu. ft. per ton (30 lb. per cu. ft.)

Home-grown Sitka spruce appears to slice well and presented no unusual feature in comparison with Norway spruce or whitewood. The corrugation of the surfaces of the boards is similar and no greater in extent than with other woods sliced by the same machine. In some of the boards the edge which first received the blow from the knife appears to have splintered about ¼ in. in and the whole length of the board. The number of boards thus affected is small. The waste was usual and no greater than with other woods. The samples received contained smaller knots than those we usually associate with home-grown Sitka spruce and were more evenly grown and less coarse than, *e.g.*, the Durris Sitka spruce which we have also handled. The boards dried flat, and were of excellent quality for ordinary box-making purposes. The surface of a sliced board is, as a rule, smoother than a sawn one and is less absorbent of printing ink accordingly. The discoloration of the heartwood is not an objection if the entire board contains heartwood. It is noticeable if the boards are streaked with heartwood. The wood answers the usual tests of nailing both by machine and by hand. Like all homewoods known to us it is better nailed by hand than by machine. In the former case the defects can be avoided. The mechanical spacing of the nails by machine prevents this being done. The wood does not answer well to further machine dressing.

The current prices for imported whitewood (Russian) suitable for box-making and of superior quality to the home-grown Sitka spruce now under test are :—

Round logs peeled 6 ft. to 9 ft. × average 7½ in. dia. small end, delivered at Aberdeen .. 10*d*. per cu. ft.

Squared logs 9 ft. × 10 in. × 10 in. delivered Glasgow or Grangemouth .. .. .. 1*s*. per cu. ft.

The boards produced were quite suitable for our ordinary purposes, and we could absorb large supplies if they were available at prices comparable to those paid by our competitors for imported whitewood used for the same purpose.

# THE SIMAR ROTOTILLER.

By W. G. Gray.

Although the use of the motor-driven machines is relatively a new feature in forest nursery operations, their introduction has given some encouraging results. It will be remembered that in the 1933 issue of this Journal, the advantages of the Auto Culto were given in an article by Mr. Popert. This article deals with another machine of a somewhat different type.

The Simar Rototiller 5 is a machine of rather higher power than the Auto Culto and has been designed principally for the market gardener, one of its most interesting features is that the usual system of cultivation by ploughshare has been entirely dispensed with. The following is a brief description of the machine.

The engine is a 5 h.p. single cylinder, air-cooled, two stroke, with petrol lubrication. It is built into a metal chassis, with a pair of flanged wheels, having an overall track of 18 ins. which can be reduced to 14 ins. The connection between the engine and wheel shaft is by a dog clutch. Two gears are provided operated by a single lever on the guiding handles. The top speed corresponds to 1½ miles per hour and the bottom to ¾ mile per hour. Tillage is effected by 12 semi-circular steel tines fitted to springs connected to a revolving miller shaft, driven independently, giving a tillage width of 20 in. and a variable depth of 2 to 9 ins., regulated by an adjustable depth shoe. The cultivating tines are covered by an adjustable metal shield. The machine is steered by two adjustable guiding handles arranged so that the driver can follow behind the machine or walk at either side according to conditions, the change being effected while the machine is working. The length of the machine is 6 ft. 9 in. and the total weight 3½ cwt. in working order.

During the past season an experiment was carried out in Kennington Nursery to test the effectiveness of this type of machine in the extermination of perennial weeds on fallow ground, and also upon its use for digging-in soiling crops. The experiment was conducted on an area of 1,044 square yards. The soil was a sandy loam practically free from stones and previously under transplants. The dominant perennial weed growth was couch (*Agropyrum repens*) which was abundant; other perennial weeds present but found only occasionally were spotted persicaria (*Polygonum persicaria*), dandelion (*Taraxacum officinale*), and field bindweed (*Convolvulus arvensis*). Apart from the removal by hand of dandelion, all tillage operations were entirely mechanical. For cleaning purposes the area was dug over four times with the Rototiller on May 4th, May 14th, June 11th and July 18th, cultivation taking place when fresh perennial weed growth appeared above ground. Perennial weeds were practically exterminated after the third digging, but a fourth digging was necessary for the destruction of annual weeds. The removal of weeds cast on the surface by the Rototiller was found to be unnecessary in this dry season as these withered completely during the intervals between cultivation. On each occasion the machine was worked in high gear, part of the shield being removed and the remainder fixed as high as possible to allow the weeds to be thrown clear on to the surface of the ground.

Following the fourth digging mustard was sown as a soiling crop at 20 pounds per acre, with sulphate of ammonia applied at 2 cwt. per acre as a manure. Before sowing it was necessary to firm the soil owing to looseness caused by tillage. The subsequent mustard crop was below average on account of the drought and gave a green-weight yield of 4·6 tons per acre. The crop was dug in by the Rototiller on September 13th after being cut down into moderately short lengths with a hook. For this operation the machine was worked in low gear and fixed for full tillage. The area was gone over once, and this was sufficient to bury the crop in a satisfactory manner.

The cost of tillage operations given below have been based on the following standard charges, but no allowance has been made for depreciation and repairs.

| | *s.* | *d.* |
|---|---|---|
| Petrol, per gallon .. .. .. .. .. | 1 | 5 |
| Oil, per gallon .. .. .. .. .. .. | 6 | 8 |
| Gear oil, per gallon .. .. .. .. .. | 4 | 0 |
| Man's time, day work, per hour .. .. | | 8·4 |

The approximate running cost of the machine has been calculated as follows :—

| | *s.* | *d.* |
|---|---|---|
| Petrol, 1 gallon .. .. .. .. .. .. | 1 | 5 |
| Lubricating oil, ½-pint per gallon of petrol .. | | 5 |
| Gear oil, ⅛-pint per gallon of petrol .. .. | | 1 |
| Running cost per gallon of petrol .. | 1 | 11 |
| Running cost per pint of petrol .. .. | | 3 |

Summary of cost of tillage :—

| | Time taken to dig 100 sq. yds. | Fuel. Pints per 100 sq. yds | Time taken in hand cleaning per 100 sq. yds. | Total cost per 100 sq. yds.* |
|---|---|---|---|---|
| 1st cultivation .. | 6·5 min. | 0·36 | †2·8 min. | 2¼*d.* |
| 2nd do. .. | 5·3 " | 0·38 | — | 2*d.* |
| 3rd do. .. | 7·7 " | 0·45 | — | 2½*d.* |
| 4th do. .. | 5·7 " | 0·38 | — | 2*d.* |
| | | | Total cost .. | 8¾*d.* |

* Includes running and labour costs.
† Removal of dandelion.

Cost of mustard crop per 100 sq. yds.

| | |
|---|---|
| Firming of soil, sowing mustard and artificial manure and harrowing .. .. .. | 6·7*d.* |
| Mustard seed at 8*d.* per lb. .. .. .. | 3·6*d.* |
| Sulphate of ammonia at 12*s.* per cwt. .. .. | 6·9*d.* |
| Cutting of mustard crop .. .. .. | 1·75*d.* |
| Digging-in of mustard by Rototiller .. .. | 3·75*d.* |
| Total cost per 100 sq. yds. .. .. | 22·7*d.* |
| or approximately 1*s.* 11*d.* | |

SUMMARY.

Perennial weeds (couch) were satisfactorily exterminated after four periods of cleaning, under ideal conditions, at a total cost of 8¾*d.* per 100 sq. yds., and a moderate mustard soiling crop was cut and dug in at a cost of 5½*d.* per 100 sq. yds. It should be emphasized, however, that conditions were exceptionally favourable for work of this kind, as a wet summer with a heavier weed growth would undoubtedly have led to higher costs.

The Rototiller is an efficient machine, suitably constructed for hard use, requiring little attention for general maintenance and no special knowledge for manipulation. The system of tillage prevents the formation of a plough pan and ensures a thorough cultivation to a spade's depth. Its use on fallow ground enables more frequent cultivation to take place than by manual labour. Further uses for which the machine has been successfully employed are the preparation of ground for seedbeds and transplants. The price of the machine is £98. The agents are Geo. Monro, Ltd., Waltham Cross, Herts.

Since the preparation of this paper it has been ascertained that the Simar Rototiller 5 has been superseded by an improved and slightly more powerful model known as the Rototiller 50 at 5·5 h.p., price £108. A slightly less powerful type, the Rototiller 30, 3·5 h.p., is also on the market, listed at £79.

# NUTRIENT CONTENT OF NURSERY PLANTS.

By W. H. Guillebaud.

There is an important article by Dr. E. Manshard in the second number of Vol. 84, 1933, of the " Tharandter Forstliches Jahrbuch," dealing with nutrient content of seedlings and transplants. Average plants were collected from a number of trade as well as State forest nurseries in Germany and these were analysed for their content of lime, magnesium, phosphoric acid, potash and nitrogen. The results were worked out in kilogrammes based on the number of plants normally raised per hectare of nursery. The writer's attention was called to the article by Mr. O. J. Sangar, who suggested that the tables should be converted into British units. This has been done and in addition the weight of each element per 100,000 plants has been calculated to facilitate the use of the data. The results obtained from the State nurseries are set out in Table I over page. Manshard gives a similar table from data derived from trade nurseries, in particular the Halstenbek Nursery in Schleswig Holstein. This table also was converted, but a comparison of the two tables as regards the weights of each nutrient per 100,000 plants showed only negligible differences and to save printing the one table only has been reproduced.

Table II is also taken from Manshard and shows by way of comparison the quantity of nutrients removed when various agricultural crops of average bulk are harvested.

It is convenient to consider separately the coniferous and broadleaved species in Table I.

## 1. Conifers.

The three species given are Norway spruce, Scots pine and Silver fir. The number of 1-year seedlings of spruce per acre given in the table, 810,000, is very low; we would expect about twice that number even taking paths and alleys into account, so that the figures for weights of nutrients per acre can be approximately doubled to meet our conditions. On this basis one acre of 1-year spruce seedlings takes out 9 lb. of lime, 1 lb. of magnesium, 3·6 lb. of phosphoric acid, 5·4 lb. of potash and 12 lb. of nitrogen. With the exception of lime, these values are all small in comparison with those removed in agricultural crops (Table II). It is interesting to find that 1-year seedlings of Scots pine make a considerably higher demand on the soil than spruce; in fact the quantities removed are almost four times as great. The difference is probably due in large measure to the difference in size of the two seedlings. In the second year, the quantities removed are quite substantial. Assuming that the beds of spruce were stocked at the rate of 1,600,000 seedlings per acre, the plants withdraw from the soil in the second year 14 lb. of phosphoric acid, 27 lb. of potash and 45 lb. of nitrogen; the nitrogen figure is about that for an average corn crop, the phosphorus and potash about half the

TABLE I.

*Quantity of nutrients removed by seedlings and transplants raised in Forest Nurseries.* (*Manshard.*)

| Species | and Age. | Number of Plants per Acre. | Lime ($CaO$) Weight per Acre. | Lime ($CaO$) Weight per 100,000 Plants. | Magnesium ($MgO$) Weight per Acre. | Magnesium ($MgO$) Weight per 100,000 Plants. | Phosphoric Acid ($P_2O_5$) Weight per Acre. | Phosphoric Acid ($P_2O_5$) Weight per 100,000 Plants. | Potash ($K_2O$) Weight per Acre. | Potash ($K_2O$) Weight per 100,000 Plants. | Nitrogen (N) Weight per Acre. | Nitrogen (N) Weight per 100,000 Plants. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 000's | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. |
| Spruce | For 1-year Seedlings | 810 | 4·5 | ·555 | 0·5 | ·061 | 1·8 | ·222 | 2·7 | ·333 | 6·2 | ·765 |
| | „ 2 „ „ | 770 | 20·5 | 2·664 | 1·8 | ·233 | 7·1 | ·922 | 13·4 | 1·741 | 22·3 | 2·897 |
| | „ 3 „ Transplants | 284 | 81·0 | 28·571 | 8·9 | 3·139 | 20·5 | 7·231 | 28·5 | 10·052 | 68·5 | 24·162 |
| | „ 4 „ „ | 284 | 65·0 | 22·927 | 9·8 | 3·456 | 27·6 | 9·735 | 42·7 | 15·061 | 69·4 | 24·479 |
| Scots Pine | „ 1 „ Seedlings | 1,094 | 8·9 | ·813 | 2·7 | ·246 | 8·9 | ·813 | 13·4 | 1·225 | 32·0 | 2·926 |
| | „ 2 „ Transplants | 284 | 6·2 | 2·186 | 1·8 | ·634 | 5·3 | 1·869 | 8·0 | 2·821 | 19·6 | 6·913 |
| Silver Fir | „ 1 „ Seedlings | 1,215 | 5·3 | ·436 | ·5 | ·041 | 2·7 | ·222 | 3·6 | ·296 | 8·0 | ·658 |
| | „ 2 „ „ | 1,094 | 18·7 | 1·710 | 2·7 | ·246 | 9·8 | ·896 | 13·4 | 1·225 | 22·3 | 2·039 |
| | „ 3 „ Transplants | 162 | 8·0 | 4·938 | 0·9 | ·555 | 3·6 | 2·222 | 7·1 | 4·382 | 11·6 | 7·160 |
| | „ 4 „ „ | 162 | 36·5 | 22·530 | 4·5 | 2·770 | 13·4 | 8·271 | 21·4 | 13·209 | 32·0 | 19·753 |
| Beech | „ 1 „ Seedlings | 243 | 16·9 | 6·954 | 2·7 | 1·111 | 4·5 | 1·851 | 6·2 | 2·551 | 10·7 | 4·403 |
| | „ 2 „ „ | 231 | 65·0 | 28·156 | 9·8 | 4·245 | 16·0 | 6·930 | 24·9 | 10·786 | 45·4 | 19·666 |
| | „ 3 „ Transplants | 61 | 18·7 | 30·781 | 2·7 | 4·444 | 3·6 | 5·925 | 4·5 | 7·407 | 11·6 | 19·094 |
| | „ 4 „ „ | 61 | 97·9 | 161·152 | 15·1 | 24·855 | 29·4 | 48·395 | 38·3 | 63·045 | 68·5 | 112·757 |
| Pedunculate Oak | „ 1 „ Seedlings | 243 | 26·7 | 10·987 | 3·6 | 1·481 | 4·5 | 1·851 | 0·9 | ·370 | 9·8 | 3·032 |
| | „ 2 „ „ | 231 | 61·4 | 26·597 | 13·4 | 5·804 | 16·9 | 7·320 | 39·2 | 16·980 | 62·3 | 26·987 |
| | „ 3 „ Transplants | 61 | 35·6 | 58·600 | 4·5 | 7·407 | 6·2 | 10·205 | 14·2 | 23·374 | 18·7 | 30·781 |
| | „ 4 „ „ | 61 | 76·5 | 125·925 | 13·4 | 22·057 | 22·3 | 36·707 | 40·1 | 66·008 | 63·2 | 104·032 |
| Red Oak | „ 1 „ Seedlings | 243 | 30·3 | 12·469 | 4·5 | 1·851 | 6·2 | 2·551 | 2·7 | 1·111 | 8·0 | 3·292 |
| | „ 2 „ „ | 231 | 96·1 | 41·628 | 16·9 | 7·320 | 25·8 | 11·176 | 61·4 | 26·597 | 74·8 | 32·401 |
| | „ 3 „ Transplants | 61 | 74·8 | 123·127 | 8·9 | 14·650 | 16·0 | 26·337 | 33·8 | 55·637 | 57·9 | 95·308 |
| Ash | „ 1 „ Seedlings | 506 | 80·1 | 15·822 | 16·0 | 3·160 | 22·3 | 4·404 | 74·8 | 14·775 | 69·4 | 13·708 |
| | „ 2 „ „ | 456 | 401·4 | 88·098 | 85·4 | 18·743 | 131·7 | 28·905 | 387·2 | 84·982 | 309·7 | 67·972 |
| | „ 3 „ Transplants | 71 | 58·7 | 82·821 | 9·8 | 13·827 | 15·1 | 21·305 | 49·0 | 69·135 | 50·7 | 71·534 |

NOTES.—To arrive at the total quantities removed by, say, a 2-year seedling the quantities given for 1-year seedlings must be *added* to the quantities given for the 2-year stage. The same applies to the transplants.

The differences between the numbers of the 1-year and 2-year seedlings reflect the losses normally occurring in the beds.

TABLE II.

*Mean quantity of nutrients removed by agricultural crops of average yield. (Manshard.)*

| | Yield in cwts. per acre. | | Nutrients in lbs. per acre. | | | |
|---|---|---|---|---|---|---|
| | Corn. | Straw. | CaO. | $P_2O_5$. | $K_2O$. | N. |
| Rye .. .. .. | 16 | 32 | 13 | 27 | 53 | 45 |
| Wheat .. .. .. | 19 | 32 | 11 | 27 | 45 | 62 |
| Oats .. .. .. | 19 | 28 | 13 | 22 | 67 | 53 |
| Barley .. .. .. | 19 | 25 | 13 | 22 | 45 | 45 |
| Potatoes .. .. | 63 | 158 | 45 | 36 | 142 | 80 |
| Lucerne hay .. .. | 63 | | 205 | 49 | 129 | 223 |

corresponding amounts. The figures for 2-year seedlings of silver fir (for equivalent numbers of plants) are of much the same order as those for Norway spruce.

These figures indicate that conifer seedlings are not the unexacting plants that they are sometimes considered to be and, even allowing for a hypothetical greater efficiency on the part of the seedlings for extracting nutrients from the soil, it is not hard to see that conifer seedlings grown year after year on the same soil are liable to exhaust it in course of time.

Turning now to the transplants, the quantities of nutrients removed in the 2-year 1-year and 2-year 2-year stages are surprisingly high. A crop of 284,000 2-year 2-year transplants removed 58 lb.* of phosphoric acid per acre, 71 lb. of potash, and 138 lb. of nitrogen. These are very substantial quantities, being equivalent respectively to about 3 cwt. of superphosphate, 4 cwt. of potash and 6 cwt. of ammonium sulphate.

## 2. BROADLEAVED TREES.

*Pedunculate Oak.*—There are some interesting comparisons to be drawn between the values for 1-year seedlings of oak and of conifers, *e.g.* Scots pine. On the basis of weight per unit number of plants, the potash and nitrogen requirements are nearly rqual in the two species; oak seedlings take twice as much phosphoric acid out of the soil as Scots pine, but the outstanding differences are in respect of lime and magnesium, oak removing thirteen times as much lime and six times as much magnesium as Scots pine. Two-year oak seedlings are considerably more exacting, the nutrient amounts removed being much the same as for 2-year 1-year spruce transplants but with rather more magnesium and potash taken out by the oak. The 2-year 2-year oak transplant removes large quantities of nutrients during the two years spent in the lines. If we assume that a normal stocking would be 150,000 plants per acre, the quantities taken out will be as follows: Lime 286 lb.; magnesium 44 lb.; phosphoric acid 70 lb.; potash 134 lb.; nitrogen 201 lb. The potash is equivalent to a dressing of about 8 cwt. of kainit and the nitrogen to 8 cwt. of ammonium sulphate. The remarkably high lime, potash and

* The quantities for the two years must be added as the figure for each stage indicates only the amount removed at that stage.

nitrogen requirements of oak transplants suggest a possible explanation of our generally unsuccessful efforts to raise good transplants of this species.

*Beech.*—The 1-year seedlings extract from the soil much the same quantities of nutrients as pedunculate oak, except, and this may be significant, in the case of potash of which beech takes seven times as much as oak. The 2-year seedlings are also similar, and it is interesting to find that at this stage the potash contents of the two species are reversed, oak containing the larger amount. The 2-year 1-year beech transplants, though a good deal more exacting than conifer transplants, take rather less from the soil than does the corresponding transplant of oak. There is, however, a remarkable jump in the quantities of nutrients removed in the 2-year 2-year stage; from five to nine times as much are taken out by a 2-year 2-year plant as compared with a 2-year 1-year. Assuming a stock of 150,000 transplants per acre the following quantities are removed during the two years in the lines:—Lime 288 lb.; magnesium 44 lb.; phosphoric acid 81 lb.; potash 105 lb.; and nitrogen 198 lb. These closely resemble the corresponding figures for oak.

*Ash.*—The ash data are the most striking of all. Assuming the rather low stocking given in Table I of 500,000 seedlings per acre, the 1-year seedlings remove as much as 75 lb. of potash and 69 lb. of nitrogen. In the 2-year stage the quantities absorbed are enormously increased; the seedlings remove in the second year 440 lb. of lime, 94 lb. of magnesium, 145 lb. of phosphoric acid, 425 lb. of potash and 340 lb. of nitrogen. To replace the last three of these nutrients would require 8 cwt. of superphosphate, 24 cwt. of kainit, and 15 cwt. of sulphate of ammonia respectively. The 2-year 1-year transplant takes out almost as much during the first year in the lines as the 2-year seedling, but the demands on the soil are less because of the smaller number of plants per acre. Comparing these figures with those given in Table II it is apparent that a crop of 2-year ash seedlings takes out of the soil from five to seven times as much phosphoric acid, potash and nitrogen and forty times as much lime as an average corn crop. Evidently the raising of ash on an impoverished nursery soil is not to be recommended.

## Conclusions.

In the first place a word about the data given in Table I. As these are based on chemical analyses of average plants and there is an almost complete correspondence between the values obtained from trade and State forest nurseries I think it is impossible to challenge their accuracy. Their practical interpretation will now be discussed.

1. We do not know the size of the plants analysed or the level of fertility of the soils in which they were raised. It does not follow that because the 2-year seedlings of ash, for example, removed 96 lb. of potash per 100,000 plants from the soil that the whole of this was necessary for the plants' development; potash might have been in excess in the soils in question, the plant tissues have taken up more than they actually required.

2. There is the difficulty that our numerous experiments with artificial fertilisers have on the whole given negative results, *i.e.*, the plants have not shown any appreciable response. To take perhaps the most puzzling instance, I.C.I. complete chemical manure, containing nitrogen potash and phosphorus, has been applied to seed beds of oak and ash and to closely planted groups of ash in the forest without effecting any improvement in growth. The soil of the nursery (Nagshead in the Forest of Dean) was certainly not over rich in food nutrients and it was surprising to find no response whatever to the manure either in the 1-year or 2-year seedling stage. It is of course possible that some other nutrient, *e.g.*, lime or magnesium was in minimum and therefore acted as a limiting factor. In the same experiment it is interesting to note that leaf mould and compost prepared from maize straw had a definite effect upon growth.

By far the most effective of the methods so far applied for stimulating the growth of ash has been the sowing of ash seed on a hot bed prepared from stable manure. By this means 1-year seedlings 12 to 18 in. high were produced. These examples show the complexity of the problem of tree nutrition, and that the creation of a productive nursery soil is not a simple matter of adding large quantities of the principal food nutriments in the form of inorganic manures applied direct to the tree plants. The mycorrhizal structure of the roots of tree plants is certainly one factor which has to be taken into account and there are probably others as to the nature of which one can only speculate at present.

3. If, as is suggested above, we are not justified in assuming that the data form a complete guide to the practice of nursery manuring, what conclusions are we entitled to draw ? I think there are several legitimate ways in which the data can be used. In the first place there is the factor of exhaustion. It seems obvious, on agricultural analogy, that several crops of 2-year 2-year spruce transplants and still more 2-year ash seedlings taken off the same ground in succession and without anything returned to the soil must leave it greatly impoverished. It is quite probable that, just as at Rothamsted wheat can be grown indefinitely on the same soil, so spruce transplants could be raised time after time without a break, but the quality is likely to leave much to be desired. It may be concluded then that it is bad practice to take two or more crops of transplants in succession off the same ground without putting anything back. The same certainly will apply to seed beds of ash and probably also to beech. There is thus the strongest justification and support for a system of rotation in forest nurseries, resting the ground either by a bare fallow or enriching it with an adequately manured green crop. Secondly the data give a clue to the differential requirements of the various species (incidentally it is much to be desired that similar data should be provided for the other species which we are raising, notably Sitka spruce, European and Japanese larch, Douglas fir, Corsican pine and sycamore). They suggest that broadleaved species require more generous treatment than conifers, especially as regards lime, magnesium, potash and nitrogen. Also it may be better to raise the broadleaved species in a separate

section of the nursery and not to follow oak or ash, for example, with conifers. Thirdly, the remarkable increase in the amounts of nutrients taken up in the 2-year 1-year stage of beech and oak suggests the desirability of experiments on the top dressing of transplant lines at the beginning of the second growing season.

4. The above conclusions leave open the knotty problem of the form in which manures should be applied and the amounts necessary to maintain the soil in a state of good heart. Such evidence as we have points to the application of manures indirectly through organic matter rather than directly in the form of inorganic fertilisers. Such substances as leaf mould, vegetable compost, dug-in crops, etc., appear much more effective, at any rate as far as seed beds are concerned, than the direct application of artificials. At the same time artificials have an important part to play in nursery practice in connection with green cropping, and a well fertilised green crop may be one of the best methods of restoring nutrients to the soil.

5. As to the quantities required of each of the principal nutrients, we are largely in the dark, and are likely to remain so until our nursery soils are analysed and the results linked up with the development of each of the major species. Work on these lines has recently been started at the Macaulay Institute for Soil Research near Aberdeen. Dr. Stewart, who is in charge of this investigation, is prepared to examine samples of nursery soils and to indicate how these compare with certain standard soils which have already been analysed. Until further information is forthcoming the aim should be to keep an adequate proportion of ground under fallow or green crops, manure the green crops generously, and keep up the humus content of the soil by every possible means.

# ROYAL SCOTTISH FORESTRY SOCIETY SUMMER MEETING, 1934.

By G. B. Ryle.

The Society held its Fifty-Second Annual Excursion in Stirlingshire and West Perthshire, from 4th to 8th June, 1934. Visits were paid to several privately owned Estates and to the Glasgow Corporation's plantations at Loch Katrine. None of the Forestry Commission's areas was included in the programme.

*Gargunnock Estate.*

A P. 26 plantation of Douglas, Sitka spruce and European larch was interesting mainly in that it had been formed without excluding rabbits. The trees were treated with " Smearoleum " at the time of planting and were again smeared over in the second year. Since then no further treatment had been given but the crop has got away well without any damage from rabbits, which are quite numerous. Several parts of the plantation were in danger of suppression from the growth of birch and coppice oak.

In Dunning Glen and Johnston's Wood, plantations aged about 90 years and less, of mixed oak and Norway spruce were examined with a view to discussion on the possibilities of hardwood growing in this part of Scotland, especially on the Old Red Sandstone and super-imposed glacial drifts. It seemed that the earlier thinnings had not been made especially with a view to the formation of a final oak crop, but it was evident that by careful further thinnings a fair proportion of the clean poles of oak could be saved. As, however, there are insufficient of virile oaks standing to form a crop alone and as the spruce will obviously reach maturity before the oak becomes of valuable size, it would seem that the only possible system of obtaining large oak timber would be gradually to cut out the spruces and concurrently to underplant with a shade bearer. This policy would be difficult to carry through economically, and it is questionable whether the oak, excepting on certain of the best lower areas, would be of sufficiently good quality to warrant the experiment.

An old established sawmill at Gargunnock Station was interesting, especially in view of the high proportion of manual labour employed. The produce brought in for conversion is very mixed, comprising mainly small mixed lots of hardwood species, and thus factory or mass-production methods are impossible.

It is difficult to obtain good oak of the sizes required (*i.e.* 16 in. quarter-girth and up), and on the other hand it is difficult to dispose of the smaller grades (about 12 in. quarter-girth) which are plentiful on the market. Good coachwork ash is scarce and even at 3*s.* 6*d.* a foot it is impossible to obtain sufficient. Beech has a steady market and is mainly converted for export to the furniture manufacturers. Poplar is scarce though the demand also is diminishing. Railway brake blocks and truck bottoms which were formerly of poplar are now increasingly made of cast-iron and sheet steel, respectively. About 1*s.* 8*d.* per foot F.O.T. is a normal price.

The sawmill possesses no proper creosoting plant but it has a steady market for cold-dipped creosoted sawn larch fence stakes.

*Gartmore Estate.*

This is another Old Red Sandstone area frequently over-laid by deep glacial deposits. The young plantations visited showed a fairly uniform neglect of thinning and management on sites which were capable of producing high quality stands.

Two mixed plantations of Japanese larch and Douglas of 1921 and 1910 planting introduced some novel problems in thinning. In the younger plot the mixture had been by 8 rows of the one species alternating with 8 rows of the others. No record existed as to the reason of this system, but it is likely that difficulties were already seen regarding the thinning of the 1910 plot, and the 8-row system was adopted with a view to facilitating the selection of stems to obtain a mixed timber crop. Generally the Douglas was tending to get ahead of the Japanese larch, but treatment to maintain a mixed wood will not be impossible or even difficult.

In the 1910 plantation the mixture had been by single trees and the majority of the Japanese larch were badly suppressed. A thinning is long overdue and the crop is rapidly becoming whippy ; but immediate treatment would enable a small proportion of the larch to be saved. There seemed, however, little to recommend in the mixtures of these two species.

Crinigart Wood had been planted in 1900 with mixed Japanese larch, Norway spruce and Silver fir at a 3-foot spacing and had not been subsequently thinned. Luckily nearly all of the two latter species had failed after planting and had not been replaced, so that the existing crop is not so dense as would seem likely. Thinning is badly overdue but the growth of Japanese larch is rapid and fairly clean. Under proper management this would have produced a very nice crop.

Another plot of oak with a few beech and birch (probably about 90 years old) had been underplanted in 1900 with Douglas at a 3-foot spacing. Apart from neglected thinning this under-storey is good in the large open spaces but is badly stunted under the canopy of the hardwood crop. Removal of the over-storey would be possible in some places to enable the younger crop to develop but it will call for great care, especially as the Douglas is unthinned and in a very weak state from wind or snow damage. Much of the Douglas will inevitably be lost as the removal of the oaks will be impossible. Had the original hardwood crop been heavily thinned before introducing the Douglas it appeared that a very nice group-mixture would have been possible and the old hardwoods would have natured at about the same time as the young conifers.

*Ardchullary Estate.*

Conifer plantations on the clay-slates with a fair western slope and rising in elevation from the shore of Loch Lubnaig up to 1,250 ft. gave interesting comparison in the growth of the commonly used species.

European larch (P. 1892-1928) has generally been very severely cankered, and in the first plot visited a half-stocked pole crop had been pruned up and interplanted two or three years ago with Sitka spruce. The future of such a mixture is very problematical, as the older European larch will almost certainly spread out to form a moderate canopy, will become coarse and rough, but will at the same time stop the useful development of the young Sitka spruce. Sitka, at any rate in its early youth, is not a good shade bearer in this climate.

Plots of Japanese larch, Sitka spruce, Norway spruce, Douglas and Scots pine were making good growth and a proper programme of thinning appeared to be receiving timely attention.

Thuja was very lightly attacked by *Keithia thujina* and was not materially affected thereby.

It was noteworthy that many of the small dingle bottoms with juncus and molinia had either been left unplanted or the crop had failed through lack of drainage. For the most part these were becoming naturally stocked with alder which might form useful firebreaks, but it seemed that some useful spruce sites had thus been wasted.

On this Estate all planting is carried out with a handy spade designed by Simpson (Brades), rather after the fashion of the semicircular spade but lighter and stiffer. Pitting with this spade it was stated could be done at a rate of 400-500 plants per day per man, the men working in pairs with a boy carrier for each pair. The method is worthy of trial as undoubtedly better results can be obtained thus than by the very slightly cheaper notching methods, especially on hard packed soils. We have many examples on our own forests where a getaway from notching methods is seen to be essential (apart altogether from the peat or pan areas, where proper soil loosening or aeration may best be achieved by subsoil ploughing).

*Dunira Estate.*

A mixed thicket crop of Douglas and Norway spruce planted in a valley flat gave good comparison of the development of these two species. In the frosty hollow the Douglas had been severely cut back year after year and were becoming completely dominated by the spruce, whereas on the slopes away from the most severe frost zone the spruce was completely ousted by the rapid growing Douglas. There was no evidence to show that the late flushing type of Norway spruce was in any way superior to the early shooting type so far as frost resistance was concerned as both types (intermixed) had made similar growth and were of equally good form.

A good crop of 70-year old European larch was examined. The policy for the continuance of this wood is to be the non-silvicultural one of removing only such of the better trees as may be required from time to time for Estate uses. Appearance indicated that the crop would be economically mature before the expiry of a further 20 years and several neighbouring trees of 100 years' growth had been found to be badly pumped.

One section of this wood had been thinned out to a stocking of about 70 per cent. and had been underplanted with Douglas which has now formed a dense under-storey, but is beginning to suffer from want of light. The removal of the upper storey would be a very difficult operation without doing serious damage to the rather whippy Douglas.

Adjacent to this was an old mixed wood of oak, birch, Scots pine and European larch over a vaccinium herbage and only thinly stocked. This had been in part underplanted with Douglas and in part with Sitka spruce. The former was successful, but obviously the Sitka spruce is far less shade-bearing in its requirements and had given very poor results. With this thin over-storey there will be less difficulty in conducting thinnings to let the Douglas get away in nice groups—some of the rough and unmarketable old trees could well be ring-barked to give space to the young crop without doing damage.

*Drummond Estates, Limited.*

Again the growth of European larch on the Old Red Sandstone formation was seen to be extremely rough and canker was serious. An extensive plantation of P. 03—P. 04 had been formed at a 3 × 3 ft. spacing, but records show that there was a heavy proportion of deaths from early canker and these were not replaced. The resultant crop had become rough and branched in its youth. With the closing of the canopy these large branches had become suppressed and killed, and very big dead snags were persistent. No thinnings or cleanings had been done to improve the condition.

A plantation of Japanese larch (P. 01—P. 02), said to be the heaviest crop of this species in the country, had recently been saw-pruned. This crop was originally planted at a spacing of 12 × 12 ft. and filled up to 3 × 3 ft. with European larch. Only a very few of the latter remain as suppressed and cankered poles and it is thought that many of them died out comparatively early. No thinning had been done except by the natural death of the European larch. The Japanese larch is mainly clean and straight, and with a good crown-height ratio, though there are several forked and corkscrewed stems. Considering that the pruning had only just been done it was notable that there were very few large branch knots to be seen.

*Airthrey.*

An exceptionally clean stand of mixed sycamore and ash of about 60 years was indicative of the fertile nature of these lower slopes of the Ochil Hills. The soil varied from a medium loam to a rough stony scree slope, but with plenty of finer deposit beneath. The history of the crop was unknown, but rows were traceable and it was evidently planted with a certain mixture of larch and pine. Only a few suppressed conifers survive beneath the canopy of sycamore, which now forms the bulk of the crop. Thinning is required and in several poorer places, possibly where trees had been removed for non-silvicultural reasons, a copious natural regeneration of both sycamore (dominant) and ash is developing but is damaged by rabbits. The site would appear an ideal one for a system of group regeneration. On leaving the better loamy soils (mercurialis type) and entering a less fertile sandy soil (bracken) the quality of ash, and less so of sycamore, rapidly deteriorates and more of the original conifer mixture remains dominant.

*Abbey Craig.*

This small woodland property is owned by the Corporation of Stirling and is managed primarily for amenity purposes as a public recreation ground around the base of the Wallace Monument. The original crop is a mixed hardwood one with sycamore, ash, elm, oak, etc., and a scattered underwood. The policy is gradually to regenerate in the weaker places and at the same time to introduce more species of evergreen foliage. Large clear cuttings in excess of a quarter of an acre alarm the Borough dignitaries and as the wood is infested with rabbits the enclosure of numerous small patches is an expensive item. Very small groups cleared and rabbit fenced have been replanted with European larch, Douglas, Sitka spruce, Scots pine, etc., but in many places are obviously suffering or getting too much drawn up by the excessive side shade. One would have thought that the amenities would have been in no way destroyed by more reasonable sized clearings : pleasant vistas would have been opened up and the regeneration of the poorer parts of the crop could have been proceeded with at less cost and with healthier results. Alternatively the use of stronger shade-bearing species, especially at the edges of the groups, under the more extreme shelter conditions would have been possible and the inclusion of beech, Silver firs, Tsuga, etc., would add to the variety of the woodland. Most of the openings were becoming filled up with natural sycamore which frequently tended to develop at the expense of the planted conifers.

*Kier.*

The most interesting woods visited on this Estate were in demonstration of the late Prof. Fisher's method recommended for the formation of oak crops, a method started over 20 years ago and still being carried on. In brief the system is to plant with about 1,200 trees per acre of 2 + 0 or 2 + 1 oak (locally collected seed and mainly pedunculate). Two years later, when the oak may be presumed to be established and beginning to make good growth, the plantation is filled up with about 600 European larch and 1,800 beech per acre. The larch fairly rapidly take the lead and after about 10 years it is necessary to go through the wood to cut out the strongest of them, trim back strong side branches of others and lop back the tops of too fast-growing beeches. From the tenth to twentieth years several thinnings are made, but as the larch is dominant it is well developed and early utilisable for fencing or pitwood. Simultaneously the beech is further lopped back whenever it becomes dominant. By the twentieth year practically every European larch has been removed and the oak should be able to hold its own against the beech, especially as future thinnings for a good many years to come will be almost entirely confined to the latter. All stages of this method were seen from about 5 years up to 20 years and some very clean oak poles were being produced, though it appeared that the beech might in some places be rather too strong and become an expensive nurse to control. The disastrous result of delaying the larch and beech thinnings was seen in one plot (where the war had prevented normal treatment) and practically no useful oak remained, having been entirely suppressed. It should be noted that *Tortrix viridana* is almost unknown in Scotland and there is thus little advantage in using sessile in preference to pedunculate oak. Hence the latter, being the locally prevalent type, is used.

Both on this Estate and at Glassingall it was possible to examine side-by-side plantations of different races of Douglas fir and in every instance it was seen that the inland races (*e.g.* Fraser River type) were tolerably immune from *Chermes cooleyi* and had a sturdier, stiffer and cleaner form than the coastal or green type. The inland types were of somewhat slower growth, though as the coastal type has been very severely checked by *Chermes* this difference was not particularly striking. One would suspect from the appearance and form of the tree that the inland one would be considerably less likely to suffer damage from snow-break than the coastal race, but the plantations seen were too young to give concrete evidence of this. Anyhow the "Fraser River," which became so unpopular with us a very few years ago, is showing itself to be by no means so deserving of our contempt. In addition to its better form and greater immunity from *Chermes* we have found it to be better able to withstand smoke and industrial fumes than the coastal race.

*Cromlix Estate.*

The main feature of interest here was in the formation of extensive wooded shelter belts on severely exposed rolling country at about 900 ft. above sea level. It was seen that Norway spruce and Sitka spruce at about 30 years of age differed but slightly in growth. The latter had a lead of about 3–5 ft. over the Norway, but balanced against this the Norway was straighter and cleaner and did not suffer from broken leaders as did the Sitka. The use of Scots pine was entirely unsuccessful, even in the side protection of the more dominant Sitka spruce. Probably a wrong race of pine had been imported into the district, which has a rainfall of about 50 in. annually. A west coastal race of tree might have been satisfactory. Japanese larch on the other hand had made very sturdy growth and was certainly as useful as the spruces for shelter belt purposes, while its form was surprisingly clean.

*Loch Katrine.*

The Corporation of Glasgow are owners of some 10,000 acres of plantable land within the catchment area of their water supply scheme.

During the past eleven years a steady afforestation programme has been conducted, annual plantations having been up to 190 acres in P. 26, but normally rather less.

To date work has been confined to the north side of the Loch, where it is intended ultimately to form a 5,000-acre forest.

One is at once struck with the careful detail lay-out of the plantations, with reasoned changes of species for every small variation in the soil or site quality as indicated by alterations in the natural vegetation. It is obvious that the Corporation has entrusted the supervision of the outside work to an intelligent forester and that he has placed great importance on this aspect of the afforestation.

Broadly, the selection of species has been along the following lines :—

(1) Douglas has been confined only to a very narrow and well sheltered strip along the lowest slopes bordering almost down to the Loch shore and on land formerly scrub clad. Only the green or coastal type has been used and it is now extremely heavily infested with *Chermes*.

(2) On the bracken-grass-bedstraw slopes, naturally well drained, but np to quite considerable elevation, European larch has been used. Some of the plantations do not appear too thrifty. There has been frost damage in several places and a good deal of harm has been done by *Argyresthia atmoriella*. In this climate, where the rainfall varies from an average of 68 in. at the east end of the Loch up to 93 in. at the west end, it is likely that European larch will not prove itself a good species for extensive use. Practically no Japanese larch has been used.

(3) The bulk of the middle and upper slopes on vegetation types ranging from bracken, juncus, calluna-molinia, myrica-molinia, pure molinia and almost pure calluna has been planted with Norway spruce and with only a very small proportion of Sitka spruce on the wetter molinia hollows. It is rather refreshing to see this policy of adherence to a known and tried European species in preference to the modern fashion of introducing huge blocks of the transatlantic Sitka. The policy seems well justified by the results so far obtained. Planting has all been done by L notch and no turf planting has been done other than in a few very small patches. Drainage, however, has been carefully laid out. Even on comparatively bad types of soil, as indicated by calluna and molinia, it was surprising with what little " check " the plantations had become established and one is led to consider whether we are not beginning to go a little too far in undertaking the expense of turf planting on many localities where good crops could be established by careful ordinary planting and by the use of good strong plants.

(4) On the dry Calluna knolls, Scots pine has been planted and is beginning to get established after a very slow start. There has been trouble with black game.

The pine used is thought to be of West Scottish origin (seed sown in the local nursery) and may thus probably be satisfactory even in this wet climate, provided that it is used only on the dry sites.

*General Observations.*

An Englishman visiting Scottish Forest Estates for the first time travels north with the preconceived notion that he is going to the ancient stronghold of true forestry, and he expects to find something very much better than can ever be seen in his own less enlightened country. Are his expectations justified ? To judge from the average standard of forestry on the estates visited on this expedition one must regretfully give a negative reply.

The usual sorry story of neglected thinnings was generally excused on the ground that there was no market for the small poles. An enquiring voice from South Wales whispers " Pitwood ? " Stirling is not remote from the Scottish coalfield. It was learned, however, that in Scotland all pitwood must be peeled and seasoned and dead true to shape and size. The price is a bit better than the Welsh price but the difficulties of marketing are apparently great. The local market for fencing materials is probably rather better than is normally the case in the south. It was rather difficult to believe that on many of the properties visited the marketing question had been really seriously gone into, especially as most of them were extremely conveniently situated for road access.

Even assuming that highly profitable markets were not obtainable, the policy of allowing the capital of the forest to deteriorate by failure to thin seems shortsighted.

# STUDY OF PINE SHOOT MOTH DAMAGE.

## RENDLESHAM FOREST, 1934.

By J. M. ROSS.

The main object of this investigation was to study the development of pine plantations which had been damaged by the pine shoot moth but which for the most part had grown out of the phase of intensive attack. Accordingly, the work was carried out in plantations twelve and thirteen years old and directed towards the obtaining of information on the following points :—

(1) The number per acre of good undamaged dominant trees and their distribution.

(2) The number per acre of good sub-dominants which are in danger of suppression by badly deformed dominants.

(3) The number per acre of dominants which have been damaged by tortrix but appear capable of straightening out to produce useful timber.

(4) A detailed study of (*a*) the development of trees with typical damage of the posthorn type—do they ever straighten out and, if so, how long does this process take ? (*b*) the minor bends, so as to have a record of the degree of curvature, etc., and the extent to which straightening can take place in the stem.

(5) The value of the early application of a combination of thinning and pruning with a view to freeing well-formed trees from the danger of suppression by " wolf " trees and improving the stem-form of damaged trees.

### *Classification.*

The following system of classification, based on height growth and stem-form, was laid down before field work commenced.

| *Class.* | *Type of Tree.* |
|---|---|
| 11 | Pre-dominants of good form. |
| 12 | Pre-dominants of poor form but capable of recovery. |
| 13 | Pre-dominants of bad form incapable of recovery. |
| 21 | Dominants of good form. |
| 22 | Dominants of poor form but capable of recovery. |
| 23 | Dominants of bad form incapable of recovery. |
| 31 | Sub-dominants of good form with room to develop. |
| 32 | Sub-dominants of good form in danger of suppression. |
| 33 | Sub-dominants of poor or bad form. |
| | Suppressed trees. |

### FIELD WORK.

The investigation was begun in Compartment 90 P. 21, a plantation of Scots pine in the Tangham area. A strip (afterwards referred to as Strip No. 1) running from south to north the whole length of the compartment was opened up by pruning the lower branches to a height of six feet from the ground. In this strip, which was four rows wide, the two middle rows were pruned completely and the two outer rows on their inner sides only. From the southern end the strip was marked off in chain lengths demarcated by serially numbered stakes. In each chain-length where growth was good, namely, from the first to the ninth chain and from the eighteenth to the twenty-third, four plots, each of $\frac{1}{200}$ acre in area, were laid out and the trees in each plot classified, separately recorded and marked as described in the previous section.

These plots were demarcated by a ring of white paint placed about seven feet from the ground on the stem of one of the trees in the first row in the plot. In each chain length the first plot began at the stake while the fourth ended short of the succeeding stake. When a row of trees intervened between the end of the fourth plot and the succeeding stake, a half-circlet of paint was placed about seven feet high on the stem of one of the trees in the last row included in the plot. This mark on the north side of the tree was so placed to explain the omission from the field-book of occasional rows of trees. These marks distinguish the rows of trees in contiguous plots and not the actual plot boundaries, which were not permanently marked.

In addition to stem classification a note was also made of trees which had lost their leading shoot by Tortrix damage in P. 33 or P. 34 and of the number of posthorn trees in the three classes.

From the ninth to the nineteenth chain growth was very poor and, as the main inquiry was directed to the areas of good growth, only ten scattered plots were established in this part of the strip. The procedure was the same as for the rest of the strip, but separate record was kept of this poorer section.

Finally, the usual locality notes were taken and height and girth data collected.

Three other strip surveys were made on similar lines to those adopted in Strip No. 1. These were Strip No. 2, which was also established in Compartment 90 and ran parallel to Strip No. 1 ; " Corsican pine Strip " in Compartment 84 P. 21 and " South Gate Strip " (Scots pine) in Compartment 118, P. 22. In these three strips there were five plots in each chain length instead of four as in Strip No. 1. The dimensions of the plots in the latter were 16 ft. × 13½ ft., and in the former three strips 13 ft. × 16½ ft. (the length along the strip being given first in each case). The difference was due to closer planting in Strip No. 1.

In addition to the strip-surveys a block, half an acre in area, was selected in Compartment 90, pruned up to six feet from the ground, laid out in one hundred plots of $\frac{1}{200}$ acre each and classified as in the strips. Each plot was recorded separately, but the trees were not given distinguishing paint marks. Instead, the block was divided into four sections, each containing twenty-five plots, and the trees in each section serially numbered. Subsequent operations in this block will be dealt with later in the report.

### Data Collected.

*Strip No.* 1. (*Scots pine, P.* 21, *Compartment* 90).

*Aspect.* General.

*Exposure.* Fully exposed.

*Soil.* Practically pure sand overlying Pliocene crag and gravel. No signs of leaching were observed and little humus had been formed. The depth of the crag from the surface varied considerably in this strip and the growth of the crop varied in accordance, thus, crag on or near the surface—crop moderately good ; crag below two to three feet of sand—crop very good ; crag very deep or absent (replaced by gravel)—crop poor.

*Vegetation.* Practically none where crop was good. Blanks were colonised by *Carex spp.* occasional bindweed and *Polytrichum commune.* On the section of poor growth the dominant covering was a lichen (Cladonia), while *Carex spp.* (scanty) and some Polytrichum moss were also present.

*Growth Data.*

*Better Growth Section.* (*Chains* 1-8 *and* 19-22).

| | |
|---|---|
| Average height of crop .. .. .. | 14 ft. 6 in. |
| Maximum height .. .. .. .. | 22 ft. |
| Average height of sub-dominants .. .. | 12 ft. |
| ,, ,, ,, suppressed trees .. .. | 9 ft. 6 in. |
| Average girth of Class 1 trees .. .. | 11 in. |
| ,, ,, ,, ,, 2 ,, .. .. .. | 9 in. |

*Poor Growth Section.* (*Chains* 9-18).

| | |
|---|---|
| Average height of crop .. .. .. | 9½ ft. |
| Maximum height .. .. .. .. | 14 ft. |
| Average height of sub-dominants .. .. | 5½ ft. |
| Average girth of Class 1 trees .. .. | 7 in. |
| ,, ,, ,, ,, 2 ,, .. .. .. | 5½ in. |

*Strip No.* 2. (*Compartment* 90, *P.* 21).

*Locality Factors.*—as described in Strip No. 1.

| *Growth Data.* | *Better Growth* (*Chains* 1-8 ; 20-22) | *Poor Growth.* |
|---|---|---|
| Average height of crop.. .. .. | 14 ft. | 11 ft. |
| Maximum height .. .. .. | 23 ft. | 17 ft. |
| Average height of sub-dominants .. | 12 ft. | 8½ ft. |
| ,, ,, ,, suppressed trees .. | 7 ft. | 7½ ft. |
| Average girth of Class 1 trees .. | 10½ in. | 7 in. |
| ,, ,, ,, ,, 2 ,, .. | 8½ in. | 6 in. |

*South Gate Strip* (*Compartment* 118, *P.* 22).

*Locality Factors.*—As described in Strip No. 1, save that there were signs of leaching in the soil, a peaty layer of humus had developed and crag was not seen. There was also a considerable quantity of birch scattered throughout the strip.

*Growth Data.*

| | |
|---|---|
| Average height of crop .. .. .. | 13 ft. 9 in. |
| Maximum height of crop .. .. .. | 21 ft. |
| Average height of sub-dominants .. .. | 13 ft. |
| ,, ,, ,, suppressed trees .. | 9 ft. |
| Average girth of Class 1 trees .. | 9 in. |
| ,, ,, ,, ,, 2 ,, .. | 7 in. |

*Corsican Pine Strip* (*Compartment* 84, *P.* 21).

*Locality Factors*—as in Strip No. 1.

*Growth Data.*

| | |
|---|---|
| Average height of crop .. .. .. | 16 ft. 3 in. |
| Maximum height of crop .. .. .. | 25 ft. |
| Average height of sub-dominants .. .. | 13 ft. |
| ,, ,, ,, suppressed trees .. .. | 10 ft. |
| Average girth of Class 1 trees .. .. | 14 in. |
| ,, ,, ,, ,, 2 ,, .. .. | 10 in. |

*Half-acre Block* (*Compartment* 90, *P.* 21).

*Locality Factors*—as in Strip No. 1.

*Growth Data.*

| | |
|---|---|
| Average height of crop .. .. .. | 14 ft. 3 in. |
| Maximum height of crop .. .. .. | 22 ft. |
| Average height of sub-dominants .. .. | 13 ft. |
| ,, ,, ,, suppressed trees .. .. | 7½ in. |
| Average girth of Class 1 trees .. .. | 10 in. |
| ,, ,, ,, ,, 2 ,, .. .. | 8½ in. |

## Analysis of Classification Data.

Table I.

*Classes* 11 *and* 21 *Trees.*

| Section or Strip. | Plots containing None. | | Plots containing One. | Plots with Two. | Plots with More than Two. | |
|---|---|---|---|---|---|---|
| Strip No. 1 (Better Growth), 47 plots | 17 | 36% | 12 | 6 | 12 | 26% |
| Strip No. 2 (Better Growth) 54 plots | 26 | 48% | 17 | 6 | 5 | 9% |
| South Gate Strip, 90 plots .. | 39 | 43% | 27 | 14 | 10 | 11% |
| ½-Acre Block, 100 plots .. .. | 53 | 53% | 34 | 10 | 3 | 3% |
| Corsican Pine, 50 plots .. .. | — | — | 2 | 2 | 46 | 92% |

TABLE II.

*Classes 12 and 22 Trees.*

| Section or Strip. | Plots containing NONE. | | Plots containing ONE. | Plots with Two. | Plots with MORE THAN TWO. | |
|---|---|---|---|---|---|---|
| Strip No. 1 .. | 1 | 2% | 3 | 10 | 33 | 77% |
| Strip No. 2 .. | 1 | 2% | 5 | 9 | 39 | 72% |
| South Gate .. | 11 | 12% | 15 | 22 | 42 | 47% |
| ½-Acre Block .. | 1 | 1% | 8 | 10 | 81 | 81% |
| Corsican Pine .. | 18 | 36% | 18 | 7 | 7 | 14% |

TABLE III.

| Strip or Section. | Plots in which good subdominants are being suppressed by malformed dominants. |
|---|---|
| Strip No. 1 (47 plots) .. | 2 |
| Strip No. 2 (54 plots) .. | 1 |
| South Gate Strip (90 plots).. | 3 |
| ½-Acre Block (100 plots) .. | 6 |
| Corsican Pine (50 plots) .. | None |

## DISCUSSION OF DATA.

From Tables I and II we can obtain a sufficiently accurate figure for the number of undamaged and recoverable dominants per acre for each of the areas examined. These figures are given below.

TABLE IV.

| Strip or Section. | No. of undamaged dominants per acre (Classes 11 and 21). |
|---|---|
| Strip No. 1 .. .. .. | 260 |
| Strip No. 2 .. .. .. | 164 |
| South Gate Strip .. .. | 200 |
| ½-Acre Block .. .. .. | 126 |
| Corsican Pine Strip .. .. | 944 |

TABLE V.

| Strip or Section. | No. per acre of damaged dominants capable of recovery (Classes 12 and 22) |
|---|---|
| Strip No. 1 .. .. .. | 659 |
| Strip No. 2 .. .. .. | 663 |
| South Gate Strip .. .. | 544 |
| ½-Acre Block .. .. .. | 866 |
| Corsican Pine Strip .. .. | 212 |

In normal, well-regulated pine plantations there should be a minimum of two hundred trees per acre of good form at the end of the rotation. To hold out reasonable hope of such a return the areas under review would need to have many more than two hundred well-shaped dominants per acre at this stage, but it was decided to accept this minimum figure, and to work accordingly with plots of $\frac{1}{200}$ acre. In regard to the distribution of such elite stems at least one in each plot is required. In considering Table IV we are immediately struck by the clear superiority of Corsican pine when compared with Scots pine in relation to resistance to Tortrix attack, amply confirming the general opinion of casual observers.

Secondly, the diversity between the data for the three areas examined in Compartment 90 must be noted. This can be fairly explained by the varying intensity of attack, but the personal factor also operates, and it appears that, unconsciously on the part of the investigator, a higher standard was introduced when the half-acre block was examined. These figures, however, with perhaps the exception of the half-acre block, are definitely encouraging when it is remembered that a great many of Class 2 trees are certain to recover, having just missed Class 1 because of minor damage. Table V reveals in each case a very substantial reserve of damaged dominants likely to recover.

Referring back to Table I it is clear that the Corsican pine is greatly superior to the Scots pine as regards distribution of undamaged trees. Each plot has at least one undamaged dominant tree. In the Scots pine there is again considerable diversity between the three areas in Compartment 90. The half-acre block with over 50 per cent. of the plots without an undamaged dominant is the poorest. Table II shows the " reserves " to be distributed very satisfactorily. The relatively large number of Corsican pine plots in the " none " class is, of course, due to the high quality which has placed so many trees in Classes 11 and 21.

Of all the plots examined only six were found to possess neither a Class 1 nor a Class 2 tree. These were confined to the South Gate strip, which had a considerable quantity of birch scattered throughout its length and, as a result, many plots had but one or two small pines left alive. From the foregoing it will be clearly seen that there is no need to fear unduly for the final crop. On the other hand the intermediate cuttings will be very difficult undertakings, calling for great care.

With a view to obtaining information about the best period to begin these intermediate cuttings a note was made of the suppressed trees and of any good sub-dominant which was being suppressed by a malformed dominant. With regard to the latter, Table III shows the number of such trees to be negligible. This is explained by the fact that when a badly formed tree has been able so to recover from Tortrix damage that it is now suppressing others, its dominance has usually been permitted by neighbours equally badly damaged. At this stage, therefore, the " wolf " trees are for the most part suppressing useless sub-dominants.

The degree of suppression which has taken place is considerable, as shown in the following table :—

TABLE VI.

| Strip or Section. | Percentage of Crop suppressed. |
|---|---|
| Strip No. 1 .. .. .. | 13% |
| Strip No. 2 .. .. .. | 8% |
| South Gate .. .. .. | 11% |
| ½-Acre Block .. .. .. | 13% |
| Corsican Pine .. .. | 10% |

On the whole, the anticipated suppression of good sub-dominants by " wolf " trees is not sufficient to call for thinning at this stage—thirteen years after planting—nor has the normal struggle for light entered on a phase requiring such treatment. There appears, however, to be some justification for pruning, as a great many of the Scots pines have developed heavy branches, following the loss of, or damage to, the leading shoots. The tendency for side branches to replace or supplant these leaders has resulted in a general upthrust from the horizontal plane to a position in which increased light encourages heavy, persistent branching. In this connection the treatment applied in the half-acre block may now be mentioned.

The original intention of confining treatment to the " wolf " trees by (*a*) beheading, (*b*) felling or (*c*) pruning these to help good sub-dominants was abandoned owing to the lack of such dominants in numbers sufficient for comparative purposes. Accordingly, it was decided that two of the four sections into which the block was divided should be subjected to a combination of light thinning and pruning and the remaining two be left as controls. Badly shaped dominant or predominant stems were removed to help better trees and small suppressed trees were slashed down with the pruning-hook. The removal of heavy branches and forks from ill-formed trees gave greatly increased light to many big branches on trees of good form, so that these were also trimmed, as it was feared that such branches would otherwise persist for many years. This pruning treatment completely transformed the appearance of the stand and several "wolf" trees were definitely Class 2 trees after having one or two big branches trimmed. Treatment was concluded by the removal of all bigger stems and rough-barked material cut from one of the pruned sections, while in the other such timber was left on the ground. The intention is to compare the effect on the bark-beetle population in these two sections. Beetle attack was observed in several places in the forest. After treatment, the trees in all four sections were numbered serially from 1 upwards, the trees in each $\frac{1}{200}$ acre plot being numbered before the adjacent plot was begun. Finally a chart of this block was made, showing the position of the sub-plots as demarcated on the area.

As already mentioned, there is justification for pruning now but little for thinning. The problem arises whether pruning should be delayed or thinning begun early in order to combine these operations. Probably the solution will be the adoption of the latter course where the trees are of a coarsely-branching type as in Compartment 90, and the former in areas of finer type as in Compartment 118.

The field-work was completed by the collection of data from posthorn trees and Class 2 trees, capable of recovery, within the half-acre Block, from which drawings to scale were subsequently constructed for purposes of record and comparison.

## Appendix 1.

*Note on the continuance of attack.*

In order to gain some idea as to the extent to which the moth was still active a record was kept of trees which had lost their leading shoots during the past two seasons, *i.e.*, the twelfth and thirteenth years after planting. The following table indicates how severe the attack has been, and also shows that there has been appreciable fresh damage within the last two years.

| Strip or Section. | Percentage of Crop attacked. | Percentage attacked during the past two seasons. |
|---|---|---|
| Strip No. 1 .. .. | 91 | 10·5 |
| Strip No. 2 .. .. | 89 | 7 |
| South Gate .. .. | 90 | 14 |
| ½-Acre Block .. .. | 84 | 4 |
| Corsican Pine .. .. | 15 | 1 |

## Appendix 2.

*Posthorn Damage.*

The typical damage done by *Evetria (Tortrix) buoliana* to pine trees is reflected in the stem-form by one or more deviations from the original vertical axis of the young tree. These bends vary greatly in curvature and degree of recovery towards the original axis, but do not immediately relegate the tree to the hopeless class. In the majority of cases there is a very good chance of recovery. This is not the case, however, when posthorn damage occurs. Here, the tree is, with very few exceptions, classed as useless.

The difference between the two types of damage is due to the fact tha in the former a side-branch has taken over the lead and tends to come into line with the portion of the stem below its origin, while the posthorn is a damaged leader, which, after attack, fell through ninety to one hundred and eighty degrees, but retained a sufficiently effective connection with the stem vessels to ensure an adequate supply of food, etc. Thereafter, in its efforts to retain the leading position it curves upward and inward towards the stem. The next season's growth may come practically into line with the main axis, but the intervening hoop or posthorn forms a hopeless blemish.

That the posthorns are by no means negligible in number will be seen from the following table which relates only to the predominant and dominant stems.

| Strip or Section. | Percentage of Posthorn trees in Classes 13 and 23. |
|---|---|
| Strip No. 1 .. .. .. | 16·6 |
| Strip No. 2 .. .. .. | 8 |
| South Gate Strip .. .. | 26 |
| ½-Acre Block .. .. .. | Not recorded |
| Corsican Pine .. .. | 7 |

Posthorn damage is virtually irremediable and it is recommended that leading shoots, which have been damaged so that they have fallen over but are not likely to die, should be removed by artificial means. They are readily recognised and can easily be removed by the ordinary forest worker when engaged on weeding or cleaning plantations up to eight feet high. When the plantation has grown beyond eight feet it is doubtful if the cost of removing leading shoots would be justifiable. For the younger plantations, however, this appears to be a practicable measure for adoption in the campaign against the almost invulnerable Tortrix.

# MECHANICAL DRAINAGE.

By J. Maxwell Macdonald.

During the past year a series of experiments in mechanical drainage has been made in the Forest of Ae. The work was done by contract. The equipment consisted of a Fordson tractor with a geared winch fitted behind the driver's seat. The winch was belt-driven so that it would slip if the excavator were suddenly stopped by a large boulder. The excavator was attached to the end of 200 yards wire rope. It is a somewhat complicated machine designed for hill, tile or mole draining. The writer has seen the same machine doing all these operations, different cutting parts being the only alteration necessary. The actual excavator is drawn by a heavy steel girder, shaped like an anchor, so that it tends to go deeper into the ground on meeting an obstruction. Above the excavator is a two-wheeled carriage, not unlike a gun carriage, to which is attached a small hand winch for lifting the excavator out of the ground.

The method of operation is for the tractor to go forward paying out the wire rope. It anchors itself and pulls the excavator up to it, the process being repeated as often as necessary. The crew consists of three men, one on the tractor and two handling the plough. An extra man attending to the finish of the drains is an advantage.

Three types of ground were tried :—

1. Undulating ground with small moraine knolls separated by hollows and in some cases small basins. On the knolls a thin layer of peat is found over the moraine. The vegetation is Erica-scirpus. The hollows are generally wet and carry a flush vegetation in which *Juncus articulatus* is dominant.

The basins hold a deep basin peat, light brown and very sour. The vegetation here is scirpus with some Erica and *Eriophorum vaginatum.*

2. Large areas of deep basin peat, extending to 20 acres or more. Here the slope is slight and the surface very even and free from undulations.

Both the above types were patches classed as unplantable and omitted from planting. About 100 acres were drained during the summer, with a total of 2,000 chains of drain. The cost was 1*s*. per chain, but this has little or no significance as the contractor was new to this type of work and was experimenting all the time.

3. The third type of ground was the most typical of that region, long gentle slopes with ten inches or so of climatic peat over the boulder clay. The geology is Tarannon series, Silurian system. Here the vegetation is pure molinia with scattered clumps of juncus.

On the first type of ground the machine was not a great success. It could not take curves easily, and consequently the drains were made with regard only to the main features of the ground. Advantage could not be taken of small hollows as it could by hand drainers. On the thin moraine peat the drains were very untidy and the turfs thin and uneven. Many small patches were encountered where peat had been cast and here the turfs became very small. On such places hand drainers would make wider drains to get the necessary large turfs for planting. The shape of the machine, however, cannot be altered.

The machine-made turfs always tend to be on the small side for satisfactory planting, as they are split in half by the machine which acts like a drill plough.

On the second type, deep basin peat, the machine gave very good results, the drains being of a very satisfactory type. Their straightness was no disadvantage in view of the even slope. Here the plough could always be buried to its full depth so that the turfs thrown out were of a satisfactory size. The only serious difficulty encountered here was that of getting the machine about the forest. The tractor stuck in practically every drain it came to, and drains could not be joined up as a space had to be left for the tractor to turn in.

Before tackling the third type of ground, even molinia slopes, a caterpillar tractor was procured. This was used with the same excavator, but pulling by direct traction instead of by winch. Some alterations were also made to the excavator to produce a tidier drain. It was found here that to give a drain of the required size (the specification was: top, 2 ft.; bottom, 10 in.; depth, 22 in., or into the clay) was really more than the tractor could do by direct traction. About 100 chains of drain were made quite satisfactorily, but it was clear that the margin of power was not large enough.

The machine appears to have considerable possibilities for development for forest draining. It is particularly well suited to the long even slopes found on the Silurian shales and Carboniferous limestones and sandstones of the south of Scotland. It could not be worked in rocky or very uneven ground, though it is surprising what large stones it can eject without effort. The turfs are not quite so satisfactory, on existing standards, as those from hand-made drains, but there are several possible ways of improving them. A turf-cutting machine might be used between the drains, or some form of turf nursery might be formed. Neither the Fordson tractor nor the present caterpillar tractor can be considered satisfactory. The addition of a winch to the caterpillar tractor is the probable solution. It is hoped that a chance may be found of trying this during the coming year.

# DAMAGE BY VOLES IN ARGYLLSHIRE.

By A. H. Gosling.

In the Journal of 1933 a short account was given of the vole plague then existing in the Benmore neighbourhood, Argyll. It may be interesting to record what has happened since then.

In the winter, 1931-32, voles were present in great numbers and damage was severe. The damage became less in extent during the summer, when other food was available, and there was no serious injury in the winter 1932-33. The record of voles caught by a boy using a constant number of traps in one plantation shows a steady increase until early August, 1932. Thereafter a decrease set in which continued until January, 1933, when trapping was abandoned as the number being caught was low. This trapping was carried out to see to what extent it was possible to protect a plantation by extensive trapping, and not with a view to recording fluctuations in the vole population. The results may, however, serve as a rough guide to this. They suggest that the reduction in numbers was gradual, not dramatically sudden as seems to have occurred before. This was confirmed by general observation. By April, 1933, there were very few voles to be found.

Research work was carried out by the Bureau of Animal Population, Oxford University, with the co-operation of the Wellcome Bureau of Scientific Research. Voles from Argyll and elsewhere were examined. It is stated that the only apparent cause of death has been the presence of cysts of a toxoplasm (a parasitic protozoan) in the brains of the voles. No field use can be made of this information at present. It is interesting to note that to obtain voles for this research work during March and April, 1933, it was necessary to go to one of the plantations where the numbers had never been excessive and damage had only been slight. The voles disappeared from the more thickly populated areas first. During the period of mortality it was not unusual to see a dead vole, or a vole in a sluggish, sickly condition. At no time, however, were these seen except in very small numbers.

In the summer of 1933 the vole population was very low throughout the whole neighbourhood. It was unusual to see even one and nests were rarely found. This may have been as abnormal a state as the plague. The summer of 1934 has brought a very substantial increase in numbers, and damage has occurred during November and December, 1934. This damage, though serious in patches, is so far much less in extent than during the winter, 1931-32, but it is greatly feared that, should conditions continue to be favourable for the voles, the position next winter will be just as bad as during the recent plague.

In the previous article it was stated that the recovery made by the spruces after severe damage was considerable. New shoots thrown out were sometimes weakly in appearance, but very few were lost during the mild winter which followed, and vigorous growth took place the next year. Recovery from severe attack was invariably greater in the younger plantations—1 year or 2 years planted. In places as many as 70 per cent. of the damaged trees survived, but this was not general and depended much on the severity of the attack. Seedling spruces did not survive severe damage. The survival of species other than spruces to severe injury was very small.

In older plantations, where girdling and root pruning were the chief forms of serious damage, recovery was not frequent. It has been suggested that, if the trees which had been completely girdled were cut back at once below the damaged portion of the stem, shoots may be thrown out. We have no experience of the results of doing this, but it would appear worth trying.

Two plantations surrounded on three sides by land grazed by sheep, and with water on the other side, escaped with little damage. One similarly situated, which was enclosed in 1929, did not fare so well. The greatest damage, however, definitely occurred in two extensive blocks of land where there is no stock. In each case the lower land is planted, or in hand awaiting planting, and the high land is not let. All the damaged plantations have now been beaten up since the 1931-32 plague. It is estimated that something of the order of one million plants were used to replace those damaged by voles.

## GROWTH OF YOUNG TREES IN RELATION TO BEATING-UP.

(*Silvicultural Circular No.* 14 (*Revised*) *issued August*, 1934.)

Where unnecessary beating-up work is done and the plants so used are likely to be lost by early suppression it generally means that the forester was in ignorance as to the rate at which his original crop was likely to develop on the site in question. He may have some idea of the upward growth of the plants, but may easily underestimate the rate of outward spread of the side branches. With the object of collecting definite information on this point the Research Branch have made a considerable number of measurements in some of our older plantations.

In Scotland, twenty-one plantations were examined by Mr. J. M. Ross, working under Mr. J. A. B. Macdonald. He investigated five plantations of Scots pine, six European larch, two Japanese larch, four Sitka spruce

| Species. | Age | Total Height | Maximum Radial Spread. | | | Present Height above ground of max. crown spread. | Vegetation type. |
|---|---|---|---|---|---|---|---|
| | | | Present spread | 2 years ago. | 4 years ago. | | |
| | | ft. | in. | in. | in. | ft. | |
| S.P. .. | 8 | 4·4 | 16 | 10 | 4 | 2·4 | Poor calluna |
| | 10 | 5·4 | 16 | 11 | 6 | 3·3 | „ „ |
| | 11 | 5·5 | 18 | 12 | 5 | 3·1 | „ „ |
| | 10 | 5·8 | 18 | 11 | 5 | 3·3 | Calluna |
| | 9 | 7·2 | 22 | 15 | 6 | 3·8 | Calluna-grass |
| E.L. .. | 7 | 6·8 | 21 | 16 | — | 4·0 | Grass calluna |
| | 10 | 9·4 | 29 | 23 | 12 | 4·4 | „ „ |
| | 11 | 9·2 | 29 | 21 | 8 | 4·2 | Calluna-bracken-vaccinium |
| | 10 | 7·8 | 23 | 17 | 9 | 4·5 | Bracken-grass |
| | 11 | 12·9 | 37 | 31 | 13 | 5·0 | „ „ |
| | 11 | 13·5 | 42 | 30 | 10 | 4·8 | Grass-bracken |
| J.L. .. | 8 | 9·7 | 28 | 18 | 13 | 4·9 | Grass-bracken-calluna |
| | 6 | 11·6 | 43 | 23 | 9 | 4·3 | Bracken grass |
| S.S. .. | 6 | 4·1 | 17 | 7 | — | 2·0 | „ „ |
| | 9 | 5·4 | 18 | 10 | 6 | 2·7 | Calluna-vaccinium |
| | 10 | 8·6 | 36 | 27 | 11 | 3·3 | Bracken-grass |
| | 10 | 10·6 | 39 | 27 | 10 | 3·2 | Grass |
| N.S. .. | 9 | 5·0 | 22 | 15 | 7 | 2·7 | Calluna-grass |
| | 10 | 7·1 | 28 | 19 | 8 | 3·1 | Bracken-grass |
| | 11 | 7·8 | 29 | 23 | 12 | 2·8 | „ „ |
| | 13 | 9·9 | 34 | 28 | 18 | 2·1 | „ „ |

and four Norway spruce ; most of these areas were from eight to eleven years old. The procedure was the same in all cases ; fifty representative trees were selected and the following information recorded :—

Height of tree and branch spread (horizontal spread of the four longest branches) at the present time, and two years, four years and six years

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back ; also the height of the branch tip above ground and the height of the origin of each measured branch on the tree. The usual locality description and notes on the establishment and subsequent treatment of the stand were also recorded.

The measurements in each plot were averaged and an average tree constructed from the data ; the size of the tree one, two, and three years back was then deduced. The results have been expressed in a series of diagrams, but part of the data are given above in tabular form.

It should be observed that the measurements were not confined to trees growing on the edges of gaps though many of these were included. In the taller stands mutual interference of trees in partial canopy may have reduced branch spread to some extent, hence the figures in column 4 of the table may be rather on the low side in some cases.

If the present maximum branch spread is plotted on graph paper against the total height it is at once seen that the two factors (branch spread and height) are closely related. The points fall along two lines,

| Years after Planting. | Total Height. | Maximum crown radius. | Height above ground of maximum crown spread. |
|---|---|---|---|
| | ft. | ft. | ft. |
| | *Scots pine.* | *Grass Heath.* | *Thetford.* |
| 4 | 2·9 | 1·2 | 1·3 |
| 5 | 4·0 | 1·9 | 1·7 |
| 6 | 5·3 | 2·5 | 2·0 |
| 7 | 6·7 | 2·9 | 2·4 |
| 8 | 8·2 | 3·4 | 2·8 |
| 9 | 9·7 | 3·9 | 3·2 |
| 10 | 11·2 | 4·3 | 3·5 |
| 11 | 12·7 | 4·7 | 3·8 |
| 12 | 14·2 | 5·1 | 4·1 |
| | *Scots pine.* | *Grass-Bracken-Calluna.* | *Allerston.* |
| 4 | 2·2 | 0·5 | 1·4 |
| 5 | 3·0 | 0·8 | 1·6 |
| 6 | 4·0 | 1·3 | 1·8 |
| 7 | 5·1 | 1·8 | 2·0 |
| 8 | 6·5 | 2·3 | 2·3 |
| 9 | 8·0 | 2·7 | 2·6 |
| 10 | 9·6 | 3·1 | 2·8 |
| 11 | 11·2 | 3·6 | 3·1 |
| 12 | 12·6 | 4·0 | 3·2 |
| | *Scots pine.* | *Call.-Vacc.-Bracken-Grass.* | *Quantocks.* |
| 4 | 2·0 | 0·4 | 0·4 |
| 5 | 2·6 | 0·6 | 0·6 |
| 6 | 3·4 | 0·9 | 1·0 |
| 7 | 4·4 | 1·4 | 1·4 |
| 8 | 5·5 | 2·0 | 2·0 |
| 9 | 6·7 | 2·6 | 2·6 |
| 10 | 8·0 | 3·1 | 3·2 |
| 11 | 9·3 | 3·5 | 3·7 |
| 12 | 10·7 | 3·8 | 4·3 |

| Years after planting. | Total height. | Maximum crown radius. | Height above ground of maximum crown spread. |
|---|---|---|---|
| | ft. | ft. | ft. |
| | *Scots pine. Calluna. Exmoor and Allerston.* | | |
| 4 | 1·7 | 0·3 | 0·9 |
| 5 | 2·3 | 0·4 | 1·2 |
| 6 | 3·0 | 0·7 | 1·5 |
| 7 | 3·8 | 1·0 | 1·9 |
| 8 | 4·7 | 1·5 | 2·2 |
| 9 | 5·8 | 1·9 | 2·6 |
| 10 | 6·9 | 2·3 | 2·9 |
| 11 | 8·2 | 2·8 | 3·3 |
| 12 | 9·4 | 3·1 | 3·6 |
| | *Corsican pine. Grass-Heath. Thetford.* | | |
| 4 | 2·2 | — | 0·4 |
| 5 | 3·4 | 1·3 | 0·7 |
| 6 | 5·0 | 2·0 | 1·2 |
| 7 | 6·9 | 2·6 | 2·0 |
| 8 | 9·0 | 3·1 | 3·0 |
| 9 | 11·3 | 3·6 | 3·7 |
| 10 | 13·5 | 4·2 | 4·3 |
| 11 | 15·3 | 4·7 | 4·6 |
| 12 | 17·0 | 5·1 | 5·0 |
| | *Corsican pine. Grass-Bracken-Calluna. Quantocks.* | | |
| 4 | 1·7 | — | 0·6 |
| 5 | 2·3 | 0·8 | 0·8 |
| 6 | 3·0 | 1·1 | 1·0 |
| 7 | 4·3 | 1·4 | 1·5 |
| 8 | 5·6 | 2·0 | 2·0 |
| 9 | 7·0 | 2·5 | 2·5 |
| 10 | 8·7 | 2·9 | 3·1 |
| 11 | 10·3 | 3·4 | 3·5 |
| 12 | 12·5 | 3·8 | 4·2 |
| | *Corsican pine. Calluna. Allerston.* | | |
| 4 | 1·2 | — | 0·8 |
| 5 | 1·6 | 0·7 | 1·0 |
| 6 | 1·9 | 1·0 | 1·2 |
| 7 | 2·4 | 1·3 | 1·4 |
| 8 | 2·9 | 1·6 | 1·8 |
| 9 | 3·7 | 2·0 | 2·1 |
| 10 | 4·6 | 2·4 | 2·5 |
| 11 | 5·6 | 2·8 | 2·8 |
| 12 | 6·6 | 3·2 | 3·1 |
| | *European larch. Grass-Rubus-Bracken Type. Exmoor.* | | |
| 4 | 4·7 | — | 1·5 |
| 5 | 6·4 | 2·2 | 2·1 |
| 6 | 8·3 | 2·9 | 2·8 |
| 7 | 10·6 | 3·5 | 3·5 |
| 8 | 12·8 | 4·1 | 4·1 |
| 9 | 14·8 | 4·6 | 4·6 |
| 10 | 16·4 | 5·0 | 4·9 |
| 11 | 17·8 | 5·5 | 5·2 |
| 12 | 19·0 | 5·9 | 5·3 |

| Years after planting. | Total height. | Maximum crown radius. | Height above ground of maximum crown spread. |
|---|---|---|---|
| | ft. | ft. | ft. |
| | *European larch.* | *Grass-Bracken.* | *Quantocks.* |
| 4 | 3·0 | — | 0·8 |
| 5 | 4·1 | 1·0 | 1·2 |
| 6 | 5·7 | 1·6 | 1·8 |
| 7 | 7·3 | 2·4 | 2·4 |
| 8 | 9·1 | 3·0 | 3·1 |
| 9 | 11·0 | 3·5 | 3·8 |
| 10 | 12·7 | 4·0 | 4·3 |
| 11 | 14·3 | 4·5 | 4·6 |
| 12 | 15·8 | 5·0 | 4·9 |
| | *European larch.* | *Call.-Vacc.-Grass-Bracken.* | *Quantocks.* |
| 4 | 2·2 | — | 0·8 |
| 5 | 3·0 | — | 1·1 |
| 6 | 4·0 | — | 1·6 |
| 7 | 5·2 | 1·4 | 2·0 |
| 8 | 6·5 | 2·1 | 2·4 |
| 9 | 8·0 | 2·7 | 2·8 |
| 10 | 9·7 | 3·2 | 3·2 |
| 11 | 11·4 | 3·7 | 3·5 |
| 12 | 13·0 | 4·1 | 3·8 |
| | *Japanese larch.* | *Grass-Bracken.* | *Allerston.* |
| 4 | 4·2 | 1·4 | 2·3 |
| 5 | 5·3 | 1·9 | 2·6 |
| 6 | 6·7 | 2·6 | 3·0 |
| 7 | 8·4 | 3·5 | 3·5 |
| 8 | 10·3 | 4·5 | 3·9 |
| 9 | 12·4 | 5·4 | 4·3 |
| 10 | 14·9 | 6·2 | 4·7 |
| 11 | 17·7 | 7·0 | 5·0 |
| 12 | 20·5 | 7·6 | 5·2 |
| | *Norway spruce.* | *Grass-Bracken-Herb.* | *Quantocks.* |
| 4 | 2·6 | — | 1·1 |
| 5 | 3·4 | 0·7 | 1·3 |
| 6 | 4·2 | 1·1 | 1·6 |
| 7 | 5·1 | 1·5 | 1·8 |
| 8 | 6·3 | 1·9 | 2·0 |
| 9 | 7·8 | 2·4 | 2·2 |
| 10 | 9·5 | 2·8 | 2·4 |
| 11 | 11·4 | 3·2 | 2·6 |
| 12 | 13·6 | 3·6 | 2·8 |
| | *Norway spruce.* | *Grass-Bracken.* | *Allerston.* |
| 4 | 1·7 | — | 0·7 |
| 5 | 2·1 | 0·3 | 0·9 |
| 6 | 2·7 | 0·5 | 1·1 |
| 7 | 3·4 | 0·9 | 1·3 |
| 8 | 4·3 | 1·2 | 1·5 |
| 9 | 5·4 | 1·5 | 1·8 |
| 10 | 6·6 | 1·9 | 2·0 |
| 11 | 7·8 | 2·8 | 2·3 |
| 12 | 9·1 | 2·5 | 2·5 |

| Years after planting. | Total height. | Maximum crown radius. | Height above ground of maximum crown spread. |
|---|---|---|---|
| | ft. | ft. | ft. |
| | *Douglas fir.* | *Grass-Bracken-Vaccinium.* | *Quantocks.* |
| 4 | 2·5 | — | 0·9 |
| 5 | 3·3 | 0·8 | 1·2 |
| 6 | 4·3 | 1·4 | 1·6 |
| 7 | 5·6 | 2·0 | 2·0 |
| 8 | 7·1 | 2·7 | 2·4 |
| 9 | 8·9 | 3·3 | 2·9 |
| 10 | 10·8 | 3·8 | 3·3 |
| 11 | 12·8 | 4·3 | 3·5 |
| 12 | 14·8 | 4·8 | 3·8 |

an upper line for European larch and Scots pine, and a lower line for the spruces. Thus in the case of European larch the maximum radial spread is 24 in. for an 8 ft. high tree and 36 in. for a 12 ft. tree. In the spruces an 8 ft. high tree has a spread of 30 in. and a 12 ft. tree a spread of 45 in.

Mr. J. Macdonald, working on somewhat similar lines in England, has carried out a series of studies on different species and vegetation types, the results are summarised in the above tables which are based on measurements taken in plantations on the point of forming canopy; the data for the branch spread relate only to trees bordering upon gaps.

### Discussion of Tables.

Assuming that two trees of Japanese larch on opposite sides of a gap are growing inwards at a uniform rate, the table for that species indicates that a 7-ft. gap would be closed in seven years, a 9-ft. gap in eight years, a 12-ft. gap in ten years and a 20-ft. gap in fourteen years. The height above ground of the "canopy" rises steadily with increasing age and total height of the trees, and though the table may only show a height of 5·2 ft. for the maximum spread when the trees are 20 ft. high, the shading influence of the higher branch whorls must also be taken into account; these must cut out a considerable amount of light above the 5-ft. level.

When it comes to the practical application of these data we are at once up against a number of unknowns. In the first place there is uncertainty as to the rate of growth of a beat-up plant. It may be assumed that a beat-up of the same species, put in one or two years after the first planting, will usually grow for a time at least at the same relative rate as the original plants (we have some direct evidence to this effect); but when beating-up has to be delayed for three years or more the original trees may cut off so much light that the growth of the beat-up will be hindered and it may fail to get through. If another species, say a shade bearer such as beech, is introduced, the future is no less problematical because we have as yet virtually no information as to the rate at which the beech will develop. Secondly, the size of the gap must be taken into account, a one-tree gap surrounded by average original plants is a different proposition from a gap resulting from the death of a group of four or five trees. In the latter case the beat-ups will have more light at the critical time when the older trees are closing up and so should have a better chance of holding their own. Thirdly, the trees may have failed in certain cases owing to unfavourable soil conditions ; such conditions may be purely local, but they are likely to retard the growth of beat-up plants and so further handicap them in their upward struggle.

While admitting the many gaps in our knowledge the present investigation does at least serve to emphasize the almost dramatically sudden development of the plants once they have got well established. A 3-ft. high (say 4-year-old) plant may look harmless enough from the point of view of beating-up, and it is hard to realise that that same plant in six years' time may be 10 or 15 ft. high and probably more than twice the height of the beat-up put in alongside. Two vigorously growing Japanese larch at 10 years old will close over with their side branches a gap 12 ft. wide, and it is easy to see how remote must be the chances of survival of a beat-up put into a single blank when the crop was three or even two years old. It is not merely a question of getting the leading shoot of a beat-up through before the side branches meet, there must be a sufficient amount of functioning leaf surface to enable the plant to build up enough food to carry on. As to what happens below ground we are largely ignorant but the root competition of the original plants may easily be a factor tending to depress the growth of delayed beat-ups.

Mr. J. M. Ross, who collected and worked up the Scottish data, gives the following table for the species investigated :—

| Species. | Vegetation type. | Limit of delay for complete B.U. with same species. |
|---|---|---|
| *S.P.* .. .. | Calluna (poor ground) .. .. .. | 2 years |
| ,, .. .. | Calluna (moderately good ground) .. .. | ,, |
| ,, .. .. | Calluna-grass .. .. .. .. .. | ,, |
| ,, .. .. | Grass-heath .. .. .. .. .. | ,, |
| *E.L.* .. .. | Bracken-grass .. .. .. .. .. | ,, |
| ,, .. .. | Calluna-bracken-vaccinium .. .. .. | ,, |
| ,, .. .. | Grass-bracken-calluna .. .. .. .. | ,, |
| ,, .. .. | Grass-heath .. .. .. .. .. | ,, |
| *J.L.* .. .. | Bracken-grass .. .. .. .. .. | 1 year |
| ,, .. .. | Grass-bracken .. .. .. .. .. | ,, |
| *S.S.* .. .. | Calluna-vaccinium .. .. .. .. | 2 years |
| ,, .. .. | Bracken-grass-heather .. .. .. .. | 3 years |
| ,, .. .. | Grass-heath .. .. .. .. .. | 2 years |
| ,, .. .. | Bracken-grass .. .. .. .. .. | 3 years |
| *N.S.* .. .. | Calluna-grass-bracken .. .. .. | 2 years |
| ,, .. .. | Bracken-grass-heather .. .. .. .. | 3 years |
| ,, .. .. | Bracken-grass .. .. .. .. .. | 2 years |

His recommendations are that " if beating-up has been delayed for one or two years more than the periods cited single blanks should be neglected ; double blanks replaced with one plant ; treble failure gaps with two and the larger gaps in similar proportions."

From the English data Mr. J. Macdonald has deduced the following table which shows the latest date at which it is safe to put a single plant (of the same species) into the centre of a gap of given width, the widths ranging from 8 to 15 feet.

| Width of Gap ft. | Limit for Beating-up. Years after Planting. Species and Vegetation Type. | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Scots pine. | | | | Corsican pine. | | | European larch. | | | Japanese larch. | Norway spruce. | Douglas fir. |
| | Grass-Heath. Thetford. | Grass-Bkn.-Call. Allerston. | Call.-Vacc.-Bkn.-Grass. Quantocks. | Call. Exmoor and Allerston. | Grass-Heath. Thetford. | Grass-Bkn. Quantocks. | Call.-Vacc.-Grass-Bkn. Quantocks. | Grass-Rubus-Bkn. Exmoor. | Grass-Bkn. Quantocks. | Call.-Vacc.-Grass-Bkn. Quantocks. | Grass-Bracken. Allerston. | Grass-Bkn.-Herb. Quantocks. | Grass-Bkn.-Vacc. Quantocks. |
| 8 | 1 | 2 | 2 | 3 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 1 |
| 9 | 2 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 3 | 2 |
| 10 | 3 | 4 | 3 | 4 | 2 | 3 | 2 | 3 | 3 | 3 | 1 | 4 | 2 |
| 11 | 3 | 5 | 3 | 5 | 3 | 3 | 2 | 3 | 3 | 3 | 1 | 4 | 3 |
| 12 | 3 | 6 | 4 | 6 | 3 | 4 | 3 | 3 | 3 | 3 | 1 | 5 | 3 |
| 13 | 4 | 7 | 5 | 7 | 4 | 5 | 4 | 3 | 3 | 3 | 1 | 5 | 4 |
| 14 | 5 | 8 | 6 | – | 4 | 6 | 4 | 3 | 3 | 4 | 1 | 6 | 4 |
| 15 | 5 | 9 | 7 | – | 5 | 7 | 5 | 3 | 3 | 4 | 2 | 7 | 5 |

It is apparent that the trend of the results as a whole is to stress the danger of delayed beating-up, and especially the risk of putting in a plant too near the territory of an established tree which is just about to make strong upward and radial growth.

## NURSERY WORK.

(*Silvicultural Circular No.* 15 *issued April*, 1934.)

The standard of nursery production as a whole is still too low. It has been calculated on the last three years' results that reasonable efficiency would have given a saving of £25,000 per annum. The causes of reduced efficiency are no doubt complex, but some at least can be definitely recognised and removed.

1.—The basis of good nursery work is the production of good seedlings. For this the two most important factors are :—

(*a*) A soil suitable as regards fertility and texture.

(*b*) Sufficient growing space for the individual seedling.

2.—Low grade and cull seedlings are a nuisance and a source of expense. For example, the lining-out losses in Grade III seedlings for all species average between 50 and 60 per cent. In some species, *e.g.*, Corsican pine, the figure is much higher ; the Research Branch have found the utmost difficulty in getting sufficient transplants of Corsican pine out of Grade III seedlings to provide two acres of experimental planting.—

The above assertions are based on Bulletin No. 11 of 1928, and extensive research work carried out since, but as yet unpublished ; they are confirmed by examination of the Nursery Returns NR.1 and NR.2 at headquarters, and field observations at a limited number of nurseries.

### NURSERY TECHNIQUE.

Unless there are good reasons to the contrary, the following procedure should be observed :—

(i) *Fertility of Seedbeds.*—The humus content should be kept high ; if there is only a limited amount of humus manure available, it should be used for the seedbeds and not expended upon the lines.

(ii) *Density of Sowing.*—Seed should not be sown denser than the rates given in the Appendix. Local experience may well justify thinner sowings.

(iii) *Time of Sowing.*—Early sowings invariably produce larger plants. In the south, sowing towards the end of March is not too early for most species.

(iv) *Method of Sowing.*—Unsuitable soil conditions are often the reason for delaying sowing. This difficulty can be largely overcome by the use of coarse silt-free sand for covering the seed.

(v) *Culling of Seedlings.*—Low grade or cull seedlings (see paragraph 2 above) are not to be lined-out, but in the case of spruces may be bedded-out (see below).

It is difficult to define precisely what is meant by " low grade and cull seedlings," but generally speaking they are suppressed plants resulting from local or general overcrowding. Mis-shapen but vigorous plants do not come into this category. (See also Silvicultural Circular No. 4.)

*Note.—Bedding-out.*—By this is meant a density of not less than 100 plants per linear yard of lines, the work being done without " singling " the individual seedlings. Where the general plant position makes it necessary to conserve stocks, bedding-out of inferior seedlings should be resorted to in place of lining-out or destruction. This applies particularly to spruces.
R. L. R.

## Appendix.

The following schedule is based on Silvicultural Circular No. 4 and Bulletin No. 11, but has been amended to accord more closely with the average laboratory germination of seed supplied since 1929 and also with the trend of recent investigations. Purity is taken in all cases as 95 per cent.

*Note.*—(i) Allowance must be made in cases where laboratory germination varies appreciably from the figures in Column 2, or where purity falls below 90 per cent.

(ii) Columns 3 and 4 are net areas of seedbed, *i.e.*, excluding alleys. The figures apply to the raising of 2-year seedlings.

| Species. | Average Laboratory Germination. Per cent. | Sq. yards per lb. of Seed. | |
|---|---|---|---|
| | | Broadcast. | Drill. |
| (1) | (2) | (3) | (4) |
| S.P. .. | 85—95 | 55 | — |
| C.P. .. | 50—60 | 35 | — |
| E.L. .. | 45—55 | 45 | 65 |
| J.L. .. | 40—50 | 60 | — |
| D.F. .. | 75—85 | 45 | 60 |
| N.S. .. | 80—90 | 45 | 60 |
| S.S. .. | 85—95 | 85 | 115 |
| P.C. .. | 85—95 | 75 | — |

## COMMISSION'S LIBRARY: NEW BOOKS.

The following books were acquired during the past year:—

"Forestry for Woodmen," 3rd Edn. (pp. 237), C. O. Hanson.

"Introduction to Forestry for Young People," 2nd Edn. (pp. 83), A. N. Agnew.

"The Woodlands and Marshlands of England" (pp. 55), H. A. Wilcox.

"Manual of Cultivated Trees and Shrubs Hardy in North America" (pp. 930), A. Rehder.

"Trees and Shrubs Hardy in the British Isles," Vol. 3 (pp. 517), W. J. Bean.

"Plant Distribution in the Aberystwyth District" (pp. 50), Lily Newton.

"Structure and Life of Forest Trees," 3rd Edn. (pp. 458), M. Büsgen. (Translated by T. Thomson.)

"Care and Repair of Ornamental Trees" (pp. 257), A. D. C. Le Sueur.

"Forests and Sea Power" (pp. 485), R. G. Albion.

"New Forest" (pp. 186), J. C. Moore.

"Exkursionsbuch zum Bestimmen der Voegel in freier Natur" (pp. 276), H. Frieling.

"Die Pflanzengeographisch—ökologischen Grundlagen des Waldbaus" (pp. 173), K. Rubner.

# ESTABLISHMENT OF PLANTATIONS.

By F. C. Best.

We probably all have in our charge plantations which, after years of expense and attention, are still unestablished, although we feel that establishment might have been secured in a reasonable period. The question is one of economy and a few years' delay is quite justifiable if the total cost of establishment can be appreciably reduced, but considerations of economy in first costs often lead to increased expenditure in second costs, resulting in equal or greater total expenditure, to say nothing of loss of time which may represent 50 cubic ft. or more of timber per acre for every year lost. Shortage of money has a tendency to reduce first costs which, if cut below the margin of safety, inevitably mean increased total costs.

The factors affecting establishment can be considered individually, and the following remarks apply to conditions in Wales.

*Choice of Species.*—Attempts to grow trees of high volume production or timber value on land more suitable to a less valuable species have led to much delayed establishment; for example, Douglas fir and European larch on land where spruces or Japanese larch are capable of good growth. Though the species most suited to the environment is not necessarily the quickest to establish itself, it is often the cheapest and at any rate the surest and least likely to involve prolonged expense. Once forest conditions are secured the introduction of a more valuable species may be possible in the second rotation.

*Type of Plant.*—The ideal plant is often unobtainable on account of cost, but suitable plants for all ordinary purposes can be produced at a reasonable cost, yet we often have to use plants that are far from being ideal (*a*) because they are cheaper, (*b*) owing to lack of more suitable stock, (*c*) to avoid destruction of unsuitable stock. Under (*a*) comes the consideration of the planting of seedlings. As regards (*b*) the difficulty in getting the required quantities of certain species for lining-out makes the production of adequate numbers of suitable plants extremely difficult and is bound to lead to the use of too young transplants. As to (*c*), overgrown plants are seldom produced now, but in the past the planting of overgrown Douglas fir by ordinary methods on anything but the very best land has led to prolonged check.

The difficulty is to produce plants large enough for all ordinary purposes at a reasonable cost. In local nurseries suitable larch can be raised as plus one plants. Douglas fir, even if well manured, is seldom fit for lifting as plus one, yet plus two plants are often too large. The production of plus one plus ones or undercut plus twos generally gives the most satisfactory results. It is seldom that plus one spruces are large enough, but plus two beds, if the nursery fertility is reasonably good, will yield sizes suitable for beating-up, for surface planting and for turf planting. If we can so improve the yield that all plus two spruces are large enough for surface planting then there may be an opening for the production of hardy seedlings for turf planting, but so long as small grade spruce transplants have to be relined there is no object in planting seedlings on turfs, especially as results so far are less satisfactory than with transplants.

The fact that sizes of plants actually received are, in the majority of cases, far below sizes stated on P. 1, and more especially on P. 2 forms, shows that there is a real need for larger plants.

*Planting.*—Where soil conditions and type of plant are favourable, cheap planting methods, if well carried out, are entirely successful. On areas of deep peat the more expensive turf-planting method meets the case very effectively, but a number of areas of intermediate type occur in Wales, ranging from thin peats to peaty turf on good subsoil. Under some of these conditions Japanese larch succeeds perfectly well notch planted, but Douglas fir, even on the better types, is seldom altogether successful and spruces are liable to check on the less favourable types.

Turf planting for spruces under these conditions is sometimes necessary, but on dry ground heavy failures may result if planting is followed by a dry summer. Planting as shallow as possible with a mattock is cheap and usually successful in preventing prolonged check.

When Douglas fir, European larch and other exacting species are planted on these intermediate soil types ordinary notch planting is not always successful as check is liable to occur, resulting in late failures and slow, irregular development. As it appears to be the surface conditions that are responsible some form of cultivation or breaking up of the soil seems desirable. In all horticultural and agricultural practice cultivation before establishing a crop of any kind is invariably carried out and one may often see how a virtually unplantable moorland can be made to grow a crop of oats after one shallow ploughing. In most Welsh areas ploughing is seldom practicable or necessary, but it is likely that some form of cultivation with a mattock before inserting the plant, or even pit planting, would in some cases justify the extra cost. The beneficial effects of pit planting can so often be seen on private estates, where all kinds of species and overgrown plants are planted on anything but favourable ground, yet they become established quickly even if subsequent growth is slow.

For any given species (or type of land) there are three factors (1) type of land (or species), (2) type of plant, (3) planting method, which together make for success or failure. If 1 and 2 are favourable there is little difficulty with 3, but if 1 or 2 or both are not all that could be desired special attention to 3 may, to some extent, make up for the failings of the other two by improving the soil conditions in immediate contact with the plant roots and giving them every chance of functioning to their full extent. This question is further considered under beating-up, when it is of greater importance.

*Beating-up.*—If planting is followed by no check beating-up presents no difficulties, but where check and delayed failures occur beating-up is far more difficult and the three factors (1) species, (2) type of plant and (3) planting method need reconsideration, as the beat-up plant must have a better chance of quick establishment than the original plants. It is under these conditions that the quick starting species are so useful, but sole reliance cannot often be placed on change of species and special attention is needed to type of plant and planting method. If first planting were always done a hundred per cent. efficiently, less late beating-up would be needed, but there are many factors outside our control and it is inevitable that when late beating-up has to be done it cannot be accomplished successfully as cheaply as early beating-up.

Late beating-up calls for observation and intelligence on the part of workmen, which mean closer supervision than almost any other forest operation. A hard-and-fast rule is difficult to lay down, but some such definite instruction as " Insert every plant at least a tree and a half's length from each surrounding tree " can be varied to suit species, and once grasped is clear enough, but in practice is surprisingly difficult to get done correctly with average labour.

*Weeding.*—Weeding is the last operation in the process of establishment and even a small amount of underweeding may impair the results so far achieved. A small saving in weeding can so easily mean injury or failures which further expense cannot altogether put right. Estimation of weeding costs is not possible with anything like the same degree of accuracy of other operations. Weeding should be governed primarily by the varying conditions of the plantations from week to week, and only secondarily by considerations of financial estimates and labour supply. It is unfortunate that the weeding season draws to a close with the termination of the financial year and all the uncertainties associated with it.

Most weeding can be classed in one of three categories : (1) long annual growths such as bracken, willow herb, and other herbaceous plants requiring weeding within certain narrow limits of time. If done too early further expense on a second weeding may be needed and if too late the benefit will be lost and injury or loss of vigour of the trees will result, the effects of which cannot easily be rectified. (2) Short annual growths, such as most mountain grass areas, which are sometimes very expensive to weed. The majority of plants, especially spruces, either struggle through little the worse or else are killed outright. The risk of a few deaths is sometimes justifiable as weeding is costly and beating-up can be accomplished with large plants or on turfs without the evil effects usually associated with delay. (3) Perennial growths such as coppice, gorse, long heather, etc., the time for weeding which is more elastic than in either of the other categories. In practice the question is complicated by areas of intermediate or mixed growths and small patches needing different treatment.

# VEGETATION AS SOIL INDICATOR.

By R. H. Smith.

In the summer of 1931 I made a vegetation survey in two plots of what would have been described as a calluna-scirpus moor at Clocaenog Forest, in Denbighshire. Naturally the vegetation types were not exactly uniform over the whole area and one plot was selected with much calluna, and one with less calluna and more of the wet soil species such as sphagnum and scirpus.

In the summer of 1934, three years later, I re-assessed both plots, which had, in the meantime, been carefully protected, the whole area having been drained and planted in P. 32.

The results are very striking and interesting and give much scope for thought and discussion, and in fact, even seem to challenge the current ideas as to the vegetation which shows one type to be better than another after drainage.

Before pursuing the matter further it will be well to state the details of each plot showing the species present at the time of both assessments in their order of prominence.

Plot I.

| *Summer* 1931. | *Summer* 1934. |
|---|---|
| 1. Calluna. | 1. Calluna (95 per cent.). |
| 2. Nardus stricta. | 2. Nardus. |
| 3. Hypnum schreberi | 3. Vaccinium. |
| 4. Potentilla erecta. | 4. Eriophorum vaginatum. |
| 5. Polytrichum. | 5. Geum urbanum. |
| 6. Vaccinium. | |
| 7. Galium saxatile. | |
| 8. Dicranum sp. | |
| 9. Carex distans. | |

Plot II.

| *Summer* 1931. | *Summer* 1934. |
|---|---|
| 1. Calluna. | 1. Calluna (60-70 per cent.). |
| 2. Sphagnum. | 2. Scirpus (30-40 per cent.). |
| 3. Molinia. | 3. Molinia (very little). |
| 4. Hylocomium sp. | 4. Vaccinium. |
| 5. Scirpus. | 5. Juncus squarosus. |
| 6. Vaccinium. | |
| 7. Juncus squarosus. | |
| 8. Polytrichum. | |
| 9. Hypnum schreberi. | |
| 10. Dicranum sp. | |
| 11. Potentilla erecta. | |
| 12. Carex distans. | |
| 13. Another moss (unidentified). | |

As will be readily seen, the calluna holds its place of prominence in both plots and is in fact increasing strongly and making an average annual growth of 5 in.

There is one very important point which makes it difficult to say what is the real cause of the change in vegetation, and it is this. These moors are grazed, as a rule very heavily, by sheep. When we drain an area the sheep are turned off within a few months and before planting. Thus, is the change due in the main to the drainage, or to the sheep grazing being stopped ? I am inclined to think that on this type of ground the grazing has more to do with the big change than the drainage.

According to present ideas as to the quality of the ground it is obvious at a glance that Plot I has a much more desirable vegetation and was on drier ground than Plot II. But again, generally speaking, we have been accustomed to regard a number of species on any ground as being an indicator of better conditions than where only a few are growing. But here it is not so, for there were 13 different species found in Plot II on the ground which appears by the dominant vegetation types to be the worst, whereas only 9 were found in Plot I on what appears to be the best.

Complete drainage was carried out and complete turf planting was done. Up to the present the plants are not looking well, although an odd one or two seem to be getting away. It was of course planted with S.S., but unfortunately, due to a shortage of plants, with seedlings.

Taking Plot I let us see what can be got out of it by a comparison between the two assessments. In the first place the calluna has not only held its own but has gone ahead and increased considerably, and it is now estimated that this constitutes 95 per cent. of the whole vegetation. Nardus holds second place still, but is not so strong as it was. Hypnum schreberi, which may or may not be a good indicator, has gone right out, but at any rate it has never been looked on as an undesirable species. The little Potentilla erecta, usually associated with rather desirable conditions, has also disappeared. Polytrichum, which on a drier soil type is definitely an indicator of ground on which spruces grow well, has also completely disappeared. Vaccinium, although now third in order of prominence, has not in any way increased but rather the reverse if anything. Then there is the new appearance of Eriophorum vaginatum, admittedly in small quantities, which has always been looked upon as being thoroughly undesirable. Galium saxatile has gone altogether. It may not be a definite indicator of good conditions, but it is usually found on land which is improving or already in good condition. Dicranum and Carex have gone right out to be replaced by the small Geum urbanum in very small quantities.

Now let us consider Plot II. Here again the calluna heads the list but is only 60–70 per cent. of the whole, while scirpus, which originally held fifth place, now practically comprises the rest of the vegetation. Sphagnum, definitely a wet ground species, has gone out altogether. Molinia has decreased if anything, while hylocomium, which is said to be a good indicator, has gone out altogether. It is reputed to be one of the chief reasons for not burning heather moors before planting that hylocomium gets destroyed and one of the most beneficial factors as far as trees are concerned is done away with, and yet here we find it going out of its own accord after draining. Vaccinium has probably not altered much, but if anything has gone out slightly. Juncus squarosus, also a wet soil indicator, is still present after draining in about the same quantity.

Then Polytrichum has disappeared, and here again a good indicator on drier conditions has been unable to survive after draining. Hypnum schreberi, a Dicranum species, Potentilla erecta, Carex distans, and an unidentified moss have all gone.

What a strange state of affairs this is. Can it be that the drainage has so increased the vigour of the calluna that nothing else can survive ? Or can it be that the drainage has, on our present knowledge of vegetation types, actually caused the moor to deteriorate ? Plot II, viewed in the light of present standards, would be regarded as poisonous and possibly temporarily unplantable.

Can it be that the sheep ate only the calluna, and did not actually interfere with the other plants except scirpus and nardus and thus, with their manure, the light, and the lack of serious root competition, the other species were able to survive ?

Altogether it offers a very difficult and puzzling problem and one inclines towards the idea, with our knowledge of the way in which drainage has improved bad conditions rapidly in other areas, that the moor is, in fact, actually improving, but that it was giving a false showing of its possibilities while being grazed and trampled by sheep.

Certainly it shows again the danger of judging land too quickly while it is still being grazed, as has often been demonstrated in the past on the calluna-gorse-grass areas, and one can easily be led into a false idea of the actual quality of the ground by its hasty assessment under these conditions.

*Postscript.*

Since writing the above article the following theory has been brought forward in discussion in explanation of the strange state of affairs described.

While the sheep are grazing, and they do graze very heavily and closely, the amount of air and sunlight let into the lower parts of the vegetation must be considerable and hence aeration is effected in a way in which it could not be when the under vegetation is thick and the formerly grazed parts cease to be grazed. Evaporation and transpiration are not together able to deal with the amount of deposited moisture and thus the immediate surface vegetation, which quickly accumulates, acts as a sponge and souring very quickly takes place, as in the forming of all bogs, with the result that only those species which tolerate sour conditions thrive.

This seems a likely explanation of the immediate change of the vegetation apparently for the worse and although this change may cause an apparent increase in the surface moisture content, a fact which has been noticed, an efficient drainage system does in fact actually reduce the water-retaining properties of the soil or peat itself. Thus it is reasonable to suppose that the ground is actually improving lower down than the immediate surface, while it gives the appearance of the reverse process if the vegetation alone is studied.

R. H. S.

# PLANTING DISTANCES.

## Silvicultural and Economic Considerations.

By R. H. Smith.

Are we planting all our trees at the proper distances apart ? Somewhere in the scale of distances there is an economic and silviculturally sound spacing for every species in every condition. This subject has been discussed in past years and many people hold their own very definite views in the matter, but the question is which is the right one.

A theory is held by some people that trees planted wide apart will not form canopy quickly enough, because when the side branches close up, towards the last few inches they begin to curl upwards to the light and depart from their former straight growth sideways, thus lengthening the time taken to close finally.

The writer has examined both shade bearers and light demanders with the object of proving or disproving this theory, but so far he has seen nothing to support it in either type of tree. Then, on the other hand, there is the all-too-often seen result of close spacing when trees get unduly drawn up, and in the normal course of events thinning has been left too late. That is a state of affairs which should never occur in properly managed woods, whether markets are available for thinnings or not. It is not always realised that the value of the final crop is round about 80 per cent. of the total value of the wood, and it is therefore surely very well worth while doing everything possible to secure a really good final crop.

It would be impossible in a limited space to discuss with any effect the individual conditions for each of the more common species planted, with relation to their planting distances, so it must suffice that a general discussion ensues. Spruces, for the most part, just for an example, are planted at five feet apart, but is not this more the result of custom than of actual reasoning ? Let us look at it this way. If two trees are planted at 5 ft. apart, each of them, assuming they are exactly similar trees, has to grow 2 ft. 6 in. sideways before the side branches meet. Now, supposing they were planted at 5 ft. 6 in. apart, each of them would have to grow 2 ft. 9 in. before their branches met. Is it essential that those extra 3 in. on each should be grown by a certain date ? Probably those 3 in. on each tree would only represent a very small portion of their growth in one growing season. Thus the consideration with regard to each individual tree seems to be of very little importance. Then again, there can be very little, if any, difference in the shelter afforded to each tree by its neighbours, whether they are planted at 5 ft. or 5 ft. 6in. apart.

Now, what about the economic conditions of the scheme ? Planting at 5 ft. spacing means 1,742 trees to the acre, whereas at 5 ft. 6 in. means 1,440 trees per acre, a difference of 302 trees in every acre planted. If the spacing was raised to 6 ft., the difference between that and 5 ft. is 532 trees per acre. That figure in itself seems to mean little when we are accustomed to think and deal more in thousands and tens of thousands, but what about it when one considers a 500 acre programme at a forest? The saving in trees in one year by 5ft. 6 in. spacing over 5 ft. spacing would be 151,000. Let us see what that might be worth in round figures.

Firstly there is the cost of the plants. Good transplants might average 30*s*. or 35*s*. per thousand. We will be conservative and take the lower figure, *viz*. 151,000 at 30*s*. equals £226. Then there is the cost of transport and haulage at both ends, which on 151,000 would vary with the distance and other factors such as accessibility, but an average might be taken at, say, about £20. Then there is the cost of planting, for which to take a fairly conservative figure, we will use the turf planting rate current in most of N. Wales, *viz*. 7*s*. 6*d*. per thousand (£59). So that the minimum saving may be put at not less than £305 per annum for every 500 acres. This is simply by asking each tree to grow another 3 in. sideways. The above figures would be less, of course, for seedlings, but then seedlings have not yet been planted for a sufficiently long time to say exactly how they will affect final costs; in some cases results are satisfactory so far, and in others they are not. Then there is the question of beating-up deaths. The number of plants put in in beating-up on our present policy would not be increased in any way by a spacing 6 in. wider, and in very few instances would it be affected by a spacing 1 ft. wider.

Is it therefore certain, in view of these facts, that we are on the right lines? Obviously there must be a limit somewhere, but are we not tending to plant too closely, and therefore plant too many trees, half of which have to come out when they are very small and are often condemned to lie and rot through the difficulties of obtaining a market, to say nothing of the cost of making these unremunerative thinnings in the very early years of the plantation. Where really good conditions prevail, naturally growth will be stronger, and in those places planting would be wider than would be the case in conditions which, due to one factor or another, are poorer.

Supposing a slightly wider spacing was adopted all through the Commission's operations, then quite a considerably larger area could be planted every year with the same money and the same number of plants. For example, if the 20,000 acres planted each year on an average, is planted at an average spacing of 5 ft. (which probably is not far out) and if this spacing is raised by 6 in., it would mean that there would be about £12,000 more available for extra area, without, in the writer's opinion, in any way causing deterioration or damage to the plantations so laid down.

Is not this a matter very worthy of really serious consideration?

# CHAFER BEETLES.

By G. W. Jones.

Serious losses are caused in the Commission's nurseries by one or other of the chafers when in the grub stage, and the fact that the damage done by several of them is so similar suggests that we may frequently have wrongly attributed the blame to the large cockchafer, a species which has long been black-listed as a serious menace in forest nurseries. The garden chafer, or coch-y-bonddu (*Phyllopertha horticola*), although known to the experts to do damage to garden and field crops, has not until recently been classed with *Melolontha*, *Rhizotrogus* and *Serica* as being specially destructive to forest nurseries, and it comes somewhat as a shock to find this species practically clearing out blocks of plants in some of our nurseries. Very little appears to be known about this pest except what we read in a publication as far back as 1896. "It has one generation per annum. Flight period late May to July generally in bright sunshine. The beetle is ¼ in. to ½ in. long, front part of body metallic greenish in colour, wing cases reddish brown hue. Male very hairy. The grubs can only be distinguished from partly grown cockchafers by microscopic examination." Yet this species of chafer is destroying small trees in thousands! By the spasmodic and unsuccessful attempts which have been made during the present century to control the pest it would seem to many observers that the damage done has not been serious enough to warrant a united effort by the collective forces of our experts, but this is not so. The perplexity of the problem may be largely instrumental in turning us to the research of more alluring but less important matters in nursery practice, with the result that we are now desperately seeking a cure for blood poisoning instead of treating the scratch and any effective and practical solution of the problem seems to be as remote as ever.

Instead of studying how to grow trees we should learn how to save them. It may be said that most of the chafer experiments have been with the large chafer (*Melolontha*), but if this so, one would naturally think that some of the measures recommended for its control would be effective when applied to the smaller chafers which are of very similar habits.

Some idea of the result of injections of carbon bisulphide compared with hand-picking done in 1933 may be gathered from the following tables :—

*Hand Picking at Linmere Nursery (Sandy Soil).*

| Plot No. | Species. | Age (years) | Area (sq. yds.) | Numbers collected. | Cost £ s. d. |
|---|---|---|---|---|---|
| 14 | S.S. | 3 | 290 | 21,785 | 2 6 6 |
| 15 | ,, | ,, | 3,987 | 32,888 | 5 1 8 |
| 16 | ,, | ,, | 2,376 | 5,585 | 1 13 5 |
| 15 | ,, | 2 | 1,394 | 626 | 8 8 |
| 15 | P.C. | 1 | 1,176 | 1,563 | 3 18 1 |
| 14 | C.P. | 1 | 1,518 | 2,850 | 1 13 9 |
| 14 | Lupins | | 1,559 | 4,365 | 1 0 5 |
| Totals .. | | .. | 12,300 | 69,662 | £16 2 6 |

*Injections of Carbon Bisulphide.*

Injections were made in the 3-year S.S. beds on Plot 14 at the same time as hand-picking was in progress. The plots were carefully measured and marked off and examined the day following injection, with results as below :—

| Number and strength of doses. (per sq. yd.) | Alive. (per sq. yd.) | Weakly (per sq. yd.) | Dead (per sq. yd.) |
|---|---|---|---|
| 9 × 5 grammes | 72 | 6 | 4 |
| 9 × 10 ,, | 63 | 3 | 6 |
| 9 × 15 ,, | 102 | 6 | 9 |
| 9 × 1 ounce | 60 | 0 | 36 |

Judging by this experiment carbon bisulphide is not an effective measure on sandy or light soils, especially when the chafers are working near the surface.

The increase of expenditure was over 100 per cent. with 5 gramme doses and we have an approximate efficiency of only 4·8 per cent. of deaths as compared with hand-picking. Other measures have been tried such as isolation of the beds from the grass paths by digging trenches, trapping with turfs and humus, but the most successful, in cost and numbers destroyed, is hand-picking and destruction of the beetles during the flight period. Surely all means by inoculation, manuring, dusting, spraying or injecting to act as a killer or deterrent to egg-laying have not yet been tried by our experts ?

Few destructive forest insects have received so much attention both at home and on the Continent as chafer beetles. The difficulties of combating pests which spend their larval life underground have to be recognised. They are baffling to the agriculturist as well as to the forester. As showing that the Commissioners are fully alive to the need for further investigation the following extract from a recently issued questionnaire is given.—*Editor.*

*Questionnaire on Chafer in Nurseries.*

1. Nature of ground surrounding the nursery (whether grass, arable land, plantation, woodland, etc.).

2. Presence of hardwood trees in the form of woods or belts surrounding or adjoining the nursery.

3. Is the damage general over the whole of the nursery, or are certain sections more severely attacked than others ? If so, are there any special features to be noted about such sections, *e.g.* soil—lighter or heavier, proximity to grass paths, hardwood belts, sections under Christmas trees, etc. ?

4. The time or times of year when damage is most common.

5. Can any connection be traced between previous treatment of a section (*e.g.* seedbeds, lines, manuring, hand-picking) and the intensity of attack ? Is chafer damage more or less severe after a successful green crop ?

6. Mention other points of interest.

# REPLANTING COPPICE AREAS.

By F. E. B. de Uphaugh.

In 1932 I contributed to the Journal an article on "The Planting of Coppice Areas." This dealt mainly with coppice only and made little reference to the accompanying weed growth. Since that date my views have changed, more particularly in regard to the question of weeding.

European larch is used as the basis of these notes not only because it is most commonly used in this district but also because it appears to be the most susceptible to damage from lack of weeding, except perhaps Scots pine, which, however, is not often used on a coppice area. The type of coppice area under consideration is one carrying a crop of all classes of hardwoods, both as high forest and coppice, which is either completely or partially cleared. Most species will tolerate a reasonable growth of bracken and surface vegetation, but larch immediately lose most of their foliage and become sickly if not looked after. I have seen, on areas properly weeded for a number of years, examples of trees 7 and 8 ft. high completely robbed of lateral branches almost to their tops by bracken which has regained strength after the cessation of normal weeding.

The first point to consider is the history of weed growth before and after felling. Before felling takes place, there is generally little if any weed growth on the ground providing the canopy is reasonably complete. A small amount of bramble and bracken in patches may be noticed but they will have little vitality. Honeysuckle and a few herbs may also be present.

After a complete felling there are two stages of development :—

1. Weed growth in the form of grasses, willow herb and foxgloves appears and the bracken and brambles spread and gain in strength and go on doing so unless kept in check.

2. About two to three years afterwards birch and sallow seedlings begin to appear if they have not already done so and begin to affect the weeding. If weed growth had not been kept in check the area would by now be a complete wilderness. From this it will be seen that in addition to the coppice there are two different types of weed growth which occur at different periods and the problem is to find the best method of dealing with them at a minimum cost but without detriment to the trees. The points to consider are (*a*) can this weed growth in part be prevented and if not (*b*) how best to deal with it at a minimum cost without detriment to the trees.

With regard to (*a*) the only method appears to be to leave as much as possible of the old hardwoods standing and the subsequent ringing of a portion of the whole. This is now a generally adopted policy with shade bearers, but the difficulty in the case of larch, which is a light demander, is to leave sufficient canopy to keep down the weed growth but not to be detrimental to the larch.

To date one or two methods have been tried, but the results cannot as yet be ascertained. However, below is the information I have so far obtained :—

1. *Strip method.*—In this case the whole of the produce was saleable, from beansticks upwards, and the idea was to utilize the produce as far as possible but to leave a proportion on the ground. Alternate strips 20 ft. to 30 ft. were completely cleared whilst intervening strips of the same width had only the most valuable produce removed from them. The idea of the cleared strips was to enable the produce to be extracted. The result was not satisfactory as the soil was consolidated in the cleared strips by the haulage and very heavy failures occurred, whilst in the partially cleared strips the failures were normal.

2. *Opening of canopy over the whole area.*—In P. 31 a trial was made along these lines. Although it appears that the weed growth has been kept down to a certain extent, the standards were left too long without being ringed, to the detriment of the larch.

In P. 34 further areas were planted in this method, and although it is too early to judge the effects on weed growth the following may be of interest.

Nine thousand seedlings 2 + 0 and 9,000 2 + 1 were used in all. They were planted in batches of 6,000 at three different periods, half under coppice and half in the open from which similar coppice had been completely cleared. The results were as follows :—

| Age. | Date Planted. | Open or Coppice. | Actual Number of Deaths out of 1,500 Plants in each Plot. |
|---|---|---|---|
| 2+1 | 5.2.34 | Coppice | 80 |
| ,, | 11.2.34 | Open | 157 |
| 3+0 | 7.2.34 | Coppice | 172 |
| ,, | 9.2.34 | Open | 178 |
| 2+1 | 20.2.34 | Coppice | 85 |
| ,, | 24.2.34 | Open | 56 |
| 3+0 | 24.2.34 | Coppice | 186 |
| ,, | 20.2.34 | Open | 214 |
| 2+1 | 28.3.34 | Coppice | 92 |
| ,, | 29.3.34 | Open | 153 |
| 3+0 | 26.3.34 | Coppice | 132 |
| ,, | 27.3.34 | Open | 307 |

This certainly points in favour of leaving cover during a dry season. At another forest where 2 + 1 were used results were far less definite, namely, 7 per cent. under coppice as against 11 per cent. in the open.

When an area is clear felled there seem to be three points to consider, namely :—

(1) Period elapsing between felling and replanting.
(2) The period of the weedings.
(3) The spacing of the trees in planting.

With regard to (1) many of the trees are either felled by the owner or sold by him to timber merchants prior to our entry. In these cases sometimes the owner has to clear and leave the ground ready for planting and sometimes it has to be carried out by the Commission after taking over. In consequence often a considerable period elapses between felling and planting. The longer this period the higher the cost both of preparation of ground and of weeding. As will be seen from the remarks on the history of the weed growth, seeds have had time to germinate and bracken and brambles will have had time to spread and gain vigour and further birch and sallow will enter more into the weeding question. The quicker an area is replanted after felling the less the weeding costs.

With regard to (2), a few years ago, I think, it was generally assumed that if a tree was well above the surrounding weed growth the tree was safe, but this has not proved to be the case with larch. Using that assumption the following programme of weeding was adopted : 2–3 years general initial weedings, followed by an interval of no weeding of 2 years or so until further coppice weeding was necessary.

The following is what occurred. In consequence of a heavy initial complete weeding, the vigour of all the coppice and weed growth was reduced and the trees looked healthy and well furnished and capable of taking care of themselves until further coppice weeding was necessary in about 3 years' time. However, during this period the bracken and brambles gradually recovered their strength, in the meantime causing some if not a considerable amount of damage to the lower branches of the trees and by the time coppice weeding was again necessary the weeds had regained full vitality and were the cause of much further cost in weeding. Also the birch and sallow growth which does not enter into the weeding question for 2 or 3 years after has received a flying start unhindered. Although by this method the larch to date have not been materially damaged they have not received a fair chance and growth must surely have been affected, which consequently means, for various reasons, prolonged weeding of birch and sallow and also cleaning.

It is much easier to pick holes in a scheme than to suggest a better one, but I think, after careful consideration of the history of the weed growth after an area has been cleared, the present general programme will attain the objects required, *i.e.*, to give the tree conditions of health in its youth but at the same time costing in the end a minimum amount of money.

Present proposals are for 4–5 years initial weeding with perhaps the coppice being neglected during the last two years. This period should sufficiently sap the strength of the bracken and brambles so that they will never enter again into consideration. This period will also cover the time when the seedling birch and sallow are beginning to enter into the question and may perhaps not have to be cut again until cleaning or coppice cuttings take place, which will possibly now be in the 7th to 9th year.

It must not be assumed that the above is a hard and fast rule but as far as I can see will prove the best on an area in which weed conditions are really bad ; but discretion, of course, must be used in regard to each area or part of an area.

Spacing (3) is generally recognised as an important factor affecting beating-up and also if much beating-up is required prolonged weeding and consequent higher costs. Further, I believe it is generally assumed that spacing can be wider in coppice areas than elsewhere in view of accepting coppice to fill blanks and form part of the crop. This latter assumption I am beginning to doubt for the following reasons. In coppice areas the types of weeds likely to cause damage to trees until canopy is formed appear to be much more numerous and luxuriant than on other areas. Besides the use of good plants and careful weeding, the only other method is close spacing. The present spacing adopted is 5½ ft. but I think 5 ft. should be seriously considered.

There is perhaps one further point worth mentioning. On many areas there are places such as dingles, the bottom of banks, etc., where it is certain that a luxuriant weed growth especially of bracken and brambles will come in and where larch should do especially well, but generally the reverse is the case owing to lack of attention. These areas need extra weeding during the normal initial weedings and also further weeding after the initial weedings are finished. In many forests, for various reasons, this is difficult to arrange, and if such is the case it is waste of money to plant larch and another species must be chosen.

# COPPICE AREAS IN THE EAST MIDLANDS.

By C. A. CONNELL.

Prior to P. 34 the method of rearing hardwoods in Whitwell, Pleasley and Bourne Forests consisted of clearing entirely all vegetation from the areas concerned and then planting up in lines regularly spaced over the area.

The preparation of ground on the areas in Whitwell and Pleasley Forests was done by one or more contractors who paid from 10*s*. to 30*s*. per acre and were then entitled to all the merchantable produce available, provided that all slash and unsaleable coppice of every description was burnt up and the ground left "swept and garnished." The produce available to these contractors was small coppice of oak, ash, birch, hazel and adventitious species used for firewood and chemical distillation. The large birch of turnery size had previously been disposed of to a timber merchant.

The Bourne areas were tackled by trainee labour, the saleable material being stacked on the rides for sale, and the unsaleable stuff burnt. However, a modification was introduced in that all well-formed natural ash was left. The general trend of vegetation on the area was poor ash coppice, hazel, willow and birch, over dense spirea· juncus and Aira caespitosa.

Whitwell and Pleasley Forests have a magnesium limestone formation producing good ash and sycamore, so that the replanting was done with these species, plus Japanese larch nurse, at spacing of 6 ft. × 5 ft. or 4 ft. × 8 ft. Very luxuriant coppice and bracken vegetation necessitated two or three weedings per year at costs varying from 5*s*. 6*d*. to 15*s*. per acre. In spite of these weedings the larch grew and are growing only moderately well, while the hardwood required generally two years in which to establish themselves before annual growth of over 6 in. took place.

Chalky boulder clay with flints is predominant at Bourne Forest and the natural species of commercial value is ash, of which natural regeneration is abundant in well-defined areas. This species was therefore planted with European larch nurse, either plant about or in alternate lines at spacings of 6 ft. × 5 ft. or 8 ft. × 4 ft. Cutting back of heavy coppice was entrusted to trainee labour, while weeding proper was done by Commission employees at from 4*s*. 6*d*. to 10*s*. 6*d*. per acre. Both species have grown and are growing well, growths of over 12 in. on ash and over 18 in. on larch being common in the second year after planting, with correspondingly enhanced growths in subsequent years.

In all areas, however, beating-up had to be done yearly for the first two years at least to an extent of 15–20 per cent. Coppice growth a year after clearing was again very great and beating-up was slow work, and therefore costly, since although at the time of planting a proper distance was kept from stools, it soon became difficult to distinguish whether an original plant had died or one had not been put in owing to the proximity of coppice.

With regard to weeding it was always borne in mind that a balance had to be maintained between cutting out coppice and vegetation to give head and lateral room in which the plant could develop and leaving sufficient coppice and vegetation to provide adequate shelter for the crop. In actual practice the maintenance of this balance required more supervision by gangers and foremen than was always possible or available, as the workmen could not be relied upon to treat each individual tree on its merits, especially when sycamore and larch were mixed. Either the larch were opened out only to the extent required by sycamore, which was insufficient for the former species, or else the sycamore were given the same amount of light as the larch, which was unnecessary and therefore caused an unjustifiable increase in costs.

The first experimental departure from the foregoing method of rearing hardwoods was made in P. 32 at all three forests previously mentioned.

At Whitwell a small area of 2–3 acres was kept back from the clearing contractors and was dealt with entirely by Commission workmen. On this area strips 12 ft. wide were cut through the existing coppice (10–15 ft. high) every 12 ft., everything on the strips being removed. Standard sized ash, sycamore and larch, *i.e.* over 15 in., were planted, mixed in blocks of 16 plants, 6 ft. between the blocks and plants 2 ft. × 2 ft. in the blocks. The P. 32 growth was substantial, considering that the plants had to establish themselves, and was not less than 9 in. In P. 33 the growth was 12 in.–18 in. for all plants, while P. 34 growth averaged 24 in. No beating-up has had to be done and the first relieving from shade of the coppice strips will be done in P. 35.

At Pleasley an area of about 5 acres was similarly taken out of the hands of the clearing contractors. No strips or groups were cleared in the existing coppice and scrub (10 ft.–15 ft. high), but all the undergrowth was removed, leaving the ash, oak and hazel coppice stems. The ash, sycamore and larch plants were planted in lines through the area as symmetrically as the presence of the coppice would allow. Their development has been good, and superior to the growth of the plants on the adjoining cleared area. Weeding has been done once each year in the undergrowth, while the relieving from coppice shade was done in the spring of P. 34. The beating-up has been confined to the replacement of some larch by sycamore.

On 1 acre, small blocks of ash and larch were set out in Bourne Forest among the original scrub and coppice stools, which had been cleared in 9-ft. squares, 18 ft. apart to accommodate 5 ash and 4 larch, equally spaced 3 ft. × 3 ft. The blocks of plants were relieved from any excessive coppice shade once per season, at low cost. The growth has been approximately 66 per cent. greater than similar plants on the cleared areas.

For P. 34 operations the principle of clearing on the lines of previous year's work was abandoned ; larch nurses were also dispensed with. The planting was done, with some exceptions, on a basis of strips and/or groups of plants among standing coppice and scrub.

The exceptions were certain areas already cleared before the instructions regarding the new technique were received. On these areas, however, an attempt was made to fall into line with the new instructions by arranging groups of plants just as if the area had not been cleared, *i.e.* approximately 100 groups of 12 ft. diameter were set out per acre, no symmetrical lay-out being rigidly adhered to, but the groups being spaced as equally apart as was compatible with the density of coppice stools over the area. Where a stool or number of stools likely to afford good shelter were found to be occupying the space where a group would be set out if in symmetrical formation, the group was set out beyond such coppice, in a place more open. In theory this would seem to give very scattered spacing of the groups, but happily in actual practice it has been possible to obtain a very regular lay-out, while full scope has been given to the coppice to develop adequate shelter. In the case of Whitwell and Pleasley the groups have been alternate ones of ash and sycamore, 16 plants per group, while ash alone has been used at Bourne (Pickworth) Forest.

A small area of approximately 8 acres was similarly treated at Bardney Forest, oak being used, 24 plants per group. The soil formation is ancient river gravels over boulder clay, and the previous crop was prime oak and ash.

Fortunately, at Whitwell Forest the year's planting area had not all been cleared, and an area of 15 acres was treated exactly to instructions on the strip basis. The coppice came into the "large" category; therefore strips 12 ft. wide, 12 ft. apart, were set out in a W.S.W.--E.N.E. direction, the fairly dense undergrowth was entirely removed and the coppice shoots, chiefly birch, ringed. The planting was done with ash and sycamore, part tree about and part alternate lines, there being three rows 4 ft. apart, plants 3 ft. apart in the rows.

The groups have been kept well weeded, the intervening coppice, of course, being allowed to grow up. Costs have been 9*s.* to 10*s.* for the Bourne area, the presence of much natural ash difficult to see, as smaller than the planted ash, making the work slow. Whitwell and Pleasley costs have been 5*s.* 6*d.* to 7*s.* per acre, and Bardney 9*s.* to 10*s.* per acre. In the latter case 1-year oak seedlings were used and therefore extra care was necessary.

The strip planting at Whitwell has not required any attention beyond weeding over 3 acres at a cost of 2*s.* 9*d.* per acre.

In every case results have proved most encouraging, and there is little difference between the groups and strips plants. Leader growth has in no case been more than moderate, but the plants look very healthy and well set, and nowhere is any beating-up necessary. This fact is significant when one considers that from the time of planting until the beginning of the " hardening-off " period no rain, beyond an odd summer shower of 5 minutes duration, fell. There is every indication that the growth in the coming years will be good and consistent, and that beating-up will be entirely unnecessary, while the fact of fast growth will reduce weeding costs considerably.

The P. 35 programme is being undertaken with great interest and minor experimental modifications are contemplated. These modifications will consist of completely grubbing up the group circles and working of the soil by trainee labour in Bourne Forest, and of widening the strips to 18 ft. in Whitwell Forest in order to note the distance over which lateral shelter is beneficent.

# MAP MEASURING.

By T. Allan.

## 1. By Planimeter.

(*a*) *Using map scale.*—It will be understood that the planimeter records accurate results only when the scale of the map is exactly 6 in. to 1 mile. Before, therefore, accepting any result as conclusive it must be ascertained whether the map has stretched or shrunk. The stretching or shrinkage may be horizontal, vertical or, as is generally the case, in both directions, though not always in equal proportion.

In order to find whether the map has shrunk or stretched, it is necessary to use a scale of known reliability. An ordinary wooden ruler is normally not sufficiently reliable for this purpose. A boxwood scale is more satisfactory and if great accuracy be required it may be tested by an electrum scale at an architect's or engineer's office, or the map itself taken and the map scale tested direct. Suppose that instead of being 6 in. to the mile, the map has stretched so that 1 mile is represented by 6·1 in. The area recorded by the planimeter must be multiplied $\left(\frac{6}{6{\cdot}1}\right)^2 = {\cdot}967$, *e.g.* if the area recorded by the planimeter were 100 acres, the correct acreage would be 96·7, the error being 3·4 per cent. As many cloth maps after use stretch even more than that amount it will be acknowledged that attention to the scale is necessary even for approximately accurate results. Should the map have a vertical scale it also is tested. The amount of stretching may be, in fact generally is, slightly less. Suppose 6 in. on the vertical scale of the map represented 6·05 in. on the ruler, the recorded area of 100 acres would in reality be $100 \times \frac{6^2}{6{\cdot}1 \times 6{\cdot}05} = 97{\cdot}6$ acres, the error in this case being 2·5 per cent.

If a compensating planimeter be used the setting for the last example would be :—Ordinary setting × 1·025, *e.g.* if ordinary setting for 6 in. scale were 24·21, revised setting to allow for expansion would be 24·21 × 1·025 = 24·82.

(*b*) *Using check area from* 1 : 2500 *scale map.*—Necessary allowance is estimated more expeditiously if a 25 in. map of part of the area included in the 6 in. map be available. On 1 : 2500 scale maps the acreage of each parcel of ground is given. Total up sufficient ground to give 40–50 acres with a more or less regular outline. Suppose on totalling contiguous parcels the result was 46·648 acres. The identical area is then planimetered with extreme care on the 6 in. map. Say the result was 47·6 acres, which means that the 6 in. map has stretched and the reducing factor to be used is $\frac{46{\cdot}648}{47{\cdot}6} = {\cdot}98$. By this method the required allowance is made for horizontal or vertical stretching as well as any inherent inaccuracy in the instrument itself.

When the area of each compartment in a continuous block, *e.g.* a particular P. year, is required, the most accurate method is to planimeter the whole block at least twice. If the same result be obtained it may be accepted as correct after making allowance for scale as already described. If the difference be up to ·5 acre per 100 acres, the mean may be taken. Should the difference exceed ·5 acre the area should be remeasured with the exercise of greater care, as it is essential to get the aggregate acreage correct in the first place. Each compartment is now measured separately. When totalled there might be a slight discrepancy which has to be distributed proportionately over each compartment, *e.g.* say there were four compartments of more or less equal area and the excess amounted to ·4 acre, ·1 acre would be deducted from each to conform with the aggregate previously agreed upon.

2. By Celluloid Computer (acre grid).

(*a*) *Using map scale.*—Quite satisfactory results may be obtained by this instrument provided the procedure below is followed. Lay bottom line of computer along any line of the area to be measured, the longest straight line normally being taken. Place a ruler close up to the bottom of the computer. Should either of the basal angles be 90° slide computer along ruler till a vertical line on the computer coincides with the perpendicular side of the area. If neither of the basal angles be a right angle slide computer along ruler till right-hand side of area in respect of bottom row of acre oblongs is bisected by a vertical line of the computer. In other words, this latter line acts as a give-and-take line for the right-hand side of this row. Count the number of full acre oblongs in the bottom row and estimate the fraction left to the nearest tenth, noting the figure obtained. For the second row repeat above process, continuing till the whole area has been treated. Total the results from each row of oblongs.

The scale must now be considered. Lay the computer along map scale. If the scales correspond (even although both may have stretched or shrunk) no amendment is necessary. Should the scales disagree the procedure given for the planimeter should be followed. An example, however, may be given. Say 80 chs. on computer = 78·4 on map, reducing factor $= \frac{(78{\cdot}4)^2}{80} = {\cdot}96$. If 80 chs. on map, however = 78·4 on computer, multiply computer acreage by $\frac{(80)^2}{78{\cdot}4} = 1{\cdot}04$. (In measuring lengths only the factors for correction would be simply $\frac{78{\cdot}4}{80} = {\cdot}98$ and $\frac{80}{78{\cdot}4}$ = 1·02 respectively).

(*b*) If desired the method outlined in 1 (*b*) may be followed, measuring check areas with computer and reducing or extending acreage as found necessary, but the fact of computer acreages being at the best only approximate does not warrant the trouble involved.

# PREPARATION AND SALE OF PRODUCE.

By T. Allan.

This matter, if not already occupying the minds of foresters, will be more or less general in a few years' time when thinning commences. The interest arising from this work is greatly enhanced when a reasonable revenue accrues therefrom, and it would appear that a discussion through the medium of this Journal among foresters who already have had experience in this business either with or without a sawmilling plant might prove helpful to those about to follow. Although it does not come naturally to broadcast one's failures, what was a stumbling block for one may thereby be turned into a stepping stone for another, hence the publishing of one's mistakes should not be withheld. Circumstances alter cases in nearly all branches of forestry, but hints though not capable of general application may help a few and so be worth while.

Different methods may be adopted in order to effect a sale as exemplified in the following illustration. We recall the enterprising fruiter of the Middle Ages, who finding trade rather dull, changed the nature of his trade on the signboard "fruiterer," literally "a vendor of fruiters." Human nature in those days appears to have been much the same as it is to-day when anything out of the ordinary attracts attention. People came to look at the sign, the shopkeeper meanwhile making a special effort towards having an attractive display, with the result that he did an exceptionally good trade, The fact of his prospering at the expense of other "fruiters," who found themselves in reality being "sold," led to the misnomer being generally adopted.

Fruit and forestry, though allied, are essentially different trades, and the latter calls for more matter-of-fact methods. Additional revenue is unlikely to be forthcoming to any extent by craftiness which in any case can last only for a time, and the point to be considered takes the form of how to reduce the cost of preparation of produce.

Some considerable time can be saved by the forester in marking larch and other deciduous trees if such be done when the trees are in foliage. Dead trees and trees of full or impaired vigour are much more easily distinguished then than in winter when the trees are bare. Should time not be available to complete the full marking, all dead and dying trees may be marked and the completion of the marking of the remainder postponed.

My chief object in writing these notes, however, is to touch briefly on the subject of rides as accesses in plantations. The provision of adequate accesses does not always receive due attention, and although it might be argued that in the near future, owing to the possibilities of air transport, roads will pale into insignificance, it is unlikely that they will be dispensed with for some time to come. This matter has to be considered before planting, as cutting roads through plantations, say, in the pole stage does not come under the category of practical forestry. I have found that with an adequate system of accesses for horse-drawn wagons a saving of 2*s*, 6*d*. per ton may be affected in removing thinnings. This saving may prove the deciding factor in regard to the question as to whether thinnings should be left in the wood or carried out and disposed of.

It is now generally admitted that accesses up to a reasonable limit are not regarded as wasted ground. This fact is borne out in the Commission's recommendation that the distance between rides or sub-rides should not exceed 150 yards. In many cases, however, this procedure does not appear to have been adopted, and moreover the rides planned are often totally useless as accesses for horse-drawn wagons or sledges, though perhaps they serve the purpose of sporting rides.

The following system is suggested :—

1. On dry flat ground, or sloping ground of uniform surface, *i.e.* not broken up by gullies, rocks or screes and where choosing of ground for accesses is practically unnecessary. Vertical 7-yard rides, 12 chains apart from centre to centre, horizontal 10-yard fire rides 25 chains apart, and a 5-yard vertical sub-ride up centre of compartment. (The marginal lines of trees on the latter may be pruned when pole stage is reached.) Total area of compartment = 30 acres. Area to be planted = approximately 28 acres. Rides = approximately 2 acres or less than 7 per cent. Thinnings, even in centre of section, require to be carried out only about 60 yards. If the gradient were steep enough, or too steep or rough for wood wagons, the use of timber chutes might be practised provided the amount of thinnings justified their erection, which, however, is doubtful, at least in respect of first thinnings.

2. Suppose the ground to be the reverse of the previous example, *i.e.* boggy ground alternating with uneven rocky and fissured areas. There are two methods of marking off rides on such ground.

(*a*) That in which the checker-board system is adopted, ignoring ground contour, gullies, etc., the object being straight compartment boundaries and compartments of uniform area. The procedure is as follows :—After the rides have been pegged off it is noted which, if any, are of use as accesses. Existing roads or tracks marked on the map are inspected and if suitable as accesses accepted as such.

The position of the peat roads might require to be checked, as present roads in some cases have been found as much as two chains distant from the original roads on the map. This is accounted for by the fact that whenever the road became badly tracked a fresh road alongside was taken. In some cases roads marked on the map now serve the purpose of streams for surface water, but often the access can be made at the side of them, and if such streams be more or less running in contour direction the lower side would normally be substituted as being naturally drier. Existing roads not marked on the map are then inspected and if suitable surveyed and plotted on the map. It is then seen from the map whether further accesses are required so that the length or breadth of any block does not materially exceed seven chains. I do not mean that neither should exceed seven chains, *e.g.* a block 20 chains long and seven broad would be satisfactory. Bogs and rocks are to be avoided, though if the former be of considerable extent it is obvious that an access through would be necessary. Draining of the bog would be postponed till after the accesses were marked off, as in most cases it is practicable to run a drain along each side of the access, the material thrown out being used to form a rough camber. The firmer ground is, of course, chosen for the access and as few cuttings as possible made across the road as these entail extra work in bridging. Nevertheless, at least one cutting is often necessary. All accesses having been marked on the map it might occur that an access lands, say, only one chain from a non-access ride. In that case the latter could be considerably narrowed, thus acting as a demarcation line only. Although compartment posts would indicate the compartment boundaries anyone unacquainted with the ground might find the system liable to confusion.

(*b*) The other alternative system of planning rides entails more initial work but would appear to be the more satisfactory. The ground is surveyed thoroughly in the first place and accesses as explained under (*a*) marked off. Sufficient areas to form compartments approximating to the desired acreages are then taken as rides, so that all rides serve as accesses also.

Appropriate breadths varying according to requirements would be designated to all rides both in this system and that of (*a*) above.

# BIRCH BROOMS.

By T. ALLAN.

Nature, which provides abundant antidotes to counteract the sufferings of mankind, *e.g.* earth for wasp stings, rumex for nettle stings, etc., has provided also an antidote or weapon of defence for the forester's greatest source of anxiety—*viz.* fire—in the shape of the birch.

In the progressive age in which we are living it is not unnatural that a laudable attempt has been made to improve upon the form and type of the fire brooms previously in general use. A man who persists in using birch brooms is regarded as old-fashioned, behind the times, bound by prejudice, etc. And the fact that wire, wire netting, sheet iron and steel are all easily procurable and capable of being bent or cut to any fantastic shape that may occur to the human mind has led to these materials being extensively substituted in the preparation of fire-fighting appliances.

It is natural to man that he views with satisfaction the product of his own hands. In course of time, if he be fortunate enough not to have occasion to prove it, he might consider it the best weapon for general use, and perhaps modestly describe it in print. I may say that I once made several types of netting and metal beaters, and, confidently armed with them, proceeded to burn protection strips in heather. We were unable to keep the fire under control and, had it not been for a patch fortunately burned by keepers in game interests some time before, into which we were eventually successful in directing our fire, the consequences might have been most serious. I was thankful that the lesson was not learned at greater cost.

Although I am by no means averse to giving any new type of beater a trial with an unprejudiced mind, I consider that any beater of the wire or metal type must be a vast improvement on recent suggestions before it can in any way compare with the birch broom in point of efficacy. I agree that the waterpack is most helpful where water is within reasonable distance, though regarded in an individual sense smothering, rather than drenching, would appear to be the more satisfactory mode of extinction. I do not intend to convey the impression that all netting beaters should be dispensed with, but to rely on them alone for the extinguishing of a fire of any but the smallest proportions appears to be a foolish policy. Suppose, however, that a sudden outbreak occurred, *e.g.* from a spark from a road engine, a man if working near would more expeditiously extinguish same by means of nearby netting beaters than by going to a depôt at a greater distance for a birch broom. The latter forms an essential standby when a fire becomes serious and fire-fighting in the true sense of the word is necessary. I would suggest that wire-netting beaters, or other type of a quasi-permanent nature be distributed over the area in the open, birch brooms in larger quantities being confined to weatherproof depôts.

Heather burning is a common cause of disastrous fires when the burning gets out of control. Birch brooms are particularly well suited to the extinguishing of heath fires as the unburned heather provides an excellent foundation for working on. It is understood, of course, that the birch broom, as the name implies, is essentially an appliance to be operated with a sweeping movement. Instead of repeated beating, prompt extinction is effected by a few men making a concentrated dash, keeping the requisite distance apart to prevent clashing and making a wide sweep with the brooms right at the outside of the fire, which smothering momentarily checks the fire, while brushing outwards completes the business. It is infinitely preferable to have burned trees rather than burned workmen, and the former part of the above procedure is applicable only in the initial stages of an outbreak or when circumstances permit. The latter part, however, *viz.*, brushing the fire towards the unburned heather, the men standing outside the burning area, is capable of general application.

In burning heather with the fire proceeding in the desired direction, the fire sometimes suddenly swings off at a tangent. This is often attributed to a change of wind when the real reason is invariably due to the contour of the ground, *e.g.*, an opening in the hills on one side causing a counter current, or perhaps if burning were being done in a sheltered valley, the wind currents in any case would naturally move either up or down the valley, when outside the wind might be in a different direction. On the fire reaching more exposed ground, if allowed, it would naturally move in the real direction of the wind. Accordingly, the contour must be studied so that an occurrence of this nature may be anticipated and requisite measures taken to cope with the contingency.

Grass fires, owing to the speed at which it is possible for them to travel, are not so easily suppressed. Netting beaters are totally useless for expeditious extinction as they are inclined to raise sparks and cause further outbreaks. Rubbing along the ground—the method advocated by their exponents—is practicable only in very small outbreaks. With the birch brooms the sweeping motion must be inwards, *i.e.* towards the fire, unless the growth of grass be extraordinarily dense.

An objection to the use of the birch is the alleged cost of upkeep and renewal. From the following figures I cannot see my way to agree with this. Where birch scrub of the proper size is plentiful a man can make a broom in ten minutes, costing less than 2d., and 14 G. wire ½d. per broom makes the total cost 2½d. each. Suppose 100 have to be transported 40 miles by motor lorry, 4 hours at 4*s.* = 16*s.*, *i.e.* 2d. per broom.

If the brooms be prepared two months after the termination of the growing season and stored in a dry shed, keeping at least the brush end off the ground, they will last indefinitely; in fact they will improve in seasoning and will require renewal only after doing service at a fire. A quantity of birch brush should be cut at the same time so that fresh material may be added to the brooms when they become charred. In preparing brooms, care should be taken not to shorten the ends of the twigs unduly. The brooms thus retain the maximum of spring, which conduces to easier manipulation.

I have made no reference to fires in the thicket or pole stages when counter firing might normally be resorted to. The reason is that my experience of them is not extensive enough to warrant remarks thereon. It is not for a forester to indulge in theory, especially in serious problems such as fires, so I shall leave that part to someone qualified therefor. The object of these remarks is merely to suggest a greater provision of birch brooms where they are procurable at moderate cost.

# FIRE PROTECTION (LOOK-OUT TOWERS).

By W. Mackay.

Prevention of fire is certainly better than cure, but no matter how much is spent in the making of fire traces, etc., with a view to preventing an outbreak, no area can be considered immune during a danger period.

When a fire does start, the chief factor in getting it under control and put out is promptness in getting to it with a properly organised and equipped squad. To do this the forester must have immediate warning, and while patrols are very useful and can often "nip a fire in the bud," it is sometimes a considerable time, especially on a scattered area, before the patrol man can get the forester notified. One way out of this difficulty is to have a man stationed on a spot where he can command a view of the whole area, the man to be equipped with a device or devices whereby he can let the forester know immediately when and where a fire has started. A look-out tower at once suggests itself.

Several towers have been erected in the North-Eastern Division. The following notes on the one erected at Roseisle may be of interest.

*Site.*—The highest point easily accessible was chosen as the site. (The question of access is rather important, as the tower may be required at a time when it is not occupied, either to localise smoke, or make use of warning devices.)

*Description of Tower.*—The top of the tower is twenty-four feet above ground level, and the supports are sunk four feet in the ground and have cross pieces fixed at the bottom for stability. Two platforms are provided, one thirteen feet above ground and the other twenty feet. The top platform is railed off to a height of four feet, and a trap door leading to it is hinged and fitted with a padlock. Ladders lead to the lower platform and from there to the top platform. The tower measures nine feet square at ground level and tapers to six feet square at the top platform.

*Material and Sizes.*—The building material is larch throughout, batted together by ½ in. bolts. The four poles supporting the structure are 3½ in. to 4 in. diameter at small end. The cross piece (platform supports, etc.) 4 in. × 2 in. The diagonals 3½ in. × 1½ in. Platform flooring 6 in. × 1¼ in. Ladder sides 2½ in. × 1½ in. and rungs 2 in. × 1½ in. These sizes have been found very suitable, being neither too light nor too heavy. To give the lengths of various pieces is unnecessary as these would vary according to height of tower.

*Method of Erection.*—The method adopted in erection is open to criticism, but it was found to work very well. Two ends were made on the ground and the poles grooved to take cross pieces to form other two ends. The prepared ends were placed opposite each other with bottoms at mouth of holes. Boards were placed upright in holes and as the top was pulled up, by means of ropes, the bottoms slid down the boards. When both ends were up and secured temporarily by ropes the cross-pieces were fitted in prepared grooves, and levelled by lowering poles. A spirit level was used.

*Method of Warning.*—A fog-horn is to be placed in the tower and used as an available means of warning. Arrangements could possibly be made whereby it could also be used to indicate the section in which fire has occurred.

Visible warning is as follows :—A red flag will be hoisted and indicator arm(s) raised to indicate section. The area is divided into three sections and three indicator arms will normally be vertical. Should fire occur in Section 1, one arm will be raised ; if in Section 2, two arms, and so on. Two pairs of field glasses will be provided, one to be kept in the tower, the other in the forester's house.

The observer will be given definite instruction as to how to act in case of outbreak, and the local policeman has been acquainted of the arrangements and has promised to co-operate, and if necessary raise a fire fighting squad to work under the direction of forester.

*Cost.*—The total cost of tower exclusive of warning devices was £9 10s. 4d., made up as under :—

| | | |
|---|---|---|
| Timber (supplied by local sawmill) .. .. .. | | £5 8 0 |
| Labour : 1 man 5 days at 6*s*. 8*d*. .. | £1 13 4 | |
| 1 man 5 days at 6*s*. 2*d*. .. | 1 10 10 | |
| 4 men ¼ day = | | |
| 1 man 1 day at 6*s*. 2*d*. | 6 2 | |
| | | 3 10 4 |
| Bolts and washers .. .. .. | | 8 6 |
| Creosote, tar and nails .. .. | | 3 6 |
| | | £9 10 4 |

*Timber used in Erection of Fire Tower at Roseisle*, 1934.

*Larch* :—

| | | |
|---|---|---|
| 4 poles | 28 ft. × 3½ in. to 4 in. | —small end. |
| 4 pieces | 8½ ft. × 4 in. × 2 in. | —Cross pieces at 3 ft. above ground. |
| 6 pieces | 7 in. × 4 in. × 2 in. | —Cross pieces at lower platform. 2 extra to support platform. |
| 6 pieces | 6 in. × 4 in. × 2 in. | —Cross pieces at top platform. 2 extra to support platform. |
| 4 pieces | 5½ in. × 4 in. × 2 in. | —Cross pieces at top of tower. |
| 8 pieces | 12½ ft. × 3½ in. × 1½ in. | —Diagonals between 1st cross pieces and lower platform. |
| 8 pieces | 9½ ft. × 3½ in. × 1½ in. | —Diagonals between platforms. |
| 14 pieces | 7 ft. × 6 in. × 1¼ in. | —Flooring for tower platform. |
| 12 pieces | 6 ft. × 6 in. × 1¼ in. | —Flooring for top platform. |
| 28 pieces | 4 ft. × 3 in. × 1¼ in. | —Upright railing round top platform. |
| 2 pieces | 12½ ft. × 2½ in. × 1½ in. | —Ladder sides. |
| 2 pieces | 9½ ft. × 2½ in. × 1½ in. | —Ladder sides. |
| | 32 ft. × 2 in. × 1¼ in. | —Ladder rungs. |

*Cost* = £5 8*s*. 0*d*.

# TENTSMUIR AND ITS FLORA.

By R. Shaw.

The large tract of land lying between the estuaries of the River Tay and the River Eden, where the expanse of golden sands and moorland merge into the blue of the North Sea, is known as Tentsmuir. This area was at some remote period covered by the sea, its soil being light and sandy. In early historical times it was a favourite hunting ground of the Scottish Kings, and a royal hunting lodge once stood on its margin in the neighbourhood of Leuchars.

Many curious relics of the primitive races that inhabited Scotland have been picked up on this vast muir, such as " arrow heads " and fragments of ancient pottery, some of the relics belonging to what is called the " Stone Age." At a later period the muir was a monster rabbit warren ; a bird sanctuary greatly frequented by bird lovers, and also a happy hunting ground for the student of botany, the muir, in itself, displaying a wonderful variety of wild flowers.

The area of Tentsmuir known as Kinshaldy was perhaps the richest in flora ; now, however, the various species have been exterminated, not by reckless gathering and uprooting, but by the hand of man in afforesting this piece of ground which, to-day, carries a flourishing young pine plantation some 2,000 acres in extent. Perhaps readers of this Journal would be interested in the flora which flourished here some 10–12 years ago, and I will endeavour to give a short list of some genera and species, each under its natural order :—

Alismaceæ
- Alisma ranunculoides.
- Naiadeæ.
- Triglochin palustre.
- Triglochin maritimum.

Cruciferæ
- Nasturtium palustre.
- Erophila verna.
- Teesdalia nudicaulis.
- Teesdalia maritima.
- Cakile maritima.
- Crambe maritima.
- Alyssum maritimum.
- Cochlearia officinalis.
- Matthiola sinuata.

Caryophyllaceæ
- Lychnus Flos-cuculi.
- Lychnus vespertina.
- Stellaria media.
- Stellaria uliginosa.
- Arenaria peploides.
- Spergula arvensis.

Callitrichineæ.. Callittriche aquatica.

Campanulaceæ.. Campanula rotundifolia.

Chenopodiaceæ
- Suæda maritima.
- Salsola Kali.
- Atriplex patula.

| | |
|---|---|
| Compositæ | Tanacetum vulgare. |
| | Artemisia vulgaris. |
| | Artemisia maritima. |
| | Hypochæris radicata. |
| | Gnaphalium uliginosum. |
| | Senecio vulgaris. |
| | Senecio Jacobæa. |
| | Senecio aquaticus. |
| | Achillea millefolium. |
| | Carduus palustris. |
| | Carduus pratensis. |
| | Taraxacum Dens-leonis. |
| | Centaurea Cyanus. |
| | Leontodon hispidus. |
| | Leontodon autumnalis. |
| Cyperaceæ | Scirpus maritimus. |
| | Scirpus setaceus. |
| | Scirpus palustris. |
| | Carex incurva. |
| | Carex arenaria. |
| | Carex vulpina. |
| | Carex leporina. |
| | Carex vulgaris. |
| | Carex glauca. |
| | Carex præcox. |
| | Carex distans. |
| | Carex paludosa. |
| | Carex ampullacea. |
| Droceraceæ.. | Drosera rotundifolia. |
| Dipsaceæ.. | Scabiosa arvensis. |
| Ericaceæ | Erica cinerea. |
| | Erica cinerea alba. |
| | Calluna vulgaris. |
| | Calluna vulgaris alba. |
| Geraniaceæ.. | Erodium cicutarium. |
| Gentianeæ | Menyanthes trifoliata. |
| | Erythræa centaurium. |
| Gramineæ | Nardus stricta. |
| | Agrostis canina. |
| | Agrostis vulgaris. |
| | Agrostis alba. |
| | Psamma arenaria. |
| | Aira præcox. |
| | Arundo Phragmitis. |
| | Poa maritima. |
| | Agropyrum repens. |
| | Elymus arenarius. |
| Halorageæ.. | Myriophyllum spicatum. |
| Juncaceæ | Juncus communis. |
| | Juncus balticus. |
| | Juncus squarrosus. |
| | Juncus compressus Gerardi. |
| | Juncus articulatus. |
| | Luzula campestris. |
| Labiatæ | Stachys sylvatica. |
| | Mentha sativa. |
| | Lycopus europæus. |

Linaceæ..Radiola Millegrana.

Lemnaceæ..Lemna minor.

Leguminosæ:
- Ulex europæus.
- Cytisus scoparius.
- Trifolium pratense.
- Trifolium scabrum.
- Medicago lupulina.
- Ononis arvensis.
- Astragalus hypoglottis.

Naiadeæ..Zannichellia palustris.

Onagraceæ:
- Epilobium tetragonum.
- Epilobium angustifolium.

Orchidaceæ..Habenaria bifolia.

Papaveraceæ..Glaucium luteum.

Plumbaginaceæ:
- Armeria vulgaris.
- Statice Limonium.

Polygmaceæ:
- Polygonum Hydropiper.
- Polygonum minus.
- Polygonum Persicaria.
- Rumex sanguineus.
- Rumex acetosella.

Primulaceæ:
- Glaux maritima.
- Anagallis tenella.

Ranunculaceæ:
- Ranunculus hederaceus.
- Ranunculus acris.
- Ranunculus aquatilis.
- Ranunculus Flammula.
- Ranunculus repens.
- Caltha palustris.

Rosaceæ:
- Potentilla palustris.
- Potentilla Tormentilla.
- Potentilla anserina.
- Alchemilla arvensis.

Rubiaceæ:
- Galium verum.
- Galium palustre.
- Galium saxatile.

Salicineæ..Salix repens.

Saxifrageæ..Parnassia palustris.

Scrophularineæ:
- Scrophularia aquatica.
- Veronica scutellata.
- Veronica Anagallis.
- Pedicularis palustris.

Typhaceæ:
- Sparganium simplex.
- Sparganium natans.

Umbelliferæ:
- Hydrocotyle vulgaris.
- Apium nodiflorum.

Urticeæ:
- Urtica urens.
- Urtica dioica.

Violaceæ:
- Viola palustris.
- Viola canina.
- Viola arvensis.

At every forest centre, where extensive afforestation is carried on, the gradual suppression of the flora is bound to take place when the forests become established, and it would be of interest if foresters would make observations of the changes taking place, both in the bird life and the flora, in order to have some record of the wild life which previously flourished on the tracts of land under their charge.

# MISCELLANEOUS NOTES.

## Weeding of Oak.

An experiment was laid down in P. 32 in Bromley Inclosure, Forest of Dean, to determine various intensities of weeding oak seedlings planted on ground on which a thin crop of mature oak had recently been felled and removed. The ground was of a type which becomes invaded after felling with a heavy growth of soft grass (*Holcus mollis*). It has been the local practice to weed oak seedlings thoroughly for the first few years on such ground to prevent the plants being smothered in the dense grass. It was desired to ascertain how far such weeding was really necessary.

The seedlings (1 year) were planted in P. 32 and fully assessed in P. 34, *i.e.*, after three growing seasons, yielding the following data :—

| Plot No. No. | Number of Trees. | Mean Height. In. | Losses Per cent. |
|---|---|---|---|
| A 1 .. .. | 447 | 11·6 | 38 |
| 2 .. .. | 519 | 11·6 | 28 |
| 3 .. .. | 572 | 13·0 | 21 |
| | 1,538 | 12·1 | 29 |
| B 1 .. .. | 599 | 11·6 | 17 |
| 2 .. .. | 499 | 10·5 | 31 |
| 3 .. .. | 674 | 10·9 | 6 |
| | 1,772 | 11·0 | 18 |
| C 1 .. .. | 599 | 11·1 | 17 |
| 2 .. .. | 626 | 10·0 | 13 |
| 3 .. .. | 609 | 11·5 | 15 |
| | 1,834 | 10·9 | 15 |
| D 1 .. .. | 599 | 10·0 | 17 |
| 2 .. .. | 595 | 10·6 | 17 |
| 3 .. .. | 620 | 10·6 | 14 |
| | 1,814 | 10·4 | 16 |

It will be observed that the losses were much heavier in the three A plots and in B 2 than in the remaining plots, but the majority of the losses occurred in patches of dense bracken which sprang up in the unweeded and lightly weeded plots. There was little evidence on the ground to show that the *Holcus* itself was harmful. The Research Foreman, Mr. D. M. Davies, reports that bracken in the unweeded A plots has become increasingly dense since 1932, until this year, in Plot A 1, it was well over 6 ft. high in one patch. Bramble has also been on the increase but not to the same extent as the bracken.

As far as height growth is concerned, there is evidently little to choose between the four methods up to the present date.

The conclusion is that intensive grass weeding is unnecessary on this type, but that bracken must be kept in control or it will endanger the life of the plants.

W. H. G.

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## HEART-ROT OF CONIFERS.

Heart-rot of conifers is a disease of considerable economic importance. In places a relatively high proportion of the stems cut in young plantations is found to be infected, and the value of the thinnings is greatly reduced in consequence. It was decided in 1933 to investigate the problem, and as a preliminary step butts affected by rot were to be sent to Mr. W. R. Day at the Imperial Forestry Institute, Oxford. It was requested that the sections should be 12 inches in length, cut from the base of stems showing signs of heart-rot, and that the samples sent should include, if possible, the earliest stages, *i.e.* staining, as well as later stages in which definite decay was visible.

As the response to date from the Divisions has been somewhat disappointing, the matter is once more brought to the attention of the field staffs. It is hoped that those in charge of thinning or felling operations in coniferous stands will keep a sharp look out for indications of butt-rot and send specimens as requested to Mr. Day. The cost of carriage should be debited to Sub-head H.1.d.

Information regarding each specimen or group of specimens sent in should be recorded on the following form :—

1. Forest. Compartment No. Elevation. Aspect.
2. Species.
3. Age.
4. Class of trees from which samples were cut, *e.g.*, suppressed, subdominant, dominant, etc.
5. Composition and Density of Stand.
6. Nature of Soil.
7. Rough estimate of the percentage of felled trees affected by heart-rot.

Signed ..................................................

Date ......................................................

W. H. G.

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## NURSERY TREATMENT OF CUPRESSUS MACROCARPA.

*Cupressus macrocarpa* is a difficult species to raise and it is apt to suffer heavy losses both in the nursery and after planting in the forest. This is due in part to the nature of the growth which is made in the nursery and which leads to the development of a long shoot and a deep-going sparsely branched root which is not altogether suitable for planting, especially in shallow soils. There is the additional difficulty that the roots become active early in the year and may indeed be growing all through the winter if the weather is mild, and if the plants are lifted when the roots are thus active drying out inevitably follows with subsequent heavy losses.

Accordingly, a small experiment was carried out during 1931–32 at Kennington Nursery, Oxford, with a view to the improvement of the root system of 1 + 1 transplants of *Cupressus macrocarpa*. It was hoped that by early lifting of the transplants and by heeling-in for a considerable period a more compact and fibrous root system might be developed, a root system more suitable for planting than that normally produced.

The following treatments were therefore carried out :—

(A) Transplants lifted from the lines and heeled-in on September 9th, 1931.
(B) Transplants lifted and heeled-in on December 4th, 1931.
(C) Transplants lifted and heeled-in on February 4th, 1932.
(D) Transplants lifted at time of despatch for planting on April 11th, 1932.

When the plants in Treatment (B) were lifted from the lines, those in Treatment (A) were also lifted from the heeling-in trench and heeled-in a second time. Similarly, when the plants in Treatment (C) were lifted in February, those already heeled-in in (A) and (B) were again lifted and heeled-in a third and a second time respectively. On April 11th all plants from each of the four treatments were lifted, packed in damp moss and despatched to the planting area.

*Treatment A.*—At the time of lifting roots were active and watering was necessary after heeling-in as the plants began to wilt. When they were lifted a second time on December 4th, root activity had increased and an abundance of new tertiary roots had been formed, while on February 4th the roots were still active and what was more or less a " ball " system had formed.

*Treatment B.*—On lifting from the lines on December 4th, the roots were found to be slightly active, but on February 4th, although a little root activity was still in evidence, there was little change in the character of the roots.

*Treatment C.*—There was no root activity noticeable when the plants were lifted and heeled-in on February 4th. No apparent change took place during heeling-in.

*Treatment D.*—There was no appearance of root activity on April 11th when the plants were lifted.

*Observations in the Forest.*—The transplants were planted out at Buriton near Petersfield, Hampshire, on a shallow soil over chalk, and in planting the nursery treatments were kept separate from each other. At the end of the first season in the forest a count was made of deaths and the following result was obtained :—

| Nursery treatment. | Percentage of deaths. |
|---|---|
| A. .. .. | 12·3 |
| B. .. .. | 37·3 |
| C. .. .. | 53·3 |
| D. .. .. | 78·0. |

These figures are interesting as showing the beneficial effect of early lifting and prolonged heeling-in on the subsequent establishment after planting. Plants which were sent straight from the nursery lines to the planting area failed disastrously, while the percentage losses increased as the period of heeling-in was shortened.

It appears that early lifting and heeling-in while the roots are still markedly active is the most promising method of producing a root system well adapted for planting, and although this conclusion is based on one year's work only it is felt that it is sufficiently definite to be brought to the notice of foresters.

J. MACDONALD.

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## NURSERY TREATMENT OF SOME LESS COMMON SPECIES.

The following notes are based on observations made over a number of years on a variety of species at Kennington Nursery. The species have been grouped according to the treatment found to be most suitable.

Stratifying the seed in sand after harvesting has been beneficial for certain species, and has in many instances increased the yield. It has invariably produced a more vigorous type of seedling. The method of stratification used has been to mix the seed thoroughly with the sand and place the mixture either in well-drained flower-pots plunged in the soil to ground level, or in a mouse-proof pit, a convenient depth for which is 18 in. In all instances the container should be filled to ground level. Under such conditions seed commences to germinate with the gradual rise in temperature in early spring, and requires frequent examination after the beginning of March.

Species requiring stratification for one year previous to sowing :—

| | |
|---|---|
| *Pinus peuke.* | *Tilia parvifolia.* |
| *Cupressus nootkatensis.* | *Liriodendron tulipifera.* |

Species to be sown immediately after harvesting or to be stratified until the following spring :—

| | |
|---|---|
| *Hicoria ovata.* | *Hicoria amara.* |
| *Hicoria cordiformis.* | *Castanea japonica.* |

*Pyrus intermedia.* For immediate sowing seed should be washed free from the ripe fruits. 1 pound of fruits yields 600 seeds.

*Pyrus aucuparia.* For immediate sowing seed should be washed free from the ripe fruits. 1 pound of fruits yields 2,400 seeds.

Species to be sown immediately after collection :—

| | |
|---|---|
| *Ulmus campestris.* | *Ulmus parvifolia.* |
| *Ulmus montana.* | |

Species for which stratification is beneficial but which can be stored dry over winter :—

| | |
|---|---|
| *Nothofagus obliqua.* | *Nothofagus dombeyi.* |
| *Nothofagus procera.* | *Cedrus atlantica.* |

Species for which the effect of stratification has not been ascertained but which have given good results after dry storage over winter :—

| | |
|---|---|
| *Pinus densiflora.* | *Pinus monticola.* |
| *Pinus thunbergii.* | *Cupressus obtusa.* |

*Pinus resinosa.*
*Pinus attenuata.*
*Pinus coulteri.*
*Pinus lambertiana.*
*Pinus sabiniana.*
*Pinus pinea.*
*Cupressus pisifera.*
*Cupressus arizonica.*
*Thuja occidentalis.*
*Libocedrus chilensis.*
*Sophora japonica.*

W. G. GRAY.

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### FROST DAMAGE TO SITKA SPRUCE.

The following observation recorded at Kennington Nursery may be of interest. 1 + 1 transplants of Sitka spruce, I. No. 33/1, origin U.S.A. (Elk Creek, Oregon, sea level), were damaged by frosts of 10° and 13° on October 31st and November 1st, whereas similar transplants of Sitka, I. No. 33/13 (Queen Charlotte Islands) growing alongside, were not affected. The latter, at the dates on which frost occurred, had ceased growth and formed buds, while the former which were damaged were still growing. Frost damage was confined to the leading shoot.

There was a marked difference in colour between the two lots. The Elk Creek lot were light green in colour while those from Queen Charlotte Islands were dark bluish green. W. G. G.

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### CONTROL OF CUTWORM IN SEEDBEDS.

The use of Paris green during the past season has been successful in reducing the number of cutworms (*Agrotis*) in the 1-year seedbeds at Kennington Nursery. The preparation of the bait and amounts required per 100 sq. yds. of bed are as follows :—

Paris green ½ oz. Bran 10 ozs. Slightly moisten the bran, then mix with the poison. Sow broadcast during dry weather and towards evening if possible. W. G. G.

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### EXTRACTION OF FOREST PRODUCE.

As the time is drawing near when the Commission will be faced with the preparation and disposal of increasing quantities of conifer thinnings, perhaps a few remarks on extraction will not be ill-timed.

It is, of course, well known that much of the produce will be of a low-grade type and that all costs must be kept to a minimum if the operation as a whole is to be an economical one. Of all costs, extraction (including delivery to railhead) is the most serious and especially so in hilly districts where steep gradients and marshlands abound and where there are no roads worth speaking of. The point then to be considered is how to overcome high extraction costs in those backlying and difficult areas. If the Commission were merely timber merchants who, after dealing with a particular parcel, were never likely again to haul from the same area, temporary measures might meet the case. The Commission, however, have to bear in mind that similar operations in the same plantation will be repeated every 10, 15 or 20 years, as the case may be. It would therefore appear that something substantially different to temporary measures ought to be undertaken.

The writer's opinion is that whenever possible the making of a system of roadways, linking up plantations with existing highways, ought to be proceeded with at once. These roads should have solid foundations, the gradients eased where necessary, and rendered capable of use by motor transport. Produce would then be delivered direct from plantation to destination at a comparatively low cost. Possibly arrangements could be made whereby the initial expenditure on roadmaking would not fall entirely upon the Commission. In many cases the road material could be quarried quite near to or alongside the proposed line of route from the Commission's quarries.

It is not intended to infer that all plantations could be dealt with in this way, but there are undoubtedly many areas that could be tackled with a resultant lowering of extraction costs. The work would not only be of benefit to the Commission, but in the event of a national emergency would be of incalculable value in the matter of the nation's timber supply.

T. Kennedy.

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## Selling low-quality Pitwood.

Having several small larch plantations of about 40–60 years old at Radnor, it was decided to fell them and sell the produce. A contract was obtained to supply a large number of split bars, which meant a sawmill. Eventually a contract was made with a sawyer to split these as and when required. Contracts also had to be made for hauling from the wood to the mill and also from the mill to the station.

Our own men were to do the felling and cross-cutting, on piece work rates. This started all right, but after felling a quantity, and tushing it out, small quantities of certain sizes were called for, which meant a tremendous amount of sorting and lifting to get a very small amount. Naturally, wages offered were very low, and this caused a great deal of dissatisfaction. However, this was smoothed over and work was carried on. Various types of orders came along, but all seemed to be for the same size of timber, making it impossible to clear any one portion. As the plantations are at an altitude of approximately 1,300 ft., small and fairly exposed, one can picture the prevailing type of timber, and, when all orders are for clean and straight stuff, the difficulties can easily be imagined.

A fairly good market is found with local farmers for stakes sawn and jointed, which accounts for much of the rougher type, although, of course, entailing a lot of waste. For some of the larger class a good order was obtained for scantling from the local County Council for use on a road-widening scheme. The smaller type of timber has not been touched yet, but doubtless orders will come along for this in due course, although by now this must have lost a tremendous amount of weight. This, doubtless, will mean another difficulty, as all felling, cross-cutting, tushing, hauling, etc., are being worked on an estimated tonnage basis (*i.e.*, 32 cu. ft. to the ton) and going out at railway weights. I am afraid there are going to be tremendous differences between actual weights and those shown on paper. Very high prices have been obtained for the produce despatched up to the present, which will no doubt compensate for loss of weight in the remainder. Nevertheless, it is a moot point as to which of the following is the better proposition : (1) a high price for the best, with a lot of waste, a great loss of weight through lying, and possibly a very low price for the remainder, or (2) a fair price for the whole.

Of course, from a working point, the latter is preferable, but final figures only will show the results from a financial aspect. From the workmen's point of view, although a poor-paying game, there is the satisfaction of knowing that if there had not been this work the men would have been unemployed as it occurred during the slack period when there was nothing else for them. Unfortunately, however, the men here are of a type who like to cry before they are hurt, so one can guess that to mention pitwood is like showing a red rag to a bull. Still, I hope to survive long enough to give my views of the finish of this operation in a future number.

P. Harrison.

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## Damage to young Plantations by Wind.

One night last May a severe gale swept across Merionethshire, and its full force was felt on the exposed areas of Vaughan Forest. The direction of the gale was W.N.W. ; consequently there was very little break between coast and forest, which are from 8–10 miles apart. The temperature at this particular period was rather low for the time of year, but well above freezing point.

On the following days, in a large number of plantations, damage was noticed to the current year's growth, specially on the branches on the side exposed to the gale. This damage took the form at first of bruising the young shoots back to the last year's wood. In about 4–7 days the damaged shoots were brown in colour, giving the appearance of an attack of a fungus, or an insect, or possibly frost injury. The temperature had been above freezing point, however, and visits paid to one or two of the plantations on the previous day showed that the trees were then uninjured.

The main species which suffered were D.F., E.L., J.L., S.S. and N.S., also a belt of *Tsuga,* which appeared to suffer more than the other species. It was also interesting to note that needles from D.F. and larches actually covered the ground in places after the gale. Bracken also suffered, causing the top to die back; this was only noticed on areas exposed to the gale.

The plantations are situated at elevations between 200 ft. and 1,000 ft., and the ages varied from 5–10 years and the heights were from 5–15 ft. Possibly, this type of damage has occurred previously to other plantations at a fairly high altitude and has been wrongly attributed to frost.

On another occasion I noticed a Norway spruce plantation, age 7 years, altitude about 1,000 ft., which had been damaged in the same way but not so extensively, and, strangely enough, very few leaders were affected; the damage had been done soon after flushing had commenced. At the time of writing the plantations have apparently suffered no check as growth is normal and the damage is disappearing. G. C. EGGLETON.

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### DIFFICULTIES OF DISPOSAL OF PRODUCE.

The wood in question is situated on a ridge running from east to west at an altitude of about 1,500 ft., with the ground sloping north and south. Peat, where present, is seldom more than an inch or two thick; the vegetation consists of bracken, bilberry, gorse, grass and heather. On the south-west aspect damage has been done by windfall, owing to overthinning when the plantation was in the hands of timber merchants, who selected the timber most in demand, *viz.*, larch, and left a poorly stocked area. Had the plantation received proper silvicultural treatment, it is clear that in spite of poor conditions the area could have produced good timber. The age of the plantation is 40 years and the average height 43 ft. The species originally consisted of a mixture of N.S., S.P. and E.L. In its present state the wood is almost pure N.S. Owing to the removal and dying-off of species other than spruce, the timber is coarse, uneven and much branched. In trying to market this wood for telegraph and scaffold poles, small ships' masts, etc., one big difficulty has been the rapid taper, for the margin allowed in the selection of poles is very small.

All poles felled have to come up to the specified measurements and cannot be taken on the same lines as felling for pitprops or for the saw-mill. Poles selected have come from all parts of the wood where suitable material could be found, and measurements have had to be taken standing and over bark. The diameter at butt can easily be obtained, but the top measurement at a given height has to be estimated, and care must be taken as the poles are checked after being felled and peeled. All poles do not turn out the same, although, when standing, the trees may appear to be identical. After peeling some may have dead, internal knots, or swellings at the whorls. Those with swellings produce the best poles providing the knots are small, whereas if the swellings are large the pole is weakened.

Dead knots give the pole a bad appearance, apart from taking longer to trim. Another defect, not very conspicuous until the bark has been removed, is where there have been two leading shoots, one of which has died off and the bark grown over leaving a long knot. The only disqualifying feature met with was crookedness, and this was confined to the upper third of six poles only.

We are trying to compete on very high exposed land with unfavourable transport conditions, and at an early felling age, with timber such as is now produced abroad in older forests. In spite of disadvantages, well-managed plantations could undoubtedly produce better stuff, and there is every reason to expect that we shall be able to rival the foreigner in the future.

S. Watkins.

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### Portable Ladder.

In hilly country such as we have at Kerry, to carry a ladder from the stores and back for tree-lopping takes up the best part of a day for two men. A ladder which is both light and efficient can be made on the spot in two hours out of a spruce pole 15 ft.–20 ft. long and 4 in. diameter, by boring the pole with ⅝ in. holes every foot and cutting pegs 10 in. long to go through the holes. This will enable a man to climb on to the lower branches of most trees.

S. W.

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### Our clerical Work.

I consider there is a vast difference now between the amount of clerical work a forester has to do compared with that required in the Office of Woods days. Now there are many forms and returns which the foresters (including foremen) only have to complete, and there are a number of points connected with them that I think, perhaps, could be altered and which would reduce work—as follows :—

(*a*) The A.35 Cash Sales form appears overdue for revision. As it is at present it is suitable for use in an office, but not for carrying round to the purchasers. Owing to its size and the paper-binding, the general method of transport is to roll it up to a reasonable size with string or a rubber band. This works fairly well when the book is new, but after a time it takes on a " permanent wave," and it is a work of art getting the carbon sheets into the right places, especially if it happens to be windy. A stiff cover book about the size of the A.70 Produce Book would be much handier.

(*b*) The new Progress Reports would be better bound at the side instead of the top. If bound at the side the previous fortnight's page could be doubled back, so that the totals to date can be seen, instead of having to turn the previous page in order to bring the totals forward one at a time. The " nature of work " column of both Part I and II could with advantage be reduced. This would give more space for the " totals to date " columns both of work and cash. The " quantity " column is wide enough for the majority of heads, but in the case of " planting and beating-up," where both acres and thousands have to be entered, it means a tight squeeze. If this were altered it would certainly help those who have to check our figures.

(*c*) I would also suggest that a standard form of bill-head be supplied for copies of accounts. In a number of cases it is hard enough to get one bill made out, let alone a copy as well, with the result that we have to make a copy on whatever paper is available. Some bills in pad form would save a lot of trouble.

(*d*) The provision of rubber stamps with the Divisional Office and District Officers' addresses would also save a lot of writing.

W. G. Roberts.

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## The Planet Junior Hoe.

It is generally found when using the planet hoe amongst large plants, that the branches of the trees catch in the square corners of the castings to which the various tools are bolted. These sharp corners catch against the stems of the plants with consequent damage.

We have overcome this at Mortimer by obtaining two pieces of hoop iron, about 1½ in. wide and long enough to reach from the wheel axle to the lower bolts that secure handles. These have been bent in a gradual sweep from the wheel, tight against the corners and up to the handle bolt. Suitable holes have then been drilled in each end and each piece has been fitted under the axle nuts and the handle bolts. This gives a streamline effect, and as the hoe is pushed forward the guards turn the branches safely to each side.

With this addition it has been found possible to use the hoe between large plants, even when the branches are almost touching across the rows.

W. G. R.

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## Cannock Chase Fire.

An outbreak occurred at noon on July 8th, on a road running along the east side of a P. 21 plantation, whilst a strong easterly wind was blowing directly into the plantation.

At the time of the outbreak I was about a mile away on one of the highest plantations, and immediately on seeing the smoke I went to investigate. On arrival I found several of our men trying to cut a way through in front of the fire, but owing to the height and density of the plantation, I came to the conclusion that this was uselsss, and even at this stage we were getting trapped as the flames were spreading very fast in three directions.

The only possible method now was to counter fire, so I gave orders to carry this out on the south, north and west sides of the fire. This was successful, and we managed to confine the fire to 15 acres. Without delay I placed men around to keep a good watch, dig a trench and bury smouldering peat, and also to use the waterpacks on peat found to be smouldering near the edge of the adjacent Compartments. Now being satisfied that matters were temporarily in hand, I released some of the men to fetch more mattocks and spades and also some to patrol the area in case of further outbreaks, as hundreds of onlookers were scattered about the forest.

About two hours after the commencement of the first outbreak, the fire started afresh in the adjoining Compartment across the ride opposite the first line, *i.e.* due west and approximately 40 yds. in from the edge of the ride. As soon as this was seen, a rush was made to beat this out, but we were held back by flames and smoke as in the first outbreak, and very shortly the fire spread in all directions and burned more rapidly. Orders were again given to counter fire and this would probably have been successful, had it not been for the wind causing particles from a bracken patch to drop over the ride into the next Compartment and setting this on fire 50 yds. in front amongst heather, at least 2 ft. high.

At this stage the wind changed slightly and caused the flames to spread back into the Compartment where the fire first started. The front was now about a mile wide and leaving no other ways or means but to counter fire on two rides, running the whole length of the flank, and let the fire burn forward through the whole plantation in front. In this we were successful. If we had not been able to confine the fire to this area, and it had broken out once more on either of the flanks, it is questionable if the whole block amounting to several hundred acres would not have been destroyed.

It appears to me that experience has been gained from this fire and I would make the following suggestions :—

(*a*) It is usually a waste of time trying to beat out a fire in a twelve-years-old plantation.

(*b*) It is better to counter fire at once on the first rides available and so prevent sparks from coming over the rides.

J. F. Cowe.

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## Hinged Turfs.

In P. 29, at Radnor Forest, owing to steepness of slope, dense bilberry and heather, great difficulty was experienced in making turfs sit properly. An area of about an acre was experimentally treated in such a way that the turf was not completely severed and the method was so successful under these conditions that it is now in general use in the district on steep slopes where turfing is essential but draining is not. This hinged turfing, as it is called, has many other advantages—especially where winds are strong and only a relatively thin turf can be cut—a description of the method may be of interest to others.

The method of cutting is as follows :—The turf is cut on three sides, the lowest side being left uncut to act as a hinge, and the turf is folded back over the hinge. In most cases, *e.g.*, grass areas and where heather or bilberry is not dense, such a turf sits well, but where the vegetation is dense a proper seating is obtained by cutting the hinge along half its length. The resulting turf is naturally thinnest on the hinged side and thickest on the lower side, so that we obtain a more or less horizontal planting surface instead of a sloping one which results from the normal method of turfing. This has the advantage of reducing the loss of soil by washing.

Turfs can be cut either with mattock or spade, but experience shows the latter produces the best results. The rates for cutting vary from 15*s*. per thousand on *aira*, *nardus* types to 20*s*. or more on bilberry and heather types, which compare favourably with the cost of the usual method.

In planting great care is necessary as regards the point of insertion of the plant. There is a tendency to plant at the hinged end ; as the depth of soil at this point is least it leads to drying out. Normally the centre of the turf is best, but as there is a gradual variation in the thickness of the turf some latitude is possible to suit the size of plant being used.

Various tools have been tried for planting. The mattock can be definitely dismissed as unsuitable. If the plant is not too large best results are obtained with the dibble, for both with seedlings and transplants failures are fewer and appearance is much healthier than with the spade.

F. E. B. de Uphaugh.

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## Check in Douglas Fir.

We are accustomed to seeing spruces check for a number of years when surface conditions are not wholly favourable and finally they come out of check and develop normally. This power of recovery after check, due to the development of an entirely new root system, is common to the spruces but is not a normal occurrence with Douglas fir, and the following observations tend to show that once really in check there is little chance of recovery.

At Dovey Forest, a steep slope with a western aspect was planted P. 27 with Douglas fir. The vegetation consisted of a mixture of grasses and mosses, with barely perceptible heather and bracken in patches. Now after seven years of enclosure from sheep the vegetation has turned to short dense heather, bell heather, lichens, mosses, scant coarse grasses and bilberry, with bracken patches as before. The soil consists of 0 in.–$\frac{1}{2}$ in. peat on 1 in.–2 in. peaty clay on 18 in.–24 in. deep yellow clay loam on deep gravel. No record was made before planting and it is possible that the peatiness of the surface has increased with the increase of peat-forming vegetation. The plants were probably not very well rooted and were planted with the mattock by the ordinary notch method. By 1931, the better parts of the plantation were growing, but the worse parts were in check, not having grown since planting, but here and there an occasional tree seemed to be beginning to grow, so it was decided to label and describe some of the worst examples and find out exactly what was happening.

After a period of three years the following results were obtained from 24 trees :—8 were dead, and of the remainder 2 were much worse, 4 slightly worse, 3 no change, 3 slightly better, 4 just starting to grow. In 1931, none was growing perceptibly and all were yellow except four, which were of an almost normal green, and it is these four which are now coming out of check.

The conclusion is that once Douglas fir get into a state of yellow check, life may hang on for years, but recovery is very unlikely and it is better to replace them with another species before many years are lost. The fact that some trees never really checked but grew slowly from the beginning suggests that check might have been avoided by destroying the unfavourable surface conditions by pit planting or some similar method, but evidence on this point is lacking.

F. C. BEST.

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### GROUPS OF ASH IN COPPICE AREAS.

An area of slightly over 20 acres was planted at Bourne, Pickworth, in P. 34, there being 100 groups of plants per acre, with 16 plants per group. Advantage was taken of natural regeneration and good coppice ash situated in each group. Each maiden ash counted as one plant towards the requisite 16, while from a coppice stool one or more of the best shoots were similarly counted.

The groups were 21 ft. from centre and of 12 ft. diameter. The planted plants (*viz.*, those required to make the total of planted and natural plants 16) were put in in rotation. No. 1 plant was in the centre of the group, Nos. 2 to 7 made a ring of six plants 3 ft. away from the centre, while Nos. 8 to 16 constituted the second ring 3 ft. out from the first. By this arrangement the plants were evenly spaced at approximately 3 ft. in each direction.

The groups were spaced so that each was opposite a group in the second row away, thus being opposite a space in the adjoining rows. The intervening spaces will be cropped with beech when the groups have reached a substantial height, unless natural ash has successfully colonised them. It is rather costly to mark the site of each group with a stick, but this is essential to facilitate weeding when the coppice growth is high. Similarly, costs mount up in the planting operation through time spent on seeking out and counting the natural ash in the groups.

The year's planting was at an elevation of 300 ft. having a soil profile thus : one in black soil with normal humus content, 2 in.–3 in. of brown loamy soil with lighter humus content, 12 in.–24 in. of clay loam merging on to limestone rubble with flints and chalk pebbles, the whole over a limestone rock bed of unknown depth. The vegetation was that usually associated with such a soil, *viz.*, ash, oak, hazel, coppice, dogwood, blackthorn, whitethorn, bramble, dog rose, honeysuckle, bracken, spirea, juncus, willow herb, wild strawberry, speedwells, etc.

The plants used were ash 1+2 or 2+2, of height 15 in.–18 in., clean-stemmed, with good fibrous root systems and sturdy growth. It is essential that such good plants be used, if quick establishment is required.

Definite procedure in weeding the group was found to be conducive to better and cheaper work. The outside circle was weeded first, then the inner circle and finally the centre plant. Costs worked out higher than in straight row by row work, being 10*s.* per acre against 7*s.* 6*d.* to 8*s.* Discretion had to be exercised in interpreting the technical weeding orders on these group areas. To prevent loss from drought, weeds such as spirea, juncus and willow herb were left. The shade thus afforded saved thousands of plants from death by insolation. Stock-taking revealed losses as low as 2½ or 3 per cent. over the area, while maximum leader growths were 9 in., minimum 3½ in. and average 5 in.

Although the initial preparation and planting costs were £2 18*s.* 0*d.* per acre, using the semi-pit method of plant insertion, results seem to uphold this technique. However, more will be said as to the advantages and disadvantages of this method over the old one of clear cutting and planting row by row, in two or three years when more information has been collected.

It would appear that the areas to be so treated should be rabbit-fenced and warrened two or three seasons in advance of planting. The great advent of natural regeneration will then afford a saving to offset expenses of earlier fencing, since the number of plants necessary to be planted will be substantially reduced.

A. Birkett.

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## Fire Fighting.

Mention was made in the Journal for 1933 of gas masks for use when fire fighting. As a rule the opinion held is that general use of masks is impracticable, and that only trained troops can be expected to carry out any arduous fire fighting so equipped.

This difficulty may be overcome by the use of vinegar on an improvised mask. If a large handkerchief or scarf is soaked with vinegar and tied lightly over the nose and mouth, it will be found that breathing will continue to be easy in the densest smoke ; also there will be no choking or burning sensation in the throat. Fresh applications of vinegar are required as the mask becomes dry, but as vinegar is easily and cheaply obtained, and can always be kept in stock by the forester along with the first aid outfit, this should present no difficulty. It is true that the use of such a mask affords no protection to the eyes, but men will work in the forefront of a fire so long as respiration is easy, for throat contraction and smoke blindness seem to be correlated.

A. B.

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## Fire Notices.

May not fire danger notices on occasions be the unwitting cause of forest fires ?

In March, 1933, and again in 1934, the forest fires broke out underneath notice boards in Sherwood Forest, and there is reason to believe that both were deliberately started by youths of an irresponsible and mischievous nature.

There is no doubt that the fire notices make careful and sensible people more wary and cautious, but there would seem to be a type of person to whom such a notice is a definite incentive. One can imagine their line of reasoning being "Fire Danger! My Goodness! I never thought of that! Come on, let's start a fire somewhere." It would be interesting to have the opinions and experiences of other foresters.

R. Bewick.

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### Fire Warnings.

It has occurred to me that a great percentage of the general public, when passing through a newly planted area, are not aware that it is a forest. If the road is one that leads to some seaside or other holiday resort, and there are many cars, etc., passing through, the existing fire notices are not seen unless the occupants happen to stop near one. If a motor vehicle is travelling fast, a cigarette end thrown out will sometimes travel a long distance into the hedgerow, thus causing a fire if it is very dry weather.

I suggest that a large board, with letters of sufficient size to be read by motorists, warning them to be careful with their cigarette ends and matches, be erected at right angles to the road at either entrance to the forest.

H. R. Halsey.

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### Fires in Hardwood Belts.

At Bawtry Forest, the main north railway line is a source of many fires. The adjoining hardwood belts are mainly of oak and recover to some extent after being burnt. Recovery is found to be surest when the oak is in fairly thick grass, which, although dry for most of its height, is generally green enough at ground level to afford some protection to the collar of the oak plant.

After a fire the oaks generally shoot away from the bottom for a height of 9 in. to 12 in., but in one case astonishing results were achieved on a small area of about 100 sq. yds. After a fire at the end of July, the burnt oak plants (P. 30) were pruned off at the bottom, and then they proceeded to put forth shoots much longer than those on trees having their year's growth untouched by fire.

A. T. Gunter.

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### Game Problems.

It would be a great boon to those in charge of nurseries if some method other than wire netting for protecting seedbeds from pheasants and partridges could be devised.

At Bawtry Forest the position has been desperate on occasions. Neither scarecrows nor personal attendance until a late hour has succeeded in keeping the birds off oak beds, as all the birds are reared in the neighbourhood and very tame. The use of netting is not always effective or desirable, while the use of a gun, although being the ideal, is not to be thought of if leases are to be honoured and neighbourly relationships left unstrained.

A. T. G.

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### Oak Seedlings on old Sawdust Dumps.

On the P. 34 area of Bardney Forest were found three old sawmill sites, on which the growth of 1-yr. oak seedlings is worthy of note. Before the area was handed over to the Commission it was cleared by burning, and these sawmill sites, thick with sawdust, burned for weeks. The result on these places was a layer of from 12 in. to 15 in. of red ash which turned to slime with the advent of wet weather.

The P. 34 planting was carried out with a mixture of five 1-yr. oak to one transplanted ash (2+1), planted after the soil had been turned over and churned up to a depth of one spit. The trees were put in early in March, and at this time the soil beneath the sawdust ash was bone dry and as hard as flint. By the middle of August, the oak seedlings had registered three periods of growth, each period coinciding with rain after a dry spell of weather. The first growth was fairly uniform, averaging 2 in., but the following two growths were very irregular. In some instances the second growth exceeded greatly the third, and in others the reverse happened, but the maximum growth put on during the summer was 22 in. A few isolated oaks have put out a fourth flush of leaves since August.

These old sawdust sites remained bare of any vegetation, yet the trees never showed the slightest signs of flagging, while on the remainder of the forest which had much protection from insolation by its natural vegetation, the drought and heat affected the plants considerably.

It is interesting to note that the ash planted with the oak on these sawdust sites have shown no difference in growth from the ash on the rest of the P. 34 area, their leaves, however, are distinctly deeper in colour.

G. H. Button.

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### Hints on Sowing Conifer Seed.

When drill sowing in drills running parallel to the length of the bed, much time can be saved after the bed has been prepared and tilthed by cutting the drills out with a home-made wooden instrument, resembling a miniature multi-shared plough. This instrument is capable of forming eight drills at once, each $1\frac{3}{4}$ in. wide, and is made as follows :—

A piece of boarding is obtained, about 4 in. wide and of a length equal to the bed width plus double the path width. This is so that when used the drills formed will be in exact relation to the adjoining beds on each side. To this board are fixed the eight wooden drill cutters, each 1¾ in. wide and spaced 6 in. from centre to centre. They are slightly pointed, 1 ft. long, and lower at the back than at the front, being 5 in. front height, decreasing to 2 in. at the rear. To the back of each is attached by a string a piece of lead 3 in. long and 1½ in. wide, the function of which is to break up and level all the pieces of earth that fall in after the passage of the cutters. To this wooden top board are attached two leading spars, one at each side, by which the whole apparatus is dragged up the bed. Owing to the upward sloping form of the cutters which gives the main board an upward cant across its width, these dragging spars rise from almost ground level to waist height, thus enabling the plough to be drawn by two men without stooping. The dragging spars should be fixed just inside each outside cutter so that the resulting outside drills can clearly be seen. A top cross-bar fastened to the dragging spars is an optional fitting to give rigidity and greater ease of dragging.

For sowing in these drills, a round ¼-lb. cocoa tin is preferable. For sowing Corsican pine seed, two holes are required in the bottom of the tin. The tin is tied tightly into the fork of a forked stick so that the two holes are in line with the drill, and the other end of the stick is held by the sower. This holds good for each outside drill, but as one works into the centre of the bed, it is necessary to twist the tin in its fork, so that the two holes are always in line with the drill even though the holding stick is at an acute angle to the bed.

The covering of these beds is swiftly and efficiently done by a chain, 24 ft. in length, having a twisted link formation. Each end of the chain is held by a man walking on the path each side of the bed, so that the chain drags behind in the form of a big loop. As the men walk up the bed so the chain sifts the covering earth over the bed regularly and in a fine state. This method is much quicker than the rake method.

J. McGlashan.

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### Sheltering of young Pine from excessive Sun and Heat.

During the drought and heat-wave periods of 1934, an area of approximately 4,000 sq. yds. of 1-yr. C.P. seedlings had to be sheltered in some form or other, as they were otherwise completely exposed to the scorching sun and would all have perished.

The method decided on was bracken fronds. The bracken was cut very carefully, special attention being paid so that the stalks were neither bent nor broken. This bracken, having been transported to the nursery, was used on 4 ft. wide seedbeds. The stem of the bracken was pushed 4–5 in. into the ground, two rows to a bed, 15 in. apart in the rows and 2 ft. between the rows. The bracken afforded the same shelter after it had died, as the frond area was not diminished, while it was firmer, due to the stiffening of the stems when dead.

This precaution saved the plants and cost 1*s*. 0½*d*. per 100 sq. yds.

J. McG.

## Pinus Contorta on Sandy Heath.

On a pure sand site, the vegetation being heather type, an experiment was carried out with 1-yr. P.C. seedlings.

The heather was screefed at the place for each tree, the soil was turned upside down for one spit depth and then trodden hard. The seedlings were slot-notched in, tightened and left for the season, no weeding being necessary. In spite of the drought these plants have grown surprisingly well, losses being 3–4 per cent. and shoot growth 2–3 in. J. McG.

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## Soil Fertility in Nurseries.

During last summer an incinerator was made with the irons from some disused hurdles to make the grating and with clods of earth for the walls. The grating was oblong in shape, and at the two smaller sides openings were left in order to extract the ashes. Only one opening was allowed according to the prevailing wind, whilst the other was closed by means of a piece of corrugated iron. On this most of the weeds were burned and a large quantity of ash obtained, which being rich in potassium carbonate was collected for manuring.

Nature, however, invariably establishes a balance in all her undertakings and the above process has disturbed this. It is therefore necessary to rectify it. By not allowing the weeds to decay or to be dug in, the soil is being robbed of organic nitrogen, which in itself is not a plant food but is essential to their requirements in the form of nitrates. In the course of the life process of plants, nitrogen of the nitrates is converted to organic compounds known as proteins. These must revert in the normal way either through animal or plant decay to the soil where ammonia salts are formed. The nitrogen of this ammonia is then converted to nitrites by nitrifying bacteria present in the soil, and there is further conversion by a second class of bacteria to nitrates. These being soluble are easily assimilated by the plant roots, and when the plant dies the process of decomposition is repeated and the nitrogen cycle continues.

To compensate for the loss by the removal of plants from the nursery and that due to combustion in the incinerator, it is necessary to give to the soil an ammonia salt which will expedite the process described. The remains (well rotted) of a nearby haystack offered what was lacking in the form of humus. This was distributed over the nursery area and ploughed in. The ashes were then scattered over the ploughed work followed by a dressing of sulphate of ammonia. The soil was then harrowed and rolled in preparation for lining-out and seedbeds.

In the nursery, ash and Douglas fir plants were standing over from the previous year, when the area was manured with farmyard manure. It will be interesting to compare their rates of growth last year with the growth of the same species lined-out this year, although account must be taken of any difference in the two seasons. C. P. Carr.

## Damage by Voles.

On April 16th, 1934, voles attacked the Douglas fir (Compartment 48) at Swaffham. The Douglas fir were planted in P. 29 average height 4 ft. 6 in., in a dense cover of privet where weeding has been done continually in the form of tracks cut through about 5 ft. wide. In many cases the voles completely peeled the main stem and part of the branches from the ground level to the extreme top. About half-an-acre suffered severely, in some rows as many as six trees were peeled without missing one. In the first 10 days after seeing the damage my warrener trapped 27 voles at the bottom of the trees where they had been at work. The traps used were the old-fashioned box traps baited with bread fried in beef fat—I tried the little nipper mouse traps, but found them unsatisfactory, the only things I caught with them being small wild birds through the bait being exposed and easily seen. With the box trap the bait is hidden.

To confine the attack to the smallest possible area, I surrounded the affected part by pouring a ring of coal tar completely round it. This was done once a week, and I am of the opinion that it gave assistance in confining the damage as some of the voles caught had tar smeared on their legs and body, showing they had tried to extend their hunting ground. In addition to the box traps, I caused the warrener to locate all holes and stumps of hollow trees and to drop a small piece of carbide into each one, so that when the dew at night dissolved it the resulting gas threw out a very disagreeable odour. Altogether we caught 30 voles in action and about 12 common field mice. It was fairly plain to see that most damage occurred in the densest ground cover and secluded places. These parts I had weeded heavily to reduce their cover. No trace of damage has been located since, and I attribute the attack partly to the very rough swampy land leading from the wood to a slowly-running stream.

Thos. Hendrie.

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## Recuperative Powers of young Plants.

Some interesting information on the recuperative powers of Corsican pine and oak was obtainable during P. 34 from Deerdale (Clipstone) Nursery and Bardney Forest respectively.

Deerdale Nursery is on Bunter sandstone formation and dries out to an extreme point in drought such as experienced in 1934. No rain fell from the time of lining-out a large quantity of 2-yr. C.P. until August 6th, and on examining the soil in July, it was found to be completely lacking in moisture down to 18 in. depth, the plant roots being extremely dry. A count taken on this occasion revealed a 78 per cent. loss of plants. Rain fell fairly plentifully after August 6th and at stocktaking time these pine had recovered to the extent that only 54 per cent. were counted as culls.

In Bardney Forest, the major portion of P. 34 planting was done on a boulder clay site with 1-yr. oak. The weather conditions following were similar to those given for Deerdale Nursery above. By the end of June, considerable numbers of plants had their leaves entirely brown and shrivelled, although the stems still appeared healthy. After a period of rain 90 per cent. of these plants flushed again producing an excellent set of leaves, and before the growing season ended had put on leads up to 4 in. At stocktaking time the losses over the whole area were so small that beating-up was unnecessary.

C. A. CONNELL.

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## WINDTHROW.

One evil which must in particular be guarded against is the danger of windthrow, and where the less windfirm species are extensively planted all precautionary measures towards rendering stability to the crop should be considered.

The windward margins of plantations are usually planted or interplanted with windfirm hardwoods where the soil is suitable. At the higher elevations, however, and especially where the soil is of a peaty nature, the growing of hardwoods might be impracticable. As this ground in all probability would be drained and mounded, it is necessary to consider the question of draining along the windward margins. This matter, of course, would not require special treatment every year. For example, should each succeeding year's planting be to the windward side of the previous year's, the final windward margin alone would require special consideration.

Trees growing on a wet soil are readily susceptible to windblow, but draining unless discriminately carried out will not altogether remedy matters. I have traced the cause of windthrow in various 20–30-yr. plantations not to lack of draining, but to the drains along the windward side of the plantation running at right angles to the prevailing wind and being too near the outside of the plantation, in many cases just beyond the marginal line of trees. The cause of blowing is obvious, *viz.*, the trees being planted say 2 ft. leeward of the drain, the windward roots which are responsible for the majority of the windstrain can spread only for a like distance, which is totally inadequate for the prevention of windblow.

I would suggest the following procedure for the various hypotheses mentioned, assuming that the ground in question is too wet to permit of *in situ* turfs being used.

1. If draining parallel to the prevailing wind be practicable, no specialised method is necessary.

2. Suppose, however, that the contour of the ground renders it necessary for the outside drain to run at right angles to the prevailing wind—cut a deep drain 10–11 yds. (depending on the planting distance for species to be used) from the boundary and spread the six rows of turfs obtained therefrom between this drain and the boundary. It is, nevertheless, usually possible to keep this drain, say, 20 yds. from the

margin, if necessary running short side drains thereto, which side drains will then be more or less in the desired direction.

3. Though not common on moorland tracts to which these remarks primarily refer, it might happen that a ditch already exists along the boundary. The method then would be—keep first row of plants at a sufficient distance—say 5 yds.—from the ditch. Keep ditch deepened, thus maintaining a lower water table and thereby encouraging a deeper root system. The consequence of the margin of a plantation being broken may become a serious problem and the necessity of keeping it intact will be readily realised. Damage from wind, however, does not always occur at the outside of plantations, but sometimes for no apparent reason in the centre. This danger might be minimised by a less number of drains of greater depth and receiving due attention rather than a super-abundance of shallow surface drains.

The foregoing remarks may be summarised as follows :— Although in some cases it might be necessary to a certain extent to ignore the general layout of main drains and the angle of confluence of main and subsidiary drains, the main object to keep in view when draining the final windward side of a plantation where it is not possible to run drains in the same, or almost the same direction as the prevailing wind, is to keep the outside drain well back from the plantation margin.

T. Allan.

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## A home-made Hypsometer.

The apparatus described below was found particularly useful for measuring trees in connection with the Plantation Census.

The materials required are a stick, 6 in. long and a piece of string about 24 in. long. A 6-in. ruler is quite convenient, while the string should be non-elastic. One end of the string is tied round the ruler just tight enough to allow of sliding movement. Knots are made at 6 in., 12 in. and 18 in. from the ruler.

The method of use is as follows, taking a perpendicular conifer as our first example. Holding stick in left hand in perpendicular position and 18 in. knot to the eye with right, slide the string up or down stick till level, meanwhile keeping the string taut. Walk backwards or forwards till the top and bottom of the tree are in a line with the top and bottom of the stick.

Measure number of yards from point of observation to base of tree by pacing, or for greater accuracy by tape. The result is the height of the tree in feet. Should it be impossible to see both top and bottom of the tree at this distance use the 12-in. or 6-in. knot, the former giving twice the height of the tree and the latter the true height. The longest distance should be taken wherever possible owing to the greater accuracy obtainable but it is seldom practicable in plantations at pole stage. In cases where both top and bottom cannot be seen at once the procedure is that applicable to all types of clinometers, *viz.*, take height from some definite mark on stem, *e.g.*, branch or knot, to top of tree, adding distance of mark from ground to the results obtained.

In the case of a leaning conifer follow above procedure, but keep stick parallel to lean of tree. The correct position of stick is more easily determined when observer stands at right angles to the direction of lean of tree.

Broadleaved trees, especially those with flat tops, can seldom be measured accurately from close quarters by any instrument, as the top is invariably obscured, and care must be exercised as the taking of a protruding branch in lieu of the top would give too high a result.

This simple apparatus has been proved to give results to within a foot of correct height. To test accuracy of the instrument, measure with it the height of a tree about to be felled, then measure with tape after felling. Should such a tree not be available, use the longest pole procurable, measuring same on the ground, then setting upright and measuring with the hypsometer. If the two measurements do not coincide make necessary adjustment or find "correcting factor" to be used.

T. A.

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### Planting Larch in frosty Weather.

In the 1933 issue of this Journal, reference was made by Mr. W. L. Ross to the effect of planting European larch in hard weather, which pointed to the fact that such weather did not adversely affect the welfare of the plants. I was interested in the statement as it coincided with my own experience. A plot of European larch was planted one frosty morning on plough-furrows which yielded with difficulty to the attacks of the spade; yet the result was highly satisfactory, no injurious effects being apparent. On the contrary, this particular plot was more successful than similar ground planted with the same lot of plants during open weather both before and after that in question, and the superiority has been maintained.

Although this practice on a large scale might not be countenanced, other factors being equal or as nearly so as possible, the planting of European larch (and perhaps other common species also) at different temperatures both above and below freezing point might prove an interesting experiment. When the native habitat of European larch is considered it would naturally be expected that the results in regard to this species would compare favourably with the others in respect of temperatures below freezing point at time of planting. Sitka spruce on the other hand might not be expected to figure prominently in point of success.

**T. A.**

## ANTS.

In a previous Journal it was asked if ants were injurious and the following may be of interest by way of reply.

On various occasions, when examining weevil traps, I have found pine weevils, longicorns and other beetles being attacked by the black ant.

Weevils and beetles when attacked by three or four ants, seem to be helpless to defend themselves. In most cases the ants would appear first to behead their victims, but in the case of weevils the wing shields are often first removed and in a short time only an empty shell remains. It is also noticeable that if weevil traps are put down where there are ants in any number, very few weevils will be found on them no matter how many may be trapped on other parts of the same area. If the ants will attack the mature weevil, there is little doubt that they must destroy large numbers of the eggs and larvae.

All the good that ants do is not underground for I have also seen them going for the larvae of the pine saw fly. On a small Scots pine, about 2 ft. high, I watched them attacking these larvae. The ants went along each twig, nipped at the larvae until they fell to the ground where others were in waiting and killed them.

I have tried confining a number of ants and weevils together, but under such unnatural conditions nothing happened.

J. MCCONNELL.

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## FROST HOLES.

The use of "late-flushing" Norway spruce for the planting of frost holes might be done more extensively, as it would appear to be a fairly successful method of getting spruce to grow where otherwise they are continually checked by frosts. This has been tried on a small scale at Montreathmont where late frosts are very bad; where they have been used there has been no check. The late-flushing in no way interferes with the annual growth, which is well up to average.

To get suitable spruces, the latest flushing ones should be marked in the transplant lines during their second year. The numbers obtainable in this way are not very large, which limits their use, but it may be possible to trace and select the seed.

J. McC.

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## BEATING-UP FROST HOLES.

The aim of every forester is to have each compartment of the forest under his charge carry one hundred per cent. stock. This is an ideal which is seldom realised, as a certain number of failures is a certainty, even on the best soils, and under favourable conditions. In the case of forests where hollows and shallow valleys which are liable to frost occur, the forester has the unenviable job of trying to produce a successful plantation under the most unfavourable conditions. The usual methods adopted to get the plants away in these bad patches are rather costly and usually entail repeated beating-up, with perhaps a change of species, heavy summer weedings, and the introduction of some new surface drains through the bad patches. Even then, quite often the net result is that the forester is left with the consoling thought that the checked plants must be developing a useful root system, and that in the near future a favourable spring will get the plants away, or at the worst when the plants surrounding the bad places get well established, the shelter thus afforded is going to bring along the bad sections.

When planting operations are under way, every forester knows fairly accurately the places on his area where he is going to have trouble with frosting, but of course the plants have got to be put in. Could it not be made possible to leave unplanted these frost holes when carrying out the usual planting programme ? The whole number of plants required for planting up a compartment could be requisitioned, but instead of planting up the frost holes, the plants so allocated could be interplanted in the lines, well clear of the frosty place. In a few seasons' time, when the plants have attained a height which is deemed sufficient to place them above danger from frosting, they could be lifted and planted in the frosty hollows. By this method the extra costs of weeding, beating-up, and over draining the bad places is eliminated, and its great recommendation is that it may be possible to have uniformly grown plantations in the place of patchy ones.

To carry the procedure a step further, could it not be made possible that in every case, when calculating the number of plants required for each compartment, to allocate a certain number over the exact amount ? These plants could be interplanted in the regular plant lines, and there the forester has to his hand plants for beating-up, which have the double advantage of being acclimatised to local conditions and of a uniform height with the remainder of the plants in the compartment. By using this type of plant, the risk of beating-up single blanks in older plantations is done away with, thus the hundred per cent. ideal is within the realms of possibility.

It should be fairly easy to estimate in the light of past experience the number of failures likely to occur on each forest in a normal season. In any case where Norway spruce is used, any surplus plants which have not been required for beating-up could be sold as Christmas trees. This might even turn out to be quite a remunerative side line.

A. Ross.

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## Recording the History of a Forest.

When re-afforesting a plantation, practical information handed down in writing by the forester who originally formed it is, in most cases, of great assistance to his successors. Scootmore Forest, however, is unfortunate in that respect, there being no such information left by the original forester, yet a comparison of former vegetation, wages, etc., with that of the present might be interesting.

The above-named forest was planted originally some 104 years ago, and at that time the plantation area, it would appear, was well enclosed by means of stone and turf dykes. Years later, on its being re-afforested, it was found necessary to erect wire netting as a safeguard against the inroads of rabbits—these destructive creatures being imported, in the intervening period, in large numbers from England. Vegetation on the original plantation was mostly heath. The herbage, at present, consists partly of heath and partly of grass, but to all appearance, broom is covering rapidly a large part of the area.

The contrast in wages is singularly striking—labour in those days being cheap compared with the present. Can we imagine a forest-worker at the present day undertaking to labour for 10*d.* a day, or to plant land at an average cost of 2*s.* per acre ? Yet such was the case a century ago.

The main species in the former forest were pine, larch and spruce. These have been selected again and areas previously considered unplantable have been drained extensively and planted with Sitka spruce. In all cases the latter have established themselves without any beat-up being necessary.

G. MURRAY.

## LIST OF TECHNICAL STAFF.

### HEADQUARTERS.

*At* 9, *Savile Row, London, W.*1.
Story, Fraser, Education and Publications Officer.
Guillebaud, W. H., Chief Research Officer.

*At Imperial Forestry Institute, Oxford.*
Macdonald, James, Research Officer, England and Wales.

*At* 25, *Drumsheugh Gardens, Edinburgh.*
Macdonald, J. A. B., Research Officer, Scotland.

### ENGLAND AND WALES.

*Assistant Commissioner's Office* (55, *Whitehall, London*).
Taylor, W. L., Assistant Commissioner.
Ross, A. H. H., District Officer (Acquisitions).
Pearson, F. G. O., District Officer (Utilization).

*Division* 1 (*Chopwellwood House, Rowlands Gill, Co. Durham*).
Hopkinson, A. D., Divisional Officer.
Batters, G. J. L., District Officer.
Fossey, R. E., District Officer.
Dicker, A. C., Estate Officer.
Thom, J. R., Probationer District Officer.

*Division* 2 (15, *Belmont, Shrewsbury*).
Long, A. P., Divisional Officer.
Fairchild, C. E. L., District Officer.
De Uphaugh, F. E. B., District Officer.
Best, F. C., District Officer.
Smith, R. H., District Officer.

*Division* 3 (*Beacon House, Queen's Road, Bristol*).
Scott, Frank, Divisional Officer.
Ryle, G. B., District Officer, Higher Grade.
Broadwood, R. G., District Officer, Higher Grade.
Cowell-Smith, R., District Officer.

*Division* 4 (55, *Whitehall, London*).
Felton, A. L., Divisional Officer.
Lowe, George, District Officer.
Stileman, D. F., District Officer.
Sanzen-Baker, R. G., District Officer.

*Division* 5 (*Llandaff Chambers, Regent Street, Cambridge*).
Jones, E. Wynne, Divisional Officer.
Muir, W. A., District Officer.
Connell, C. A., District Officer.
Cownie, F., Estate Officer.
Cadman, W. A., Probationer District Officer.

*Division* 6 (*The King's House, Lyndhurst, Hants*).
Young, D. W., Deputy Surveyor.
Forbes, R. G., District Officer, Higher Grade.
MacIver, L. E., District Officer, Higher Grade.
Yarr, W. J., Assistant to Deputy Surveyor.

*Division* 7 (*Whitemead Park, Parkend, Lydney, Glos*).
Popert, A. H., Acting Deputy Surveyor.
Forster Brown, W., Deputy Gaveller (Mines).
Wylie, N. A., Probationer District Officer.
Ross, J. M., Probationer District Officer.
Roper, John, Survey Clerk.

*School for Forest Apprentices.*
Russell, W. D., District Officer (Instructor).—Parkend, Lydney, Glos.

SCOTLAND.

*Assistant Commissioner's Office* (25, *Drumsheugh Gardens, Edinburgh*).
Murray, J. M., Assistant Commissioner.
Cameron, John, Land Agent.
Mackie Whyte, J.P., District Officer (Acquisitions).
Webster, John, District Officer.

*Northern Division* (51, *Church Street, Inverness*).
Fraser, James, Divisional Officer.
Mackay, J. W., District Officer.
Oliver, F. W. A., District Officer.
Beresford-Peirse, H. C., District Officer.
Spraggan, D. S., District Officer.

*North-Eastern Division* (12, *North Silver Street, Aberdeen*).
Steven, H. M., Divisional Officer.
Newton, L. A., District Officer, Higher Grade.
Bird, D. H., District Officer, Higher Grade.
Warren, A., District Officer.
Watt, A., Probationer District Officer.

*South-Eastern and Western Division* (53, *Bothwell Street, Glasgow*).
Sangar, O. J., Divisional Officer.
Whellens, W. H., District Officer.

Gosling, A. H., District Officer.
Macdonald, J. M., District Officer.
James, J. E., Probationer District Officer.

*School for Forest Apprentices.*
Watson, Harry, District Officer (Instructor).—Benmore, Argyll.

## FORESTERS.

### *England and Wales.*

| *Name.* | *Grade.* | *Name.* | *Grade.* |
|---|---|---|---|
| *Division* 1. | | | |
| Anderson, T. E. | Head | Hodgson, William | II |
| Weir, A. B. | I | Gilson, R. B. | II |
| Bewick, W. J. | II | Simpson, G. A. | II |
| Anderson, J. T. | II | Liddell, Joseph | II |
| McNab, Colin | II | Frank, H. | II |
| Gough, W. R. | II | | |
| *Division* 2. | | | |
| Butter, Robert | Head | Lomas, John | II |
| Jones, H. W. | I | Edwards, D. T. | II |
| Shaw, J. L. | I | Jones, David | II |
| Anderson, J. W. | I | Jones, Alfred | II |
| Fraser, Robert | I | Evans, J. E. | II |
| Roberts, W. G. | I | Reese, W. H. | II |
| Harris, W. A. | II | Watkins, S. | II |
| Harrison, Percy | II | Wilkinson, W. E. | II |
| Brown, G. H. | II | Tucker, E. J. | II |
| Cowe, J. F. | II | | |
| *Division* 3. | | | |
| Williams, John | I | Wild, P. W. S. | II |
| Squires, C. V. | I | Harrison, Phillip | II |
| Hollis, G. W. | I | Caddy, Thomas | II |
| Laney, Horace | II | Edwards, L. T. | II |
| Wallington, H. J. | II | Reid, Duncan | II |
| Pritchard, Roderick | II | Wellington, C. R. | II |
| Jones, A. H. | II | Carnell, R. | II |
| Pallett, R. E. | II | Jones, W. E. | II |
| *Division* 4. | | | |
| Dyer, H. C. | I | Aston, T. H. | II |
| Nelmes, F. J. | I | Phelps, S. E. | II |
| Wallington, A. W. | I | Saunders, H. J. | II |
| Richards, G. H. | II | Kent, William | II |
| Butler, Robert | II | McKenzie, Colin | II |
| Johnson, A. E. | II | Kirkup, J. T. | II |
| Cottenham, W. C. | II | Hyetts, S. | II |
| Gulliver, G. H. | II | | |

*England and Wales.—continued.*

| Name. | Grade. | Name. | Grade. |
|---|---|---|---|
| *Division* 5. | | | |
| McGlashan, John | I | Parry, A. A. .. | II |
| Tribe, William .. | II | Smith, J. J. .. | II |
| Hendrie, T. F. | II | Wyatt, Lionel .. | II |
| Clark, J. S. .. | II | Jackson, W. V. | II |
| Bewick, Robert | II | Halsey, H. R. .. | II |
| Johnson, Harry | II | Birkett, A. .. | II |
| Everitt, F. W. | II | Button, G. .. | II |
| Price, Alfred | II | | |
| *Division* 6. | | | |
| Forgan, William .. | Head | Adams, J. H. .. | II |
| Aston, O. R. T. .. | I | Gale, Bertie .. | II |
| Hale, W. J. .. .. | I | Colwill, S. W. .. | II |
| Parker, F. H. .. .. | II | Kennedy, J. B. | II |
| *Division* 7. | | | |
| Smith, Frank .. .. | Head | Taylor, G. J. .. | II |
| Humphries, W. J. .. | I | Adams, Isaac .. | II |
| Lewis, Tom .. .. | I | Watson, Frank | II |
| Williams, D. N. (School) | I | Lees, George .. | II |
| Walker, A. E. .. .. | II | Morgan, T. R. .. | II |
| Christie, W. L. .. | II | Roberts, James | II |

*Scotland.*

| Name. | Grade. | Name. | Grade. |
|---|---|---|---|
| *N. Division.* | | | |
| Anderson, William .. | Head | Kennedy, John | II |
| McEwan, James .. | I | Cameron, Roderick | II |
| Murray, William .. | I | Stewart, P. C. .. | II |
| Mason, William .. | I | Mackenzie, John | II |
| McClymont, William | I | Mackintosh, A. | II |
| Mackay, Kenneth | I | Ferguson, J. M. | II |
| Macdonald, Donald | II | Gordon, J. .. | II |
| Drysdale, A. .. | II | Munro, G. .. | II |
| Macintosh, William | II | Mackenzie, G. .. | II |
| Gunn, John .. | II | | |
| *N.E. Division.* | | | |
| Cameron, John .. | Head | Allan, Thomas .. | II |
| Shaw, Robert .. .. | Head | Kennedy, J. M. .. | II |
| Lamb, J. A. .. .. | I | Murray, G. J. A. M. .. | II |
| Edwards, Johnston .. | I | Mackay, William .. | II |
| Mitchell, F. M. .. | II | Kennedy, J. A. M. .. | II |
| Robbie, John D. .. | II | Robbie, James D. .. | II |
| McConnell, James .. | II | Scott, J. .. .. | II |
| Corbett, John .. | II | Ross, W. L. .. .. | II |
| Allan, James .. | II | Ritchie, M. A. .. .. | II |
| Ross, Allan .. | II | | |

*Scotland.—continued.*

| *Name.* | *Grade.* | *Name.* | *Grade.* |
|---|---|---|---|
| *S.E. and W. Division.* | | | |
| Paterson, S. H. A. | I | Macmillan, Hugh | II |
| Simpson, A. N. | I | Macrae, Murdo | II |
| Macintyre, J. F. | I | Grant, Alastair | II |
| Cameron, Hugh | I | McDonald, J. D. | II |
| Reid, J. M. .. | I | Watson, James | II |
| Calder, J. M. .. | II | Sinclair, Laurence | II |
| Fraser, A. M. .. | II | Graham, J. McK. | II |
| Graham, Alexander | II | Steele, R. .. | II |
| Cameron, Alistair | II | Munro, D. .. | II |
| Thomson, G. J. .. | II | Macrae, A. D. .. | II |
| Donald, R. R. .. .. | II | | |

*Research and Experiment.*

| | | | |
|---|---|---|---|
| Gray, W. G. (Oxford) .. | II | Mackenzie, A. M. (Headquarters) .. .. | II |
| Grant, Alexander (Edinburgh) .. .. | II | Maund, J. E. (Oxford) .. | II |
| Farquhar, J. (Edinburgh) | II | | |

# REGISTER OF IDENTIFICATION NUMBERS

## Forest Year, 1934.

The order of arrangement is as follows :—

Serial numbers (preceded by the last two numbers of the forest year in which supplies were received) ; quantity ; species ; crop year ; origin ; vendor ; purity per cent. ; germination and fresh seed per cent.

34/1 2 lb. ; *Alnus glutinosa ;* 1933 ; Central France (Massif Central) ; Vilmorin-Andrieux.

34/2 2 lb. ; *Alnus incana ;* 1933 ; Central France (Massif Central) ; Vilmorin-Andrieux.

34/3 9 lb. ; *Pyrus intermedia ;* 1933 ; Northern Europe ; Soren Hermansen.

34/4 6 lb. ; *Nothofagus obliqua ;* 1933 ; Chile ; gift from Chilean Government.

34/5 ½ lb. ; *Nothofagus procera ;* 1933 ; Chile ; gift from Chilean Government.

34/6 2 oz. ; *Nothofagus dombeyi ;* 1933 ; Chile ; gift from Chilean Government.

34/7 4,600 lb. ; *Fagus sylvatica ;* 1933 ; Holland (Arnhem-Zutphen and Arnhem-Wageningen, altitude 80–160 ft.) ; Nederlandsche Heidemaatschappij.

34/8 401 lb. ; *Quercus rubra ;* 1933 ; Holland (Arnhem-Zutphen and Arnhem-Wageningen, altitude 80–160 ft.) ; Nederlandsche Heidemaatschappij.

34/9 6½ lb. ; *Castanea japonica* var. *shiba gouri ;* 1933 ; France (Pyrenees) ; Vilmorin-Andrieux.

34/10 6 oz. ; *Pinus contorta ;* 1933 ; U.S.A. (S.W. Lincoln City, Oregon, altitude 100 ft.) ; gift from U.S.A. Forest Service.

34/11 2,245 lb. ; *Pinus laricio* var. *corsicana ;* 1933 ; France (Valdoniello, Corsica, altitude 3,900–4,600 ft.) ; J. Grimaldi ; 99·5 ; 55 + 10.

34/12 20 lb. ; *Picea sitchensis ;* 1933 ; Canada (Skidegate, Queen Charlotte Islands, British Columbia) ; Canadian Government ; 92·2 ; 93 + 2.

34/13 11 lb. ; *Tsuga heterophylla ;* 1933 ; Canada (Coast, British Columbia) ; Canadian Government ; 98·3 ; 76 + 4.

34/15 3¼ lb. ; *Thuya plicata ;* 1933 ; Canada (Coast, British Columbia) ; Canadian Government.

34/16 12½ lb. ; *Abies grandis ;* 1933 ; Canada (Coast, British Columbia) ; Canadian Government ; 92·6 ; 37 + 9.

34/17 1½ lb. ; *Alnus sitchensis ;* 1933 ; Canada (Frozen Lake, Yale, British Columbia) ; Canadian Government.

34/18 6½ lb. ; *Alnus oregona ;* 1933 ; Canada (Parsons Bench, Chilliwack, British Columbia, altitude 1,000–1,200 ft.) ; Canadian Government.

34/19 1 lb. ; *Alnus oregona ;* 1933 ; Canada (Skidegate, Queen Charlotte Islands) ; Canadian Government.

34/20 3½ lb. ; *Alnus oregona ;* 1933 ; Canada (Coast, British Columbia) ; Canadian Government.

34/21 19½ lb. ; *Alnus oregona ;* 1933 ; Canada (Oyster River, Vancouver Island, altitude 1,500–2,500 ft.) ; Canadian Government.

34/22 10 oz. ; *Cupressus nootkatensis ;* 1933 ; Canada (North Shore, Burrard Inlet, British Columbia) ; Canadian Government.

34/23 73 lb. ; *Pinus contorta ;* 1933 ; Canada (Shuswap Lake, British Columbia, altitude 2,100–2,700 ft.) ; Canadian Government ; 97·9 ; 94 + 3.

34/24 12 oz. ; *Pinus contorta ;* 1933 ; Canada (Prince George, British Columbia) ; Canadian Government.

34/25 13 oz. ; *Pinus contorta ;* 1933 ; Canada (Coast, British Columbia) ; Canadian Government.

34/26 100 lb. ; *Larix europaea ;* 1933 ; French Alps (altitude 2,800 ft.); Vilmorin-Andrieux ; 98·9 ; 43 + 3.

34/27 5 lb. ; *Chamaecyparis lawsoniana ;* 1933 ; France (South) ; Vilmorin-Andrieux.

34/28 3 lb. ; *Pinus insignis ;* 1933 ; France (South) ; Vilmorin-Andrieux.

34/29 5 lb. ; *Pinus montana ;* 1933 ; Germany ; Vilmorin-Andrieux.

34/30 1 lb. ; *Picea alba ;* 1933 ; Germany ; Vilmorin-Andrieux.

34/31 ½ lb. ; *Cupressus macrocarpa ;* 1933 ; France (South) ; Vilmorin-Andrieux.

34/32 1½ lb. ; *Pinus strobus ;* 1933 ; Italy ; Vilmorin-Andrieux.

34/33 30 lb. ; *Quercus palustris ;* 1933 ; France (South-west) ; Vilmorin-Andrieux.

34/34 98 lb. ; *Picea sitchensis ;* 1933 ; U.S.A. (Cape Flattery) ; Long-Bell Lumber Co. ; 82·4 ; 38 + 13.

34/35 595 lb. ; *Picea excelsa ;* 1933 ; Northern Tyrol (Inn Valley, altitude 1,950–2,600 ft.) ; J. Jenewein ; 97·7 ; 89 + 2.

34/36 274 lb. ; *Larix europaea ;* 1933 ; Northern Tyrol (Inn Valley, altitude 1,950–2,600 ft.) ; J. Jenewein ; 89·5 ; 51 + 2.

34/37 47 lb. ; *Alnus incana ;* 1933 ; Northern Tyrol (Inn Valley, altitude 1,650–1,950 ft.) ; J. Jenewein.

34/38 134 lb. ; *Picea sitchensis ;* 1933 ; Germany (Flensburg, Schleswig-Holstein) ; Schultz & Co. ; 92 ; 62 + 4.

34/39 1 lb. ; *Pinus contorta ;* U.S.A. (Coast, altitude 50–100 ft.) ; Manning Seed Co.

34/40 85 lb. ; *Pinus contorta ;* U.S.A. (Olympic Peninsula, altitude 300–500 ft.) ; Manning Seed Co. ; 92·2 ; 87 + 6.

34/41 96 lb. ; *Picea sitchensis ;* U.S.A. (Callam County) ; Manning Seed Co. ; 81·5 ; 61 + 6.

34/42 333 lb. ; *Picea excelsa ;* 1933 ; Germany (Black Forest) ; J. Rafn & Son ; 99 ; 86 + 2.

34/43 1 lb. ; *Sequoia gigantea ;* 1933 ; U.S.A. (California) ; J. Rafn & Son.

34/44 ½ lb. ; *Pinus resinosa ;* 1933 ; Canada (N.W. Ontario) ; J. Rafn & Son.

34/45 20 lb. ; *Hicoria ovata ;* 1933 ; U.S.A. (Western Tennessee, altitude 1,200 ft.) ; O. Katzenstein & Co.

34/46 20 lb. ; *Hicoria cordiformis ;* 1933 ; U.S.A. (Western Tennessee, altitude 1,200 ft.) ; O. Katzenstein & Co.

34/47 1 oz. ; *Picea sitchensis ;* 1933 ; Japan ; Vilmorin-Andrieux.

34/48 512 lb. ; *Larix leptolepsis ;* 1933, Japan ; S. Ando ; 98!5 ; 57 + 6.

34/49 49 lb. ; *Picea sitchensis ;* 1933 ; reputed U.S.A. (Washington) ; J. Stainer ; 82·8 ; 42.

34/50 98 lb. ; *Larix europaea ;* 1933 ; Silesia (Sudeten) ; H. Hanel ; 82·9 ; 39.

34/51 12 lb. ; *Tsuga heterophylla ;* 1933 ; U.S.A. (Rainier National Forest, Western Washington) ; Manning Seed Co. ; 97 ; 61 + 11.

34/52 14 lb. ; *Tsuga heterophylla ;* U.S.A. (St. Helens Township, Cowlitz County, Washington, altitude 1,700–2,000 ft.) ; Long-Bell Lumber Co. ; 99 ; 47 + 14.

34/53 488 lb. ; *Larix europaea ;* 1933 ; Central Alps (Valley of Eysack-Isarco, altitude 2,300–3,900 ft.) ; Silvaterra (Wallpach-Schwanenfeld) ; 86·7 ; 48 + 1.

34/54 758 lb. ; *Picea excelsa ;* 1933 ; Central Alps (Valley of Eysack-Isarco, altitude 2,300–3,900 ft.) ; Silvaterra (Wallpach-Schwanenfeld) ; 98·2 ; 86.

34/55 24 lb. ; *Picea omorica ;* 1933 ; Serbia (Sarajewo, altitude 2,600 ft.) ; J. Morawitz & T. Kluger ; 97·1 ; 56 + 6.

34/56 1 lb. ; *Picea excelsa ;* 1933 ; Roumania (Western Carpathians, altitude 3,600–5,600 ft.) ; gift from Roumanian Government.

34/57 ½ lb. ; *Alnus viridis ;* 1933 ; Roumania (Meridional Carpathians, altitude 4,900 ft.) ; gift from Roumanian Government.

34/58 2 lb. ; *Acer campestre ;* 1933 ; Southern Europe ; J. Rafn & Son.

34/59 2 lb. ; *Acer negundo ;* 1933 ; Southern Europe ; J. Rafn & Son.

34/60 1½ lb. ; *Cupressus macrocarpa ;* 1933 ; U.S.A. ; J. Rafn & Son.

34/61 5 lb. ; *Pinus insignis ;* 1933 ; U.S.A. (California) ; J. Rafn & Son.

34/62 1½ lb. ; *Chamaecyparis obtusa ;* 1933 ; Japan ; J. Rafn & Son.

34/63 ½ lb. ; *Larix koreensis ;* 1933 ; Korea (Kankyo-Hokudo, altitude 2,300–3,300 ft.) ; J. Rafn & Son.

34/64 ¼ lb. ; *Larix europaea ;* 1933 ; Silesia (Sudeten, altitude 2,000–3,100 ft.) ; J. Rafn & Son.

34/65 ¼ lb. ; *Larix europaea ;* 1933 ; Tyrolese Alps ; J. Rafn & Son.

34/66 ¼ lb. ; *Larix europaea ;* 1933 ; Swiss Alps ; J. Rafn & Son.

34/67 ¼ lb.; *Larix europaea;* 1933; France (Haute Alps, Briançon, altitude 6,600 ft.); J. Rafn & Son.

34/68 2 oz.; *Pinus contorta;* 1933; U.S.A. (West Yellowstone, Montana, altitude 6,700 ft.); gift from U.S. Forest Service.

34/69 1 lb.; *Pinus contorta;* 1933; U.S.A. (Priest River Valley, N. Idaho, altitude 2,380 ft.); gift from U.S. Forest Service.

34/70 2 lb.; *Pinus insignis;* 1933; Italy; Vilmorin-Andrieux.

34/71 410 lb.; *Pinus pinaster;* 1933; Portugal (Leiria); gift from Portuguese Government.

34/72 3½ lb.; *Pinus sylvestris;* 1933; Scotland (S.E.); own collection.

34/73 9¼ lb.; *Pinus sylvestris;* 1933; Scotland (West); own collection.

34/74 262 lb.; *Larix europaea;* 1933; Scotland (S.E.); own collection.

34/75 180 lb.; *Larix europaea;* 1933; Scotland (West); own collection.

34/76 609 lb.; *Larix europaea;* 1933; Scotland (N.E.); own collection.

34/77 108 lb.; *Larix europaea;* 1933; Altyre, Morayshire; E. S. Grant.

34/78 30 lb.; *Larix europaea;* 1933; Murthly, Perthshire; Col. Steuart-Fothringham.

34/79 47 lb.; *Larix europaea;* 1933; Carron, Spey, Banffshire; own collection.

34/80 11¼ lb.; *Larix europaea;* 1933; Fochabers, Morayshire; own collection.

34/81 56 lb.; *Larix europaea;* 1933; Auchlunkart, Banffshire; own collection.

34/82 20 lb.; *Larix europaea;* 1933; Gordon Castle, Morayshire; own collection.

34/83 21 lb.; *Larix europaea;* 1933; Blackhills, Morayshire; own collection.

34/84 56 lb.; *Larix europaea;* 1933; Kirkhill, Aberdeenshire; own collection.

34/85 22½ lb.; *Larix europaea;* 1933; Drummuir, Banffshire; own collection.

34/86 20½ lb.; *Larix europaea;* 1933; Advie, Morayshire; own collection.

34/87 51 lb.; *Larix europaea;* 1933; Richmond-Gordon, Morayshire; own collection.

34/88 43 lb.; *Larix europaea;* 1933; Longmorn, Morayshire; own collection.

34/89 93 lb.; *Larix europaea;* 1933; Dunbennan, Morayshire; own collection.

34/90 73 lb.; *Larix europaea;* 1933; Altyre, Morayshire; own collection.

34/91 56 lb.; *Larix europaea;* 1933; Monaughty, Morayshire; own collection.

34/92 5½ lb.; *Larix europaea;* 1933; Blackcraig, Perthshire; own collection.

34/93 25 lb.; *Larix europaea;* 1933; Blervie, Morayshire; own collection.

34/94 25 lb.; *Larix europaea;* 1933; Cawdor, Morayshire; Col. D. Baillie.

34/95 66 lb.; *Larix leptolepis;* 1933; Scotland (S.E.); own collection.

34/96 1½ lb.; *Larix leptolepis;* 1933; Scotland (West); own collection.

34/97 2 oz.; *Larix leptolepis;* 1933; Scotland (N.E.); own collection.

34/98 16¾ lb.; *Larix leptolepis;* 1933; Altyre, Morayshire; E. S. Grant.

34/99 12 lb.; *Larix leptolepis;* 1933; Gordon Castle, Morayshire; own collection.

34/100 1¾ lb.; *Larix leptolepis;* 1933; Blervie, Morayshire; own collection.

34/101 10 lb.; *Larix leptolepis;* 1933; Richmond-Gordon, Morayshire; own collection.

34/102 2 oz.; *Pinus montana;* 1933; Scotland (S.E.); own collection.

34/103 20 lb.; *Larix eurolepis;* 1933; Murthly, Perthshire; Col. Steuart-Fothringham.

34/104 20 lb.; *Larix eurolepis;* 1933; Atholl, Perthshire; Duke of Atholl.

34/105 10 lb.; *Larix eurolepis;* 1933; Glamis, Angus; Earl of Strathmore.

34/106 ¾ lb.; *Tsuga heterophylla;* 1933; Angus; F. D. S. Sandeman.

34/107 4¾ lb.; *Tsuga heterophylla;* 1933; Scotland (West); own collection.

34/108 ¾ lb.; *Tsuga heterophylla;* 1933; Scotland (S.E.); own collection.

34/109 20 lb.; *Tsuga heterophylla;* 1933; Murthly, Perthshire; Col. Steuart-Fothringham.

34/110 5 lb.; *Abies nobilis;* 1933; Altyre, Morayshire; E. S. Grant.

34/111 223 lb.; *Abies nobilis;* 1933; Scotland (West); own collection.

34/112 ¾ lb.; *Abies nordmanniana;* 1933; Scotland (West); own collection.

34/113 ½ lb.; *Abies lowiana;* 1933; Scotland (West); own collection.

34/114 1½ lb.; *Abies grandis;* 1933; Murthly, Perthshire; Col. Steuart-Fothringham.

34/115 ½ lb.; *Abies pindrow;* 1933; Scotland (West); own collection.

34/116 1 lb.; *Abies veitchii;* 1933; Scotland (West); own collection.

34/117 ½ lb.; *Abies spectabilis;* 1933; Scotland (West); own collection.

34/118 ¼ lb.; *Abies brevifolia;* 1933; Scotland (West); own collection.

34/119 ½ lb.; *Picea morindoides;* 1933; Scotland (S.E.); own collection.

34/120 1 lb.; *Picea excelsa;* 1933; Scotland (West); own collection.

34/121 3 lb.; *Picea sitchensis;* 1933; Murthly, Perthshire; Col. Steuart-Fothringham.

34/122 ½ lb.; *Cupressus nootkatensis;* 1932; Scotland (West); own collection.

34/123 1½ lb.; *Cupressus nootkatensis;* 1933; Scotland (West); own collection.

34/124 9 lb.; *Cupressus macrocarpa;* 1933; Scotland (West); own collection.

34/125 15 lb.; *Chamaecyparis lawsoniana;* 1933; Scotland (West); own collection.

34/126 1 lb.; *Chamaecyparis lawsoniana;* 1933; Scotland (N.E.); own collection.

34/127 1 lb.; *Sequoia gigantea;* 1933; Scotland (West); own collection.

34/128 12½ lb.; *Thuya plicata;* 1933; Scotland (West); own collection.

34/129 2 oz.; *Thuya orientalis;* 1933; Scotland (West); own collection.

34/130 ¼ lb.; *Thujopsis dolabrata;* 1933; Scotland (West); own collection.

34/131 55 lb.; *Fraxinus excelsior;* 1933; Scotland (West); own collection.

34/132 408 lb.; *Fagus sylvatica;* 1933; Scotland (S.E.); own collection.

34/133 300 lb.; *Fagus sylvatica;* 1933; Stanley, Perthshire; F. D. S. Sandeman.

34/134 185 lb.; *Fagus sylvatica;* 1933; Altyre, Morayshire; E. S. Grant.

34/135 5,335 lb.; *Fagus sylvatica;* 1933; Scotland (N.E.); own collection.

34/136 20 lb.; *Fagus sylvatica;* 1933; Scotland (West); own collection.

34/137 6 lb.; *Aesculus hippocastanum;* 1933; Scotland (West); own colleccion.

34/138 250 lb.; *Castanea sativa;* 1933; Scotland (S.E.); own collection.

34/139 385 lb.; *Quercus robur (sessiliflora);* 1933; Kincairney, Perthshire; J. McMaster.

34/140 569 lb. ; *Quercus pedunculata ;* 1933 ; Scotland (S.E.) ; own collection.

34/141 461 lb. ; *Quercus pedunculata ;* 1933 ; Scotland (West) ; own collection.

34/142 28 lb. ; *Quercus pedunculata ;* 1933 ; Glenfarg, Perthshire ; P. McAinsh.

34/143 1 lb. ; *Acer platanoides ;* 1933 ; Scotland (West) ; own collection.

34/144 6 lb. ; *Acer platanoides ;* 1933 ; Scotland (N.E.) ; own collection.

34/145 40 lb. ; *Acer pseudoplatanus ;* 1933 ; Scotland (N.E.) ; own collection.

34/146 50 lb. ; *Acer pseudoplatanus ;* 1933 ; Scotland (S.E.) ; own collection.

34/147 12 lb. ; *Rhamnus ;* 1933 ; Scotland (N.E.) ; own collection.

34/148 ¼ lb. ; *Betula alba ;* 1933 ; Scotland (West) ; own collection.

34/149 5,000 transplants (2 + 1) ; *Pinus contorta ;* crop year unknown ; Pollok, Renfrewshire ; Landowners' Co-operative Forestry Society.

34/150 2,760 transplants (2 + 1 + 1) ; *Pinus contorta ;* crop year unknown ; Corrour, Invernessshire ; Landowners' Co-operative Forestry Society.

34/151 6,000 transplants (2 + 2) ; *Pinus contorta ;* crop year unknown ; origin unknown ; Howden & Co., Inverness.

34/152 3,023 lb. ; *Fagus sylvatica ;* 1933 ; England (West) ; own collection.

34/153 66 lb. ; *Fagus sylvatica ;* 1933 ; England (North) ; own collection.

34/154 3,365 lb. ; *Fagus sylvatica ;* 1933 ; England (South) ; own collection.

34/155 183 lb. ; *Fagus sylvatica ;* 1933 ; Wales (South) ; own collection.

34/156 3,626 lb. ; *Fagus sylvatica ;* 1933 ; England (East) ; own collection.

34/157 286 lb. ; *Fagus sylvatica ;* 1933 ; England (Midlands) ; own collection.

34/158 4,108 lb. ; *Castanea sativa ;* 1933 ; England (South) ; own collection.

34/159 28 lb. ; *Castanea sativa ;* 1933 ; England (North) ; own collection.

34/160 16 lb. ; *Castanea sativa ;* 1933 ; Wales (South) ; own collection.

34/161 200 lb. ; *Castanea sativa ;* 1933 ; England (East) ; own collection.

34/162 220 lb. ; *Castanea sativa ;* 1933 ; England (Midlands) ; own collection.

34/163 6,277 lb. ; *Castanea sativa ;* 1933 ; England (West) ; own collection.

34/164 14 lb. ; *Aesculus hippocastanum* ; 1933 ; England (North) ; own collection.

34/165 112 lb. ; *Quercus pedunculata* ; 1933 ; England (North) ; own collection.

34/166 224 lb. ; *Quercus pedunculata* ; 1933 ; England (North) ; R. Mounsey Heysham.

34/167 23,961 lb. ; *Quercus pedunculata* ; 1933 ; England (Midlands) ; own collection.

34/168 59,764 lb. ; *Quercus pedunculata* ; 1933 ; England (South) ; own collection.

34/169 433 lb. ; *Quercus pedunculata* ; 1933 ; Wales (South) ; own collection.

34/170 17,573 lb. ; *Quercus pedunculata* ; 1933 ; England (West) ; own collection.

34/171 31,051 lb. ; *Quercus robur* (*pedunculata*) ; 1933 ; England (East) ; own collection.

34/172 1,000 lb. ; *Quercus sessiliflora* ; 1933 ; England (North) ; own collection.

34/173 550 lb. ; *Quercus sessiliflora* ; 1933 ; England (East) ; own collection.

34/174 8,431 lb. ; *Quercus sessiliflora* ; 1933 ; England (West) ; own collection.

34/175 560 lb. ; *Quercus sessiliflora* ; 1933 ; England (West) ; Liverpool Corporation.

34/176 214 lb. ; *Quercus sessiliflora* ; 1933 ; Wales (South) ; own collection.

34/177 104 lb. ; *Acer pseudoplatanus* ; 1933 ; England (West) ; own collection.

34/178 34 lb. ; *Acer pseudoplatanus* ; 1933 ; England (South) ; own collection.

34/179 385 lb. ; *Acer pseudoplatanus* ; 1933 ; England (East) ; own collection.

34/180 35 lb. ; *Acer pseudoplatanus* ; 1933 ; Wales (South) ; own collection.

34/181 27 lb. ; *Fraxinus excelsior* ; 1933 ; Wales (South) ; Lord Merthyr.

34/182 3 lb. ; *Alnus glutinosa* ; 1933 ; England (South) ; own collection.

34/183 16 lb. ; *Alnus glutinosa* ; 1933 ; England (West ; own collection.

34/184 6 lb. ; *Alnus glutinosa* ; 1933 ; Wales (South) ; own collection.

34/185 $1\frac{1}{2}$ lb. ; *Betula pubescens* ; 1933 ; England (South) ; own collection.

34/186 80 lb. ; *Betula alba* ; 1933 ; England (East) ; own collection.

34/187 1 lb. ; *Larix leptolepis* ; 1933 ; England (South) ; own collection.

34/188 $\frac{1}{2}$ lb. ; *Larix leptolepis* ; 1933 ; Wales (South) ; own collection.

34/189 10 lb. ; *Carpinus betulus ;* 1933 ; England (East) ; own collection.

34/190 6 lb. ; *Thuya plicata ;* 1933 ; England (East) ; own collection.

34/191 35 lb. cones ; *Thuya plicata ;* 1933 ; England (West) ; own collection.

34/192 4 bush. cones ; *Alnus incana ;* 1933 ; England (West) ; own collection.

34/193 2½ lb. ; *Chamaecyparis lawsoniana ;* 1933 ; Wales (South) ; own collection.

34/194 30 lb. ; *Chamaecyparis lawsoniana ;* 1933 ; England (West) ; own collection.

34/195 650 lb. ; *Pinus sylvestris ;* 1933 ; England (East) ; own collection.

34/196 100 lb. ; *Juglans regia ;* 1933 ; England (South) ; own collection.

34/197 560 lb. ; *Juglans regia ;* 1933 ; England (West) ; F. Smith.

34/198 5 lb. ; *Pyrus aria ;* 1933 ; England (West) ; own collection.

34/199 78,000 plants 12 in.–18 in. ; *Fagus sylvatica ;* crop year unknown ; origin unknown ; G. W. Pledge.

34/200 188,000 plants 12 in.–18 in. and 18 in.–24 in. ; *Fagus sylvatica ;* crop year unknown ; origin unknown ; J. Hill & Sons.

34/201 290,000 plants 12 in.–18 in. and 18 in.–24 in. ; *Fagus sylvatica ;* crop year unknown ; origin unknown ; English Forestry Association.

34/202 125,000 2-year seedlings ; *Picea sitchensis ;* crop year unknown ; origin unknown ; Clairmount & Caldecot Nurseries.

34/203 201,000 2-year seedlings ; *Pinus sylvestris ;* crop year unknown ; origin unknown ; Clairmount & Caldecot Nurseries.

34/204 47,000 2-year seedlings ; *Pseudotsuga douglasii ;* crop year unknown ; origin unknown ; Clairmount & Caldecot Nurseries.

34/205 100,000 2-year seedlings ; *Larix europaea ;* crop year unknown ; origin unknown ; Clairmount & Caldecot Nurseries.

34/206 8 lb. ; *Betula pubescens ;* 1933 ; Wales (South) ; own collection.

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